CONTENT

1. General Information

The HANBELL RG series open-type screw compressor is developed especially for ammonia application. HFC and HCFC refrigerants can also be used with RG series compressor without any problem. When other gases are used, customer should consult Hanbell in advance to ensure the proper usage and compressor warranty. With built-in high operating load design and advanced 5 to 6 Patented Screw Rotor Profile, RG compressors lead high efficiency and reliability in all operating condition. All compressors are carefully manufactured and inspected by highly precise THREAD SCREW ROTOR GRINDING MACHINE, CNC MACHINING CENTER, and 3D COORDINATE MEASURING MACHINE. Also HANBELL is in conformance to ISO 9001 standard, which means the fabrication is controlled under quality procedures and Hanbell is capable to provide fine service to customers.

RG series compressors have 11 quality bearings (5 radial bearings and 6 axial bearings) which result in longer bearing life comparing to traditional 9-bearing design. These bearings provide strong support to screw rotors especially against heavy duty applications. Oil injection ports can be utilized when extra cooling is necessary. This can control discharge temperature within reasonable level and can ensure refrigeration oil remain sufficient viscosity for lubrication. Economizer port can be used to reach higher cooling capacity and efficiency especially at high pressure differential working condition or at extra low evaporating temperature. Capacity indicator port is designed for capacity indicator when step-less capacity control is adopted. With capacity indicator, cooling capacity can be monitored and controlled precisely. Hydraulically balanced mechanical seal is designed for general and high pressure sealing duties, including chemical processing, refinery and petrochemical plants. Its multiple-spring design, even loading of sealing surface can be ensured and easy replacement can be achieved. All these new designs strengthen compressor reliability, extend bearing life and simplify regular maintenance works.

This Technical Manual contains all basic information about dimensions, handling, installation, operation, trouble shooting, and system application. It is highly recommended read carefully the contents before handling, installing, and operating the RG compressor in order to avoid any damage on it. For any technical issue about RG series compressor, please contact HANBELL or local distributors/agents for information and assistance.

2. Design and Specifications

2.1 Design features

HANBELL screw compressor's feature is simple and robust construction, without some components such as pistons, piston rings, valve plates, oil pumps, and mechanical linkages…, which are found in reciprocating compressors. Without these components, features of the screw compressor have resulted in low noise, minimized vibration, high reliability and durability. HANBELL screw compressors are of two-shaft rotary displacement design with the latest and advanced screw rotors with 5:6 patented profile designs. The screw rotors are precisely situated at both the suction and discharge ends by rolling contact bearings, including axial and radial bearings.

The design features of RG series are listed below:

a. Full product range**-** RG series has 5 models with displacement ranging from 190/228 m3/hr up to 1268/1521 m3/hr (50/60Hz) compatible for different refrigerants and applications.

b. Multi-nation patents of high efficiency screw rotor- The new 5:6 ratio high efficiency screw rotor profile is patented in Taiwan, the UK, the US, Japan, and China. This new high volume and high efficiency rotor profile was designed specifically for modern refrigerant characteristics. The screw rotor is accomplished by precise CNC rotor milling machines and grinding machines. Strict ISO 9001 process control and the use of precise inspection equipment, such as ZEISS 3D coordinate measuring machine, ensuring high efficiency, high quality, low noise and low vibration of HANBELL RG screw compressors.

c. Long life bearings and high reliability- The screw compressors utilize the combination of 11 axial and radial bearings for excellent bearing life and superior compressor reliability.

d. Precise capacity control- The capacity control slide valve is located in the compressor chamber. The slide is actuated by the piston which is connected with slide valve by a piston rod. The piston is actuated by the oil pressure which comes from the pressure differential between the suction and discharge sides. For step-less capacity control, capacity indicator (Optional) can be installed to precisely control the compressor capacity. For 4-step capacity control, the piston can be positioned at 25%, 50%, 75% and 100% for cooling control.

e. Mechanical seal- For open type screw compressor, mechanical seal plays an important role. Hanbell uses hydraulically balanced o-rings pusher seals of multi spring type or bellow type. Hydraulically balanced seal face gives lower face loading at high pressure. Multiple spring arrangement ensures even loading on seal face.

f. Adaptable with additional cooling**-** oil injection connection port is located at the compression chamber for customer's desired system application.

RG series compressors not only have characteristics of high efficiency & reliability design mentioned above, but also are designed with the following newly added advantages to meet customers' needs more adequately:

1. Economizer operation with floating ECO port can be worked under partial load and full load (for RG-200~RG-830).
2. Coupling housing helps to get quick alignment for compressor and motor in the jobsite. (Optional)

2.2 Compressor nomenclature

RG – x x x x

x x x x: Compressor Displacement at 50Hz (m^3/hr)

RG: Open-type compressor for gas compression

2.3 Compressor specifications

Model		RG-200	RG-410	RG-620	RG-830	RG-1270
Theoretical Displacement (m^3/hr)	@2950	190	402	619	816	1268
	@3550	228	482	743	979	1522
Weight	kg	232	320	475	513	1166
Refrigerant	—	NH 3 , HFC				
Number of lobes per rotor MR/FR	—	5/6				
Rotation direction	—	CCW viewed from motor				
Suction flange	—	3”	4”	5”	5”	8”
Discharge flange	—	2”	2 1/2”	3”	4”	5”
Oil injection port	—	5/8” ODF				1 1/8"ODF
Oil supply	—	1 1/8"ODF				
Design pressure	—	28 kg/cm2				
Economizer port	—	7/8”	1 1/8”	1 1/8”	1 1/8”	1 1/2”
Oil pressure differential *	—	“Oil pressure –Suction pressure ≧ 6 bar				
Minimum suction temperature	—	-60				
Maximum discharge temperature	—	110				
Maximum lubrication temperature	—	Ammonia: 50℃ 、 HFC: 60℃				
Speed, max	rpm	4500				3600
Speed, min	rpm	1500				
Range of capacity control	-	25,50,75,100% or 25~100%				
Vi-adjustment ranges	-	2.6~5.1				2.6~5.6
Vibration level	mm/s	2				2.5
Flange for coupling housing		Available				
Sound pressure level	dB(A)	86	88	89	90	93

Note:
1. Sound pressure level is based on ISO-2151, R22, 50 Hz, SST -30℃/ SCT 40℃ to be measured.
2. ±2 dB(A) tolerance of sound pressure level is expected due to different operating condition and motor noise condition.

2.4 Compressor outline

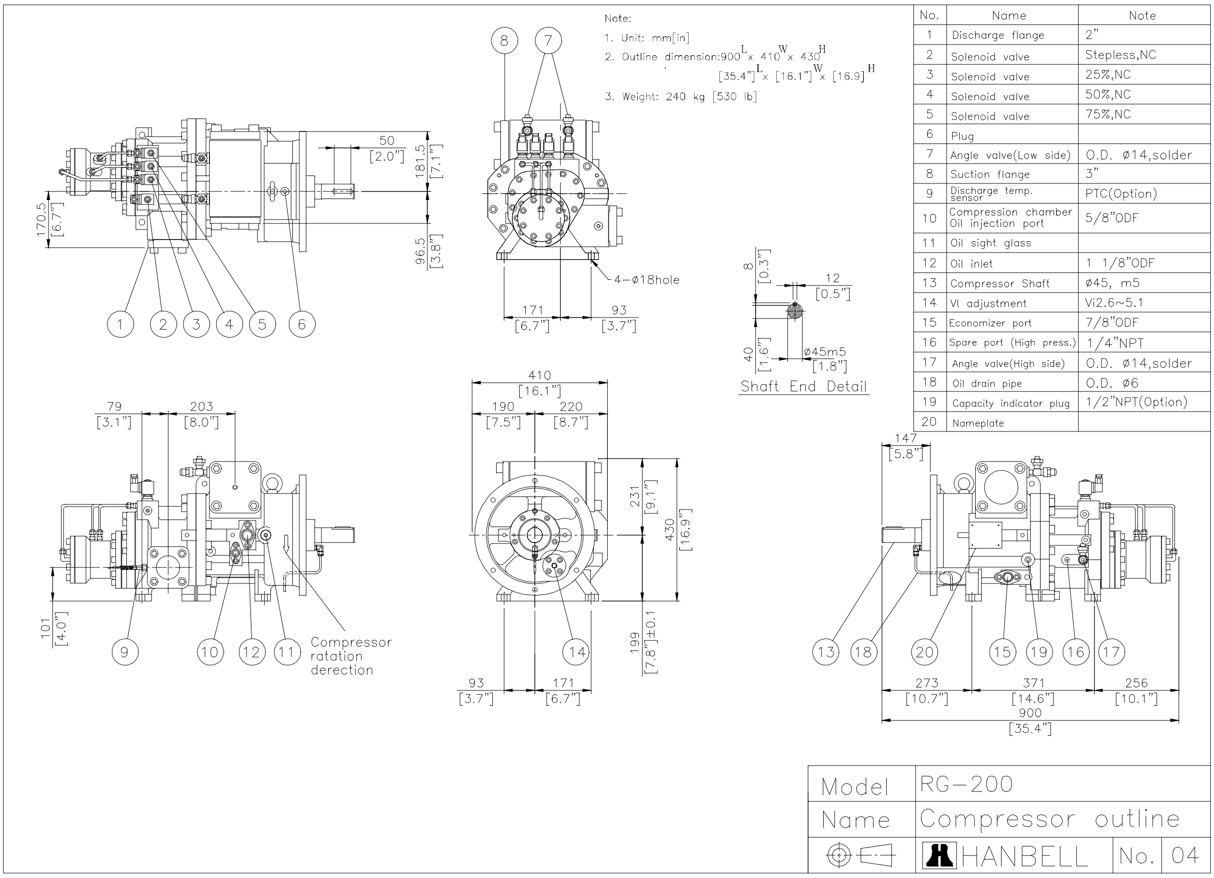


Figure 2.1: RG-200 outline drawing

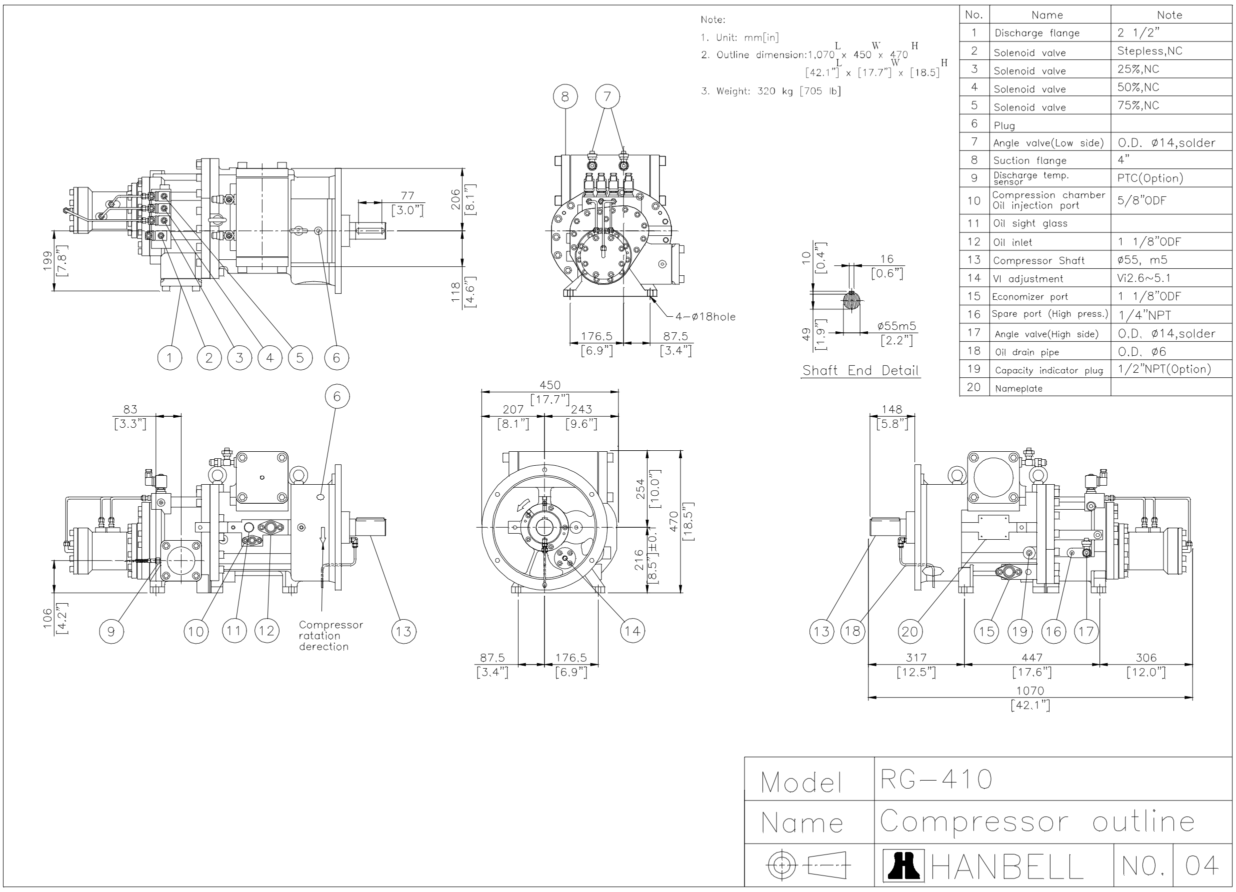
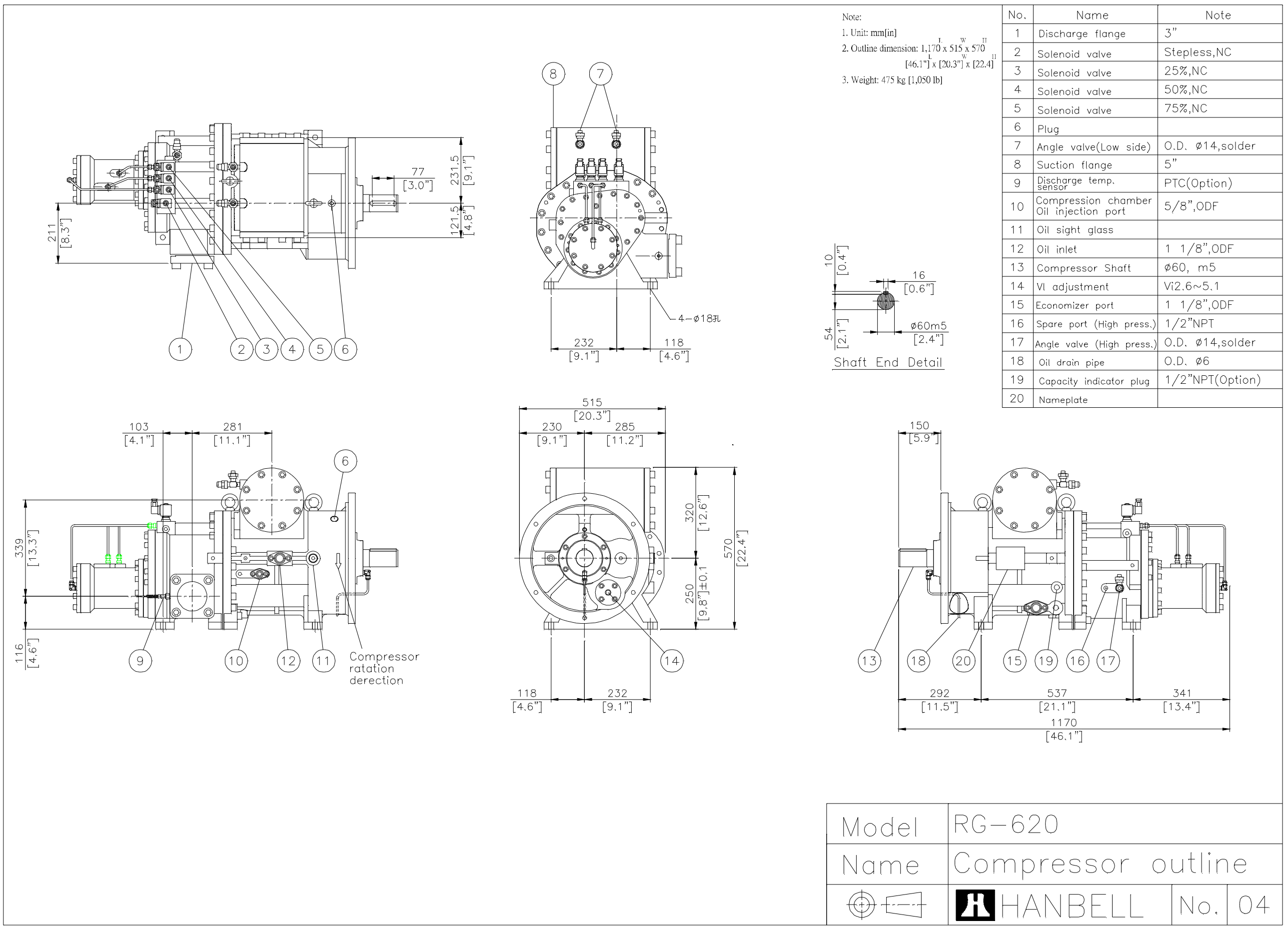
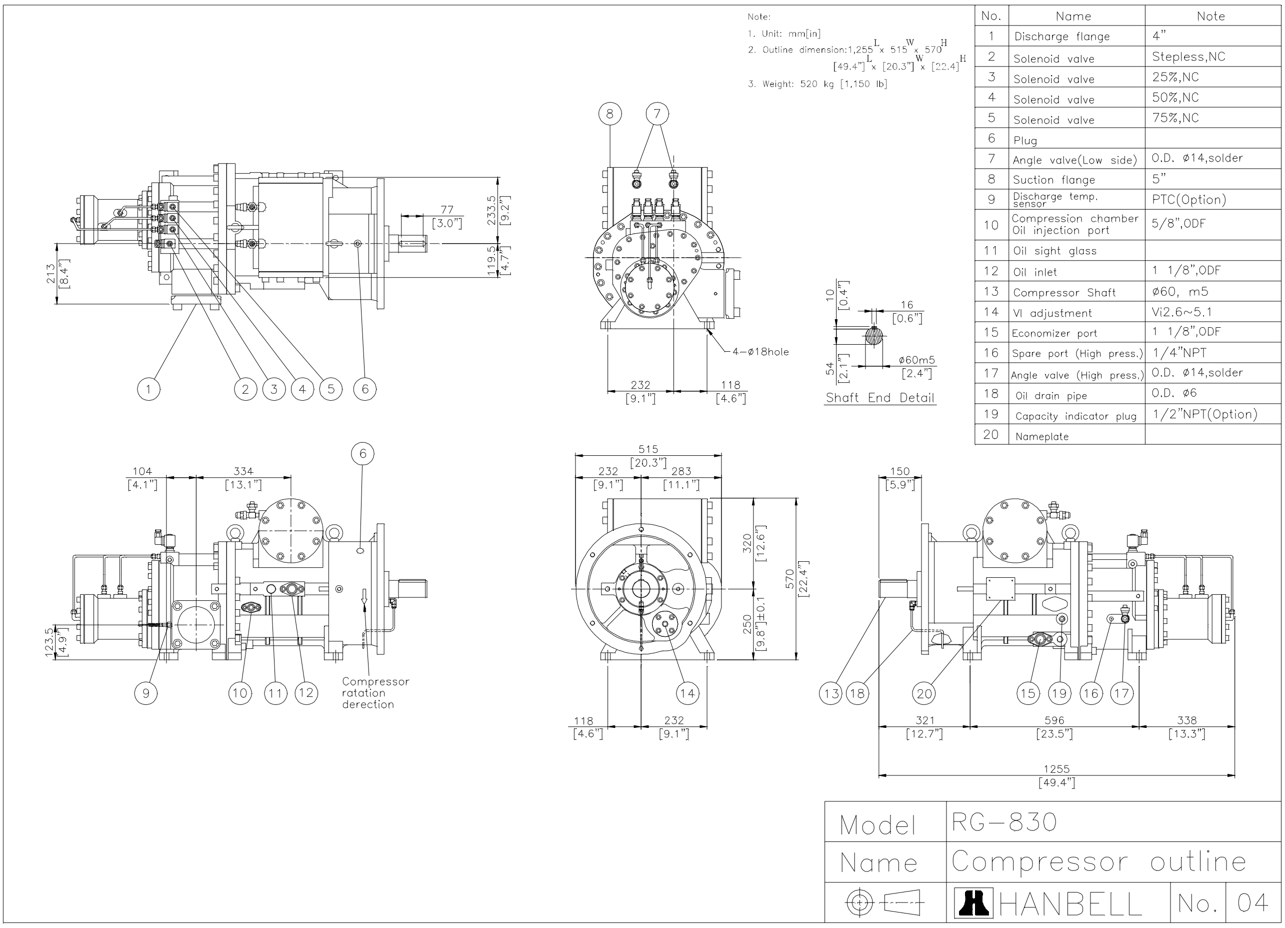


Figure 2.2: RG-410 outline drawing



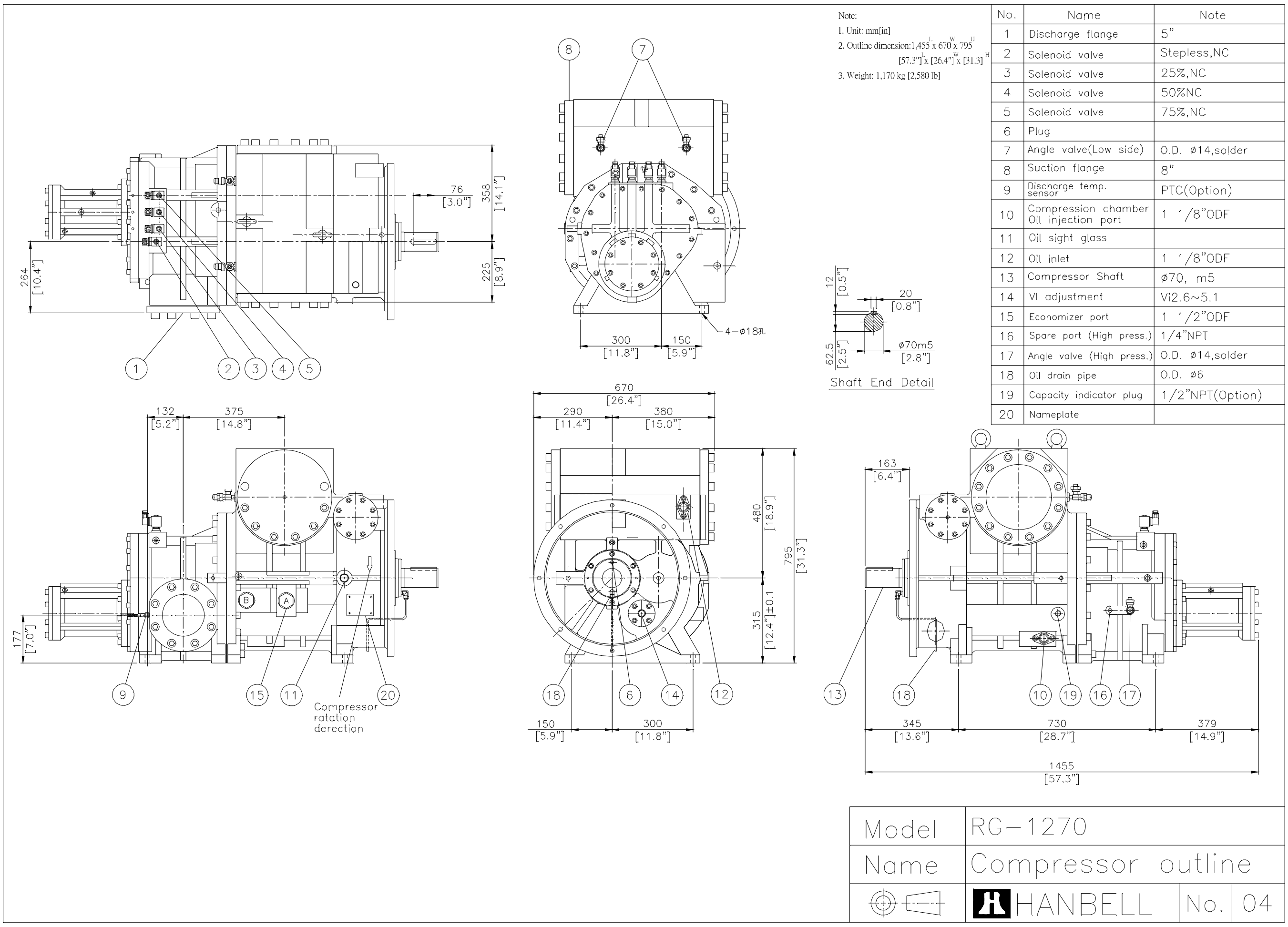
No.	Name	Note
1	Discharge flange	3"
2	Solenoid valve	Stepless,NC
3	Solenoid valve	25%,NC
4	Solenoid valve	50%,NC
5	Solenoid valve	75%,NC
6	Plug	
7	Angle valve(Low side)	O.D. ø14,solder
8	Suction flange	5"
9	Discharge temp. sensor	PTC(Option)
10	Compression chamber Oil injection port	5/8",ODF
11	Oil sight glass	
12	Oil inlet	1 1/8",ODF
13	Compressor Shaft	ø60, m5
14	VI adjustment	Vi2.6~5.1
15	Economizer port	1 1/8",ODF
16	Spare port (High press.)	1/2"NPT
17	Angle valve (High press.)	O.D. ø14,solder
18	Oil drain pipe	O.D. ø6
19	Capacity indicator plug	1/2"NPT(Option)
20	Nameplate	

Figure 2.3: RG-620 outline drawing



No.	Name	Note
1	Discharge flange	4"
2	Solenoid valve	Stepless,NC
3	Solenoid valve	25%,NC
4	Solenoid valve	50%,NC
5	Solenoid valve	75%,NC
6	Plug	
7	Angle valve(Low side)	O.D. ø14,solder
8	Suction flange	5"
9	Discharge temp. sensor	PTC(Option)
10	Compression chamber Oil injection port	5/8",ODF
11	Oil sight glass	
12	Oil inlet	1 1/8",ODF
13	Compressor Shaft	ø60, m5
14	VI adjustment	Vi2.6~5.1
15	Economizer port	1 1/8",ODF
16	Spare port (High press.)	1/4"NPT
17	Angle valve (High press.)	O.D. ø14,solder
18	Oil drain pipe	O.D. ø6
19	Capacity indicator plug	1/2"NPT(Option)
20	Nameplate	

Figure 2.4: RG-830 outline drawing



No.	Name	Note
1	Discharge flange	5"
2	Solenoid valve	Stepless,NC
3	Solenoid valve	25%,NC
4	Solenoid valve	50%NC
5	Solenoid valve	75%,NC
6	Plug	
7	Angle valve(Low side)	O.D. ø14,solder
8	Suction flange	8"
9	Discharge temp. sensor	PTC(Option)
10	Compression chamber Oil injection port	1 1/8"ODF
11	Oil sight glass	
12	Oil inlet	1 1/8"ODF
13	Compressor Shaft	ø70, m5
14	VI adjustment	Vi2.6~5.1
15	Economizer port	1 1/2"ODF
16	Spare port (High press.)	1/4"NPT
17	Angle valve (High press.)	O.D. ø14,solder
18	Oil drain pipe	O.D. ø6
19	Capacity indicator plug	1/2"NPT(Option)
20	Nameplate	

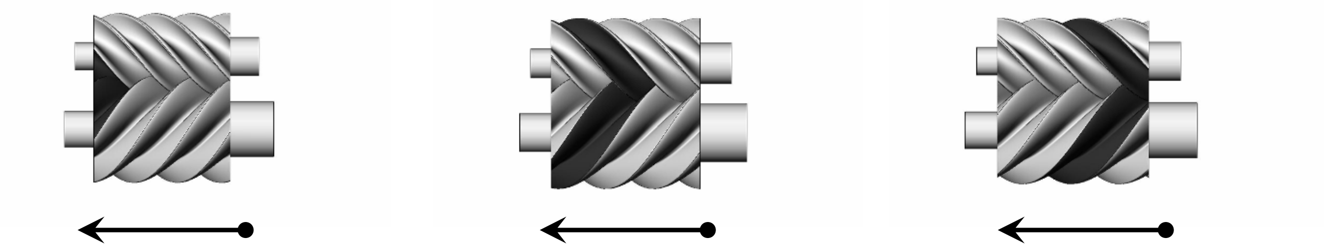
Figure 2.5: RG-1270 outline drawing

2.5 Compression process

a. Suction and sealing:
At the beginning of the compression cycle, as the male rotor and female rotor unmesh, gas from suction port fills the interlobe space (refer to the dark area in Figure 2.5). Refrigerant at suction pressure continues to fill it, until the trailing lobe crosses the suction area and the gas is trapped inside the interlobe space.

b. Compression:
As the male rotor and female rotor meshes, the interlobe space moves towards to discharge end and its volume decreases so that gas pressure increases consequently.

c. Discharge:
Gas is discharged from the interlobe space when the leading lobe crosses the discharge port whose volume ratio is designed differently for various applications.



(C) Discharge **(B) Compression** **(A) Suction and sealing**

Figure 2.5 Compression process

2.6 Capacity control system

RG 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. When the slide valve moves toward the suction side, effective compression volume increases. This means the displacement also increases and as a result, the refrigeration capacity increases. However, when any one of solenoid valves (for 4-step capacity control system) is opened, the high-pressured oil in the cylinder will return to the suction side. In this way, the piston along with the slide valve will move toward partial load positions (either 25%, 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 decreases because of reduction in displacement of 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 the controller to modulate the position of the piston smoothly for loading, holding or unloading.

If solenoid valves and the piston do not work well in the capacity control system, it 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 at least 60 seconds so the piston in the cylinder can go back to the minimum-load position to minimize electric startup current.

2.7 4-step capacity control system

There are three solenoid valves that control compressor capacity from the minimum load to full load. In general, normally closed (NC) solenoid valves are used. For the compressor with 4-step capacity control system, the recommended loading sequence is 25%-50%-75%-100% capacity and recommended unloading sequence is 100%-75%-50%-25%.

a. Min % capacity

When starting the compressor min% solenoid valve is energized and the piston is at min% capacity position, so even the oil is coming from the external oil separator, the high pressure oil in the cylinder bypasses directly into the suction port, so the piston is held to its minimum position.

※ It is strongly recommended to energize min% solenoid valve for 1~3 minutes before start the compressor to ensure the slide valve is in min% position and do not run compressor at minimum capacity continuously.

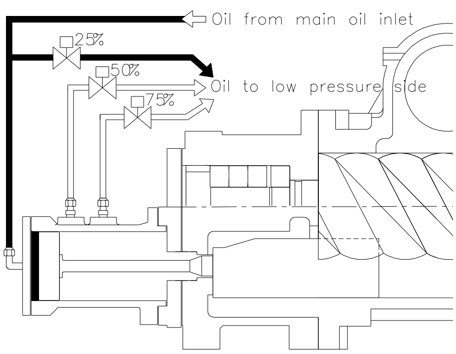


Figure 2.6: 25% capacity

b. 50% capacity

When 50% solenoid valve is energized, the high-pressure oil in the oil reservoir flows into the cylinder due to the closing of min% solenoid that pushes the piston moving toward the position where a hole at exactly 50% position drains the oil back to the suction port then the piston is held at that position.

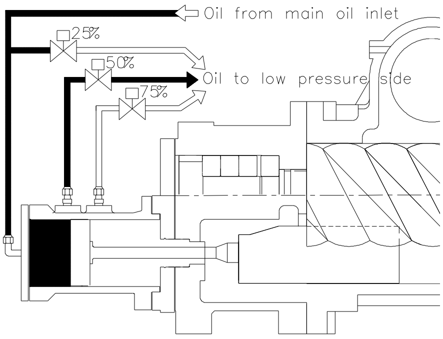


Figure 2.7: 50% capacity

c. 75% capacity

When 75% solenoid valve is energized, the 50% solenoid valve will be de-energized simultaneously, the high pressure oil will push the piston towards the position where a hole at exactly 75% position drains the oil back to the suction port and the piston will be held at that position.

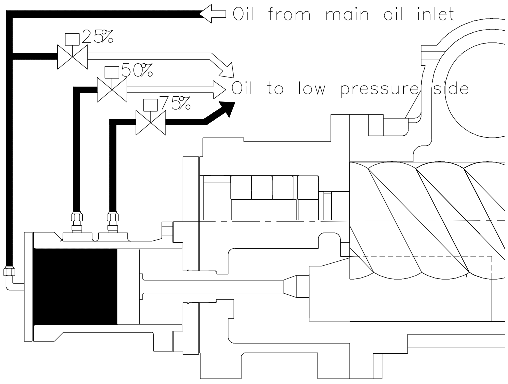


Figure 2.8: 75% capacity

d. 100% full load

When all the three modulation solenoid valves are de-energized, the high-pressure oil flows into the cylinder continuously to push the piston toward the suction side gradually until the slide valve touches the Vi adjusting slide and the piston also reaches its dead end entirely where no bypass of compression gas occurred. So 100% load is achieved.

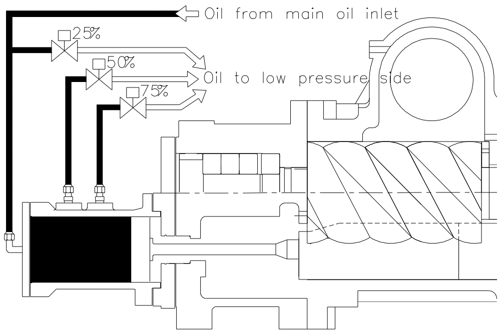


Figure 2.9: 100% capacity

2.8 Continuous (Step-less) capacity control system

In continuous (Step-less) capacity control system, 2 solenoid valves are equipped for the capacity control. Refrigeration capacity hence can be modulated at anywhere within min% ~ 100%.

Note: For continuous (step-less) capacity control system, Hanbell equips with two normal-close solenoid valves as standard accessory.

	Unloading SV(NC)	Loading SV(NC)
Start	Energized	not energized
Loading	not energized	energized
Unloading	Energized	not energized
Stable	not energized	not energized

a. Loading

When NC loading SV is energized but NC unloading SV is not energized, oil will flow continuously into the cylinder and will not bypass through NC unloading SV so compressor keeps loading.

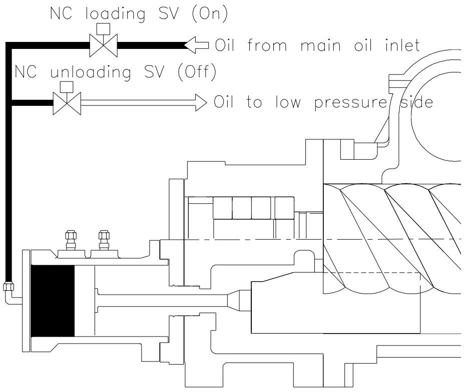


Figure 2.10: Loading with NC loading valve

b. Unloading

When NC unloading SV is energized but NC loading SV is not energized, oil in the cylinder will bypass to suction port through NC unloading SV.

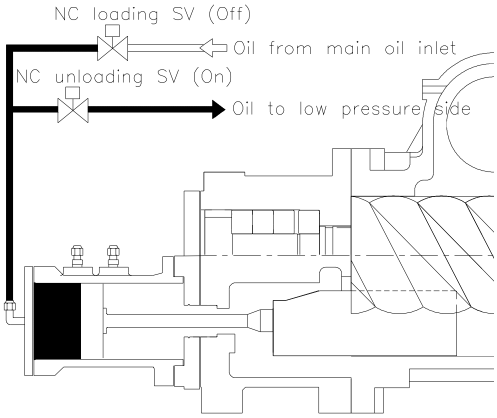


Figure 2.11: Unloading with NC loading valve

c. Holding/Stable

When both NC loading and unloading SV are not energized, piston can be held at stable position.

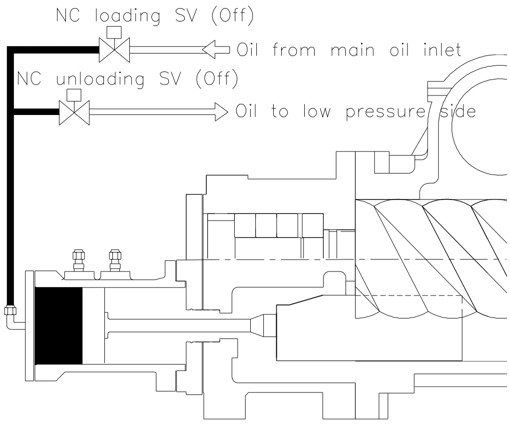
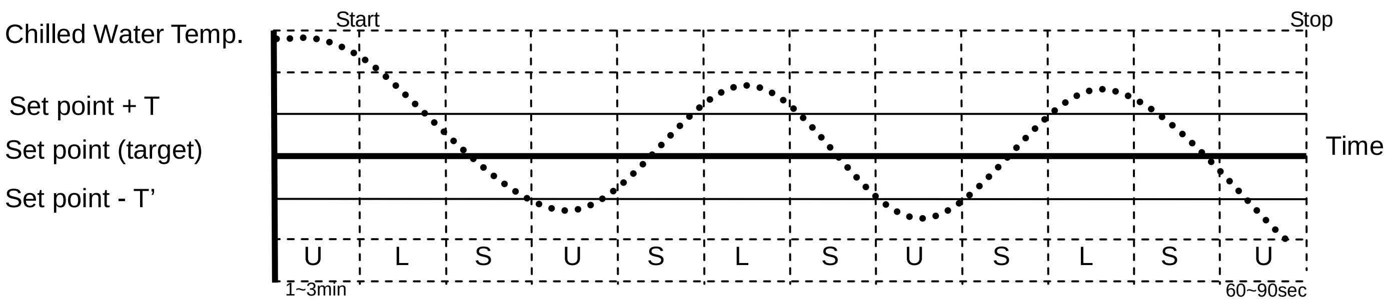


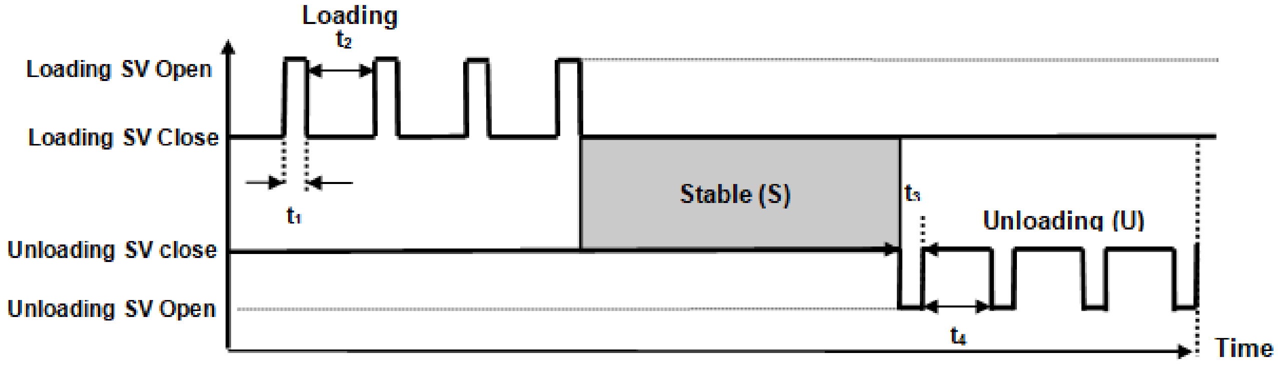
Figure 2.12: Holding with NC loading valve



••••• - Chilled water temperature
U - Unloading
S - Stable(holding)
L - Loading

Figure 2.13: Continuous/ step-less capacity control principle

Note: 1. Above T. & T' should be determined by system designer’s experience and end user’s application.
2. Capacity control must be kept at unloading for 1~3 min before start and for 60~90 sec before stop..



t_1, t_3: Pulse time 1 ~ 1.5 seconds

t_2, t_4: Pause time 15 ~ 20 seconds

Figure 2.14: Loading and unload function

Hanbell not only provides continuous-capacity-controlled compressors with above mentioned standard accessories and control logic, but also supplies special models with step + continuous capacity control system. If special solenoid valve for capacity control is needed, please contact Hanbell directly.

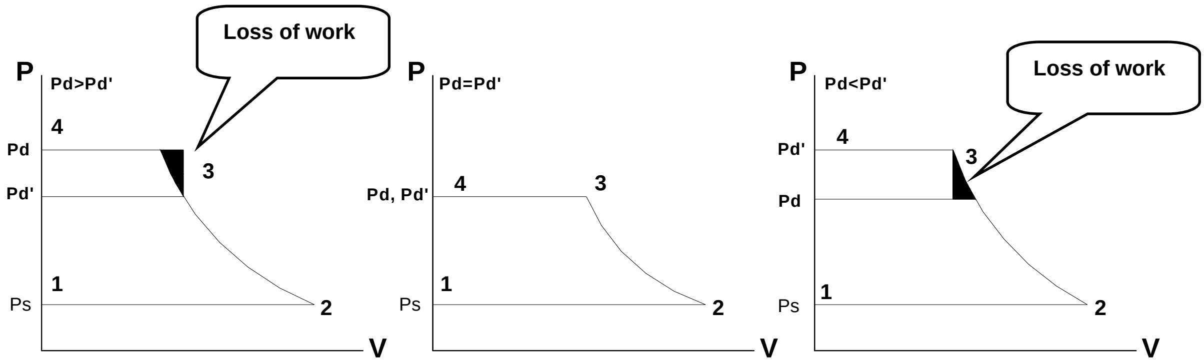
2.9 Compressor volume ratio (Vi)

The Volume ratio (Vi) of the compressor can be defined as the ratio of suction volume of gas divided by discharge volume of gas of the compressor. The volume ratio directly affects the internal compression ratio or Pi of the compressor. A low Vi compressor corresponds to a low compression ratio compressor and high Vi compressors are used on higher compression ratio systems. In the equation below, in order to avoid over or under compression, the system compression ratio **(CR)** should be equal to the compressor internal compression ratio **(Pi)**. Refer also to the P-V (pressure – volume) diagram below to show the relation.

CR = Pd/Ps

Pi = Vi ^{k}

Vi = Vs/Vd



Under compression (CR > Pi) **CR = Pi** **Over compression (CR < Pi)**

Figure 2.8: P-V Diagram

Where: **CR:** system compression ratio
Vi: internal volume ratio
Pd': discharge pressure (absolute pressure)
Vs: suction volume **Vd:** discharge volume
Pi: internal compression ratio
Pd: system pressure (absolute pressure)
Ps: suction pressure (absolute pressure)
K: refrigerant specific heat ratio

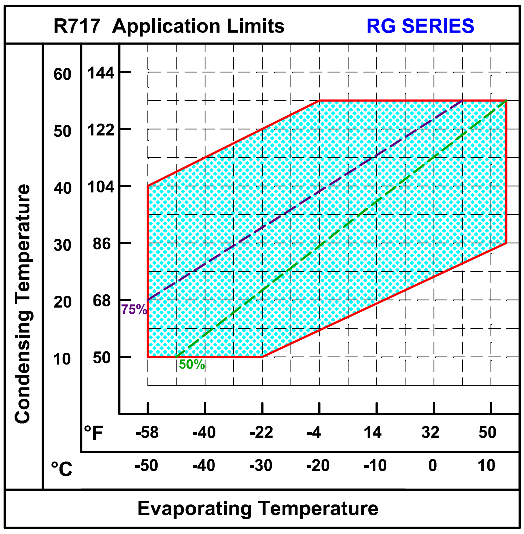
Note:

1. Hanbell recommends using selection program to get the suggested Vi because inappropriate Vi selection will cause higher power consumption, vibration and discharge temperature.

2.10 Application limits

Compressor Operating Limits vary significantly with the type of refrigerant used. The operating limits shown below are based on saturated suction and discharge operating conditions. For continuous operation over extended periods of time, it is important to operate the compressor within these limits to maintain proper compressor life.

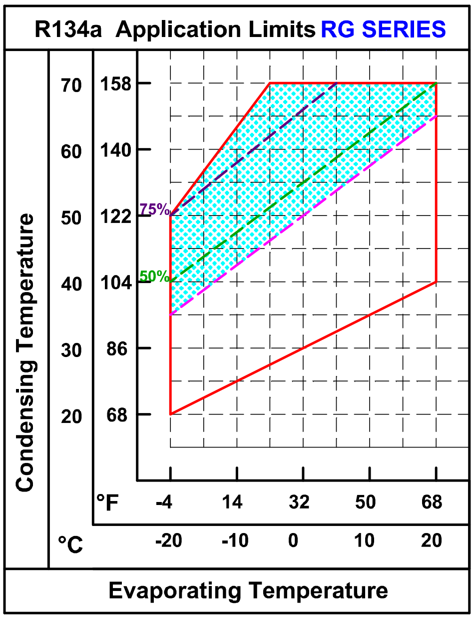
R717 Application Limits



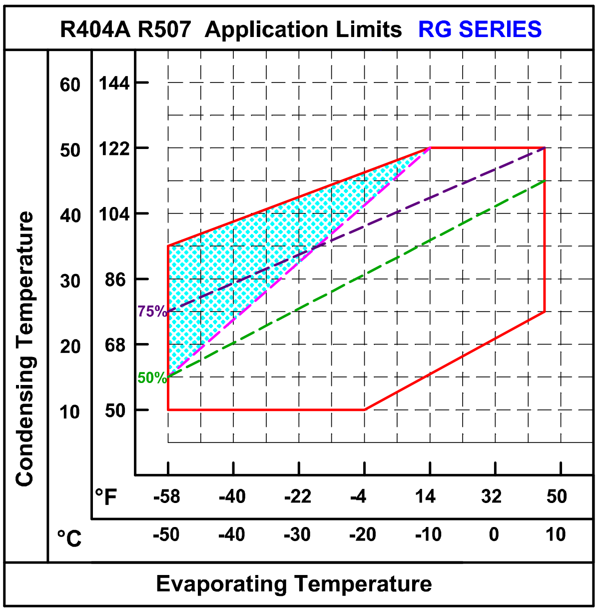
: Oil Injection Area

Below ——— : Oil Pump Working Area

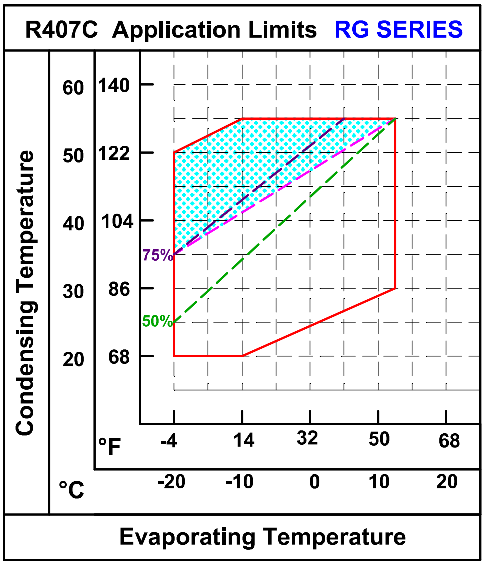
R134a Application Limits



R404A&R507 Application Limits



R407C Application Limits



Discharge pressure (condensing pressure)	$P_{discharge}$	bar G	max	< 28
Pressure difference ($P_{oil} - P_{suction}$)	ΔP	bar	min	≧6
Suction temperature (compressor inlet)	t_{in}	℃	min	> -60
Discharge temperature (compressor outlet)	t_{out}	℃	max	< 110

Note:
1. When Hanbell screw compressor operates in partial or full load within limits, discharge temperature might rise above the desire setting. In order to keep compressor running safely, Hanbell recommends using External oil cooler with oil injection to chamber.
2. The minimum discharge superheat is recommended to be kept 10° K higher than the condensing temperature (normally discharge superheat is around 20° K for R134a, R404A, R507A and 30° K for R22, R407C,R717) to avoid liquid filling back to compressor and lubrication failure. According to EN12900, the minimum suction superheat is 10° K and liquid sub-cooling is 0° K.
3. Contact with Hanbell to verify potential operating conditions outside the limits shown

3. Lubricant

The main functions of the lubrication oil in the screw compressor are lubrication, internal sealing, cooling, silencing and capacity control. The positive oil pressure in the cylinder pushes the piston and the slide valve which are connected by a piston rod to move forward and backward in the compression chamber. Hanbell suggests to install an extra oil pump in the system for pre-lubrication before compressor starts to ensure oil circulation for mechanical seal. Oil pressure differential “P oil – P suc ≧ 6 bars G” is mandatory for the compressor operation. (The selection of oil pump and its start timing, please consult Hanbell to get more information).

Bearings used in RG compressor require a small but steady quantity of oil for lubrication; the oil injection into the compression chamber creates an oil sealing film between screw rotors which secures the volumetric efficiency and absorbs a part of compression heat. In order to separate the oil from the refrigerant or gas, an oil separator is required to ensure the least amount of oil carried into heat exchangers. High oil carryover will reduce the heat exchanger performance or simply block the pipe. For synthetic oil, it has high tendency to react with water (Hydrophilic), acid and metal particle and generates slurry. Compressor operates without sufficient oil supply will lead to high discharge temperature, bearing failure or screw rotor jam. Pay attention to the oil temperature, which has a very significant factor to the compressor’s bearing life. High oil temperature will reduce the oil viscosity and cause the poor lubrication and heat absorption in the compressor as well. Too much refrigerant dissolved in the oil will also reduce the oil viscosity which might become the root cause of bearing failure in the future. The oil viscosity is required at least 8 mm^2/s at any temperature. If the compressor operates under the critical operating condition (low evaporating temperature/high condensing temperature), an extra oil cooler will be needed.

High viscosity oil is recommended to be applied in the strict working condition (heat pump/ air-cooled). Users should take notice on the oil level in the external oil separator because if oil returns from the evaporator is less than the oil carryover to the system from oil separator, the oil separator will lose oil gradually and comes to the system stop in the end. Therefore, when users have an oil return problem, a fine oil separator is highly recommended to be installed between the oil separator discharge port and condenser. If the distance between evaporator and compressor is long, Hanbell also recommends to be installed with a fine oil separator to ease an oil carryover problem.

Low viscosity oil is recommended to be applied in the low evaporating temperature (SST< -20℃). Selecting an oil which can maintain at least 8 mm^2/s for its viscosity under operating. Miscibility of oil with refrigerant is usually an important index for the selection of oil. The oil with good miscibility with refrigerant should have low miscibility value at high working temperature and high miscibility value at low working temperature to ensure the oil viscosity not declined too much at different operating conditions.

Tables as below show the recommended lubricant with different kinds of refrigerants.

Applicable oil types (R134a, R407C, R404A & R507)

SPECIFICATION		UNITS	HBR -B05	HBR -B08	HBR -B09	HBR -B04
COLOR, ASTM			–	–	–	–
SPECIFIC GRAVITY			0.945	0.94	0.95	0.95
VISCOSITY	40℃	mm^2/s (cSt)	64	131	175	215.9
	100℃		8.9	14.53	16.5	20.8

Applicable oil types (R717)

SPECIFICATION		UNITS	Shell Clavus G				CPI CP 1009		CPI CP 4600		Mobil Gargoyle Arctic		Mobil Gargoyle Arctic SHC			Kluber Summit
			32	46	68	100	68	100	46	68	C Heavy	300	224	226E	NH68	RHT 68
COLOR, ASTM			–	–	–	–	–	–	–	–	L1.0	L1.0	–	–	–	–
SPECIFIC GRAVITY			0.883	0.888	0.95	0.900	0.867	0.87	0.829	0.835	0.91	0.91	–	–	0.85	0.86
VISCOSITY	40℃	mm^2/s (cSt)	30	44	64	100	69	108	46.9	68.5	46	68	29	64	97	68
	100℃		4.6	5.6	6.9	8.7	9.1	12	7.9	10.4	5.4	6.5	5.6	8.5	13.7	8.8

Note:

a. Use prescribed oil only because its viscosity, solubility and foaming characteristics will largely influence the system's reliability in the future. Do not mix different brand of oil together. Mixing of oil may cause excessive oil foaming, nuisance oil level cutouts, oil pressure loss, gas or oil leakage and catastrophic compressor failure. Different kinds of refrigerant should apply with different kinds of oil. Most of synthetic oil is incompatible with mineral oil. Therefore the system should be totally cleaned up before refill the different kind of oil and might need to change the oil again to ensure its characteristics and lubrication ability.

b. For a chiller system using synthetic oil, user should avoid the exposure of oil to the atmosphere. It is also necessary to vacuum the system completely before charging the oil into oil reservoir.

c. In order to prevent the moisture into the system, it is suggested to clean the system by nitrogen then vacuum the system as soon as possible.

d. Consult with Hanbell representative firstly for the use of unmentioned oil to protect the right of compressor warranty.

e. It is recommended to do oil analysis regularly to ensure oil quality and system integrity. Oil samples for analysis should be taken after the oil filter.

4. Installation

4.1 Compressor lifting

After the compressor arrives at the warehouse, check the crate if it is kept in good condition and check all the compressor accessories and the shipping documents to see if there is any discrepancy. Please note that the compressor is charged with 0.5~1 bar nitrogen gas. Therefore release inner pressure before loosing any parts on the compressor.

Each HANBELL screw compressor is fully tested at the factory where every precaution and care is taken to make sure that the compressor is in perfect condition. When lifting the compressor, it is recommended to use a steel chain or steel cable as shown in the figure 4.1. The safety rope can also be used if it is proofed to resist the compressor weight.

Make sure that the chains, cables, ropes or other lifting equipment are properly positioned to avoid possible damage to the compressor or its accessories. Keep the compressor in horizontal position when lifting, and avoid the compressor from crashing or falling on the ground, hitting the wall or any other event that may damage it or its accessories.

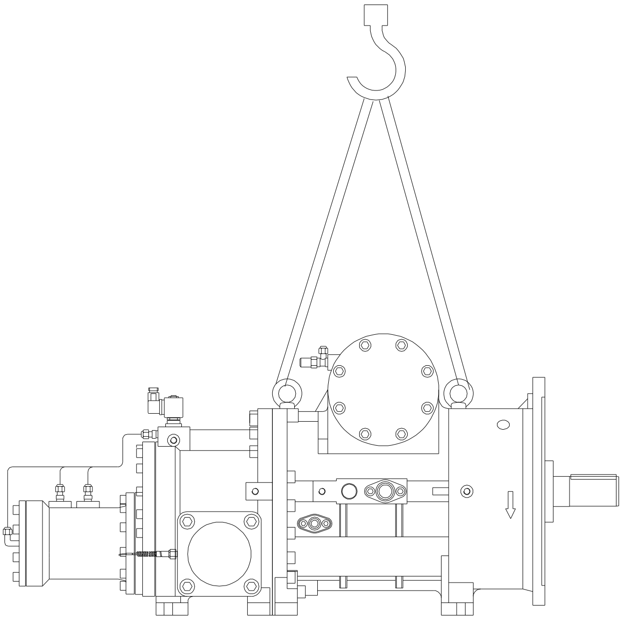


Figure 4.1: Lifting compressor with steel rope

Foundation where the compressor unit is installed is also critical. It must be able to support the compressor unit and other parts including oil cooler, charged oil, charged refrigerant and etc. Because high frequency vibration will happen during the operation of the unit, it is recommended using proper vibration isolators to absorb the vibration from the unit and ensure a trouble-free installation.

4.2 Shaft alignment without coupling housing

Shaft alignment is very important to increase the operating life span of rotating machinery. Correct shaft alignment helps to ensure the smooth, efficient transmission of power from the motor to the compressor. Incorrect alignment leads to excessive vibration, noise, coupling and bearing temperature increases, and premature bearing or coupling failure.
In the case of shaft alignment without coupling housing, misalignment should be controlled within the following requirement.

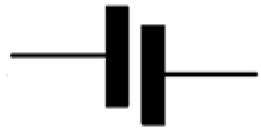
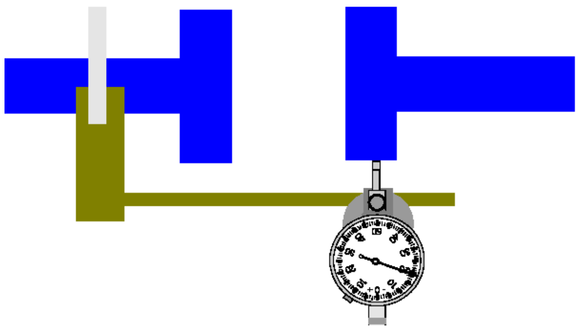
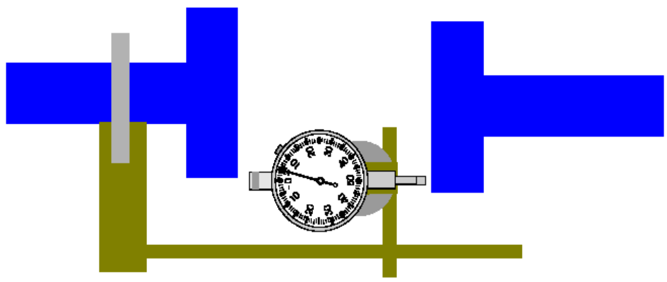
Angular Misalignment	Offset Misalignment
	
Less than 0.03 mm per 100mm	Less than 0.05 mm

Figure 4.2: Requirement for centering work

To do the shaft alignment, users can use a dial gauge with 0.01 mm for its scale units and mount it like the demonstration below to measure the angular difference and the offset difference between the compressor shaft and the motor shaft. If coupling has been installed separately on the motor shaft and the compressor shaft, users should loose the connection part to allow both shafts rotate freely and do the centering work before tighten it. The adjustment should be done with a dial/feeler gauge mounted on both motor and compressor shafts to ensure the misalignment can be minimized.



Measuring the offset misalignment



Measuring the angular misalignment

Figure 4.3: Demonstration of shaft alignment work

After complete the centering work, user can start tightening the coupling to connect the motor and the compressor shaft. When the compressor installed without the coupling housing, the following points should be noted during the installation:

a. The compressor and the motor should be installed on rigid base.
b. The compressor should be installed horizontally.
c. Use slim metal below compressor and motor for alignment work.
d. The rigid base should not be upon the condenser or the evaporator.
e. Two coupling surfaces should not be in contact with each other.
f. Follow the instruction above (Refer to Figure 4.2) to finish alignment work.
g. Fixing bolts for motor & compressor have to be tightened firmly on rigid base.

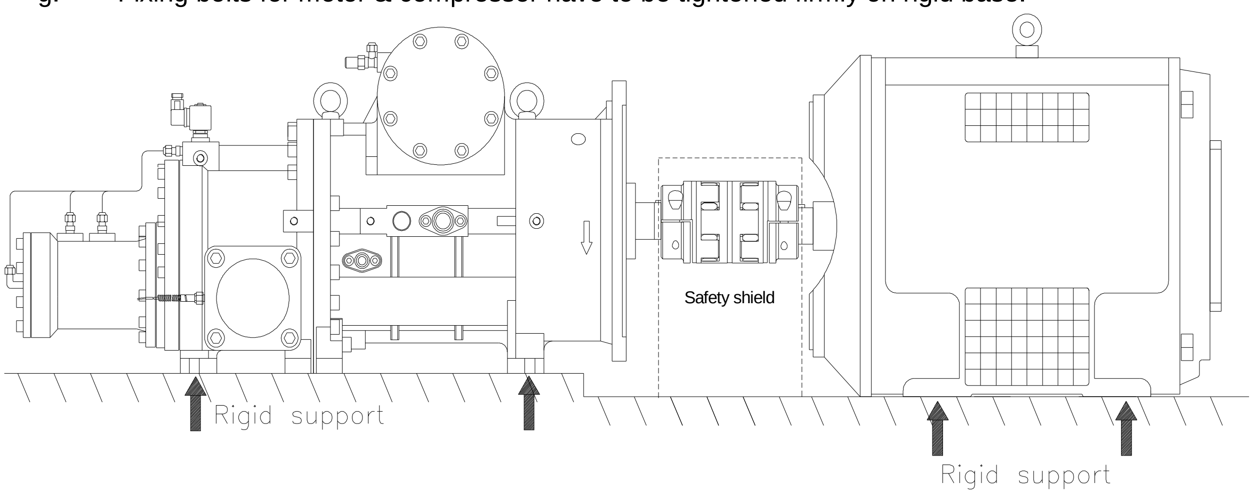


Figure 4.4 Connection without coupling housing

Note:
1. Use a cover on the opening of coupling housing for safety purpose.
2. Follow the installation instruction from coupling manufacturer to install the coupling.
3. Please refer to the motor's maximum torque value to select a proper coupling.
4. Only torsionally flexible couplings can be used when using coupling housing for alignment work.
5. The compressor and the motor should be installed on rigid base.
6. The rigid base should not be upon the condenser or the evaporator.
7. Two coupling surfaces should not be in contact with each other.
8. Fixing bolts for motor & compressor have to be tightened firmly on rigid base.
9. Follow the instruction from motor manufacturer to install the motor.
10. The motor rotation direction should be correspondent with the compressor rotation direction.

4.3 Shaft alignment with coupling housing

Using a coupling housing can help user save time for alignment. Hanbell provides following options for customers:

Option 1 - Customer needs a coupling housing from Hanbell, but prefers to use his own couplings.
In this case, Hanbell needs 2D drawing of flange-type motor and couplings to design the coupling housing for customer. Customer should assist Hanbell to get enough input for coupling housing design and Hanbell will supply the coupling housing along with compressor to customer. Therefore, customer can get coupling housing and compressor from Hanbell for their project application.

Option 2 - Customer needs both coupling housing and couplings from Hanbell.
In this case, Hanbell needs 2D drawing of flange-type motor to design the coupling housing for customer. Customer should assist Hanbell to get enough input for coupling housing design. Hanbell will help customer select a proper coupling and design a suitable coupling housing according to the information from customer then ship both of them along with compressor to customer. Therefore, customer can get coupling housing, couplings and compressor from Hanbell for their project application. Procedures and information on how to assemble couplings and coupling housing supplied by Hanbell can be reached on request.

About the compressor installed with the coupling housing, the following points should be noted during the installation:

a. The compressor and the motor should be installed on the rigid base.
b. The compressor should be installed horizontally.
c. Use vibration isolation pad below compressor and motor. (Refer to Figure 4.5)
d. The rigid base should not be upon the condenser or the evaporator.
e. Two coupling surfaces should not be in contact with each other.

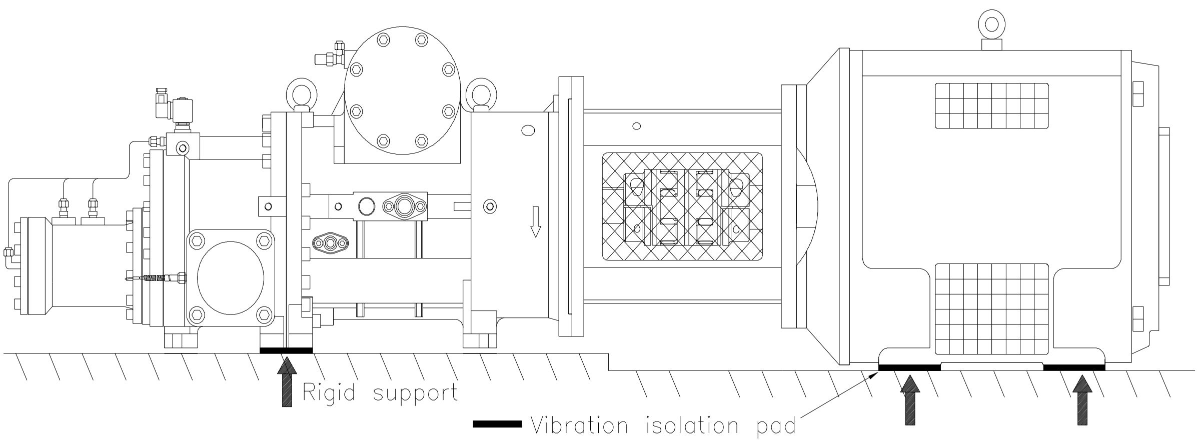


Figure 4.5 Connection with coupling housing

Note:
a. Follow the instruction from motor manufacturer to install the motor.
b. The selection of motor should base on its max working condition and add 20% safety factor to achieve motor nominal HP.
c. The motor rotation direction should be correspondent with the compressor rotation direction.

4.4.Oil charge (to oil separator)

Oil charge should be done after finishing the piping works. Before charging the oil, user should confirm no moisture and air or other contaminants in the system, otherwise, oil quality will rapidly deteriorate and cause the compressor failure in the future. User can use a suitable pressure type hose and connect one side to the oil charging valve on the oil separator. Oil charge can be made by the help of an oil pump or using pressure differential (when system pressure reaches -300 mmHg during the evacuation by a vacuum pump). If the oil pump is used in the system, the stop valve between the oil pump and the compressor shall be closed during the oil charge and user shall always use the recommended oil (Please refer to section 3.1 for more information). When charging the oil, fill it slowly because oil will fit up in the separator faster than it looks in the sight glass. Make sure that the oil level is midway in the top sight glass located on the oil separator shell. Similar equipment (like oil cooler and oil filter) should be filled with oil prior to unit operation. Before the unit operation, reconfirm the oil level in the oil separator is also very important.

Note:

1. Do not fill oil into the compressor because this will lead start-up difficulty during commissioning.
2. The total oil volume should be considered by oil separator size, oil line length and solubility of refrigerant.
3. Different type of oil cannot be mixed.
4. Check oil level during the commissioning and add oil by extra oil pump if oil is not sufficient. Avoid charging air into oil separator during oil charge.

4.5 Suction strainer

The cleanness of suction gas is very important to the compressor life and working efficiency. Hanbell uses a reinforced stainless steel wire mesh to entrap particles and debris in the gas.

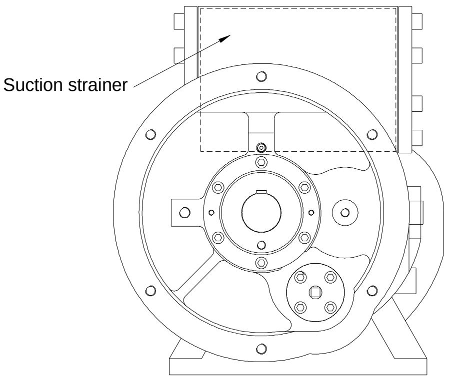


Figure 4.6: Position of suction strainer

The suction strainer is located on the top of compressor as shown in the Figure 4.5. Because low temperature gas will pass the suction port during operation, insulation foam is always recommended to be used on the outer surface of suction area to avoid energy loss and frozen ice on the compressor. For a new system, suction strainer should be cleaned after the first commissioning and be checked at each regular maintenance period. The new compressor normally has higher suction volume which causes higher gas speed in the old piping system. Debris might come back to the compressor during the operation. Therefore, review suction strainer after system commissioning is necessary.

4.6 Adjustment of volume ratio (Vi)

Vi adjustment is important feature to ensure compressor efficiency from over/under compression. RG compressor volume ratio can be adjusted by rotating Vi adjusting rod. Figure 4.6 below shows how the Vi adjustment is made. Each HANBELL RG compressor has been adjusted to required Vi. Unless different Vi setting is needed, it is not necessary to change it.

In case the current Vi ratio is forgotten, user can rotate the adjusting rod clockwise or counterclockwise to make Vi from 2.6 to 5.1 (5.6 for RG-1270) then refer to table 4.1 below to know how many turns you should apply to get the Vi you need. For a safe and proper Vi adjustment, always do the Vi modification when the compressor stops and slide valve is at minimum position. The recommended Vi setting can be obtained by using Hanbell selection program.

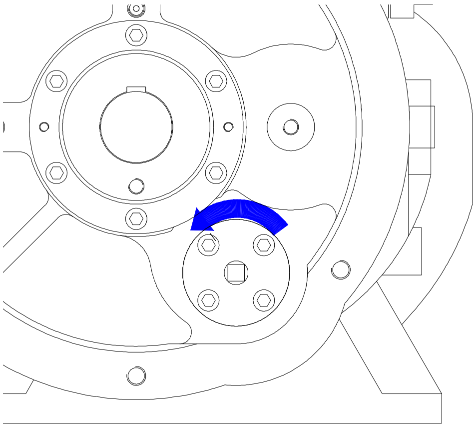


Figure 4.7: Rotate Vi adjusting rod counterclockwise to increase Vi ratio

Table 4.1 Vi table

Vi\Turns	0	2	4	6	8	10	12	14	16	18	20
RG-200	2.6	2.8	3.2	3.6	4.2	5.1	----	----	----	----	----
RG-410	2.6	2.8	3.0	3.2	3.4	3.7	4.1	4.6	5.1	----	----
RG-620	2.6	2.8	3.0	3.2	3.4	3.7	4.1	4.6	5.1	----	----
RG-830	2.6	2.8	3.0	3.1	3.2	3.5	3.7	4.0	4.3	4.7	5.1
RG-1270	2.6	3.0	3.3	3.6	4.0	4.3	4.6	4.9	5.3	5.6	----

Note:
1. If Vi mismatches, it will cause unwanted system vibration and higher power consumption.
2. It is necessary to recalibrate the capacity indicator after Vi modification

4.7 Vacuum the compressor

The vacuum of compressor can be achieved by connecting the vacuum pump to the suction side connector or discharge side connector on compressors. The oil line solenoid valve or oil line service valve should not be opened during the vacuum of compressor; otherwise the oil will enter to the compressor. For solenoid valves on the compressor, they should be energized during the vacuum of compressor because this will ensure no air exists in the capacity control oil line. Normally the compressor system should reach 1.5 mbar as the vacuum standard and don't start the compressor when the compressor is at vacuum status.

4.8 Refrigerant charge

The initial charge of refrigerant should be executed only to condenser. Follow the system design to add proper quantity of liquid refrigerant into condenser. Too much or too less refrigerant is not good for system commissioning. In the case of using blend refrigerant, only charge liquid refrigerant to the system. If refrigerant is not enough during the commissioning, charge refrigerant by connection port before evaporator if possible. Charging refrigerant via compressor's suction port can only be performed when the system already has some refrigerant and no other connection port before evaporator can be used for refrigerant charge. Refrigerant charge via compressor's suction port should be slow to avoid liquid compression in the compressor.

4.9 Compressor protection devices

All Hanbell RG compressors are equipped with a PTC temperature sensor at discharge port. The PTC temperature sensor can be connected to an INT69HBY motor protector to monitor the discharge temperature. When the discharge temperature exceeds the nominal response temperature (R717: 90^{o}C, other refrigerants: 110^{o}C), the resistance of PTC sensor increases to a trip point causes the relay output of INT69HBY motor protector opened which helps to shut down the compressor. User can follow the connection diagram below for proper installation.

INT69HBY motor protector can also be used to monitor phase loss and phase sequence. These two functions are active 1 second after the motor start and will last 10 seconds to protect the motor. If one of these parameters is not correct, the relay locks out (The contacts M1-M2 are open). The lockout can be cancelled by manual reset for approximately 5 seconds. (Disconnect L-N)

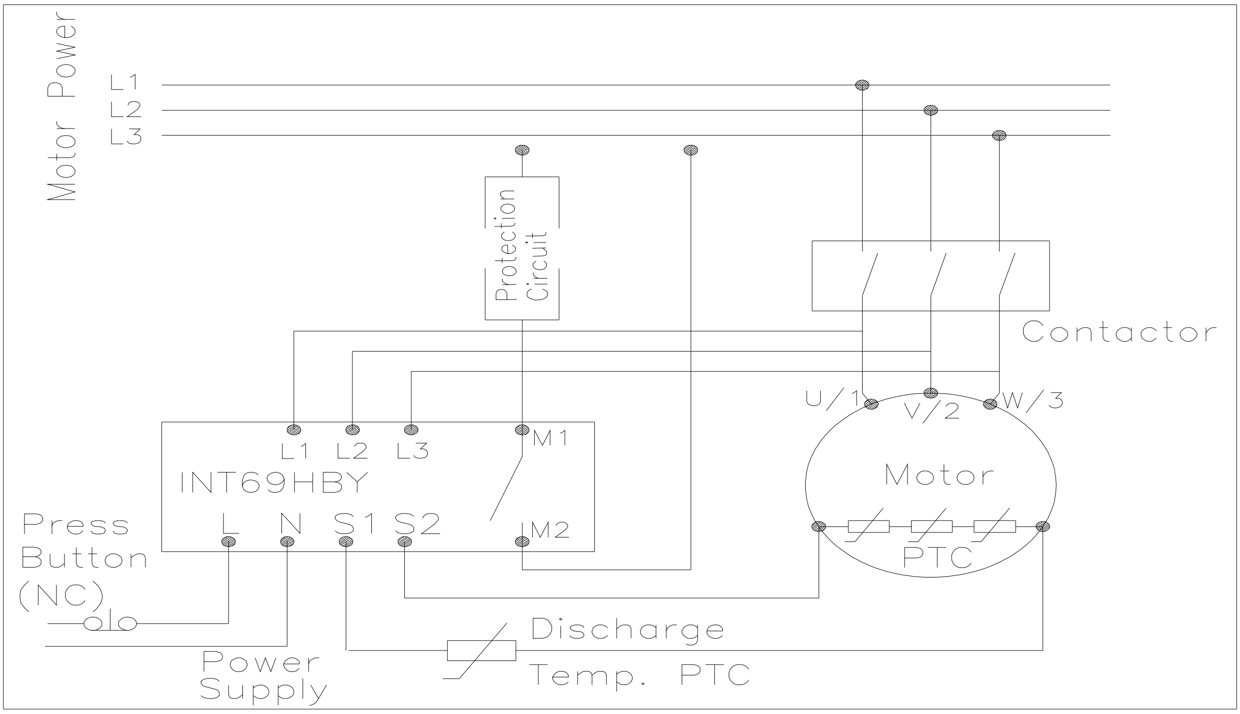


Figure 4.8: INT69HBY connection diagram

4.10 Oil circulation

Hanbell RG compressor uses an external oil separator to separate oil and gas. The oil separator plays a role like an external reservoir for the oil supply to the compressor. Oil supply can be achieved by pressure differential between the reservoir and the injection port. Oil pump is suggested to install to ensure a sufficient oil supply for bearing lubrication, rotor sealing, pre-lube and post-lube for mechanical seal, and capacity control. Oil pressure differential “P oil – P suc ≧ 6 bars G” is mandatory for the compressor operation.

4. 11Accessories

For system application with RG compressor, Hanbell provides all necessary technical information to help customer select proper accessories for the system usage. Available accessories are shown as the list below.

1. Compressor standard and optional accessories

RG-Series ● (Standard), Δ (Option)

Item	Item Name	Compressor accessory
1	Capacity control: 25%, 50%, 75%, 100% 4-Steps or 25%~100% step-less	●
2	Suction coupling bushing	●
3	Discharge coupling bushing	●
4	Liquid / oil inject port	●
5	Economizer port	●
6	Suction check valve (RG-200~RG-410)	Δ
7	Suction stop valve (RG-200~RG-410)	Δ
8	Screw in discharge temperature sensor	Δ
9	Suction check valve (RG-830~RG-1270)	Δ
10	Discharge check valve (RG-200~RG-1270)	Δ
11	Suction stop valve (RG-620~RG-1270)	Δ
12	Discharge stop valve (RG-200~RG-1270)	Δ
13	Capacity indicator	Δ
14	Liquid injection expansion valve	Δ
15	Liquid injection solenoid valve	Δ
16	External oil separator	Δ
17	Coupling	Δ
18	Coupling housing	Δ
19	External motor	Δ

2. Description of accessories

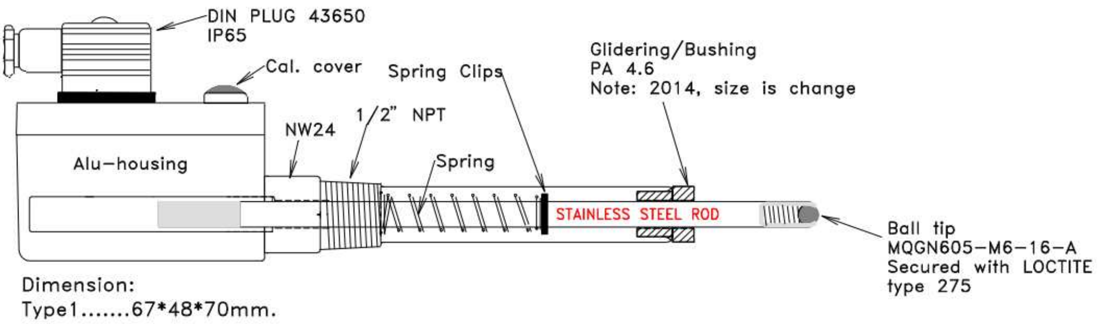
a. Capacity indicator (As standard accessory for step-less capacity control)

Hanbell provides capacity indicator as the optional accessory for its open type compressor. The short stroke linear displacement sensor/transmitter is designed specially for use in refrigeration compressors to detect the position of slide valve. The stroke distance is 25mm which can be calibrated by desired range. Temperature compensation is also done by its sensor coil directly. Please refer to the information below for its specifications and dimensions.

Specifications:

Supply---------------------------- 24V DC +/- 10%
Measuring ranges-------------- 0 to 25 mm
Output---------------------------- 4-20mA, load max 500 ohm
Resolution----------------------- Endless
Linearity-------------------------- Better than 1% FS
Response time----------------- Better than 2 seconds
Ambient Temp------------------ -20 to +70℃ (electronic)
Temp. range sensor----------- -40 to +120℃
Temp. Coeff.--------------------- Better than 0.01% FS/℃
Vibration-------------------------- IEC 68-2-6
Pressure-------------------------- Max 100 bar

The instruction of calibration can be referred in section 5.2-16



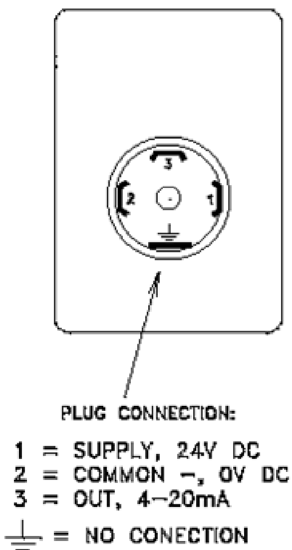
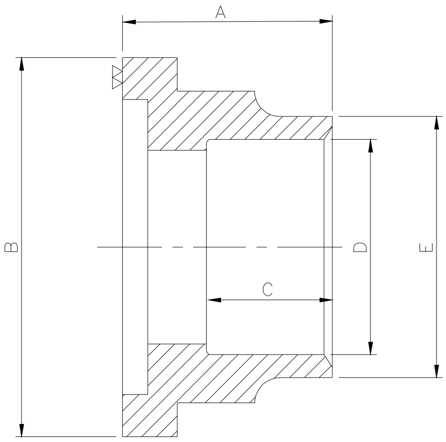


Figure 4.9: Construction of capacity indicator

b. Suction and discharge connection bushings (Standard accessory)

Suction and discharge connection bushings are standard accessories for RG compressor. User can follow the information below to know the size and dimensions for their installation. Welding job on connecting bushings, flanges or valves should not be performed when they are on the compressor. Please take them off before welding. Clean debris or metal impurities after the welding job to avoid severe damage on screw rotors during commissioning.



Model	Standard Discharge Bushing		Standard Suction Bushing	
	Steel pipe	Copper pipe	Steel pipe	Copper pipe
RG-200	2 ″	2 1/8”	3″	3 1/8”
RG-410	2 1/2″	2 5/8”	4″	4 1/8”
RG-620	3″	3 1/8”	5″	5 1/8”
RG-830	4″	4 1/8”	5″	5 1/8”
RG-1270	5″	---	8″	---

Figure 4.10: Flange bushing dimensions

Note: The above table lists specification of standard bushing for Hanbell RG compressors. User can refer to their dimensions via the table above. If bushing size is not indicated in the purchasing order, Hanbell will provide the standard type. Bushing size is also shown in the table below for customer’s reference. If non-standard bushing is needed, please double-check with Hanbell sales representatives when placing order for compressors.

Specification and dimension of flange bushing

Model	Discharge / Suction port	Materials and Sizes of pipes		Dimension of flanges bushing				
				A	B	C	D	E
RG-200	Discharge	Copper	1 5/8"	50	90	30	41.6	55
			1 3/4"				44.8	55
			2"				51.1	62
			2 1/8"				54.3	65
			2 1/2"				63.8	74
			2 5/8"				67	74
		Steel	1 1/2"				49.3	60
			2"				61.3	74
	Suction	Copper	2'	66	120	45	51.1	62
			2 1/8"				54.3	65
			2 3/8"				60.7	71
			2 1/2"				63.8	74
			2 5/8"				67	77
			3"				76.6	87
			3 1/8"				79.8	90
		Steel	2"				61.3	76
			2 1/2"				77.2	92
			3"				90.2	103
RG-410	Discharge	Copper	1 5/8"	60	110	35	41.6	52
			1 3/4"				44.8	55
			2"				51.1	62
			2 1/8"				54.3	65
			2 1/2"				63.8	74
			2 5/8"				67	77
			3 1/8"				79.8	90
		Steel	1 1/2"				49.3	64
			2"				61.3	76
			2 1/2"				77.2	90
	Suction	Copper	2 5/8"	76	145	50	67	87
			3"				76.6	87
			3 1/8"				79.8	90
			3 5/8"				92.4	103
			4"				102	112
			4 1/8"				105.1	116
		Steel	3"				90.2	105
			3 1/2"				102.8	117
			4"				115.6	128
RG-620	Suction	Copper	2'	66	120	45	51.1	62
			2 1/8"				54.3	65
			2 3/8"				60.7	71
			2 1/2"				63.8	74
			2 5/8"				67	77
			3"				76.6	87
			3 1/8"				79.8	90
		Steel	2"				61.3	76
			2 1/2"				77.2	92
			3"				90.2	103
	Suction	Copper	4 1/8"	80	174	35	105.1	121.2
			5 1/8"	75			130.5	146.5
			5"	75			127.5	146.5
		Steel	4"	80			115.6	134
			5"	75			141.3	154
RG-830	Discharge	Copper	2 5/8"	76	145	50	67	87
			3"				76.6	87
			3 1/8"				79.8	90
			3 5/8"				92.4	103
			4"				102	112
			4 1/8"				105.1	116
		Steel	3"				90.2	105
			3 1/2"				102.8	117
			4"				115.6	128
	Suction	Copper	4 1/8"	80	174	35	105.1	121.2
			5 1/8"	75			130.5	146.5
			5"	75			127.5	146.5
		Steel	4"	80			115.6	134
			5"	75			141.3	154
RG-1270	Discharge	Steel	5"	75	174	35	141.3	154
	Suction	Steel	8"	75	260	40	218	241

c. Suction and discharge stop valves (Optional accessory)

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

Model	Stop Valve Size		Model	Stop Valve Size	
	Discharge	Suction		Discharge	Suction
RG-200	2″	3″	RG-830	4″	5″
RG-410	2 1/2″	4″	RG-1270	5"	8"
RG-620	3"	5″			

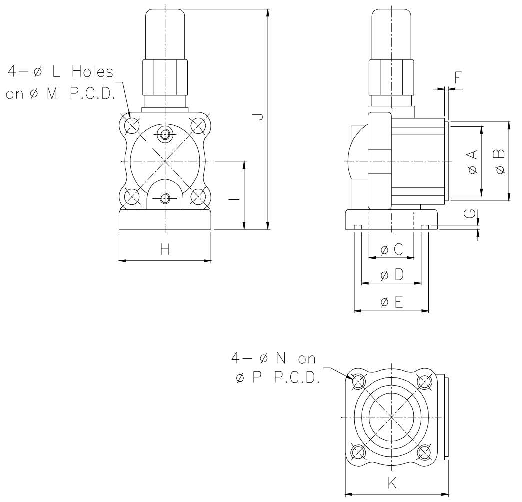


Figure 4.10: Dimensions for 2”~4” stop valves

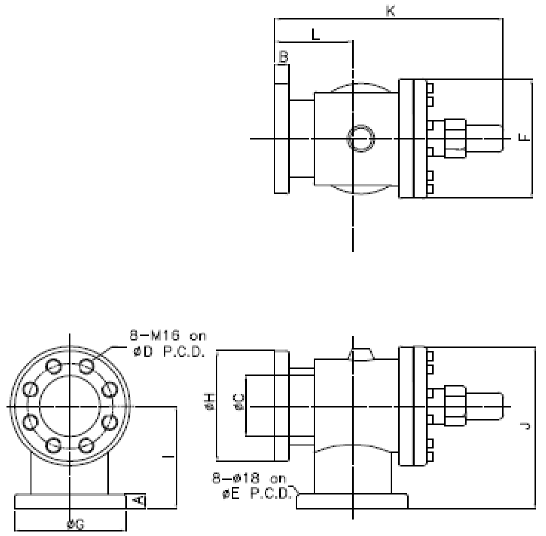


Figure 4.11: Dimensions for 5” stop valve

Dia.	Dimensions													unit: mm
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P
2”	70	90	60	69	91	6	5	122	86	280	128	18	120	M16x2	120
2 1/2”	90	110	67	89	111	6	5	137	95	307	153	18	140	M16x2	140
3”	100	120	80	99	121	6	5	154	117	398	177	22	160	M20x2.5	160
4”	125	145	105	124	146	6	5	171	130	445	201	22	185	M20x2.5	185
5”	30	30	126	194	194	248	230	230	214	338	474	161	--	--	--

Specification of stop valve

Maximum working pressure	Hydrostatic pressure test	Refrigerant	Temperature range
28 kg / cm² g	42 kg / cm² g	HFC, HCFC, R717	–40˚C~120˚C

Please contact Hanbell for specification of 6” and 8” stop valves.
Note:
1. If RG compressors are applied to R717, the original copper connectors cannot be used and were removed on the stop valves.
2. There are total four stainless steel connectors and four plugs in accessory boxes.
3. One stop valve has two holes. You can install stainless steel connectors for detecting pressure or other purposes. Or, screwing plugs in holes on the stop valves.

d. Suction and discharge check valves (Optional accessory)
Hanbell designs a complete series of suction and discharge check valves for customer’s application. Suction check valves are widely used in the refrigeration system (SST< -10℃) or system with a high compression ratio. With the help of suction check valve, it can help to reduce the reversal run time after compressors stop to protect bearings. For a parallel system, a discharge check valve on the oil separator outlet is necessary. With an additional suction check valve installed on each compressor, it can help to separate the suction pressure side from discharge pressure side if a common oil separator is used in the system. Besides, suction check valve can prevent refrigerant’s entering to the suction port of non working compressor because of hydraulic head.

The inner structure of suction check valve is opposite to that of discharge check valve as shown in the Figure 4.9 & 4.10 below. Users can contact Hanbell representative to get more information on the suction and discharge check valves.

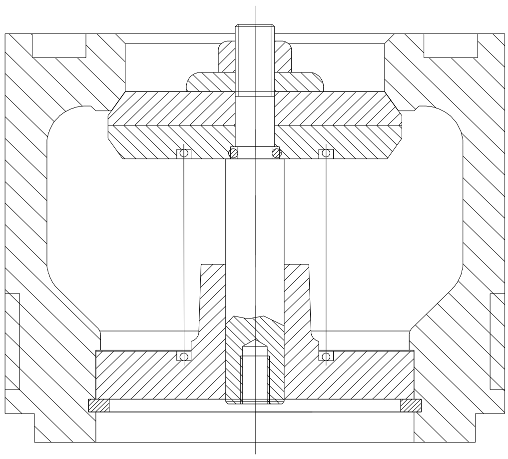


Figure 4.12 Suction check valve

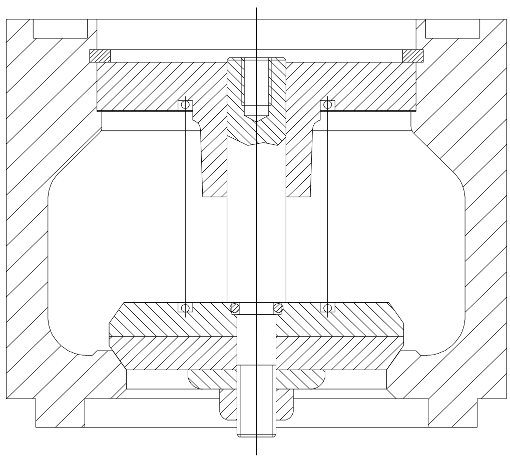


Figure 4.13: Discharge check valve

e. Coupling

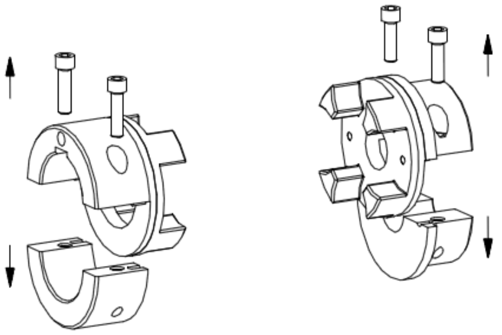
A coupling is a device used to connect two shafts together at their ends for the purpose of transmitting power. There are two types of coupling: rigid coupling and flexible coupling. Rigid couplings are used when precise shaft alignment is required; shaft misalignment will affect the coupling's performance as well as its life. Flexible couplings are designed to transmit torque while permitting some radial, axial, and angular misalignment. Flexible couplings can accommodate angular misalignment up to a few degrees and some parallel misalignment. Hanbell provides flexible couplings which are characterized by small dimensions, low weight and low mass moments of inertia yet transmit high torques. Running quality and service life of the coupling are improved by accurate all-over machining. These couplings are torsionally flexible and designed for positive torque transmission. They are fail-safe. Operational vibrations and shocks are efficiently dampened and reduced. The two congruent coupling halves with concave claws on the inside are periphally offset in relation to one another by half a pitch. In addition, they are designed in such a way as to enable an involute spider to be located between them. The teeth of the spider are crowned to avoid edge pressure if the shafts are misaligned.
In contrast to other flexible couplings, the intermediate members of which are subject to bending stress and are therefore prone to earlier wear, the flexible teeth of these couplings are subject to pressure only. This gives the additional advantage of the individual teeth being able to accept considerably higher loads. The elastomer parts show deformation with load and excessive speeds.

Product characteristics

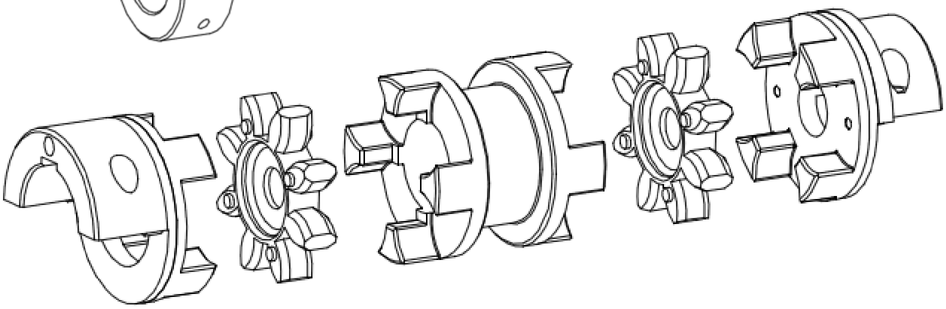
- Assembly/disassembly through 4 screws only
- Compensates for high shaft displacements due to double-cardanic
- Remains torsionally symmetric in case of shaft displacements
- Reduced vibration and noise
- Low restoring forces - Increase of the total lifetime of all adjacent components (bearings, seals etc.)

Assembly procedure

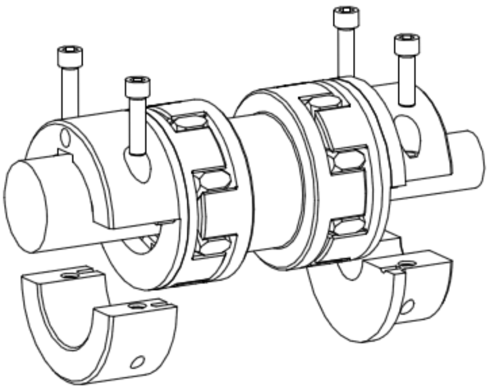
Step 1: Disassembly of shells

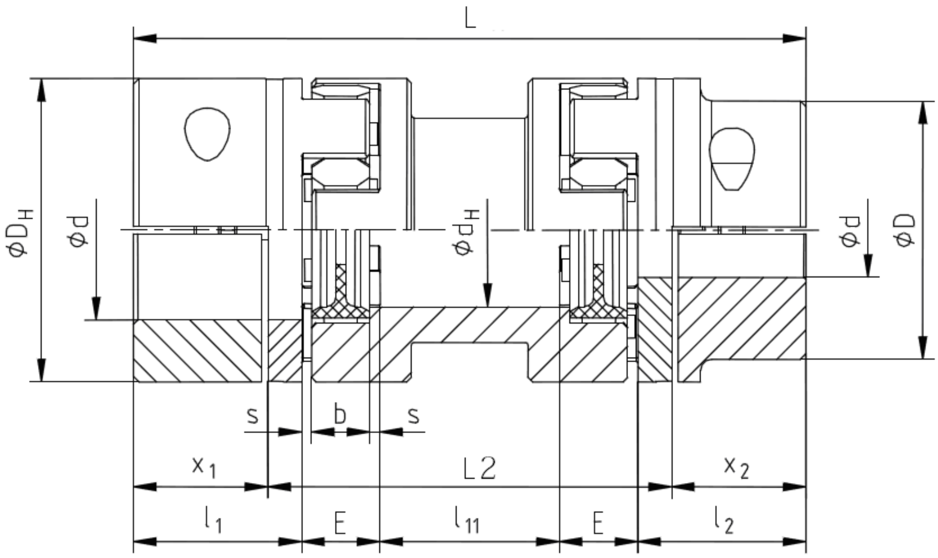


Step 2: Assembly of hub bodies, spiders and middle spacer



Step 3: Assembly of subassembly onto the shafts





Specification:

Model	Nominal Torque N.m	Peak Torque N.m	Max Speed r/min	$\varphi\ d_1/\varphi\ d_2$ max (mm)	L (mm)	L2 (mm)	$x_1;x_2$ (mm)	$l_1;l_2$ (mm)	l_{11} (mm)	E (mm)	Clamp Screw & Torque
RG-200 ROTEX42	450	900	6000	55	178	100	39	50	26	26	M10 69 Nm
RG-410 ROTEX48	525	1050	5600	60	190	100	45	56	22	28	M12 120 Nm
RG-620/830 ROTEX65	940	1880	4250	80	260	140	60	75	40	35	M12 120 Nm
RG-1270 ROTEX75	1920	3840	3550	90	275	140	67.5	85	24	40	M16 295 Nm

5. Operation and Troubleshooting

5.1 Oil Pump Setup

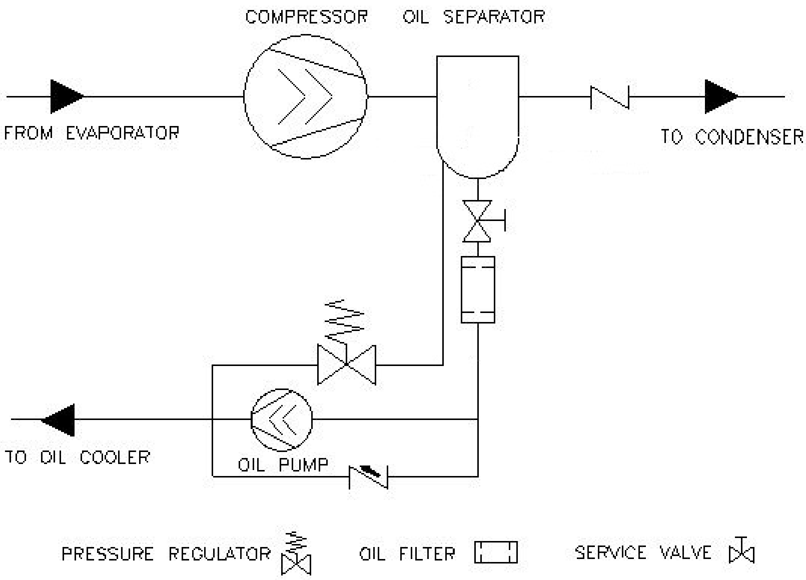


Figure 4.14: Oil pump application

Oil pump is required for RG series to maintain pressure differential between Oil pressure and Suction pressure during operation (at least 6 kg/cm^2). Oil pump also ensures the sufficient lubrication to mechanical seal before compressor starts (PreLube) and after compressor stops (PostLube) which is critical to the life of mechanical seal. Please refer to the chart above for piping reference. In the chart, an oil filter can be found before the oil pump. It is installed to protect the oil pump away from debris and piping dirt. A pressure regulator can be seen parallel to the oil pump line. It is used to control the maximum oil pressure. The function of check valve is letting oil pass through it when the oil pressure is enough. Under such condition the oil pump won't need to work and oil can be supplied from the oil separator to the compressor directly. The other function is to prevent back-flow of oil when oil pump works.

Note:

a. If the compressor is planned to be not started for more than 1 month, please turn the compressor shaft manually before next start (3 to 5 turns)
b. The piping size and distance between the oil separator and compressor shall be considered when setting the time for PreLube and PostLube.
c. The pressure drop between oil separator and compressor shall be maintained lower than 1 bar.

5.2 Before compressor commissioning

After finish the installation of compressor unit and all system components, user should follow the procedures below before the initial start-up of system.

1. Initial start-up is recommended to be performed under the supervision of a Hanbell authorized representative. Doing initial start-up without system pre-check by a Hanbell representative will lead to the loss of compressor warranty.
2. User should finish the compressor prestart check list in advance for Hanbell to review before start-up.
3. After the confirmation by a Hanbell representative at prestart check list, the electrical power can be supplied. (Main motor, oil pump motor)
4. Supply cooling water. (if applicable)
5. Check the oil temperature and make sure the temperature is above 30℃.
6. Check all valves to ensure that they are in the correct position, opened or closed.
7. Check all readings (pressure, temperature) on the control panel or meters to see if anything abnormal.
8. Check slide valve position and make sure the slide valve is at its initial position (minimum capacity). If the slide valve is not back fully, energize the SV1 solenoid (N.C.) to reach it. The table below lists the recommended energizing time for SV1 solenoid valve.

Model	RG-200	RG-410	RG-620	RG-830	RG-1270
SV1 solenoid energizing time	10 min	15 min	15 min	15 min	20 min

9. Turn the compressor coupling by hand to check if the rotor turns smoothly.

Note:

1. During pipe air-tight test, the compressor (oil separator and oil cooler) must not be included – keep the stop valves closed.
2. Don't use oxygen or other industrial gases for system pressure test.

5.3 Initial start-up

Initial start-up of compressor is very important because internal moving parts will have their initial mechanical contacts which will cause damage to parts if user doesn't handle it properly. Therefore, initial start-up should be executed manually with care in order to avoid any unwanted damages to the rotating elements of the compressor. Following steps are important to the initial start-up.

1. Set the operation mode of compressor unit to manual mode.
2. Apply supply voltage to capacity indicator for the step of calibration and wait for 2 minutes. (if applicable)
3. Prepare compressor operating log sheet (refer to p. 47) and use it to record all working parameters. The data is extremely important as reference for the diagnosis when system encounters unexpected errors.
4. Start the motor and check the rotation direction of motor shaft before connecting with compressor shaft. If the motor has difficulty to start up, there might be too much oil in the compression chamber. Please drain oil from the 1/4" angle valve (refer to No.17 at RG-200~RG-1270 2D drawings from Page 4 to 6). The main oil line solenoid valve (if installed) should be energized when the motor starts. In the case of using oil pump, oil pump should be started before the motor starts and the oil pump stops when the oil pressure at main oil inlet port is higher than suction pressure 6 bar at least to ensure sufficient oil supply.
5. Make sure that the slide valve is at its minimum position. Push the calibration bottom on capacity indicator once if applicable.
6. Load the compressor gradually after the start-up and make sure the compressor is running above 50% all the time. 25% is only for compressor start.
7. If this pressure differential can't be achieved within 30 seconds, users should consider using an oil pump for the compressor.
8. Check oil supply by its sight glass and monitor the compressor running status all the time. If any abnormal noise or vibration happens during this period of time, users should stop the compressor immediately. The oil pump (if there is in system) should be closed when the compressor is stopped. Find out the problem and solve it before start the compressor again. When the problem is solved, follow initial start-up procedures to start the compressor and repeat the calibration procedure for capacity indicator.
9. For step-less capacity control, check section 2.8 for loading and unloading procedures. For 4-step capacity control, run compressor at each step for at least 3 minutes. Check section 2.7 for details.
10. When loading the compressor, debris or unwanted particle might enter the compressor because of the increasing of flow velocity. Users should stop the compressor if any abnormal situation (leakage of oil or gas, abnormal noise, vibration) is found.
11. For 4-step capacity control, the capacity indicator is not necessary to be installed.
12. After the compressor running at 100%, pay attention to observe suction/discharge temperature，suction / discharge pressure, mechanical noise, vibration of compressor and motor, oil level at oil separator, and oil supply situation. Stop compressor running if any abnormal situation comes out.
13. When the system reaches its operating condition and runs stably, user should finish the compressor commissioning report and send it to Hanbell for compressor warranty purpose.
14. Initial vibration analysis and noise analysis are recommended to be executed during the compressor's initial start and file them for reference in the future.
15. Load and unload the compressor gradually and measure all working parameters. Write them down on the operating log sheet.
16. Calibration of capacity indicator must be done before operation:

- Apply supply voltage min. 2 min. before Calibration.
- Move the Slide valve to 0% (min.) position, and then push the calibration's button once, the red LED switch ON, when the red LED flash quickly its ready for 100% calibration.
- Now move the Slide valve to 100%(max) position, and push the calibration once again, the red LED switch ON, when the red LED switch OFF, the calibration is done.
  *The green LED indicate working and end position.
  < 1% = green LED flash quickly.
  1 to 99% green LED flash normal (slowly).
  > 99% = green LED ON.

Note:
1. Don't start the compressor when the system is vacuumed.
2. Please remove a small plastic cover which is attached with connector on seal outer cover (Please consult Hanbell if any question you have)
3. 28 bar is the highest pressure test level at the jobsite.
4. Danger or severe damage to compressor is possible if the compressor is flooded with oil during standstill.
5. Don't touch the compressor surface during compressor operation to avoid burns.
6. Don't remove any parts of compressor before release the compressor inner pressure.
7. The discharge temperature of compressor is recommended to be controlled at 80℃ for and HFC application, 75℃ for ammonia application. Normally the discharge temperature doesn't increase quickly after starting. If it increases quickly during commissioning, user should review the oil supply situation and additional cooling status.
8. The supply oil temperature should be kept below 50℃ for ammonia application and 60℃ for and HFC application.

9. The oil level in oil separator might slightly drop after the start-up. A lower level happened by gas spot which is existed in oil circuit. If the level continuously goes down, an oil separator problem should be assumed. User should check the working condition and find out the problem during the commissioning.
10. During the commissioning, users should listen if any abnormal noise comes out. Users should stop the compressor immediately when irregular, high tone and metallic noise is heard.
11. Vibration shall be checked carefully by using a vibration analyzer on compressor casing, the surface of the base frame and piping. Compressor itself doesn't generate excessive vibration if mechanical condition and shaft alignment are normal.
12. Mechanical shaft seal should be checked during the commissioning. Sometimes a certain leakage of oil can be found during the beginning of commissioning and will stop after a few days of running. The maximum oil leakage is 3 ml/hr. If excessive oil leakage is found, the mechanical shaft seal must be checked. Mechanical seals in Hanbell compressors are follow Leakage Limited by Standard API 682/ISO 21049.
13. Normally the pressure drop at oil filter should be around 0 to 0.5 bar. If the pressure drop is continuously rising and reaches 1 bar. The oil filter cartridge should be cleaned or replaced to ensure a sufficient oil supply.
14. Normally the pressure drop at suction strainer is around 0 to 0.2 bar. If the pressure drop is continuously rising and reaches 0.5 bar. The suction strainer should be cleaned or replaced immediately.
15. Oil injection can be used to maintain discharge temperature.
16. Check suction gas superheat not only at 100% capacity, but also 75%, 50% and 25% capacity to ensure sufficient superheat for system operation.

5.4 Oil injection and Economizer

This session is mainly focused on system adjusting besides compressor. The information here is based on general type or common situation. Any special design or different case should be reviewed separately with Hanbell representative

Oil injection to chamber

Oil injection to chamber is widely used for the controlling of discharge temperature. In the case of using oil injection to chamber for the discharge temperature control, the oil line should be controlled by oil line solenoid valve (Normally Closed type). For HCFC and HFC application, the oil line solenoid valve is suggested to be energized when the discharge temperature reaches 80℃. For ammonia application, if the discharge temperature under normal operation without additional cooling will excess the target working temperature (normally 75℃), we recommend energize the oil injection line solenoid 15 seconds after the compressor finishes its start-up process. On the oil line, there should be a regulation valve after the solenoid valve to adjust the injection flow rate. Before the start-up of compressor, user should slightly open the regulation valve. When the system is running and the oil injection line solenoid valve is energized, user can check the variation of discharge temperature then adjust the regulation valve to the position that the discharge temperature reaches the target temperature then keep the valve at this position for a while. When the discharge temperature down to 75℃ (HCFC and HFC application), the liquid line solenoid valve can be de-energized to stop the injection. But for the ammonia application, the oil injection should be continuously and keeps the discharge temperature stable at target temperature. Normally the discharge temperature will increase after stopping of oil injection. Therefore, user should observe the working situation for some time to ensure the proper work of oil injection.

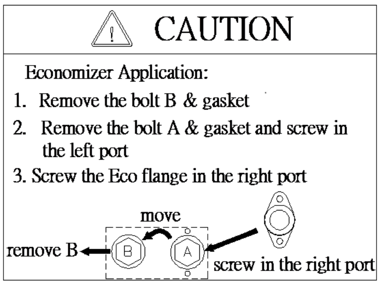
Note: The adjustment of oil injection regulation valve should be executed at all operating conditions, including partial load.

ECO function

ECO is often used in the refrigeration system to get higher cooling capacity. Compared with using 2 compressors at a 2-stage compression system, using ECO can save the initial investment and simplify the system design. The information below should be noted when user applies ECO in the system.

1. There should be a muffler connected to the ECO port directly to absorb the pulsation caused by high speed refrigerant gas flow. Sight glass is recommended to be used on the ECO pipe to know whether liquid exists or not. If liquid refrigerant enters the compression chamber, this will cause damage to screw rotors and bearings. Accumulator can be used in this line to avoid liquid compression.
2. In a regular start procedure with ECO application, ECO line solenoid valve (Normal Close Type) should be energized after the slide valve reaches 75% position at least. Running compressor without sufficient cooling might cause severe damage to compressor.
3. Before compressor stops, the controlling program should unload the slide valve to its initial position (minimum capacity). ECO line solenoid valve should be off when the slide valve position is below 50%.

P.S. For RG-1270, please note a sticker on RG-1270 casing before connecting economizer line. Kindly consult Hanbell if any question you have.



5.5 Before compressor stop

Compressor stop should be executed under regular procedure. The controlling program should unload the compressor gradually to its minimum capacity and stop the compressor after it reaches the minimum load. Oil line solenoid valve and oil pump (if apply) should be closed at the same time when the compressor stops. ECO line should be closed when the slide valve position is below 50%. Oil injection line should be closed 3 to 5 seconds before the compressor stops. For the first start-up, check and clean the suction strainer and oil filter after the commissioning is very important to ensure the future operation.

In case of emergency stop, the oil injection line, oil line, and ECO line should be closed immediately. If discharge bypass line is designed in the system, it should be opened to balance the pressure differential between high and low pressure side then close itself for the next running. With the help of suction check valve and discharge bypass line, the reverse running time can be limited to a few seconds. If the reverse running doesn't stop in about 10 seconds, the leakage at suction check valve and the malfunction of discharge bypass line can be assumed, User should check them during the stop of compressor. Before starting the compressor next time, user should correct the problem first then energize all solenoid valves to help the slide valve back to its initial position.

For a short period of non-operation, the oil heater power should be switched on to keep the oil temperature at proper temperature for the next start up.

For a long period of non-operation or overhauls, the power source for main and oil pump should be cut off. The oil heater power should be switched off, too. The control panel should be kept power on to resist moisture. All the stop valves related to the system should be closed. Cooling water supply should be stopped and cooling water in the condenser and oil cooler must be drained completely.

Note: Start and stop of compressor should not be repeated more than 4 times per hour.

5.6 Trouble shooting

Trouble shooting is really important during the commissioning of compressor. Sometimes the problem we find might be caused by not only one reason. User should review all possible causes before taking actions. Otherwise, new problem might come right after the old problem solved.

The table below shows some problems that might happen in the jobsite during commissioning or compressor operating. All symptoms listed below are only for technicians as reference to solve the problem in the jobsite.

Symptom	Cause	Countermeasures
Abnormal vibration at compressor during the start-up which disappears immediately	Too much oil in the chamber which causes oil compression	Main oil line solenoid should be closed all the time when the compressor is not running.
	Liquid remained in the suction piping causes liquid compression during the start-up	
Abnormal vibration at compressor during the start-up which exists all the time	Compressor and motor are not correctly centered	Check their angular displacement and offset displacement.
	Coupling is not assembled properly or balanced	Check the coupling and reassemble
	Compressor or motor is not fixed firmly	Check all fixing bolts for compressor and motor
Abnormal vibration and sound at compressor during operation	Main oil injection valve may be closed.	Open valve
	Insufficient lubrication oil.	Check pressure differential between main oil inlet and suction port
	Debris or piping residue enters compressor which causes rotor damage	Check rotor status from suction port
	Bearings damaged or with excessive wear	Change bearings
	Electromagnetic sound of the solenoid valve	Check solenoid valve
	Friction between rotors or between rotor and compression chamber.	Change screw rotors or/and compression chamber.
	Rotors scratched because worn out of bearings	Contact Hanbell
	Inappropriate Vi setting	Check Vi setting
	Loosen internal parts.	Dismantle the compressor and change the damaged parts.
	Friction between slide valve and rotors.	Dismantle the compressor and change the damaged parts.
	Refrigerant flood back	Check system design and correct system suction superheat
Compressor unable to load	Low ambient temperature or high oil viscosity.	Turn on the oil heater before compressor start.
	Internal built-in oil line clogged.	Check and clean oil circuit with high pressure gas
	Modulation solenoid valve clogged or solenoid valve coil burnt.	Clean / purge solenoid valve core or replace the solenoid valve coil
	Piston stuck-up.	Change piston or piston ring
	Oil filter cartridge clogged.	Clean oil filter (replace if needed)
	Insufficient oil pressure compared with suction pressure. (Poil-Ps<6 bar)	Minimum pressure differential is 6 bar. Consider to install an oil pump.
Compressor unable to unload.	Modulation solenoid valve clogged or burnt.	Clean or replace the solenoid valve
	Piston rings worn off or broken, or damaged cylinder resulting leakage.	Change piston (if cylinder damaged severely, change the cylinder)
	Solenoid valve voltage misused.	Check the control voltage
	Piston stuck-up.	Change the piston set, and check the cylinder and slide valve.
	Capacity control logic unsuitable.	Check capacity control logic
Compressor does not run	Motor line open	Check the motor wiring
	Tripped overload	Check the electrical connection
	Screw rotors seized	Replace screw rotors, bearings etc.…
	Too much oil inside compression chamber	Drain the oil out
	Safety protection device trips	Find it out and solve the problem before reset it
	Motor broken	Change motor.
High discharge temperature	Insufficient refrigerant.	Check for leakage. Charge additional refrigerant and adjust suction superheat around 10°K
	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 oil supply status.
	Damaged bearings.	Stop the compressor and change the bearings and other damaged parts.
	Improper Vi value.	Change the slide valve.
	No system additional cooling (Liquid injection or oil cooler)	Install additional cooling (liquid injection or oil cooling or both based on operating condition)
Shaft seal leakage exceeds 7 drops per minute (3 ml/hr)	Seal surface damaged by oil contamination	Replace mechanical seal
	Uneven contact of seal surface due to improper centering	Do the centering work again

Note: The replacement of compressor internal parts should be performed only by a qualified/certified service technician with full knowledge of Hanbell screw compressor.

6. Maintenance

Periodical check and regular maintenance are very important for the long and trouble-free compressor life. The content in this chapter is to help the operator and service people to know how the regular maintenance can be done and when the suitable time is for each work. Operators and service people should follow the instructions below when working on the maintenance job.

Besides the regular maintenance, user should check the system's working status by noting down its working parameters every day. Most of time abnormal system condition can be found via comparing its working parameters with its daily operating data.

6.1 Short term maintenance

During commissioning period or after a few hundred hours of compressor running, the following checks and replacement shall be done in order to protect the compressor and understand the compressor's working status.

a. Shaft alignment
In case of not using coupling housing for shaft alignment, user should check the shaft alignment at the end of commissioning or after 200 hours of initial operation. If the alignment error is large, the shaft alignment must be done once again. Please refer to P. 20 for the instruction of shaft alignment.

b. Suction strainer
Suction strainer plays a very important role to long compressor life. In the initial commissioning, debris and welding slag might find its way to compressor's suction side. With the help of suction strainer, debris will be gathered inside strainer to protect the compressor away from rotor damage. User should check the suction strainer at the end of commissioning and after 200 hours of initial running. Any dirt and unwanted material should be removed during the checking. Wash the strainer basket in solvent and blow clean with air.

c. Oil analysis
At the end of commission or after 200 hours of initial running, oil analysis is recommended to be executed at jobsite. The purpose of doing oil analysis is to understand the compressor's working environment and ensure the oil quality. If moisture contamination exists in the system, this will lead to changing of oil quality and cause poor lubrication for internal moving parts which will come to severe damage at compressor in the future. User should replace the oil immediately to protect the internal moving parts with good lubrication and recheck the oil again after 200 hours operation. If the oil analysis shows the oil is in good condition, recheck the oil every 6 months to ensure the oil condition.

In the case of being unable to do the oil analysis periodically, consult Hanbell to confirm the oil change schedule because the interval of oil change varies by the oil type and compressor operating condition.

Note:
1. Acidification of lubrication oil causes the reduction of bearing'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 system dryness.
2. Compressor unit should be stopped before doing the maintenance job.
3. Disconnect power from unit before doing the maintenance job.
4. Close all the isolation valves before doing the maintenance job.
5. Wear safety equipment when doing the maintenance job.
6. Ensure adequate ventilation before doing the maintenance job.
7. Take safety precaution for the refrigerant used and work with care.

6.2 Long term maintenance

The information below is focusing on standard long term maintenance. User should understand that these items are not assumed to take over all the necessary routine checks. Daily check for operation conditions is also very important to have a stable operating system.

Please refer to P. 69 for the recommended maintenance schedule. This schedule is only for users' reference and should be considered as the minimum guideline to maintain the system's normal operation. User still can do any examination by his own will to ensure a stable system operation. In case of any irregular situation or abnormal condition takes place on the compressor system, user should stop the compressor and review the system to find out the problem.

a. Oil analysis
The same content as above (short term maintenance)

b. Mechanical seal
Shaft seal leakage should be observed everyday and be inspected by removing the cover at least once per year when doing other regular maintenance. Special attention should be given to hardening and cracking of the O-ring, wear, scoring, material deposits, oil coke and copper plating. The purpose of checking mechanical seal every year is to ensure the stable operation for the following year. Wearing parts of shaft seal are recommended to be changed with a new one.

TABLE 7-1 RECOMMENDED MAINTENANCE SCHEDULE

Check Points	Hours of Operation								
	200 hrs	1000 Hrs	2000 Hrs	5000 hrs	10000 hrs	15000 hrs	20000 Hrs	25000 hrs	30000 Hrs
Change oil	According to oil analysis result								
Oil analysis	○	Every 6 months							
Vibration analysis	○	Every 6 months							
Refrigerant quantity	○	Every 3 months							
Coupling	○	Annually regardless of operating hours							
Oil Filter Cartridge	○/△	○/△	○/△	○/△	○/△	○	○/△	○	○/△
Liquid strainer	○			○	○		○		○
Suction Strainer / Filter	○/△	○/△	○/△	○/△	○/△	○	○/△	○	○/△
Piston Rings				○	○/△	○	○/△	○	○/△
Coupling element	○			○	○/△		○/△		○/△
Oil separator element	○			○	○/△		○/△		○/△
Check valve					○		○		○/△
Leakage of connections					○		○		○
Check electrical connections	○			○	○		○		○
Check sensor calibration	○			○	○		○		○
Replace coalescers	○/△				○/△		○/△		○/△
Shaft alignment	○			○	○		○		○
Screw Rotors					○		○		○/△
Bearings					○		○		○/△
Mechanical seal	When leak rate exceeds 7-8 drops per minutes (3 ml/hr)								

○ Check or Clean, △ Replace

Note:

1. Table 7-1 is only rough estimate, not a basis for any claim. The most appropriate running period for each check point is varied with operating condition (air-cooled or water-cooled), control logic, refrigerant and lubricant (synthetic or mineral) or long-term partial loading. Check frequently in early time is recommended.
2. Replacement of piston rings and bearings should be performed by HANBELL authorized technicians.

c. Piston sealing

Piston is also recommended to be inspected every year to ensure the function of capacity control. If abnormal wearing is found, the corresponding part should be replaced by a new one.

d. Vibration analysis

Vibration analysis can help to detect bearing wear and other mechanical failures. Please be noted that always take vibration readings from exactly the same places and at exactly the same operating conditions (SST/SCT/Vi/ % of load). User should use the vibration data taken from the initial start-up as the base line reference and compare them with the new data from the system. Because vibration data can be easily misinterpreted, user should evaluate vibration readings carefully. The table below shows the recommended vibration value for RG series compressors. When the measured value is bigger than the recommended value, user should review the compressor unit before running the compressor continuously.

Model	RG-200	RG-410	RG-620	RG-830	RG-1270
Vibration value (mm/s)	3.0	3.8	3.8	3.8	3.8

e. Complete overhaul

Complete overhaul is recommended to be done at least every 3 years. It is the best time to review the internal parts and replace all wearing parts for the following long-term operations.

Note: If the compressor system is not going to operate for a period of time, evacuating the system, charging with dry nitrogen and draining out the oil is necessary to avoid any moisture which might cause rusting on the inside surface of system component.

7. Hanbell Selection Program

Selection program is available on Hanbell official website http://www.hanbell.com/index_eng.html

1. This program is suitable for the operating system of Windows 7 and above edition.

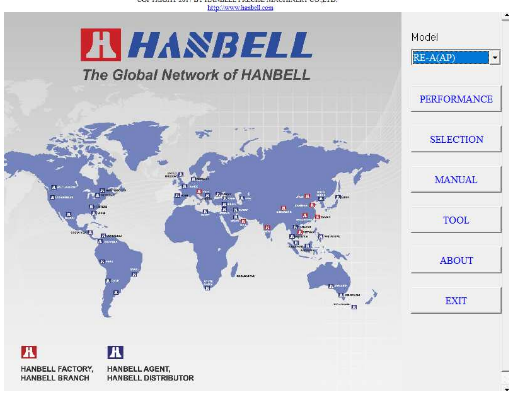
2. The monitor resolution shall be 1280 x720 or higher.

3. Double click the Hanbell Selection V5.0.4.exe file to start the setup.

4. Please follow the procedure and complete the installation.

Operating Procedure:

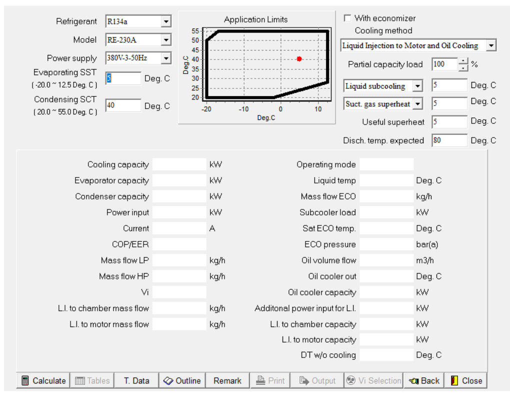
Step:
1. Before operating our selection software, please check any upgrade of selection software on Hanbell website.



2. There are 「RC2」, 「RE」, 「LT」 , 「RG」,「LB」 , 「RT」 product on the menu

3. For example, selecting「RE-A」compressor, will bring user to next page of program. Then select Model and click「*PERFORMANCE*」button.

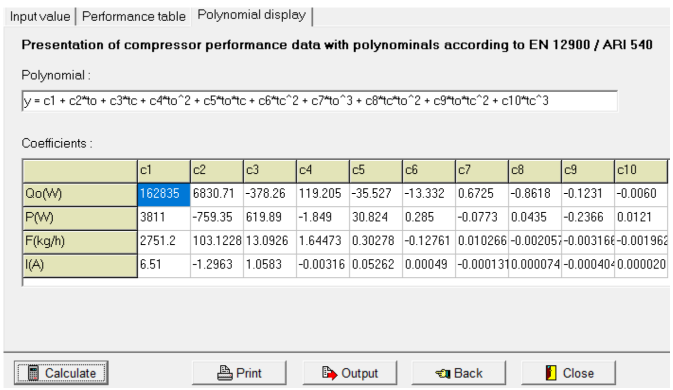
Following is a page to put into operation condition inputs, key-in the following condition and then click the「**Calculate**」button.
- Refrigerant type
- Compressor model
- Power supply (default is 380V 3 50Hz)
- Evaporating SST (default is 5 ˚C)
- Condensing SCT (default is 40 ˚C)
- Additional cooling method: oil cooler or liquid injection
- Partial load condition (%)



Click the「**Calculate**」button and it will show the performance data in the middle of the window.

There are additional functions available:
「**Tables**」: Calculate the polynomial coefficient
「**T.Data**」: The technical data is the same with function key of technical data
「**Outline**」: Pop-up the compressor outline selecting
「**Print**」: Print out the calculated performance data
「**Output**」: Save the calculated performance data as an file
「**Vi selection**」: Manually select Vi value

(3.2.1) Click「**Tables**」button and double check the input value to be calculated, then click calculate, coefficients will will display on polynomial display. User can output or print out the data.


Input value | Performance table | Polynomial display

Presentation of compressor performance data with polynominals according to EN 12900 / ARI 540

Polynomial :

y = c1 + c2*to + c3*tc + c4*to^2 + c5*to*tc + c6*tc^2 + c7*to^3 + c8*tc*to^2 + c9*to*tc^2 + c10*tc^3

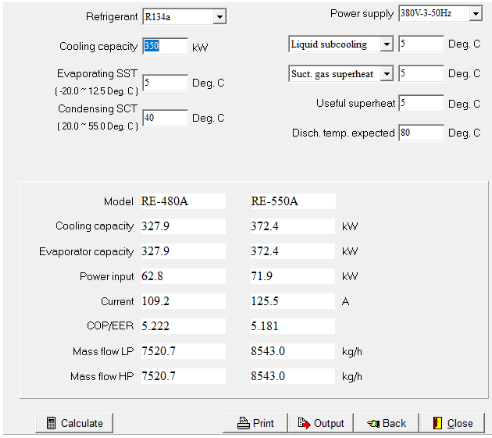
Coefficients :

	c1	c2	c3	c4	c5	c6	c7	c8	c9	c10
Qo(W)	162835	6830.71	-378.26	119.205	-35.527	-13.332	0.6725	-0.8618	-0.1231	-0.0060
P(W)	3811	-759.35	619.89	-1.849	30.824	0.285	-0.0773	0.0435	-0.2366	0.0121
F(kg/h)	2751.2	103.1228	13.0926	1.64473	0.30278	-0.12761	0.010266	-0.002057	-0.003166	-0.001962
I(A)	6.51	-1.2963	1.0583	-0.00316	0.05262	0.00049	-0.000131	0.000074	-0.000404	0.000020

Calculate | Print | Output | Back | Close

In the 「RG」menu, we can select 「*SELECTION*」 to decide the most suitable compressor model.

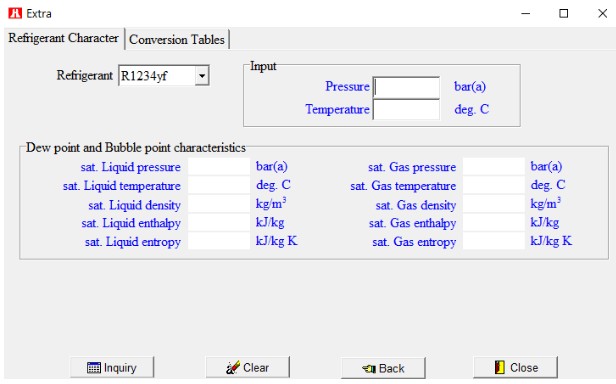
Use will need to input the following operating conditions:
- Refrigerant type
- Cooling Capacity requirement (kW)
- Evaporating SST
- Condensing SCT
- Power supply



Then click 「Calculate」 to have two most suitable compressor models suggested and their performance data

Click「*MANUAL*」button is a link to the technical manual on Hanbell website

Click「*TOOL*」**as an functional spreadsheet**, it has following two tools



「**Refrigerant Characteristic**」 (R134a, R22, R407C)
「**Conversion Tables**」:
Temperature, length, area, volume, Mass
Pressure, Specific Volume, density, Velocity
Flow rate, power, Specific Enthalpy, Specific Entropy, specific heat

Click「**ABOUT**」to know the edition of this software.

Click「**EXIT**」Leave current window

8. Warranty

All HANBELL screw compressors pass strict quality and performance tests in our factory prior to delivery. The screw compressors are manufactured by quality materials and under warranty for: 1) One year after completion of installation and commissioning at jobsite. 2) 18 months from the original date sold by HANBELL/ designated sales agents, whichever expires earlier.

However, HANBELL will not honor warranty if the compressor fails due to the following reasons: 1) Damage caused during shipping or by war or force majeure incidents, etc... 2) Damage caused by improper installation, operation or maintenance that is not in accordance with HANBELL Technical Manual or instruction. 3) Damage caused by modification of any part on or connected to the compressor. 4) Damage caused by improper maintenance or repair by non-authorized technician. 5) HANBELL is not responsible for any accident which might happen to personnel while installing, setting up, operating, maintaining, and/or repairing the compress