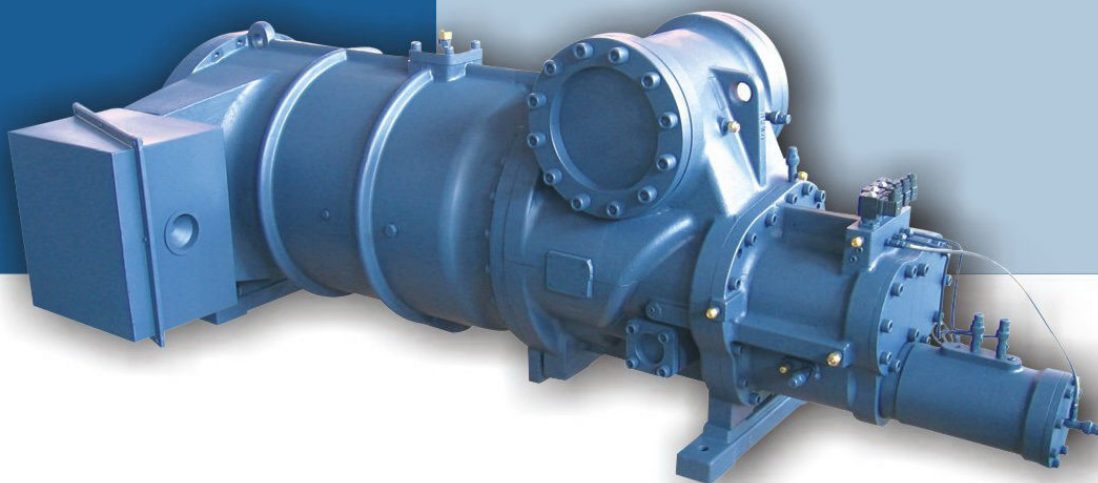


RC2 Series High Voltage Screw Compressor Technical Manual



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HBME-HV-10-A(200)

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1. General

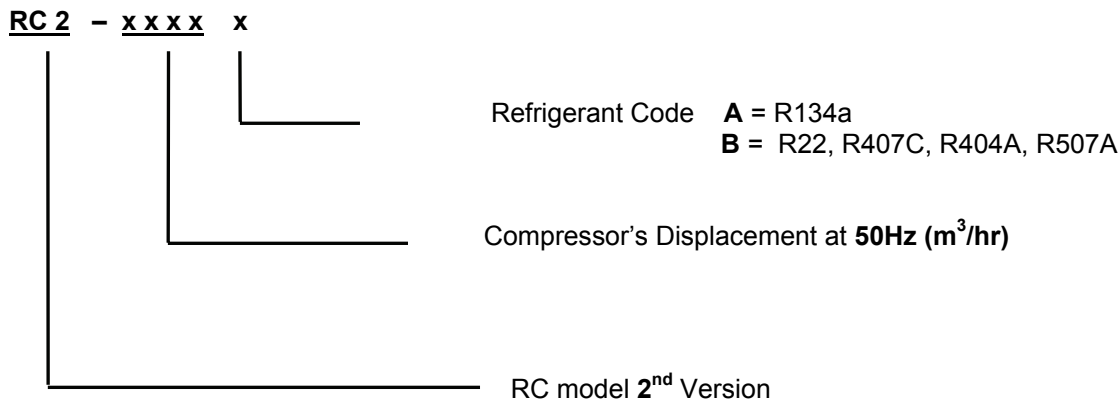
HANBELL **RC2** series semi-hermetic screw compressor is developed especially for applications in air-conditioning and refrigeration. With high operating load design, each HANBELL compressor is of high efficiency and reliability in all operating conditions such as thermal storage, heat pump system & refrigeration. Each HANBELL compressor has the latest and advanced **5-to-6 Patented Screw Rotor Profile** designed to ensure high capacity and efficiency in all operating conditions. Each unit is carefully manufactured and inspected by high precision THREAD SCREW ROTOR GRINDING MACHINE, CNC MACHINING CENTER, and 3D COORDINATE MEASURING MACHINE. Each **HANBELL** compressor follows **ISO 9001** quality system. This certification assures that its quality is controlled under severe quality procedures and good service to all customers.

High Voltage RC2 series compressor is equipped with separated radial and axial bearings, liquid injection and economizer connection, PTC motor temperature thermistors and discharge temperature thermistors, a motor protector, and other accessories. The complete accessories and their new designs guarantee the compressor has the best reliability, longest bearing life during heavy duty running and strict operating conditions.

This Technical Manual contains information about lifting, dimensions, installation, operation, applications and basic trouble-shooting. It is strongly recommended that contents of this manual should be referred carefully prior to lifting, installation, and commissioning of High Voltage RC2 compressor in order to prevent any accident or damage. Please contact HANBELL or its local distributors/agents for more information or further assistance.

2. Specifications and concept of design

2.1 Compressor nomenclature





2.2 High Voltage compressor specifications

a. RC2-A

MODEL	COMPRESSOR					MOTOR						Hydrostatic Pressure Test	WEIGHT		
	Displacement 60 / 50Hz m³/hr	Rated Speed 60 / 50Hz	VI	Cap. Control (%)		Type	Nominal Hp		Starting	Voltage (V)		Insulation	Protection	kg/cm²	kg
				STEP	STEPLESS		60Hz	50Hz		60Hz	50Hz				
RC2-1090A	1310/1089	3550/2950	2.2	35, 50, 75, 100	35~100	3 Phase, 2 Pole, Squirrel Cage, Induction Motor	247	205	DOL	3300 4160 6600	6000 10000	Class F	PTC Protection	42	1710
RC2-1280A	1535/1276		2.6	30, 50, 75, 100	30~100		286	238							1890
RC2-1520A	1832/1523		3.0	25, 50, 75, 100	25~100		331	275							1940
			3.5												

b. RC2-B

MODEL	COMPRESSOR					MOTOR						Hydrostatic Pressure Test	WEIGHT		
	Displacement 60 / 50Hz m ³ /hr	Rated Speed 60 / 50Hz	VI	Cap. Control (%)		Type	Nominal Hp		Starting	Voltage (V)		Insulation	Protection	kg/cm ² g	kg
				STEP	STEPLESS		60Hz	50Hz		60Hz	50Hz				
RC2-1090B	1310/1089	3550/2950	2.2	35, 50, 75, 100	35~100	3 Phase, 2 Pole, Squirrel Cage, Induction Motor	402	335	DOL	3300 4160 6600	6000 10000	Class F	PTC Protection	42	1710
RC2-1280B	1535/1276		2.6	30, 50, 75, 100	30~100		471	392							1890
RC2-1520B	1832/1523		3.0	25, 50, 75, 100	25~100		534	443							1940
			3.5												

Model	Compressor weight kg		
	380V	6000V	10000V
RC2-1090	1430	1710	---
RC2-1280	1580	1890	---
RC2-1520	1630	1940	---

Nominal Horse Power:

All the above Nominal Hp's are not equal to the maximum compressor Hp. Please refer to Hanbell selection software's output for rated current and Maximum Continuous Current-M.C.C according to various operating conditions while selecting sizes of contactor, cable, fuse and wire, etc...

2.3 Compressor construction

High Voltage RC2- 1090, RC2-1280, RC2-1520 construction

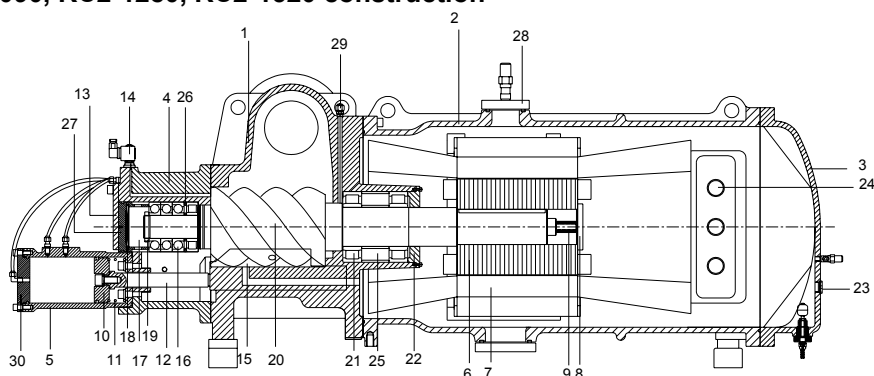


Figure 1: Compressor construction

Item	Description	Item	Description	Item	Description	Item	Description
1	Compressor casing	9	Motor rotor spacer ring	17	Discharge fixed ring	25	Suction bearing inner/outer spacer ring
2	Motor casing	10	Piston	18	Disc spring	26	Discharge bearing inner/outer spacer ring
3	Motor cover casing	11	Piston spring	19	Bearing lock nut	27	Seal plate
4	Bearing seat	12	Piston rod	20	Male rotor	28	Motor cooling inlet
5	Piston cylinder	13	Bearing seat cover plate	21	Suction bearings	29	Oil inlet connection
6	Motor rotor assembly	14	Solenoid valve	22	Suction bearing fixed ring	30	Piston cylinder cover
7	Motor stator assembly	15	Slide valve	23	Sight glass		
8	Motor rotor washer	16	Discharge bearings	24	Power bolt		

2.4 Design features

HANBELL screw compressors feature simple and robust construction by elimination of some components such as pistons, piston rings, valve plates, oil pumps which are found in reciprocating compressors. Without these components, screw compressors run with low noise level, minimized vibration, high reliability and durability. HANBELL screw compressors are of two-shaft rotary displacement design with the latest and advanced 5:6 patented screw rotors. Screw rotors are precisely installed with roller bearings, i.e. radial bearings at both suction and discharge ends as well as angular contact ball bearings i.e. axial bearings at discharge end. A three-phase, two-pole squirrel-cage induction motor drives the compressor. The motor rotor is located on the shaft of male screw rotor. Motor cooling is achieved by independent motor cooling system.

Compressor technical features:

Full product range- Hanbell provides a variety of high voltage motors, 3300V, 4160V, 6600V, 6000V and 10000V, for customer's selection, which are compatible with R22, R134a, R404A, R507A and R407C. Other special working voltage and frequency are available after consulting Hanbell.

Multinational patents of high-efficiency screw rotors- The new 5:6 high efficiency screw rotor profile is patented in Taiwan, UK, US, and China. This new large-volume, high-efficiency rotor profile is designed especially for modern refrigerant characteristics. High-efficiency screw rotors are accomplished by using precision CNC machining centers, rotor milling machines, rotor grinding machines. Strict ISO 9001 process controlling and the application of precise inspection equipments, such as ZEISS 3D coordinate measuring machines, ensure high-efficiency, high-quality, low-noise and low-vibration HANBELL RC2 series screw compressors.

Precise capacity control- Slide valve for capacity control is located in the compressor cylinder. Slide valve is actuated by oil with solenoid valves.

Wide range of operating conditions- Evaporating temperatures can be between -25°C and 15°C while condensing temperatures can be 65°C maximum.

High-efficiency motors- Premium-grade low-loss core steel with special independent motor cooling design provides the highest operating efficiency no matter how strict operating conditions are.

Long-life bearings and high reliability- The screw compressors utilize a combination of 10 axial and radial bearings to ensure longer bearing life and higher compressor reliability.

Double-walled rotor housing- Double casing structure with high strength inner ribs has been designed to minimize noise and ensure rigidity. The rotor housing is made of high-strength gray cast iron FC25 that is extremely stable, therefore no expansion will occur even at high-pressure condition. These casings are machined by computer aided machining centers and inspected by precision measuring machines to enhance reliability.

Perceptive electronics- High Voltage series screw compressors are equipped with PTC thermistors and motor protection module which could monitor discharge and motor coil temperatures. The oil flow switch and oil temperature thermistors are optional for your application.

Independent motor cooling and liquid injection- Independent motor cooling and liquid injection to chamber greatly help heat dissipation in heavy-duty condition.

High Voltage series compressors not only inherit RC2 series compressors' characteristics of high efficiency & reliability design mentioned above, but are also designed with the following new advantages to meet customers' needs:

1. Design the fittest high-efficiency motor for respective refrigerants, operating conditions and applicable power.
2. Dual capacity control provides flexibility in change of control (optional).
3. Floating ECO port design results in partial load effective economizer operation.



2.5 Compression process

As shown in Figure 2 below, during the rotation of the rotors, the meshing shifts from the suction side to the discharge side. The meshing rotors enclose a working space, which is continuously reduced as it moves in the axial direction. This causes a V-shaped lobe space between each male and female lobes. This lobe space is maximum at suction and sealing process. As the rotors rotate further, the new meshing at the suction side closes the V-shaped lobe space. The lobe space is then constantly reduced by continuous intermeshing of the lobes (compression process).

A reduction in lobe space takes places during its movement from the suction side of the rotors towards the discharge side. The volume is steadily reduced and it is thereby compressed in the sealed condition. As soon as the peaks of the rotor teeth are free to the outlet port, compressed vapor is discharged to the high-pressure side and flows to the oil separator where the high-pressured gas is separated from lubrication oil. The size and geometry of the outlet port determine the so-called “internal volume ratio (V_i)” of the compressor. This ratio must have a defined relationship with operating pressure ratio to avoid losses in efficiency due to under or over compression.

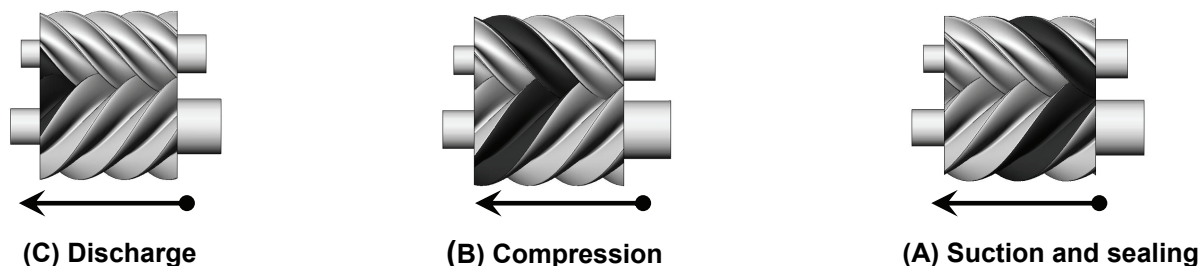


Figure 2: Compression process

2.6 Capacity control system

High Voltage series screw compressors are equipped with either 4-step capacity control system or continuous (step-less) capacity control system. Both of these capacity control systems consist of a modulation slide valve, a piston rod, a cylinder, a piston and piston rings. The slide valve and the piston are connected by a piston rod. The principle of operation is using oil pressure to drive the piston in the cylinder. For example, lubrication oil flows into the cylinder due to oil pressure of which resultant is bigger than spring force plus the force of high-pressured gas in the other side of the piston. Oil inside the cylinder pushes the piston toward the suction side. When the slide valve moves toward the suction side, the effective compression volume is increased in the compression chamber. This means the displacement of refrigerant gas is also increased; as a result, the refrigeration capacity is also increased. However, when any of solenoid valves (for 4-step capacity control system) is opened, the high-pressured oil in the cylinder will be bypassed to the suction side. In this way, the piston together with the slide valve will move toward partial load positions (either 25%, or 50%, or 75% for 4-step capacity control system) and then some of the refrigerant gas will be bypassed from the compression chamber back to the suction side. As a result, the refrigeration capacity is decreased because of reduction in displacement of refrigerant gas flowing in the system.

A piston spring is used to push the piston back to its initial position, i.e. the minimum-load position, in order to reduce starting current for the next start. If the compressor starts at full load, over current may happen. Orifices are used to maintain a suitable amount of oil flow into the cylinder. Solenoid valves (SV1 and SV2) for step-less control are controlled by a micro controller or a temperature switch to modulate the position of the piston smoothly for loading, or unloading or stable.

If solenoid valves and the piston do not work well in the capacity control system, this may result in capacity control failure. Before compressors stop, HANBELL strongly recommends that the unloading solenoid valve for step-less control system or the minimum-load solenoid valve for step control system should be kept opened for 30~60 seconds so the piston in the cylinder can approach the minimum-load position for lighter duty in next start.

2.6.1 4-step capacity control system

There are three solenoid valves equipped that control compressor capacity from the minimum load (please refer to 2.2 for different minimum capacity in each model) to full load (100%). In general, normally closed (NC) solenoid valves are used to control variation of loads. For the compressor with 4-step capacity control system, usual use the sequence of min%-50%-75%-100% to load the capacity of compressor and use the sequence of 100%-75%-50%-min% to unload the capacity.

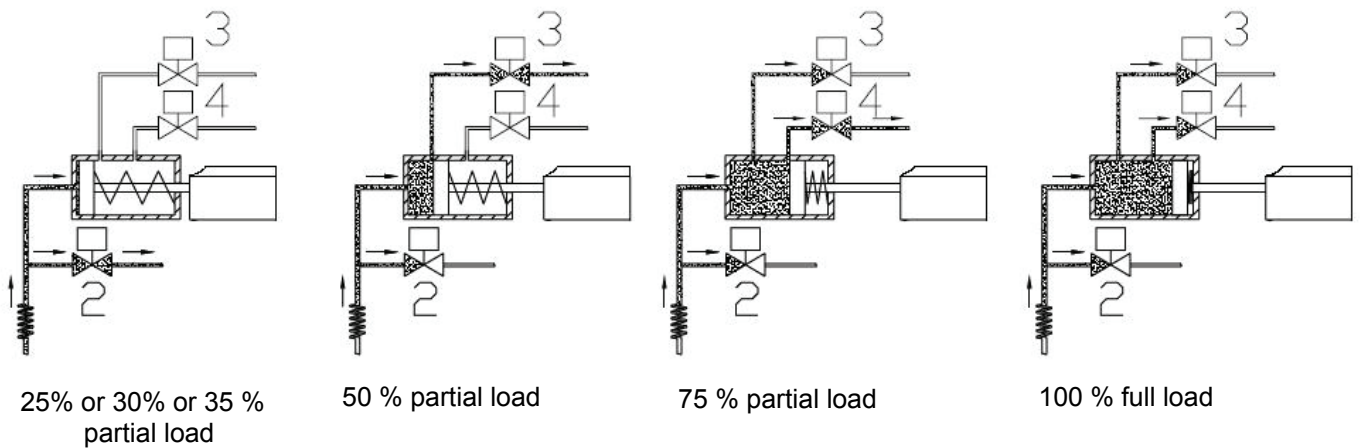


Figure 3: 4-step capacity control

Note: For 4-step capacity control system, Hanbell equips normally closed (NC) solenoid valves as standard accessory. To equip normally open (NO) solenoid valves, please specify it to Hanbell when placing orders.

4-step capacity control system	SV2(NC)	SV3(NC)	SV4(NC)
100% full load	Not energized	Not energized	Not energized
75% of partial load	Not energized	Not energized	energized
50% of partial load	Not energized	energized	Not energized
min% (for starting)	Energized	Not energized	Not energized

2.6.2 Continuous (step-less) capacity control system

In continuous (step-less) capacity control system, a normally closed solenoid valve SV1 (for loading) and a normally closed solenoid valve SV2 (for unloading) are equipped respectively as shown in Figure 4. These two solenoid valves are controlled by chiller temperature controller or micro controller, the refrigeration capacity hence can be modulated at anywhere within min% ~ 100%

It is very important for any controller to control loading and unloading in moderate condition. For smooth modulation, HANBELL installs an orifice in loading oil line to prevent too fast loading.

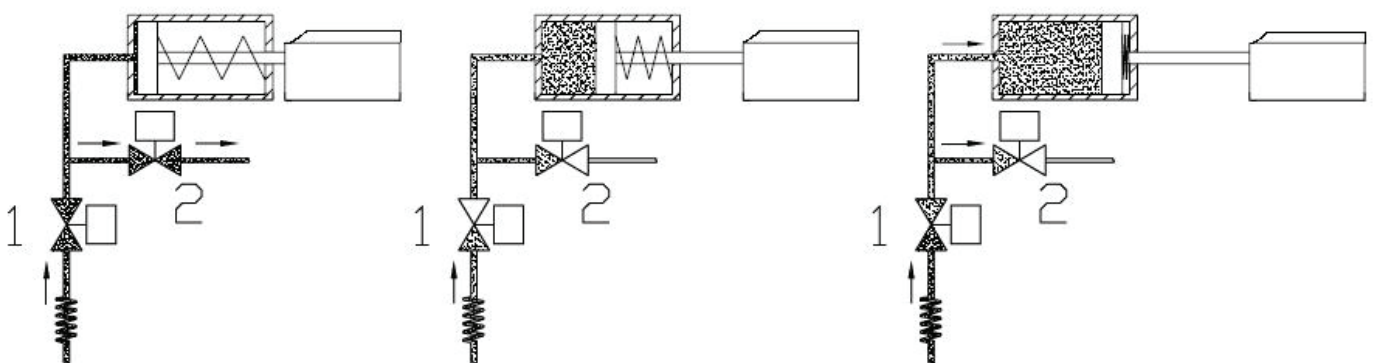


Figure 4: Step-less capacity control

- Note: 1. For continuous(step-less) capacity control system, Hanbell installs one normally closed solenoid valve for loading and another normally closed solenoid valve for unloading as standard. If it is necessary to install other type of solenoid valves, please specify it to Hanbell when placing orders.
2. To equip loading orifice or not depends on system applications, please discuss it with Hanbell when placing orders.

	SV1(NC)	SV2(NC)
Start	Not energized	energized
Loading	energized	Not energized
Unloading	Not energized	energized
Stable	Not energized	Not energized



2.6.3 Dual capacity control system (optional)

Hanbell can provide dual capacity control system which is compatible for 4-step & step-less capacity control for customers' ease of change as shown in Figure 5, and its control logic is the same as explained in either 2.6.1 or 2.6.2.

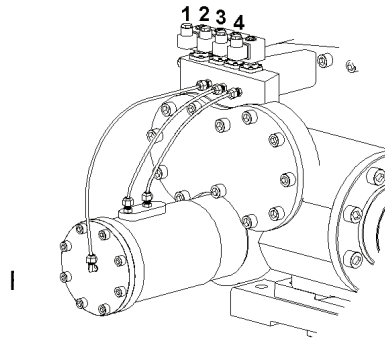


Figure 5: Solenoid valves for dual capacity control

2.7 Compressor volume ratio (Vi)

The volume ratio (**Vi**) of the compressor can be defined as the ratio of suction volume to discharge volume in the compressor. The smaller the concavity of slide valve in the discharge end, the larger the volume ratio. The volume ratio directly affects the internal compression ratio (**Pi**). Low **Vi** corresponds to low **Pi** and high **Vi** corresponds to high **Pi**. In the equation below, in order to prevent over or under compression, the system compression ratio (**CR**) should be equal to compressor's internal compression ratio (**Pi**). Please refer to P-V (pressure – volume) diagram below to figure out this relation.

$$CR = P_d / P_s$$

$$P_i = V_i^k$$

$$V_i = V_s / V_d$$

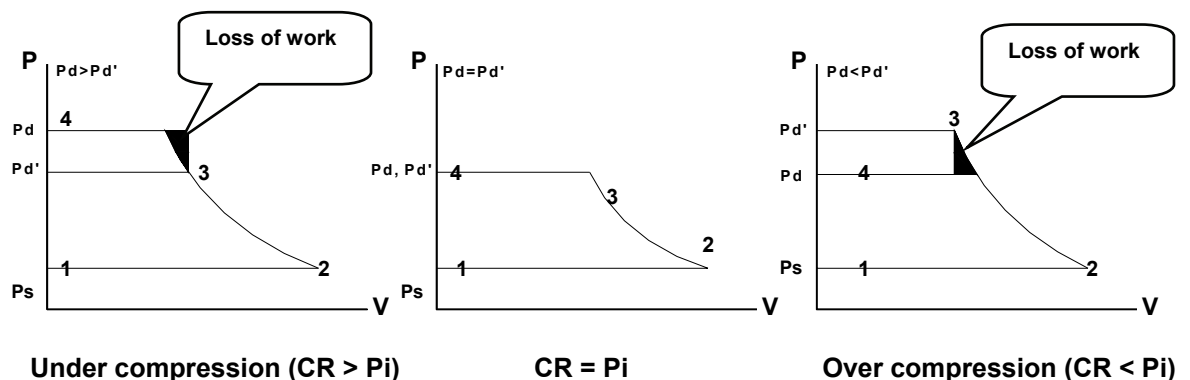


Figure 6: P-V Diagram

CR: system compression ratio

Vi: internal volume ratio

Pd': discharge pressure (absolute pressure)

Vs: suction volume

K: refrigerant specific heat ratio

Pi: internal compression ratio

Pd: system condensing pressure (absolute pressure)

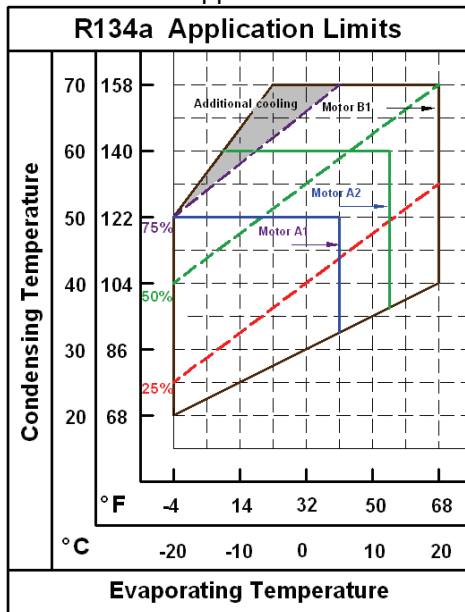
Ps: suction pressure (absolute pressure)

Vd: discharge volume

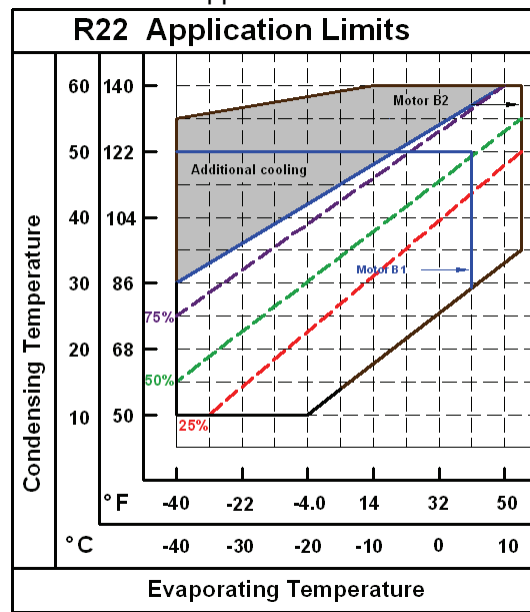
2.8 Application limits

Compressor application limits vary significantly with types of refrigerant used. Application limits shown below are based on operating conditions, i.e. saturated suction and discharge temperatures. For continuous long-term operation, it is important to operate within these limits to maintain compressors' life expectancy. Operating at extra low saturated suction temperatures may cause oil management and motor cooling problems, while operating at extra high saturated condensing temperatures may shorten compressors' lifetime due to insufficient motor and compressor chamber cooling.

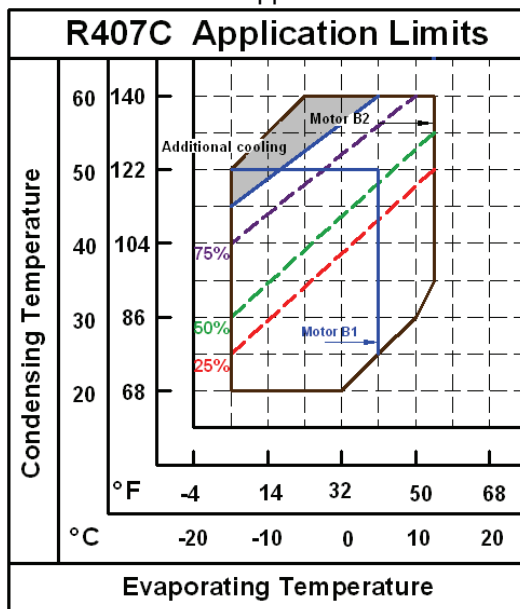
R134a Application Limits



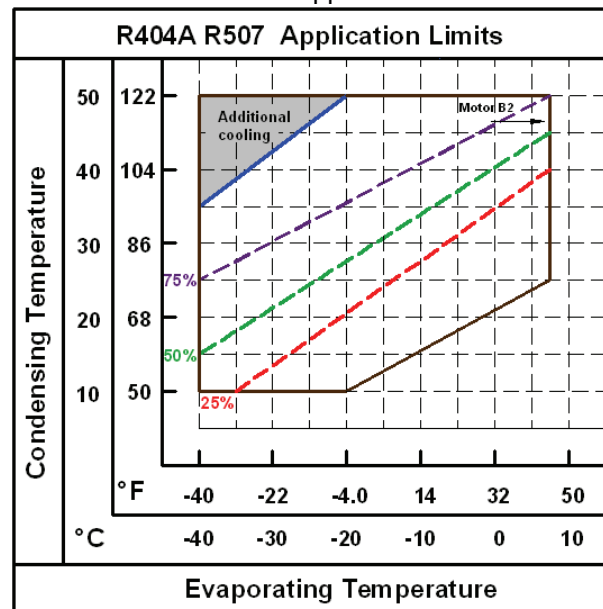
R22 Application Limits



R407C Application Limits



R404A&R507 Application Limits



Note:

1. Different types of motor, A1, A2, B1 and B2 applies to respective refrigerants and operating conditions as shown in the above application limits.

2. When High Voltage series screw compressors operate under partial or full load within application limits, motor and discharge temperatures will rise concurrently. In order to keep compressors' continuous running safe, Hanbell recommends using the following additional cooling devices :

(1) Oil cooler (2) Liquid injection to chamber

Please refer to Hanbell selection software for the application of additional cooling systems.

Hanbell recommends monitoring oil pressure differential and keeping it 4kg/cm²g over the suction pressure for adequate seal, lubrication and capacity control by pressure differential switches passively or by additional oil pumps actively. Especially under operating conditions with low condensing temperatures and high evaporating temperatures like applications in water-cooled flooded chillers, high-low pressure differential tends to be less than 4kg/cm²g, The installation of oil pumps is recommended to ensure regular oil supply.

Please contact Hanbell to verify potential operating conditions outside the application limits shown above.

3. The minimum discharge superheat is recommended to be kept 10K higher than the condensing temperature (normally discharge superheat is around 20K for R134a and 30K for R22, R407C) to avoid liquid compression and lubrication failure.



2.9 MCC & LRA

Refrigerant : R134a

Model	50Hz				60Hz				Unit: Ampere	
	6000V		10000V		3300V		4160V			
	MCC	LRA	MCC	LRA	MCC	LRA	MCC	LRA	MCC	LRA
RC2-1090A	20	128	12	80	44	263	35	196	22	144
RC2-1280A	23	133	14	76	50	267	40	205	25	147
RC2-1520A	27	137	16	90	58	276	46	230	29	152

Refrigerant : R22, R407C, R404A

Model	50Hz				60Hz						Unit: Ampere
	6000V		10000V		3300V		4160V		6600V		
	MCC	LRA	MCC	LRA	MCC	LRA	MCC	LRA	MCC	LRA	
RC2-1090B	32	163	19	93	70	330	56	273	35	185	
RC2-1280B	38	177	23	101	82	377	65	301	41	192	
RC2-1520B	42	201	25	112	92	424	73	343	46	222	

3. Lubricants

The main functions of lubrication oil in screw compressors are lubrication, internal sealing, cooling and capacity control. Positive oil pressure in the cylinder pushes the piston together with the slide valve that is connected by a piston rod to move forward and backward in the compression chamber. The design of positive pressure differential lubrication system makes RC2 series normally omit an extra oil pump which is necessary for reciprocating compressors. However, in some special applications, it is still necessary to install an extra oil pump to screw compressors for safety.

Bearings used in RC2 series compressors require a small and steady quantity of oil for lubrication. Oil injection into the compression chamber creates a film of oil for sealing in the compression housing to increase efficiency and also can dissipate part of compression heat. In order to separate oil from refrigerant gas, an external oil separator is required to ensure the least amount of oil carried into the system.

Please pay more attention to the oil temperature, which is crucial to compressor bearings' life. Oil has a much lower viscosity at high temperatures. Too low viscosity of oil will result in poor lubrication and heat dissipation in the compressor. Viscosity is recommended to keep over 10mm²/s at any temperatures for oil. Oil temperature in the oil sump should be kept above the saturated condensing temperature to prevent refrigerant migration into lubrication system. Oil has a higher viscosity in low ambient temperature circumstances. When viscosity is too high, slow flow speed of oil into the cylinder may result in too slow loading of the compressor. To solve this problem, use of oil heaters can warm up oil before start.

If the compressor operates under critical operating conditions, an extra oil cooler is required – please refer to Hanbell selection software for the required capacity and oil flow of the extra oil cooler. High-viscosity oil is recommended to apply in high operating conditions because high discharge temperatures will make viscosity of oil lower. Oil return from the evaporator may be insufficient in such as refrigeration systems, flooded chillers...etc. , in which it's difficult for oil to be carried back.

3.1 Lubricant table

Applicable oil types (R22)

SPECIFICATION	UNITS	HBR -B10	HBR -A02	HBR -A04	HBR -B09	HBR -B02	HBR -B01
COLOR, ASTM		1.5	L1.0	L1.0	–	–	–
SPECIFIC GRAVITY		0.883	0.914	0.925	0.95	1.01	1.05
VISCOSITY	40℃	56.0	54.5	96.5	175	168	298
	100℃	7.0	6.07	8.12	16.5	20.2	32.0
FLASH POINT	℃	220	188	198	265	290	271
POUR POINT	℃	-40	-35	-25	-30	-43	-35
T.A.N	mg KOH/g	0.01	0.00	0.01	–	–	–
COPPER STRIP	100℃/3hr	1a	1a	1a	–	–	–
MOISTURE	ppm	15	20	20	–	–	–
FLOC POINT	℃	-75	-45	-35	–	–	–
DIELECTRIC STRENGTH (2.5mm)	kV	75	50	50	46.6	–	–

Applicable oil types (R134a, R404A, R407C)

SPECIFICATION	UNITS	HBR -B05	HBR -B08	HBR -B09	HBR -B04
COLOR, ASTM		–	–	–	–
SPECIFIC GRAVITY		0.945	0.94	0.95	0.95
VISCOSITY	40℃	64	131	175	215.9
	100℃	8.9	14.53	16.5	20.8
FLASH POINT	℃	266	254	265	271
POUR POINT	℃	-43	-36.5	-30	-25
T.A.N	mg KOH/g	–	–	–	–
COPPER STRIP	100℃/3hr	–	–	–	–
MOISTURE	ppm	–	–	–	–
FLOC POINT	℃	–	–	–	–
DIELECTRIC STRENGTH 2.5mm	kV	–	–	46.6	–

Note: For other applicable oil types, please consult HANBELL for further approval.

3.2 Pre-cautions of changing oil

1. Use only qualified oil and do not mix different brands of oil together. Choice of oil should match characteristics of the refrigerant used. Some types of synthetic oil is incompatible with mineral oil. Oil remained in the compressor should be totally cleaned up in the system before charging different brands of oil. Charge the compressor with oil for the first start and then change it into new oil again to ensure that there's no mix at all.



2. When using polyester oil for chiller systems, please make sure not to expose oil to the atmosphere for prevention of change in its property. Therefore, it is necessary to vacuum the system completely when installing the compressor.
3. In order to ensure no moisture inside the system, it is suggested to clean the system by charging it with dry Nitrogen and then vacuum it repeatedly as long as possible.
4. It is a must to change oil especially if the motor has burned out because acid debris may still remain inside the system. Please follow the procedures mentioned above to change oil in the system. Check acidity of oil after 72 hours of operation and then change it again until acidity of oil becomes normal.
5. Please contact Hanbell local distributors/agents for choices of oil to be used.

3.3 Oil change

Lubrication oil is an important element in chiller systems. The main functions of lubrication oil in the screw compressor are lubrication, internal sealing, cooling and capacity control. Some problems which may exist in the system are as below.

1. Foreign debris contaminates lubricant and causes clog in oil filter.
2. Moisture in the system will make the system acid and motor corroded.
3. When the system is under an operating condition with high discharge temperature for a long time, oil viscosity will decrease and shorten bearing's life.

The correct ways to change lubrication oil are as below

1. Change oil periodically: Check lubrication oil every 10,000 hours of continuous running. For the first operation of the compressor, it is recommended to change the oil and clean the external oil filter after running 2,000 hours. Check the system whether clean or not and then change oil every 20,000 hours or after 3 years' continuous running while the system operates in good condition.
2. Debris in the system may block up external oil filter. To avoid this problem, it is recommended to add an oil pressure differential switch. When oil pressure differential before and after the external oil filter is over the set-point, the system should stop to protect compressor from oil loss.
3. If the system is under an operating condition with high discharge temperature for a long time, it is recommended to check oil quality every 2 months. If the elements of oil have changed, change oil immediately.
4. Acid oil will shorten motor's life. Check acidity of oil periodically. If it is below pH6, change oil immediately as well as the dryer filter to ensure no moisture in the system.
5. After change of the burned motor, it is necessary to check oil condition every month. Moisture and acidity of oil should be checked.

4. Compressor lifting and installation

4.1 Compressor lifting

Each HANBELL screw compressor has been carefully tested at the factory and every precautionary measures have been taken to make sure that compressors will keep in perfect condition when reach customers' work. After the compressor arrives at your warehouse, please check if its crate is kept in good condition and check all the compressor accessories with shipping documents to see if there is any discrepancy.

When lifting the compressor, it is recommended to use a steel chain or steel cable which can be used for loading capacity of 3000kgf as shown in the figure below.

Make sure that chains, cables or other lifting equipments are properly positioned to protect the compressor and its accessories from damaging. Keep the compressor in horizontal position when lifting, and prevent it from crashing or falling on the ground, hitting the wall or any other accident that may damage it or its accessories.

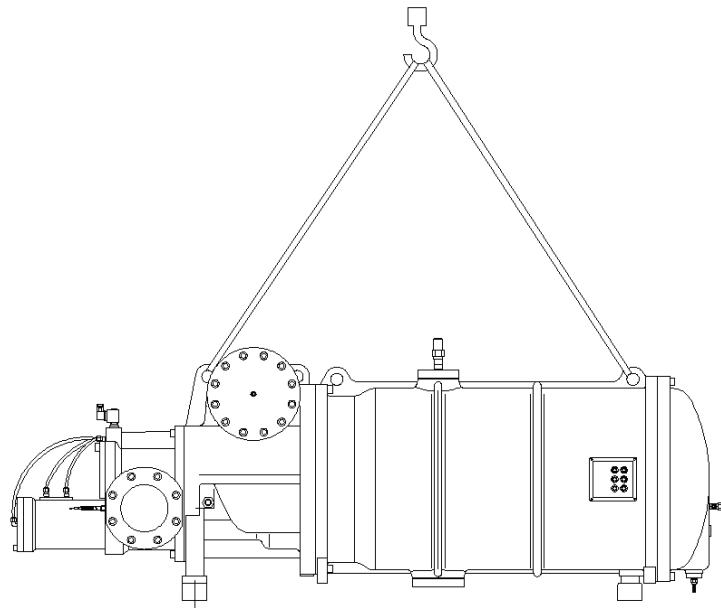


Figure: 7 Lifting the compressor with steel chain or steel cable



4.2 Compressor mountings

The position of the compressor in refrigeration system should be accessible and make sure the chiller base or its site is far away from any heat source to prevent heat radiation. The compressor should also be installed as close as possible to the power supply for easier connection and it's a must to keep good ventilation and low humidity condition in the site. Please make sure that the frame or support is strong enough to prevent vibration and noise when compressor is running and its clearance is enough for compressors' future overhauling work.

The compressor must be installed horizontally. To prevent vibration transferred from the structure and piping of the chiller during operation, cushions or anti-vibration pads (mounting pads) should be installed. The installation of anti-vibration pads is shown in Figure 8. Bolts can not be tightened until some slight deformation of rubber pads is visible.

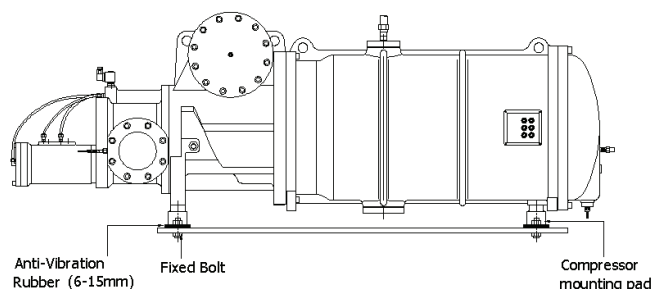


Figure 8: Installation of anti-vibration pads

4.3 Piping work

Improper piping works could cause abnormal vibration and noise that might damage compressor. Please pay attention to the following points to prevent any accidents:

1. Clean the system after welding of piping to avoid any swarf or debris contained inside the system because it may cause serious damage to compressor during operation.
2. In order to reduce vibration in piping, it is recommended to install muffler on discharge piping and economizer piping. In discharge piping, use of flexible stainless steel piping is also helpful to reduce vibration. Muffler should be installed as close to economizer port or discharge port as possible.
3. The material of suction and discharge flange bushings is forged steel and it can be welded directly with piping connection. Welding of flange bushing onto piping must be cooled down by ambient air. Do not use water to cool it down because water quenching will destroy its structure.
4. Flowing gas will cause resonance especially in discharge or economizer piping, so it is necessary to avoid the frequency that results in resonance between compressor and piping. It is also necessary to consider operating condition, flowing speed of refrigerant, and compressor's vibration frequency. The inherent harmonic frequency approximates 250Hz for 50Hz application and 300Hz for 60 Hz application. Their multiples should be considered as well.
5. It is recommended that the position of the compressor be higher than that of the evaporator.

4.4 Installing the compressor in a sloping position

Figure 9 shows a 15° limit of oblique angle for installation of compressor. In case the oblique angle is higher than the limit, compressor will be shut down easily. For special applications like the installation in ships, fishing boats, etc..., where the oblique angle might exceed the limit, external oil separators, oil tanks and related accessories are recommended to be installed. Please contact HANBELL or local distributors for further layout recommendation.

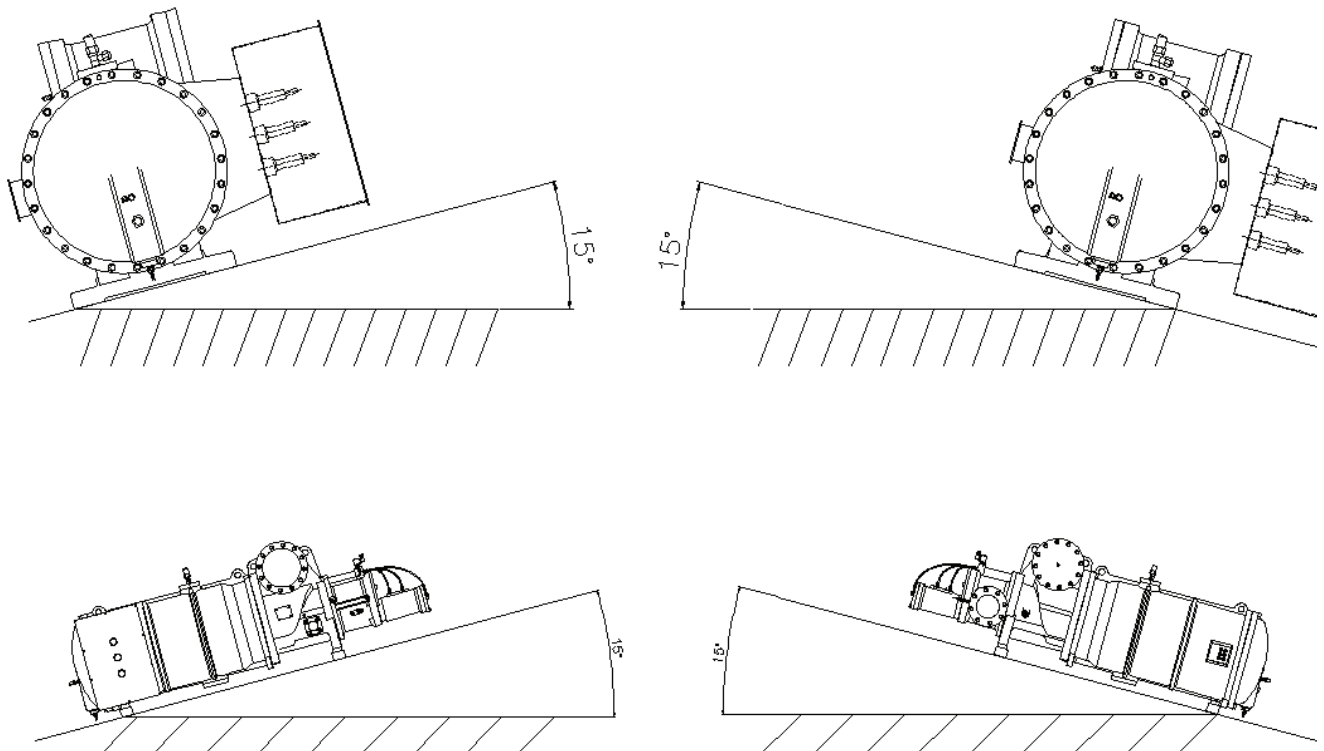
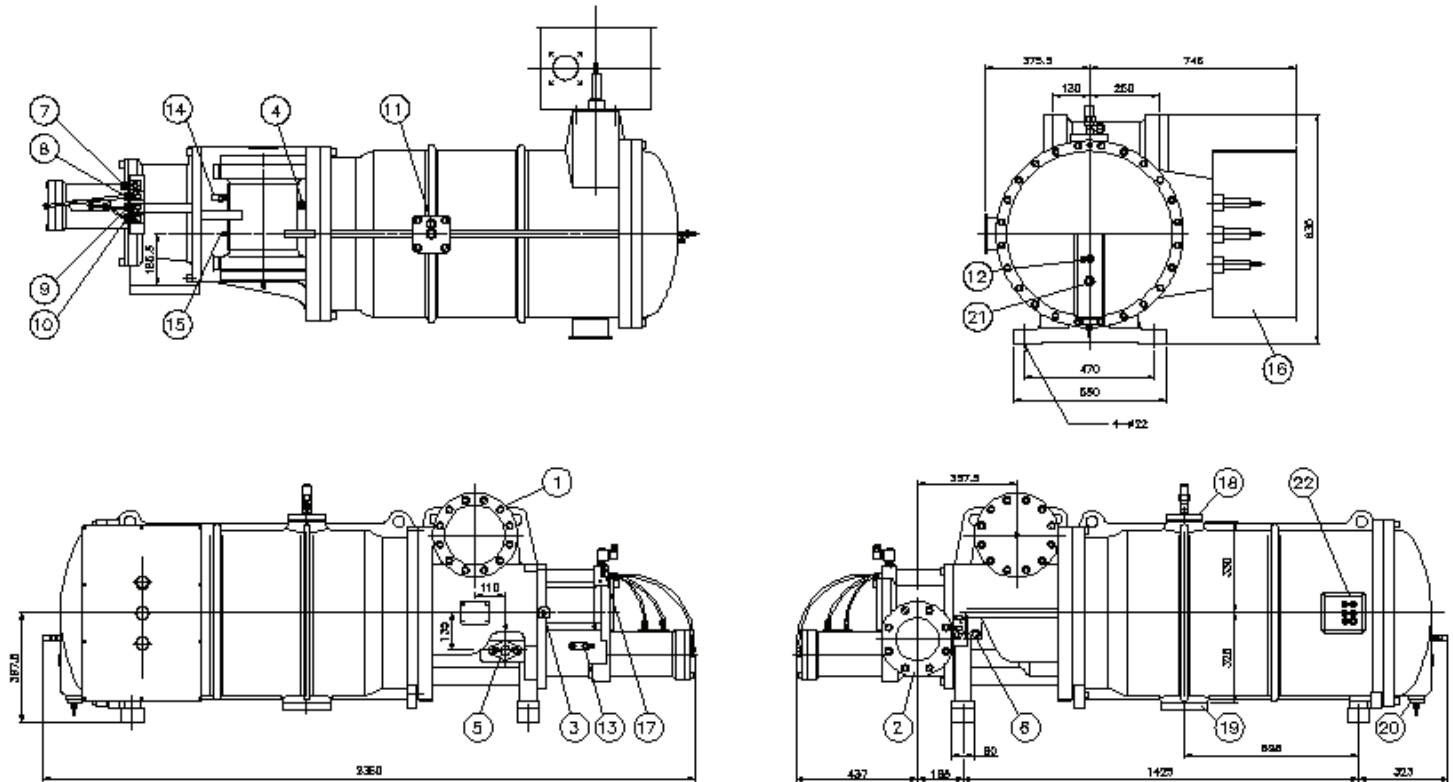


Figure 9: Limits of oblique angle for the installation of the compressor



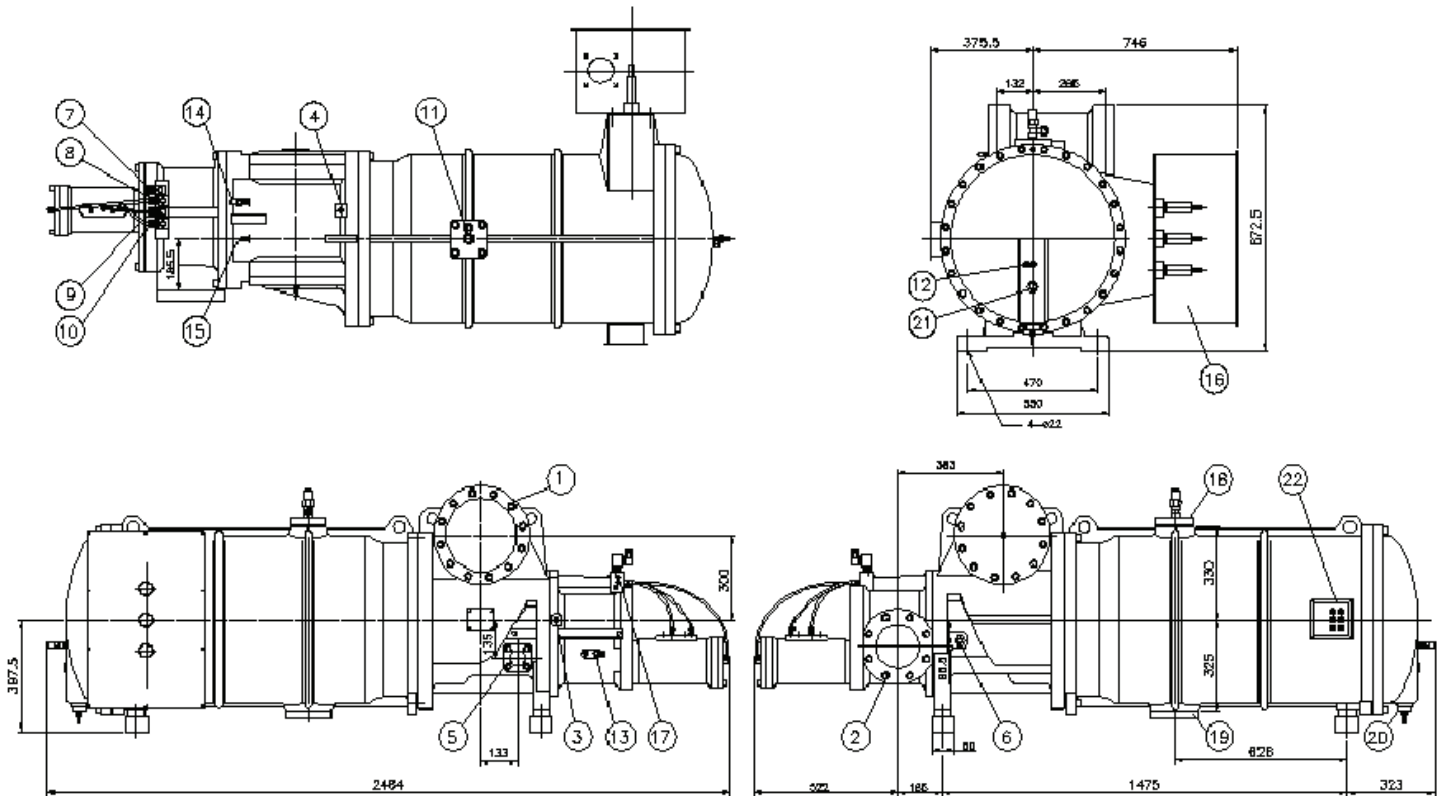
4.5 Compressor outline drawings

RC2-1090



No.	Name	Note	No.	Name	Note
1	Suction flange	6"	12	Angle valve	1/4"Flare
2	Discharge flange	5"	13	Angle valve	1/4"Flare
3	Oil connection	1/4"Flare	14	Angel valve	1/4"Flare
4	Oil connection	3/8"Flare	15	Refrigerant service valve	1/4"Flare
5	Economizer port	1 1/8", solder	16	Cable box	
6	Liquid injection connector	5/8"Flare	17	Modulation control oil connector	1/4"Flare
7	Solenoid valve	Stepless(NC), option	18	Economizer flange(In)	2 1/2"
8	Solenoid valve	25%(NC)	19	Economizer flange(out)	4"
9	Solenoid valve	50%(NC)	20	Level switch	
10	Solenoid valve	75%(NC)	21	Sight glass	
11	Liquid injection connector	1/2"Flare	22	Controller cable box	

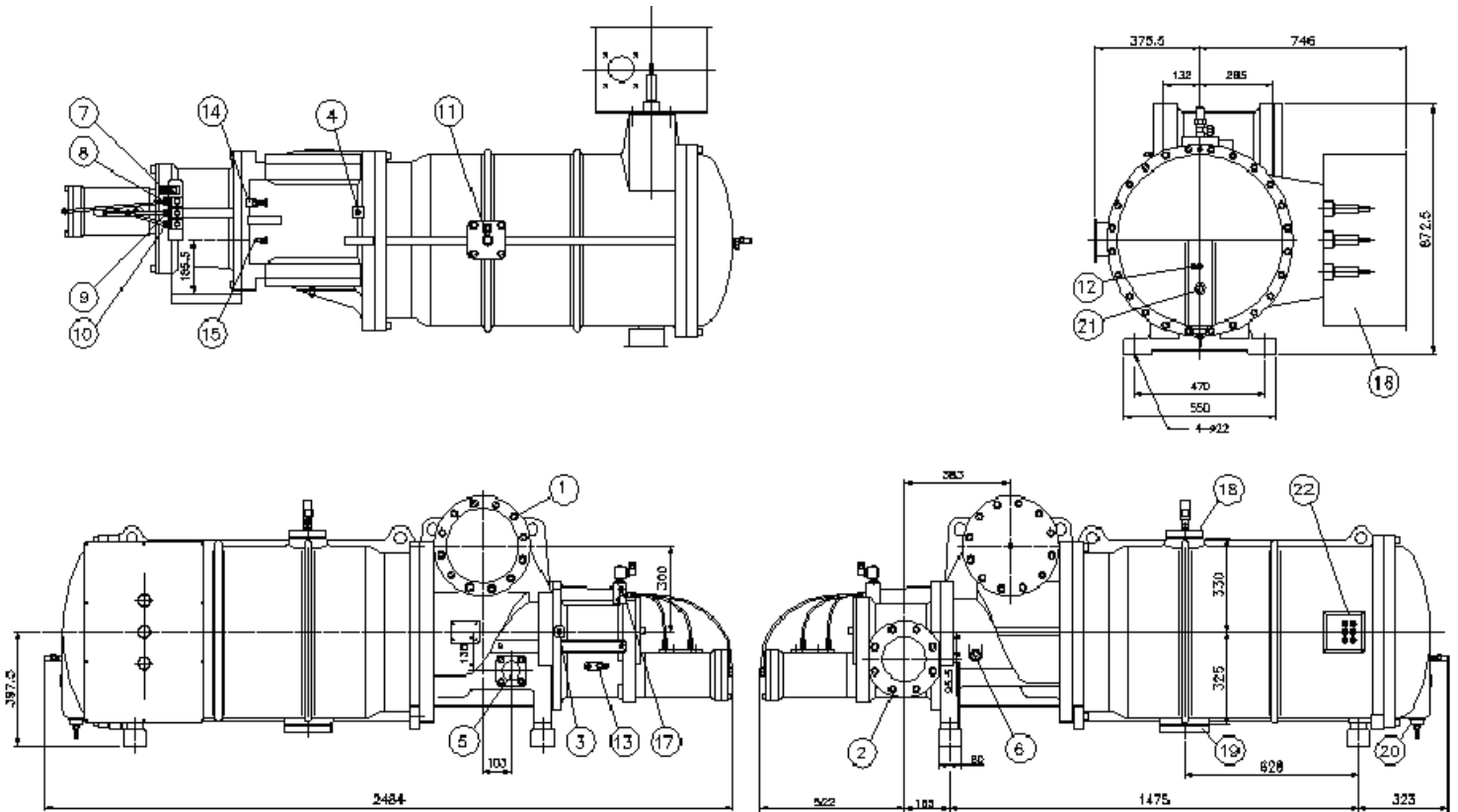
RC2-1280



No.	Name	Note	No.	Name	Note
1	Suction flange	8"	12	Angle valve	1/4"Flare
2	Discharge flange	5"	13	Angle valve	1/4"Flare
3	Oil connection	1/4"Flare	14	Angel valve	1/4"Flare
4	Oil connection	3/8"Flare	15	Refrigerant service valve	1/4"Flare
5	Economizer port	1 5/8", solder	16	Cable box	
6	Liquid injection connector	5/8"Flare	17	Modulation control oil connector	1/4"Flare
7	Solenoid valve	Stepless(NO), option	18	Economizer flange(in)	2 1/2"
8	Solenoid valve	25%(NC)	19	Economizer flange(out)	4"
9	Solenoid valve	50%(NC)	20	Level switch	
10	Solenoid valve	75%(NC)	21	Sight glass	
11	Liquid injection connector	1/2"Flare	22	Controller cable box	



RC2-1520



No.	Name	Note	No.	Name	Note
1	Suction flange	8"	12	Angle valve	1/4"Flare
2	Discharge flange	5"	13	Angle valve	1/4"Flare
3	Oil connection	1/4"Flare	14	Angel valve	1/4"Flare
4	Oil connection	3/8"Flare	15	Refrigerant service valve	1/4"Flare
5	Economizer port	2 1/8", solder	16	Cable box	
6	Liquid injection connector	5/8"Flare	17	Modulation control oil connector	1/4"Flare
7	Solenoid valve	Stepless(NO), option	18	Economizer flange(in)	2 1/2"
8	Solenoid valve	25%(NC)	19	Economizer flange(out)	4"
9	Solenoid valve	50%(NC)	20	Level switch	
10	Solenoid valve	75%(NC)	21	Sight glass	
11	Liquid injection connector	1/2"Flare	22	Controller cable box	

4.6 Compressors accessories

To supply "Total Solution" for customers, Hanbell designs complete standard and optional accessories according to various application requirements for safe and steady running as well as the best performance of compressors.

1. Compressor standard and optional accessories

● : Standard, △ : Optional, X : No need

Model & Accessory	RC2-		
	1090	1280	1520
Steps or Step-less capacity control system	●	●	●
Dual capacity control system	△	△	△
Horizontal check valve	●	●	●
Suction & discharge connection bushings	●	●	●
Suction & discharge stop valves	△	△	△
PTC thermistor	●	●	●
IP54 cable box	●	●	●
INT69HBY motor protector	●	●	●
Liquid injection system (solenoid valve + expansion valve)	△	△	△
Economizer	△	△	△
Pt100 or Pt1000 temperature sensors- (motor coil temp. monitoring)	●	●	●
Safety valve	△	△	△
Explosion-proof accessories	△	△	△
Micro controller	△	△	△
Mounting pad	△	△	△
Sound jacket	△	△	△
Oil filter pressure differential switch	△	△	△
External oil separator	△	△	△
Lubrication oil	△	△	△
150W/300W oil heater	X	X	X
Oil level switch	X	X	X
Oil drain valve	△	△	△
External oil filter	△	△	△
Oil flow switch	△	△	△
Oil cooler	△	△	△
Oil pump	△	△	△

Note: The accessory chart is just for reference only. Actual specification and accessories enclosed might vary with different quotation and agreement respectively. If any optional accessory is required and out of above mentioned standard accessory, please contact Hanbell for detailed specifications.



2. Description of accessories

a. 4-step or step-less capacity control system

Please refer to 2.6.1 and 2.6.2 for the detail of step or step-less capacity control system.

b. Dual capacity control system

For customers' ease of stock control, possible modification of capacity-control logic in the future, or other special requirements of capacity control, Hanbell deliberately designs devices for stepless/step dual capacity control as optional accessory for customers' choices. Logic of stepless/step dual capacity control is basically identical to that of stepless or step capacity control respectively. Please refer to 2.6 & 2.7 for further details. If you have special requirements of capacity control, please contact Hanbell.

c. Discharge check valve

Horizontal check valve is standard accessory of RC2-1090~1520 compressor. Its dimension and installation drawing are as follow:

Dimension:

Diameter	Dimension Unit: mm	
	A	B
5"	150	203
6"	160	238

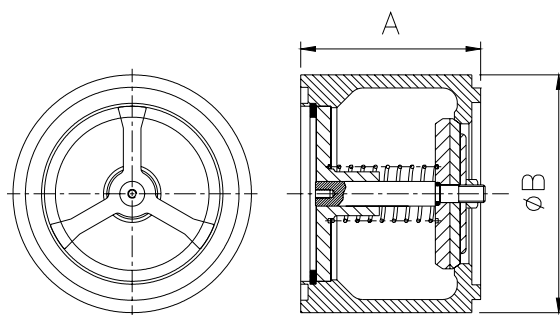


Figure 10: Horizontal check valve outline drawing

Installation of 5" & 6" horizontal check valve:

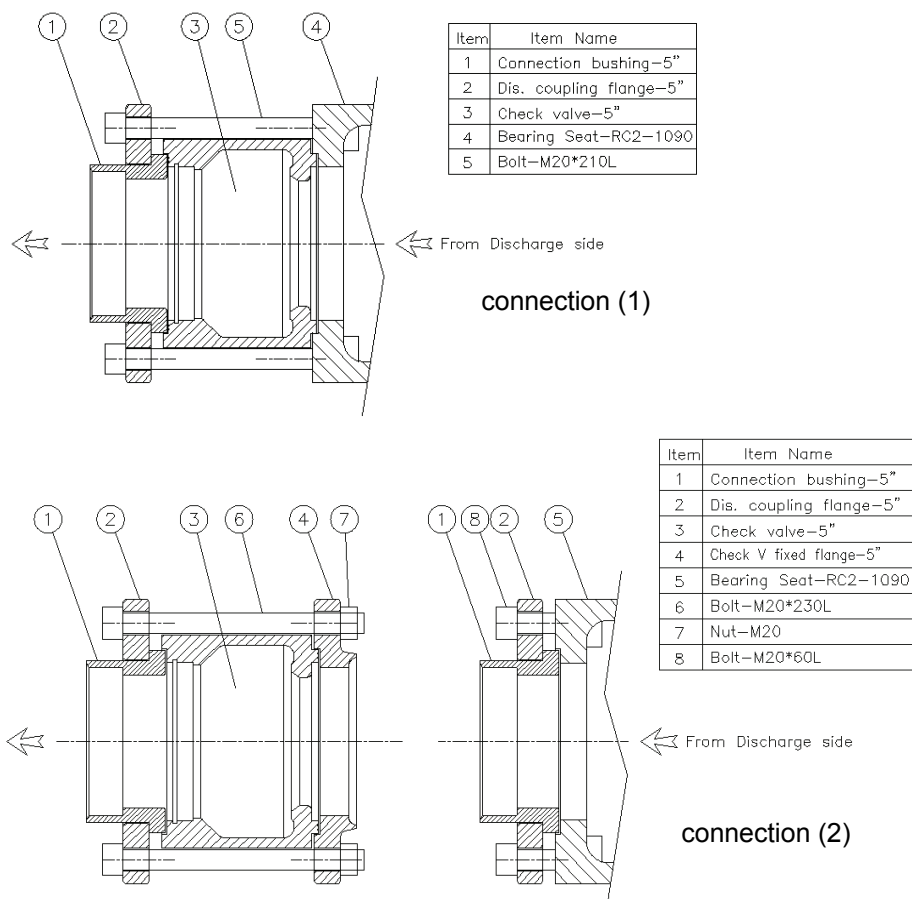


Figure 11 Installation of 5" check valve for RC2-1090

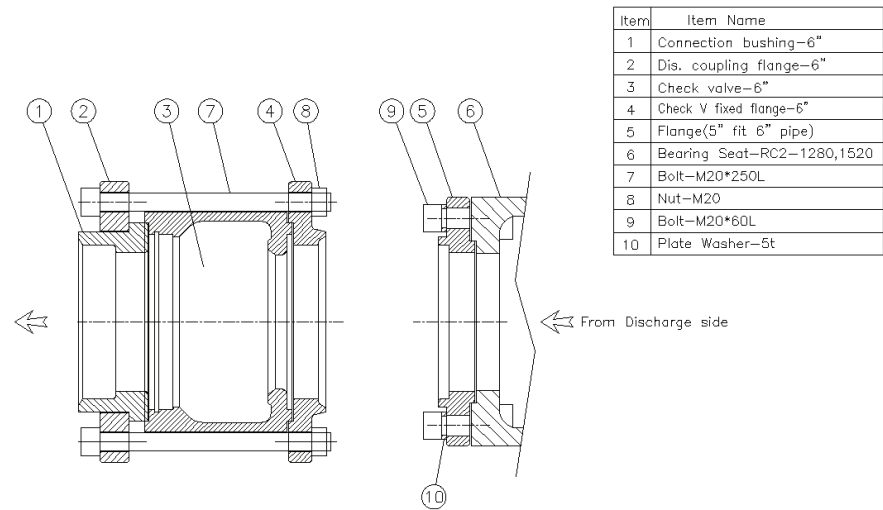
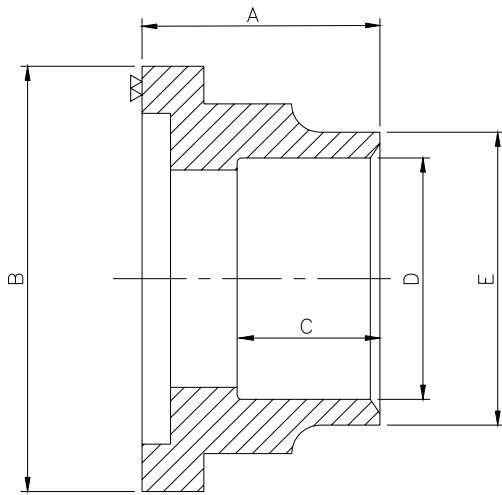


Figure 12: Installation of 6" check valve for RC2-1280&1520

d. Suction and discharge connection bushings



Model	Standard Discharge Flange Bushing		Standard Suction Flange Bushing	
	Steel pipe	Copper pipe	Steel pipe	Copper pipe
RC2-1090	5"	---	6"	---
RC2-1280	6"	---	8"	---
RC2-1520	6"	---	8"	---

Figure 13: Flange bushing dimensions

Note: The above table lists specification of standard bushing for every model of High Voltage series RC2 compressors. Their dimensions refer to flange bushing dimensions and the table below. If bushing dimensions are not indicated in purchasing order, Hanbell will provide standard type. Suitable piping size for customers' choice is also shown in the table below. If non-standard bushing is needed, please double-check with Hanbell sales representatives when placing order of compressors.



Specification and dimension of optional flange bushing

Model	Discharge / Suction port	Materials and Sizes of pipes		Dimension of flanges bushing				
				A	B	C	D	E
RC2-1090	Discharge	Steel	5"	80	174	35	141.3	154
	Suction	Steel	6"	75	215	40	166.7	196
RC2-1280 RC2-1520	Discharge	Steel	6"	75	215	40	166.7	196
	Suction	Steel	8"	75	260	40	218	241

e. Suction and discharge stop valves

For maintenance and service of compressor, it is recommended to install suction and discharge stop valves. Please refer to the following details of Hanbell stop valves.

Model	Stop Valve Size	
	Discharge	Suction
RC2-1090	5"	6"
RC2-1280	6"	8"
RC2-1520	6"	8"

* Specification of stop valve

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

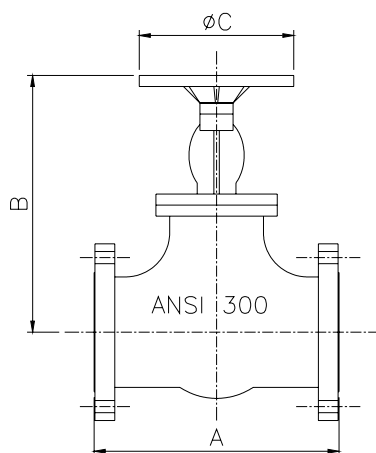


Figure 14: Drawing of stop valve

Dimension: mm Weight: kg					ANSI300				
Stop Valve					Flange				
Bore	A	B	C	Wgt.	OD	Thickness	Hole PCD	Hole size	NO.
5" (DN 125)	400	415	220	58	280	33	235	22	8
6" (DN 150)	444	465	280	84	320	36	270	22	12
8" (DN 200)	559	570	330	128	380	40	330	25.4	12

Dimension of stop valve for RC2-1090~1520

f. PTC temperature sensor

In order to protect compressor, each High Voltage RC2 series compressor is installed with three PTC temperature sensors inside motor coil and another one at the discharge side of compressor. These sensors are connected with INT69HBY control module to monitor motor coil temperature and discharge temperature as well. If the temperature in one of the positions monitored exceeds the nominal response temperature of the respective PTC thermistor, resistance of sensor will increase and INT69HBY control module output relay will trip consequently.

g. INT69HBY motor protector

Hanbell provides INT69HBY motor protector which major functions are motor temperature, discharge temperature protecting with manually reset function.

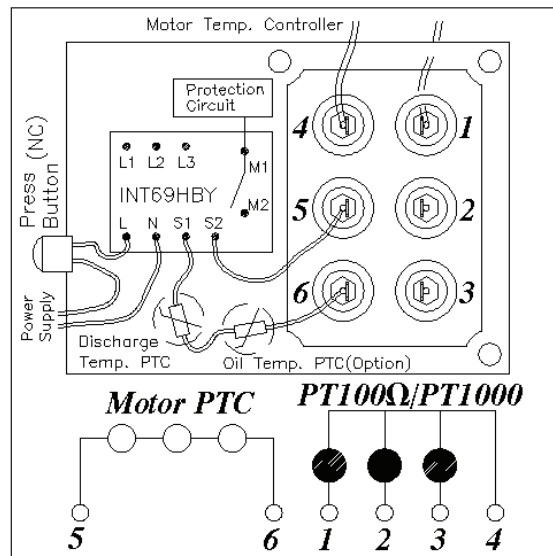


Figure 15: INT69HBY & PTC temperature sensors connection diagram

Other major functional descriptions are as follow:

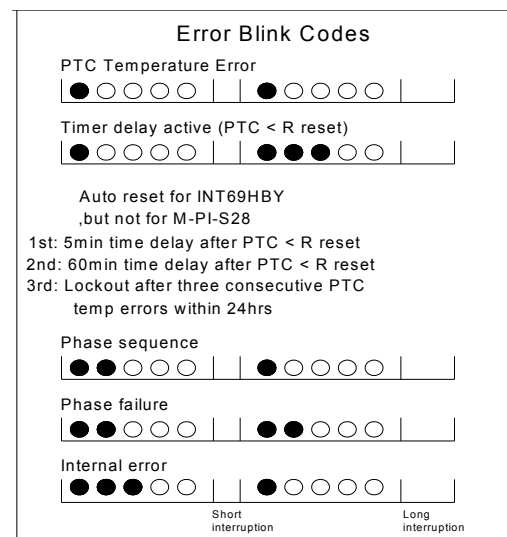
1. After the supply voltage has been connected, a three second initialisation period follows. Provided the PTC chain resistance is below the reset threshold (2.75kΩ), the relay trips after these 3 seconds have expired.
2. 1 to 9 PTC thermistors with different nominal response temperature may be connected serially to the PTC input.
3. If any thermistor resistance increases above trip level the relay drops out. This failure results in a lockout. (5 minutes delay for 1st PTC failure, 60 minutes delay for 2nd failure, lockout for 3rd failure.)
4. The Lock-out and delay time may be lifted by cycling the power off for approx. 5 seconds.
5. A dual LED (red / green) provides additional information about the motor protector and compressor status.
6. The relay is fed out as a N/O dry contact, which is closed under good conditions.
7. Sensor and supply circuits are galvanic isolated.
8. The motor protector is not suitable for use with frequency converters.

Note:

Motor protector phase monitor (phase loss, phase sequence) function is not suitable for high voltage application.

Technical data of INT69HBY

- Supply voltage
AC 50/60 Hz 115/120V-15 ...+10% 3VA
AC 50/60 Hz 230/240V-15...+10% 3VA
- Ambient temperature
-30 ... +70 °C
- Relay output
max. AC 240V, max. 2.5A, C300
min. > 24V AC/DC, >20 mA
- Phase monitor
3 AC, 50/60Hz, 200 ~ 575 V ± 10%





h. IP54 cable box

Hanbell designs and makes cable box which meets IP54 specification.

Dimensions of cable box and size of opening in cable box (for motor power line and control power line) refer to the drawing below.

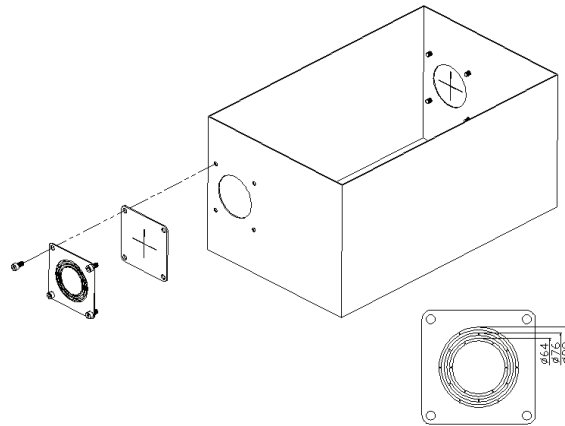


Figure 16: RC2-1090, RC1280, RC1520 cable box

i. External oil separator

Hanbell specially designs a complete series of external oil separators – OS series with characteristics of high filtration efficiency and low pressure drop. The following table shows details of OS series:

Note : It is recommended to install a buffer before the external oil separator to avoid noise and vibration which caused by resonance.

(I) Technical data :

Model	Type	Oil Volume (Liter)		Range of application based on Displacement (m ³ /hr) (Recommended)	Shell Diameter
		High level	Low level		
OS40	Vertical	17	9	205	14"
OS50	Vertical	22	12	206~270	16"
OS65	Vertical	31	18	271~440	18"
OS80	Horizontal	33	20	441~705	20"
OS100	Horizontal	40	27	706~1120	20"
OS125	Horizontal	50	30	1121~1310	24"
OS150	Horizontal	60	36	1311~1835	24"

(II) Accessories :

No.	Description	OS40	OS50	OS65	OS80	OS100	OS125	OS150
1	Refrigerant inlet	1 1/2"	2"	2 1/2"	3"	4"	5"	6"
2	Refrigerant outlet	1 1/2"	2"	2 1/2"	3"	4"	5"	6"
3	Oil outlet	5/8" Flare	5/8" Flare	5/8" Flare	1" PF	1" PF	1 1/4" PF	1 1/4" PF
4	Oil charge valve	1/4" Flare						
5	High oil S.G.	1 PCS						
6	Low oil S.G.	1 PCS						
7	Oil level switch	1 PCS						
8	Oil heater	150W	150W	150W	150W	150W	300W	300W
9	Oil drain valve	1/4" Flare						
10	Oil temp. protection (option)	1/8" NPTF						
11	Safety valve (option)	1/2"	1/2"	1/2"	1"	1"	1 1/2"	1 1/2"

(III) Dimensions :

No.	OS40	OS50	OS65	OS80	OS100	OS125	OS150
A	930	1050	1110	1227	1637	1829	2229
B	505	585	595	650	1000	1080	1480
C	240	275	300	568	354	409	409
D	300	350	350	300	300	400	400
E	18	22	22	23	23	23	23
F	320	360	360	688	698	830	830

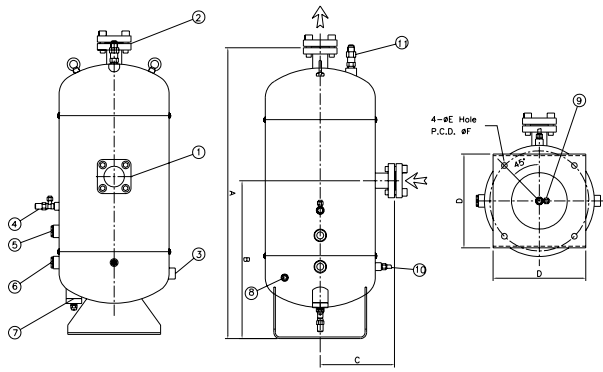


Figure 17: Vertical - OS40, OS50, OS65

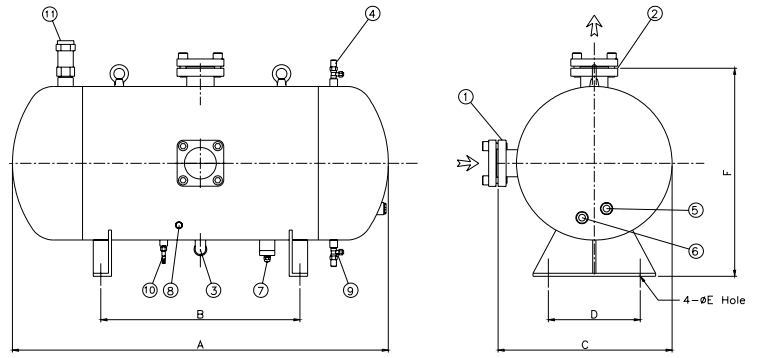


Figure 18: Horizontal - OS80

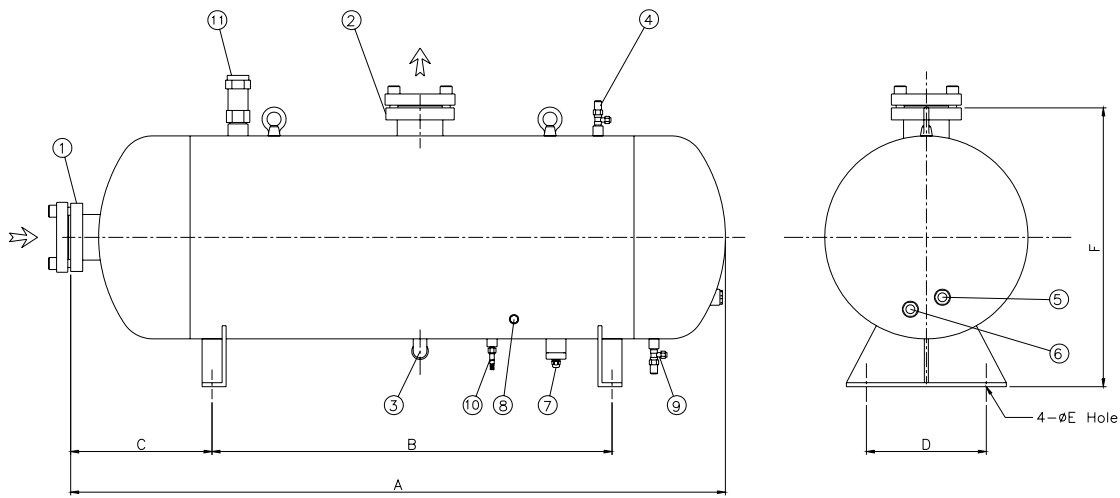


Figure 19: Horizontal - OS100, OS125, OS150



k. External oil filter

It is suggested to install external oil filter in oil return line before suction port of compressor for safe running of compressor.

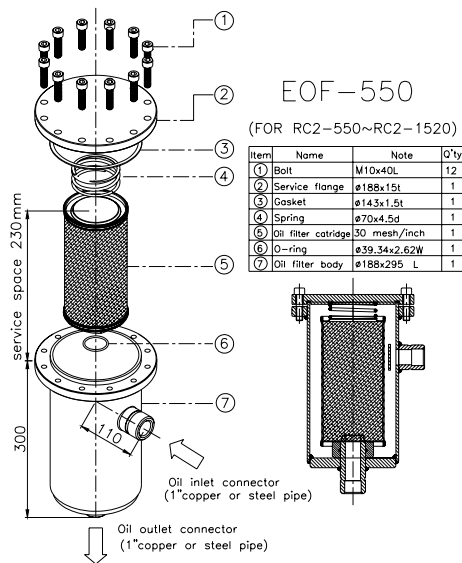


Figure 20: External oil filter

l. Oil flow switch

Oil flow switch operates with external oil separator to prevent oil deficient compressor. Specification and installation of oil flow switch are shown as below:

Specification:

Type	Size	Process connection d1	Setpoint range(H ₂ O, 20°C)		Max. flow rate [l/min]	Dimensions		
			Increasing flow [l/min]	Decreasing flow [l/min]		l ₁	Nut size sw[mm]	
							Brass	Stainless steel
VHS 15M	DN 15	1/2" BSP	3, 4...4,2	3,0...3,8	67	11	19	27
VHS 20M	DN 20	3/4" BSP	7, 0...9,1	6,4...8,2	180	15	27	32
VHS 25M	DN 25	1" BSP	13,5...17,0	12,0...15,5	195	15	32	41

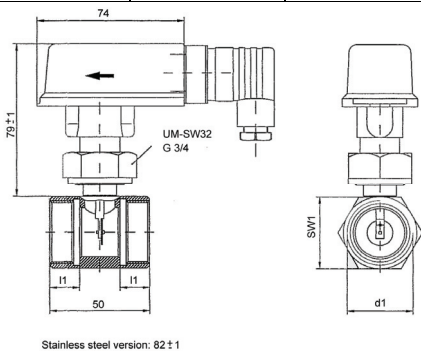


Figure 21: Oil flow switch

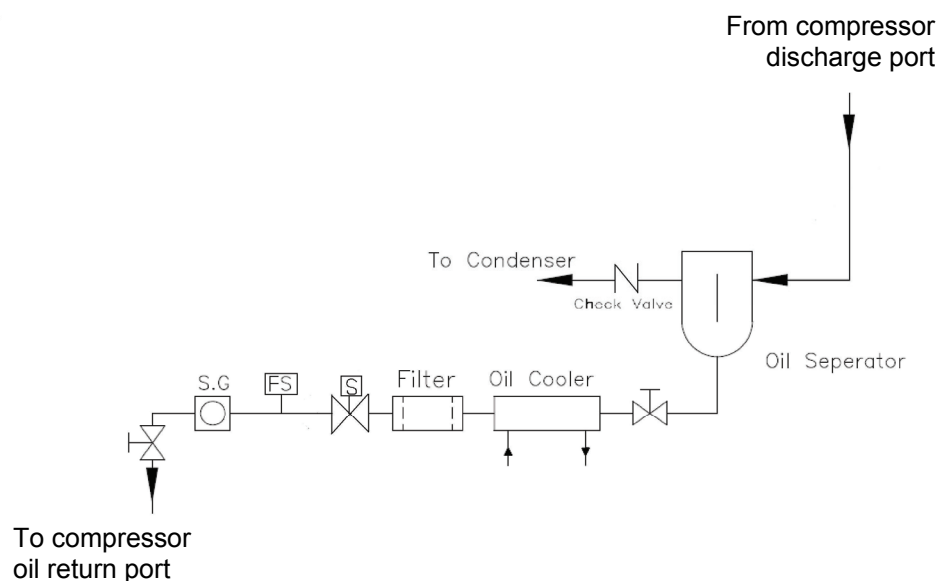


Figure 22: Installation of oil flow switch

m. Mounting pad

To avoid extra vibration and noise resulted from direct contact between compressor footings and the base on which compressor is mounted, it is recommended to add mounting pads in between as the drawing below shown.

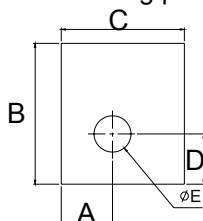


Figure 23: Compressor mounting pad

Model	A	B	C	D	E	Thickness
RC2-1090, RC2-1280, RC2-1520	42.5	105	85	41	22	15 mm

n. Temperature sensors Pt100 or Pt1000

Motor of RC2-1090, 1280 & 1520 compressor adopts independent liquid injection cooling system, other models utilize suction return gas to cool motor coil. To effectively detect temperature of motor coil and adequately adjust volume of liquid injection by measured temperature, Hanbell specially mounts Pt100 or Pt1000 sensor on motor coil as a standard accessory for RC2-1090, 1280 & 1520. This temperature sensor along with controller of the system monitor motor coil temperature and then control on/off of liquid injection valve accordingly to provide suitable liquid injection as shown in the diagram below.

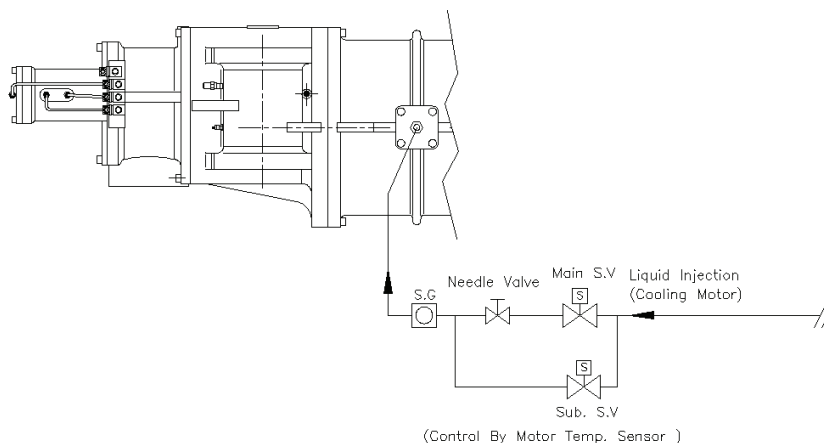


Figure 24: Liquid injection connection diagram

Note:

1. Liquid injection solenoid valve is controlled by controller according to temperature measured by Pt100/Pt1000 sensor.
2. Hanbell suggests to control temperature of motor coil at 60°C (not higher than 60°C)

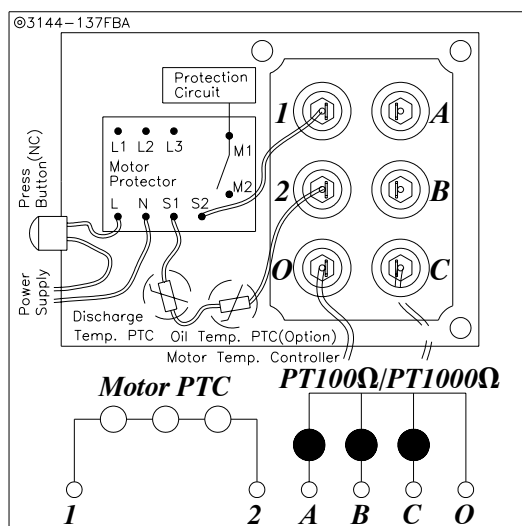


Figure 25: Connection diagram of Pt100/Pt1000 sensor



Specification : Pt100 sensor

- Recommended max. meas. Current for heat coefficient $< 0.1\text{K}$ - DC $1 \sim 3\text{ mA}$
- Heating coefficient - $10\text{m}\Omega/\text{K}$
- Sensor resistance at 0°C - $100\Omega \pm 0.12\Omega$
- Change of resistance $0 \sim 100^\circ\text{C}$ - $0.385\Omega/\text{K}$
- Insulation test voltage U is – AC 1.5kV

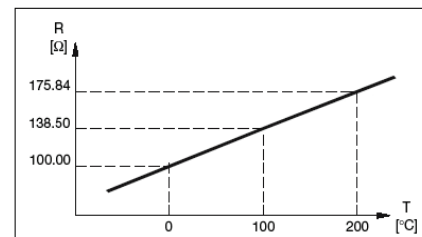


Figure 26: Pt100 sensor

Specification : Pt1000 sensor

- Recommended max. meas. Current for heat coefficient $< 0.1\text{K}$ – DC $0.2 \sim 2\text{mA}$
- Sensor resistance at 0°C - $1000\Omega \pm 1.20\Omega$
- Change of resistance $0 \sim 100^\circ\text{C}$ - $3.85\Omega/\text{K}$
- Insulation test voltage U is – AC 1.5kV

Please specify Pt100 or Pt1000 sensor when placing orders to Hanbell.

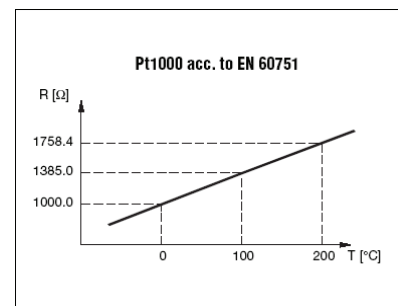
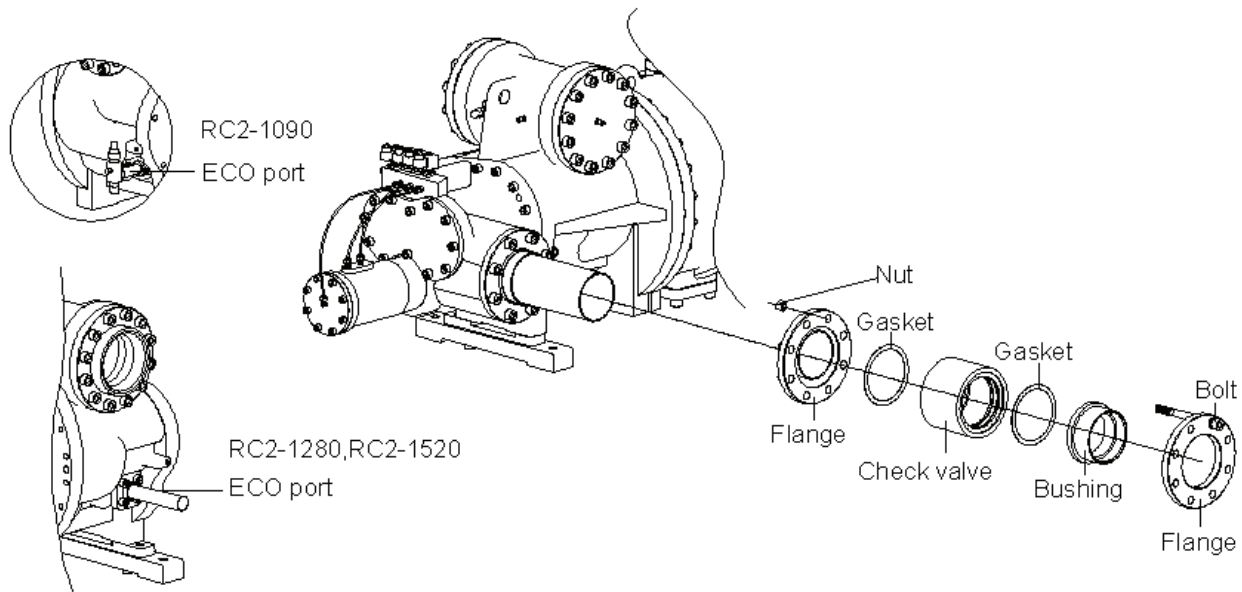


Figure 27: Pt1000 sensor

4.7 Installation and connection of the compressor

The diagrams below show installation and connection of compressors

. RC2-1090, RC2-1280, RC2-1520



◆ Capacity control system module :

A. Step-less capacity control:

1 (step-less) + 2 (25% ,30% ,35%)

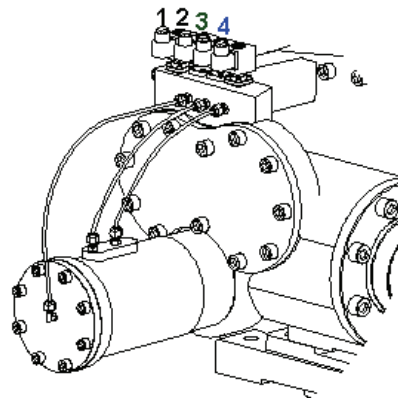
B. 4 step capacity control:

2 (25% ,30% ,35%) + 3 (75%) + 4 (50%)

C. Step-less+step capacity control:

1 + 2 + 3 + 4

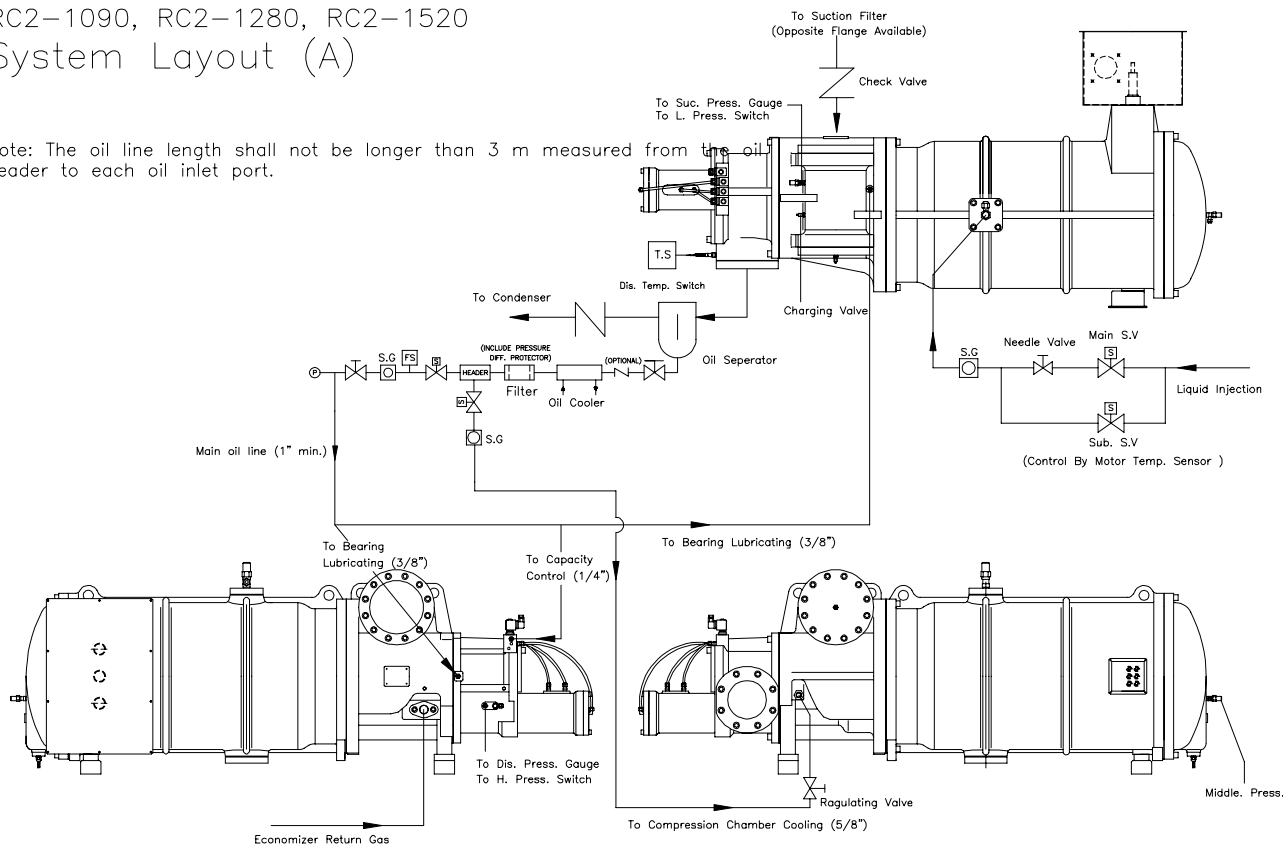
1. Solenoid valve only stepless
2. Solenoid valve 25%(30%,35%)
3. Solenoid valve 50%
4. Solenoid valve 75%





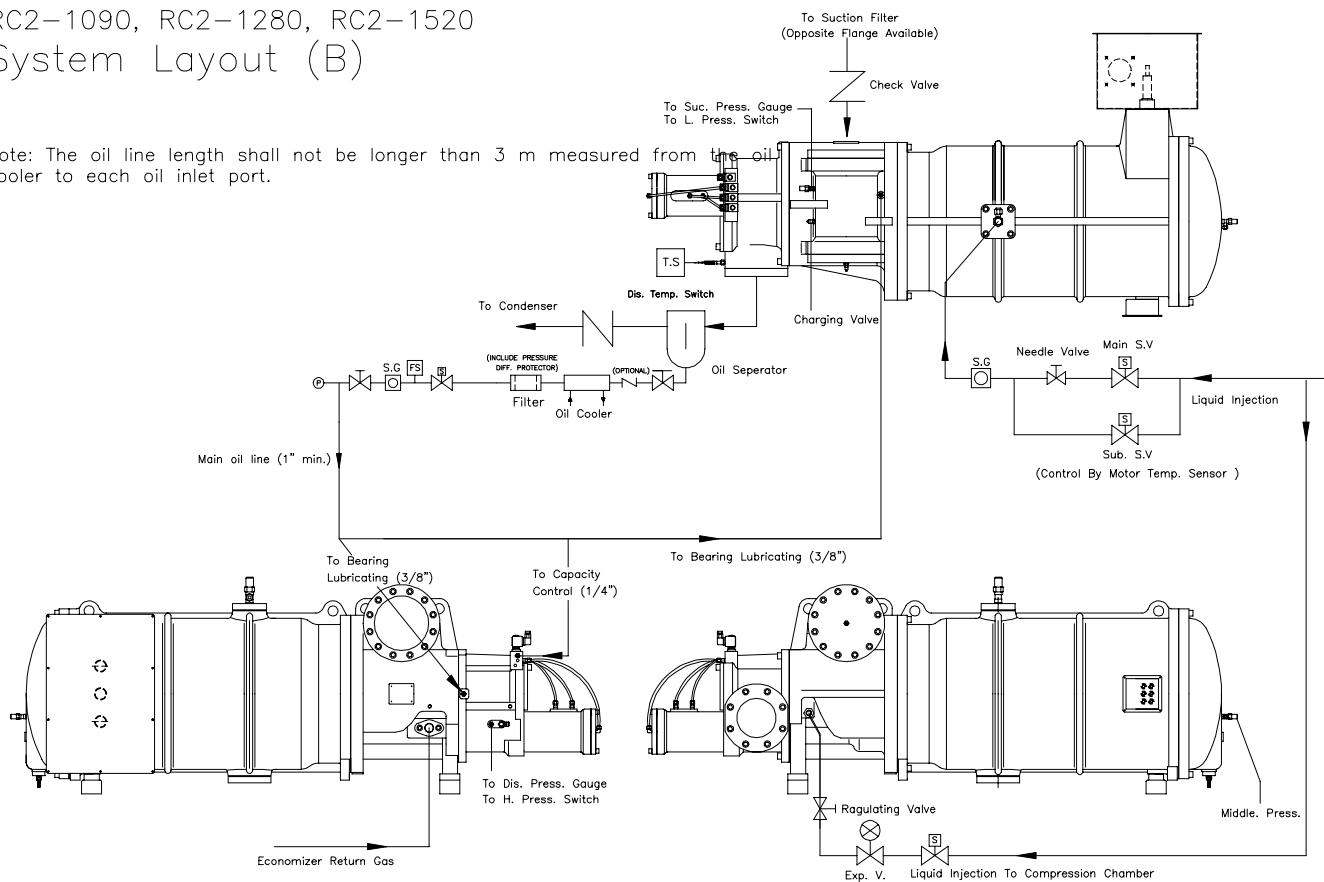
RC2-1090, RC2-1280, RC2-1520 System Layout (A)

Note: The oil line length shall not be longer than 3 m measured from the oil header to each oil inlet port.



RC2-1090, RC2-1280, RC2-1520 System Layout (B)

Note: The oil line length shall not be longer than 3 m measured from the oil cooler to each oil inlet port.



5. Electrical data and design



Warning

During the installation, testing, service and troubleshooting of this compressor, it may be necessary to work with live electrical components. Please have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or other serious injury.

Installation wiring must conform to National Electric Code (NEC) guidelines, as well as to any applicable state and local codes. Be sure to satisfy proper equipment grounding requirements per NEC. All field-installed wiring must be checked for proper terminations, and for possible shorts or grounds.

5.1 Direct-on-line start for High Voltage compressor

Motors of high voltage series compressor should be started by direct-on-line starting method.

5.1.1 Power supply wiring application

To assure that power supply wiring to starter panel is properly installed and connected, please review and follow the guidelines outlined.

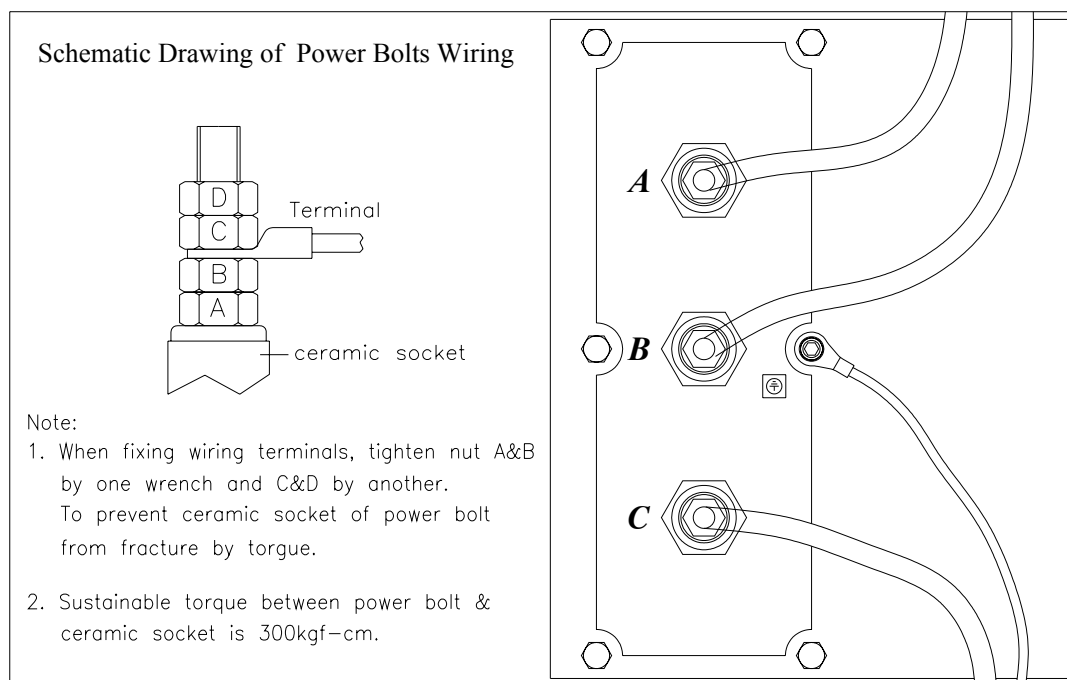


Figure 28: Power bolt connection

1. Power source application

- a. Verify that nameplate ratings are compatible with the power supply characteristics and with the electrical data on the nameplate.
- b. Use copper conductors to connect the power supply
- c. Size the power supply wiring of the compressor: max current in required operating condition X 1.25
- d. Make sure that incoming power wiring is properly phased; each power supply conduit connects to each conductor in correct sequence to ensure equal phase representation as number 1-2-3 in order.
- e. Use flexible conduit to enhance serviceability and minimize transmission of vibration.
- f. Size the circuit breaker or fuse in compliance with NEC or local guidelines.
- g. As install the power supply conduit, make sure that its position does not interfere with any compressor components, nor with other equipments.

2. Accessories for connection between the starter and the motor

- a. Grounding wire terminal lugs are provided inside the motor terminal box.
- b. Terminal clamps are supplied with motor terminals to accommodate standard motor wire terminal lugs.



3. Wire terminal lugs

- a. Use field-provided crimp-type wire terminal lugs properly sized for the application.
- b. Carefully choose the size of wire lugs for compatibility with the conductor sizes specified by the electrical engineer
- c. Use copper washers on power bolt connections.
- d. Tighten each bolt to 300kgf-cm
- e. These connections should be completed under supervision of a qualified engineer in compliance with NEC or local guidelines

Caution: Ensure the power supply wiring and output motor wiring are connected to the proper terminals. Failure to do so will cause catastrophic failure of the motor.

5.2 Compressor protection devices

The table below shows a list of protection devices which are essential to safe operation of the compressor. Please follow suggestion in this table to ensure the compressor will operate in normal condition.

Protection device	Set point	Resuming point
Motor temperature thermistors	Cut-out 110°C	Cut-in 100°C
Discharge temperature thermistors	Cut-out 110°C	Cut-in 100°C
High-Low pressure differential switch	Minimum pressure differential 4 kg/cm ² g	Manual reset
Motor overload relay	Set with practical value, any setting should be tripped in 10 sec,	
High pressure switch	According to system design	
Low pressure switch	According to system design	

※Manual reset suggested

Motor thermistors and discharge thermistors are temperature sensors with quick response while the temperature approach to their set point; thermistors must be connected in series to a controller (INT69HBY) in terminal box as a guardian to protect compressor. Alarm lamp for this protector is required to be embedded on control panel as indicator. Any intention to short controllers for starting of compressors is prohibited. It is beyond Hanbell's warranty of compressors if there is any action above mentioned found.

Note: when any protection device trips, please do troubleshooting and reset manually. Do not let the compressor reset automatically after abnormal trip!



NEMA states that poly-phase motors shall operate successfully under running conditions at rated load when voltage unbalance at the motor terminals does not exceed 1%. Furthermore, operation of a motor with over 5% unbalance is not recommended for it probably results in motor damage.

Unbalanced voltages at motor terminals cause phase current unbalance ranging from 6 to 10 times the percent of voltage unbalance for a fully loaded motor. This causes motor over current resulting in excessive heat that shortens motor life, and hence, eventual motor burnout. If the voltage unbalance is great enough, the reduced torque capability might not be adequate for the application and the motor will not attain rated speed.

Some of the more common causes of unbalance voltages are :

- Unbalanced incoming utility supply
- Faults or grounds in power transformer
- Large single phase distribution transformer in the system
- Open phase on the primary 3-phase transformer in the distribution system
- Blow fuse on 3 phase bank of power factor improvement capacitors
- Unequal impedance in conductors of power supply wiring
- Unbalanced distribution of single phase loads such as lighting
- Unequal transformer tap settings
- Open delta connected transformer banks
- Heavy reactive single phase loads such as welders

A 3-phase unbalanced voltages protector is upon request as optional accessory. Please contact Hanbell for more details.

5.4 Selection of magnetic contactors

Please refer to AC3 specification, compressor's selection program and design conditions of system to choose suitable contactor. The following table shows recommended contactor size(for Y- Δ start) fit for all models in different design and operating conditions by AC3 specification .(If its design and operating conditions differ, a second choice is a must.)

Refrigerant		R134a							
Condensing / Evaporating Temp.		Air-cooled (55/4℃)				Water-cooled (38/4℃)			
Contactor size (Amp)		MCM	MCD	MCS	O.L	MCM	MCD	MCS	O.L
	RC2-1090A	260	260	150	450	181	181	104	313
	RC2-1280A	301	301	174	521	208	208	120	361
	RC2-1520A	348	348	201	603	242	242	140	419
Refrigerant		R134a							
Condensing / Evaporating Temp.		Air-cooled (55/4℃)				Water-cooled (38/4℃)			
Contactor size (Amp)		MCM	MCD	MCS	O.L	MCM	MCD	MCS	O.L
	RC2-1090A	329	329	190	569	228	228	132	396
	RC2-1280A	380	380	220	659	264	264	153	458
	RC2-1520A	440	440	254	762	305	305	176	529

5.5 Grounding

There's a grounding terminal inside cable box. Please accurately connect it to grounding of control panel for the system.
Suggestion:

- The regular setting of electric leak protection should be greater than 50mA; for a humid location, 25mA is better.
- Grounding voltage of casing should be no greater than 50V; for a humid location, the limit is 25V.
- Grounding resistance should be no greater than 500 Ohm.
- Air cut board (ACB) is regularly equipped with electric leak protection. Please refer to related settings for its normal action.
- If electric leak protection is active, please check if insulation of equipments is normal and if its wiring and setting are correct. Please make sure nothing is wrong before turning on the power. If there are any questions, please contact the supplier of equipments.

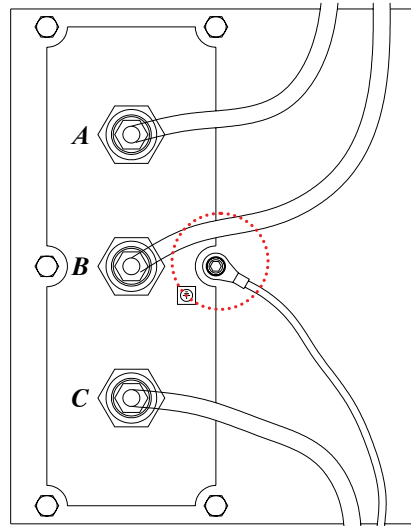


Figure 30: Grounding terminal

6. Operation and maintenance

6.1 Compressor starting

PRE-START CHECKING- the table below shows the required procedures and check list before starting of compressor during commissioning or initial operation of the unit.

Items	Things to be checked	States or standard values
1. Accessories	- Oil level - Oil heater - System valves status - Solenoid valves - Capillary	- Higher than the middle line of oil level sight glass - Should be kept energizing after compressor shut down. - Opened - Fixed - No serious distortion or damaged
2. Electrical system	- Voltage of main power - Voltage of control circuit - Insulation resistance value of the motor between phase to phase and phase to ground. - Power terminals and wire cables' terminal connection. - Grounded - Capacity of electrical accessories - Settings of switches, sensors and controllers.	- 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. - Standard voltage is 220V. Maximum voltage is 230V. If there is other demand, contact HANBELL. - Insulation resistance value should be above 5MΩ. - 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. (Ruled by the local Electricity Regulations.) - Properly selected (or inquired by the system designer.)



		7. Properly set (or inquired by the system designer.)
3. Piping system	1. Outer piping system 2. Leakage test 3. Bolts to fix the compressor.	1. Fixed firmly. 2. No leakage. 3. Fix the compressor tightly.
4. Safety devices	1. Motor coil sensors (thermistors) 2. Discharge sensors (thermistors) 3. Controller	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.

In addition to the pre-start checking given in the above table, please also consider the following:

- a. It is necessary to pay more attention to the auxiliary facilities while the chiller is commissioning at the job-site and the periodic maintenance after the initial start-up.
- b. In order to keep the capacity control smoothly under the low ambient temperature with the normal viscosity of oil, oil heater should be kept energizing after compressor has been shut down for preparation for the next start-up.
- c. Check that all the settings on each pressure switch are correct.
- d. Check if all the stop valves in the system are already open.
- e. Check the rotating direction of the compressor by starting the compressor for a split second (approx. 0.5...1 sec.) and check the suction and discharge pressure gauges. The correct rotating direction is: suction pressure drops immediately and the discharge pressure will go up.
- f. Compressor's lubrication oil should be checked immediately after starting. Oil level should be within sight glass range or higher than the middle line of oil level sight glass.
- g. Oil foaming can be generated during starting phase, but it should reduce when the compressor is under stable operating conditions. Otherwise this can indicate excessive liquid in the suction gas.
- h. The running condition of compressor after commissioning at the job-site should be adjusted as; the discharge temperature will be at least 20K above the saturated condensing temperature and the suction vapor superheat should be within 10K to the saturated evaporating temperature.
- i. The whole plant, especially the pipelines and capillary tubes must be checked for abnormal vibrations. Please contact HANBELL or local distributor if any abnormal vibrations or noise found while compressor is running.
- j. Regularly check the plant according to national regulations and the following items should also be checked:
 - Operating data of the machine
 - Check the lubrication/ oil level
 - All compressor protection devices
 - Check electrical cable connections and tightness

6.2 Troubleshooting

The table below shows some problems that might be encountered in the jobsite during commissioning or operation of the compressor. This table is only served as a guide for engineers to understand the situation once the problem occurs in the site.

PROBLEMS	PROBABILITY CAUSES	REMEDY / CORRECTIVE ACTION
Sudden trip of motor thermistors / sensors	Low suction pressure cause low refrigerant flow rate	Install liquid injection to motor coil
	Refrigerant shortage	Charge refrigerant
	Suction filter clogged	Clean filter
	High suction temperature	Adjust superheat of motor independent cooling
	High suction superheat	Adjust the superheat less than 10K
	Unstable electricity system or failure	Check electricity power supply
	Motor overload	
Compressor unable to load	Bad motor coil causing temperature rising rapidly	
	Low ambient temperature or high oil viscosity.	Turn on the oil heater before compressor start.
	Capillary clogged	Clean or replace capillary
	Modulation solenoid valve clogged or solenoid valve coil burnt.	Clean / purge solenoid valve core or replace the solenoid valve coil
	Internal built-in oil line clogged.	Check and clean the compressor oil circuit
	Piston stuck-up.	Change piston or piston ring
	Oil filter cartridge clogged.	Clean oil filter (replace if needed)
Compressor unable to unload.	Too small the high-low pressure differential.	Minimum pressure differential is 4 bar. Consider to install an oil pump.
	Modulation solenoid valve clogged or burnt.	Clean or replace the solenoid valve
	Piston rings worn off or broken, or cylinder damaged resulting leakage.	Change piston (if cylinder damaged severely, change the cylinder)
	Lubrication oil insufficient.	Check the oil level of the compressor if enough, add some oil if necessary
	Leakages at internal discharge cover plate end side.	Check or replace the gasket and tighten the bolts.
	Solenoid valve voltage misused.	Check the control voltage
	Piston stuck-up.	Change the piston set, and check the cylinder and slide valve.
Poor insulation of motor	Capacity control logic unsuitable.	Check
	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.	
Compressor starting failure or Y-Δ shift failure	7. Compressor restart counts too many times.	Check the coil or change the motor stator
	Slide valve piston unable to go back to its lowest % original position.	Check if the unloading SV is energized once the compressor shut down. Unload the compressor before shot down.
	Voltage incorrect.	Check the power supply
	Voltage drop too big when starting the compressor or magnetic contactor failure or phase failure.	Check the power supply and the contactor.
	Motor broken down	Change the motor
	Motor thermistor sensor trip.	See "sudden trip of motor sensor" above
	Incorrect supply power connection.	Check and re-connect
Abnormal vibration and noise of compressor	Y-Δ timer failure.	Check or replace.
	Discharge or suction stop valve closed.	Open the stop valve
	Improper connection between node terminals of Y-Δ wiring.	Check and re-connect the wiring
	Rotor locked	Check and repair
	Earth fault	Check and repair
	Protection device trip	Check
	Damaged bearings.	Change bearing.
Compressor does not run	Phenomenon of liquid compression.	Adjust proper suction superheat
	Friction between rotors or between rotor and compression chamber.	Change screw rotors or/and compression chamber.
	Insufficient lubrication oil.	Check the oil level of the compressor if enough, add some oil if necessary.
	Loosen internal parts.	Dismantle the compressor and change the damaged parts.
	Electromagnetic sound of the solenoid valve.	Check
	System harmonic vibration caused by improper piping system.	Check the system piping and if possible improve it using copper pipe.
	External debris fallen into the compressor.	Dismantle the compressor and check the extent of the damage.
High discharge temperature	Friction between slide valve and rotors.	Dismantle the compressor and change the damaged parts.
	Motor rotor rotates imbalance.	Check and repair.
	Motor line open	Check
	Tripped overload	Check the electrical connection
	Screw rotors seized	Replace screw rotors, bearings etc....
	Motor broken	Change motor.
	Insufficient refrigerant.	Check for leaks. Charge additional refrigerant and adjust suction superheat less than 10°K
Compressor loses oil	Condenser problem of bad heat exchange.	Check and clean condenser
	Refrigerant overcharge.	Reduce the refrigerant charge
	Air / moisture in the refrigerant system	Recover and purify refrigerant and vacuum system
	Improper expansion valve.	Check and adjust proper suction super heat
	Insufficient lubrication oil.	Check the oil level and add oil.
	Damaged bearings.	Stop the compressor and change the bearings and other damaged parts.
	Improper Vi value.	Change the slide valve.
Low suction pressure	No system additional cooling (Liquid injection or oil cooler)	Install additional system cooling (liquid injection or oil cooling or both base on working condition limitation)
	Lack of refrigerant	Check for leaks. Charge additional refrigerant.
	Improper system piping	Check and correct the piping or install an external oil separator
	Liquid fills back	Maintain suitable suction superheat at compressor
	Lack of refrigerant	Check for leaks. Charge additional refrigerant.
	Evaporator dirty or iced	Defrost or clean coil
	Clogged liquid line filter drier	Replace the cartridge
Compressor loses oil	Clogged suction line or compressor suction strainer	Clean or change suction strainer
	Expansion valve malfunctioning	Check and reset for proper superheat
	Condensing temperature too low	Check means for regulating condensing temperature

Note: The replacement of compressor parts should be performed only by a qualified / certified serviceman with full knowledge of HANBELL screw compressors or HANBELL service engineers.



6.3 Compressor check list

Please fill out the blanks on the compressor checking list and send it to Hanbell when any compressor failure happens. Hanbell will reply and suggest a solution to the failure.

CHECK LIST FOR TROUBLESHOOTING OF HANBELL SCREW COMPRESSOR

Compressor model :				Compressor S/N :			
System design condition SCT/SST :				Evaporator type :			
Refrigerant type :				Liquid injection : ☐ Motor ☐ Chamber			
Voltage : R-S:		S-T:		R-T:		Over load setting : A	
Y-Δ setting:		Sec		Δ-Δ setting :		Sec	
Starting current :		A		Δ current :		A (end of starting)	
Operating current (full load) : R:				S:		T:	
Description of problem :							
☐ A : abnormal noise dBA at % capacity							
☐ B : abnormal vibration							
☐ C : over current							
☐ D : motor burnout							
☐ E : unable to load							
☐ F : unable to unload							
☐ G : leakage (Photo would be a plus)							
☐ H : accessory parts damaged (Photo would be a plus)							
☐ I : other (Detail would be a plus)							

Suction pressure	Discharge pressure	Suction temp.	Discharge temp.	Liquid line temp.	Condenser water temp.		Chiller water temp.		Oil cooler temp.		Economizer temp.	
					inlet	outlet	inlet	outlet	inlet	outlet	inlet	outlet

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7. Applications

7.1 Additional cooling

When compressors operate in the following application conditions, installation of an additional auxiliary cooling apparatus is recommended to lower discharge temperature, maintain proper temperature of lubricant and additional cooling for motor coil to ensure safe running of compressors with efficiency.

- Air-cooled system
- High compression ratio system such as heat pump, low temperature and refrigeration system
- High discharge temperature system such as heat recovery system
- If compressors have to run at partial load below 50% continuously in a long term.
- Any other heavy duty application

There are two type of additional cooling of compressor that described separately as below.

a. Liquid injection applications

In areas with high condensing temperature and/or low evaporating temperature as in the limitation diagram, additional cooling is required in order for the compressor to work properly. A relatively simple method of additional cooling is direct refrigerant injection in the compressor either in the motor side or compression chamber side.

The purpose of installing a liquid injection system is to prevent the compressor from overheat. The system installed a liquid injection expansion valve between the liquid line and compressor for cooling down the compression chamber and motor to ensure the continuous and safe running of the compressor. Suction superheat should be controlled between 5K~10K for the application of air-cooled and heat pump chillers by means of 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 is heavy due to the high temperature of chilled water, so the liquid injection devices capacity should be selected or calculated enough to reduce the overheat of the compressor.

Calculating the cooling capacity of liquid injection devices

Liquid injection devices can be calculated with the **HANBELL selection software** or manually. For manual calculation, consider the most extreme conditions to be expected during actual operations i.e. minimum evaporating temperature, maximum suction gas super heat and condensing temperature.

Liquid injection applied with low temperature expansion valve

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. The design of the liquid injection system for low temperature application is similar to the illustration shown in figure below. There are two connectors for the liquid injection in the compressor, one is in the motor side to cool down the motor temperature and reduce the discharge temperature. The other is in the compression chamber side and its function is to reduce the discharge temperature and increase the compression efficiency. However, when additional cooling in compression chamber like economizer operation, oil cooler application is used or when condensing temperature is low, discharge temperature be kept low and liquid injection may not be turned on, although motor load is severe and motor coil temperature is high. This may lead to motor failure. Therefore, in application mentioned above Pt100 or Pt1000 for liquid injection to motor is recommended instead.

Liquid injection 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 .

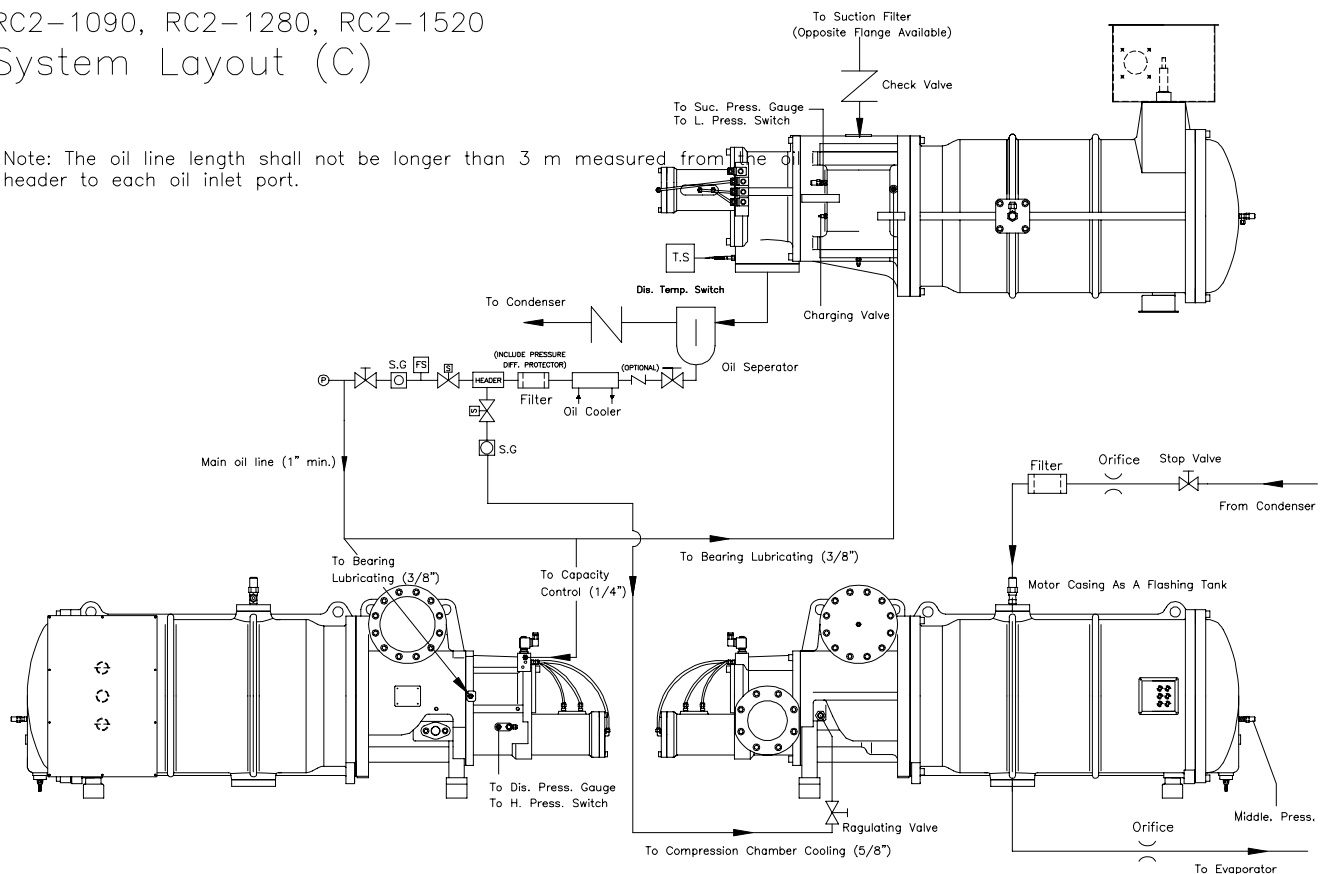
It can also be installed with an additional solenoid valve or service valve in front of the high temperature expansion valve for the maintenance purposes. The solenoid valve will be opened while starting the compressor. The equilibrium tube of high temperature expansion valve should be connected to the high-pressure side to counter the internal pressure.

However, when additional cooling in compression chamber like economizer operation, oil cooler application is used, or when condensing temperature is low, discharge temperature may be kept low and liquid injection may not be turned on, although motor load is severe and motor coil temperature is high. This may lead to motor failure. Therefore, in applications mentioned above, Pt100 or Pt1000 for liquid injection to motor is recommended instead.



RC2-1090, RC2-1280, RC2-1520 System Layout (C)

Note: The oil line length shall not be longer than 3 m measured from the oil header to each oil inlet port.



7.2 Economizer applications

HANBELL screw compressor can be fitted with an additional middle-pressure connection for economizer operation. With this form of operation, refrigeration capacity as well as system efficiency can be improved by means of a sub-cooling circuit or two-stage refrigerant expansion.

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

Please refer to Hanbell selection software for calculation of economizer capacity at different operating conditions.

Principle of operation

As opposed to the reciprocating operation of a piston compressor, compression in the 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-pressure 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 compared to the additional work that takes place at a better level of efficiency.

7.3 Parallel system applications

In the rack or parallel system, it is possible that unequal-distribution of returned oil from the evaporator causing low oil level in one or more of the compressors. Install oil flow switch in each oil return line to ensure the returned oil in each compressor is with normal oil level.

The basic design of the system is shown in Figure 34, twin-compressor parallel system connections. The accessories installed are basic and if there are more applications or protection required, please contact HANBELL or local distributor/agents for more information or further confirmation.

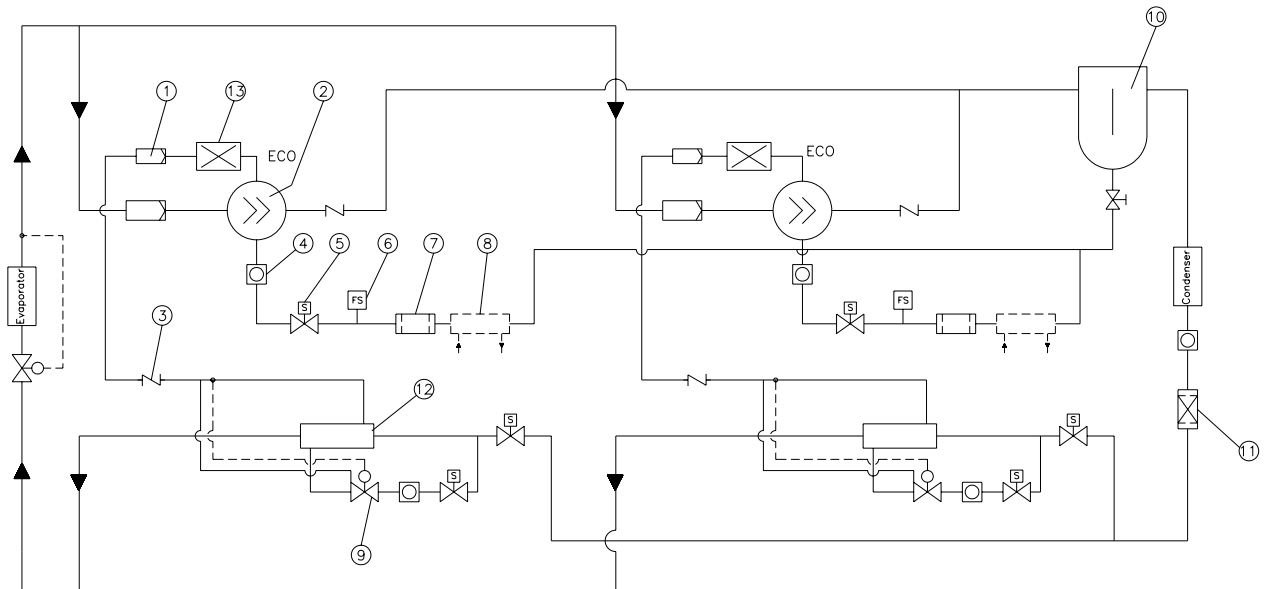


Figure. 34 Parallel system with two compressors

Item	Description	Item	Description	Item	Description
1	Filter	6	Flow switch	11	Dryer
2	Compressor	7	Oil filter	12	Secondary cooler
3	Check valve	8	Oil cooler	13	Muffler
4	Sight glass	9	Expansion valve		
5	Solenoid valve	10	Oil separator		

7.4 Oil pump application

An additional oil pump is recommended to be installed in the system when the differential between oil pressure and suction pressure is less than 4bar (for example: water-cooled, flooded chiller). If the compressor is operating in the mentioned condition, the failure of modulation and lubrication might happen. In addition to the installation of additional oil pump, high – low pressure differential switch is also recommended to be installed in this kind of system. Please contact Hanbell for more detailed information of oil pumps.

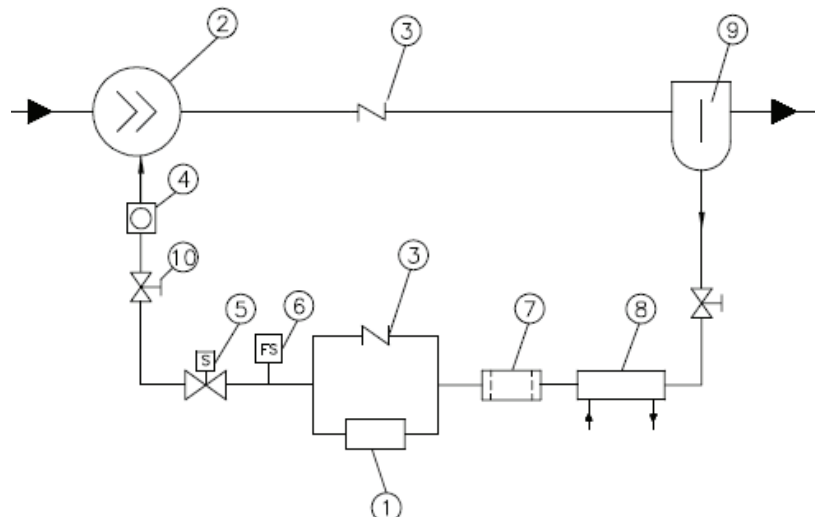


Figure.35 Additional oil pump

Item	Description	Item	Description	Item	Description
1	Oil pump	5	Solenoid valve	9	External oil separator
2	Compressor	6	Flow switch	10	Service valve
3	Check valve	7	Oil filter cartridge		
4	Sight glass	8	Oil cooler		



7.5 Important notes of compressor applications

1. Pump down

Do not pump down the compressor in chillers as a routine operation except only for temporary maintenance or a long term shut down. Because pump down will cause extremely high temperatures in the compression chamber and overheat of motor as well due to less amount of refrigerant in the suction side. When doing pump down, be sure to take notice of the items listed below :

- a. Whenever pumping down the compressor, the compressor is recommended to be at 100% capacity.
- b. Pump down should be done once each time. It is dangerous to pump down the compressor repeatedly.
- c. The minimum suction pressure in pump down should be over 0.5kg/cm²g
- d. The allowable length of time for pump down of the compressor should not be over 15 seconds.
- e. When pumping down the compressor, the discharge temperature should not exceed 110°C.
- f. Pay attention to high/low pressure by monitoring oil level of the compressor and noise level as well. If there is any abnormal value or situation, then emergently stop pump down.

2. Low pressure receiver

When the compressor operates in the following applications, the installation of a low pressure receiver is recommended in order to prevent massive liquid refrigerant from returning to the compressor under momentary changes of operating conditions.

- Heat pump
- Parallel system
- System with long piping
- Operating in low ambient temperatures
- System with heating load varied widely

8. Warranty

All HANBELL screw compressors are put through strict quality and performance testing prior to shipping from the factory. The screw compressors are manufactured with finest quality material and are warranted for one year after completion of installation and commissioning at jobsite or up to 18 months from the original date of sales by HANBELL or designated sales agent, whichever comes first.

However, HANBELL will not be responsible if the compressor does not work properly for any of the following reasons:

1) damaged caused by others including shipping, natural disaster, war, etc. 2) damage caused by improper installation, 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) damage caused by improper maintenance or repair by a non-authorized technician. HANBELL is responsible for any accident which occur to personnel while installing, setting up, operating, maintaining, and/or repairing the compressor.