RG Series

TECHNICIAL MANUAL

State-of-the-art twin-screw compressor designed for:

R717 and low temp. application.

R22, R134A, R410A, R407C, R507A, R717

Open-type Model

RG Series

Screw Compressor

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1. General

The HANBELL RG series open-type screw compressor is developed especially for applications with ammonia in refrigeration field. HFC and HCFC refrigerant 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 a built-in high operating load design and advanced 5 to 6 Patented Screw Rotor Profile, each compressor has high efficiency and reliability in all operating condition. Each unit is carefully manufactured and inspected by high precision THREAD SCREW ROTOR GRINDING MACHINE, CNC MACHINING CENTER, and 3-D COORDINATE MEASURING MACHINE. Each compressor at HANBELL also follows the ISO 9001 certification quality system which assures the best quality control and production process to customers.

The new developed RG series compressors use 11 high quality bearings (5 radial bearings and 6 axial bearings) which resulted in longer bearing life compare to traditional 9-bearing design. These 11 bearings provide strong support to screw rotors especially for the heavy duty application. Oil/Refrigerant injection port can be utilized when external cooling is needed at chamber. This can keep the compression chamber at proper discharge temperature and ensures sufficient oil viscosity for moving parts lubrication. Economizer port can be used to reach higher cooling capacity and working efficiency especially at high pressure ratio working condition or at very low evaporating temperature. Capacity indicator plug is designed for working with capacity indicator when step-less capacity control is applied to the compressor. With the help of capacity indicator, the system cooling capacity can be controlled precisely to reach very low temperature variation at cold room side. Hydraulically balanced mechanical seal is designed for use in general and high pressure sealing duties, including chemical processing, refinery and petrochemical plants. With multiple spring arrangement at mechanical seal, even loading of seal face can be ensured and easy replacement can be achieved. All these new designs guarantee that the compressor has the best reliability, longest bearing life and easiest regular maintenance work.

This Technical Manual contains all basic information about dimensions, handling, installation, operation, trouble shooting, and system application. It is highly recommended that the content of this manual should be read carefully prior to handling, installing, and operating the RG compressor in order to prevent any unwanted damage on it. For any technical issue related to RG series compressor, please contact HANBELL or local distributors/agents for more information and assistance.

2. Design and functions

2.1 Design features

HANBELL screw compressor features simple and robust construction, by elimination of some components such as pistons, piston rings, valve plates, oil pumps, and mechanical linkages…, which are found in reciprocating compressors. With the elimination of such components, such 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 in rolling contact bearings, i.e. axial and radial bearings.

The design features of RG series are listed below:

a. Full product range**-** RG series compressor consists of 6 models with displacement ranging from 190/228 m3/hr up to 1476/1771 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, UK, US, Japan, and China. This new high volume, high efficiency rotor profile was designed specifically for modern refrigerant characteristics. The new higher efficient screw rotor is accomplished by using high precision CNC machining center, rotor milling machines, rotor grinding machines. Strict ISO 9001 process control and the use of precise inspection equipment, such as ZEISS 3D coordinate measuring machine, ensures high efficiency, high quality, low noise, low vibration HANBELL RG series screw compressors for worldwide distribution.

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.

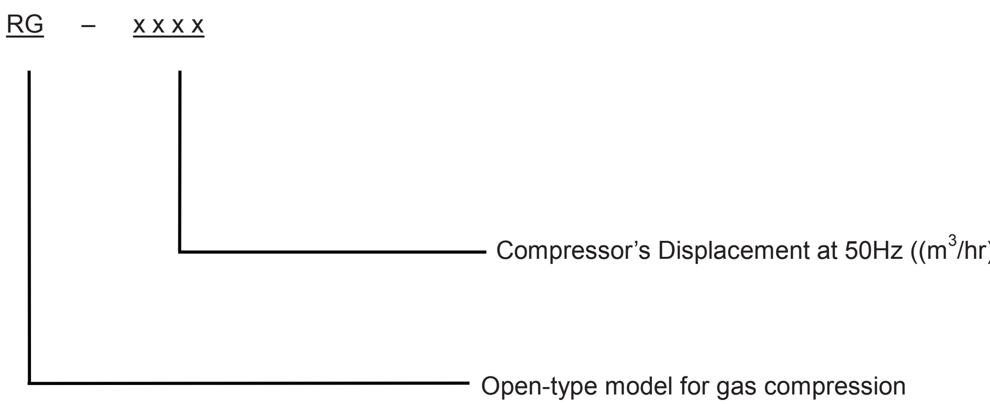
e. Mechanical seal- For open type screw compressor, mechanical seal plays an important role. Hanbell uses a general purpose hydraulically balanced, multi spring, o-ring pusher seal. Hydraulically balanced seal face gives lower faceloading at high pressure. Multiple spring arrangement ensures even loading on seal face.

f. Adaptable with additional cooling**-** Liquid/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.
2. Coupling housing helps to get quick centering for compressor and motor in the jobsite. (Optional)

2.2 Compressor nomenclature



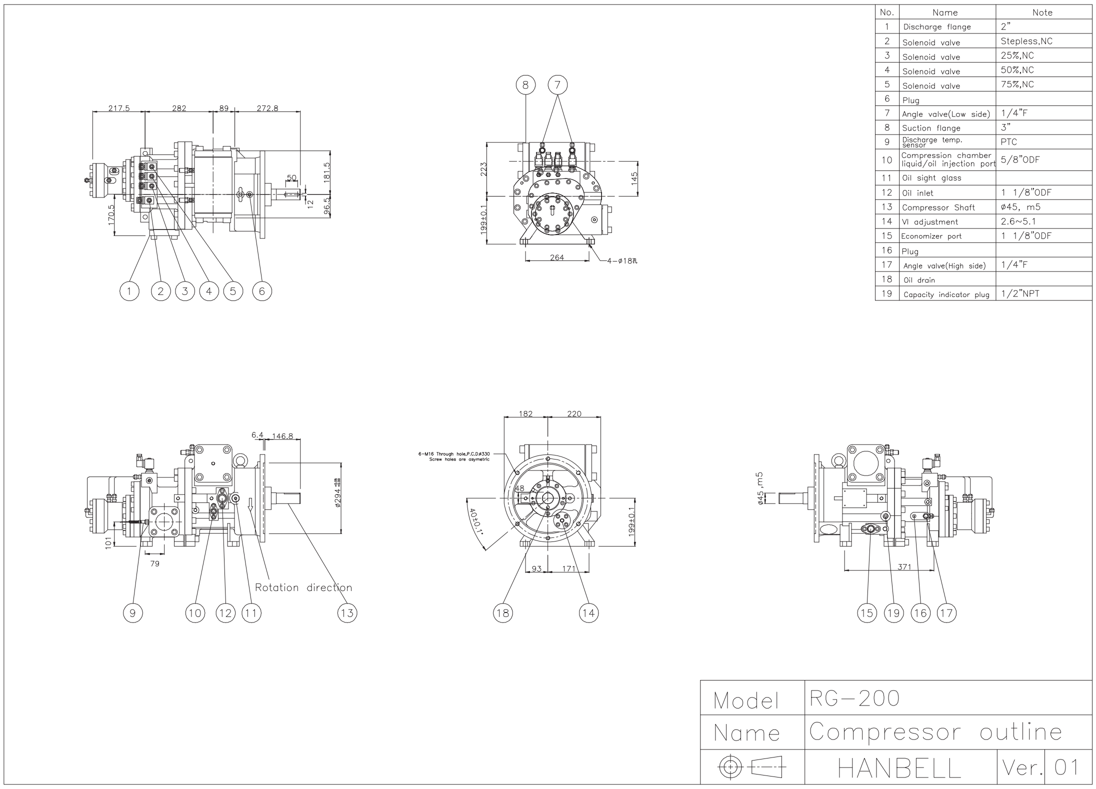
2.3 Compressor specifications

Model		RG-200	RG-410	RG-830	RG-1090	RG-1280	RG-1520
Displacement at 50 Hz	m^3/hr	190	402	816	1089	1276	1476
Number of lobes per rotor MR/FR	-	5/6	5/6	5/6	5/6	5/6	5/6
Speed, max	rpm	4500	4500	4500	3600	3600	3600
Speed, min	rpm	1500	1500	1500	1500	1500	1500
Range of capacity control	-	25~100%	25~100%	25~100%	25~100%	25~100%	25~100%
Available Vi (fixed Vi)	-	-	-	-	**2.2,2.6,3.0,4.8**	**2.2,2.6,3.0,4.8**	**2.2,2.6,3.0,4.8**
Vi-adjustment ranges	-	2.6~5.1	2.6~5.1	2.6~5.1	-	-	-
Sound pressure level	dB(A)	86	88	90	92	94	95

Note:

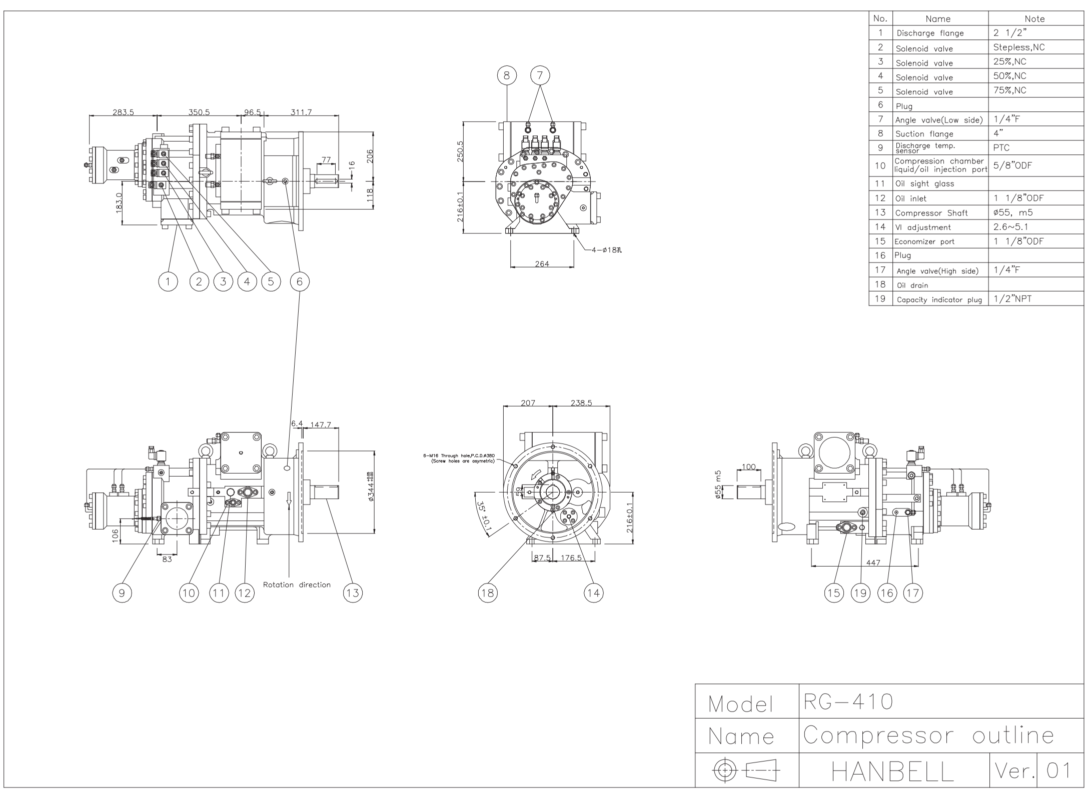
1. Sound pressure level is based on ISO-2151, R22, 50 Hz, SST -30℃/ SCT 40℃ to be measured.
2. ±2 dB(A) tolerance of sound pressure level is expected due to different operating condition and motor noise condition.

2.4 RG series compressor outline drawing



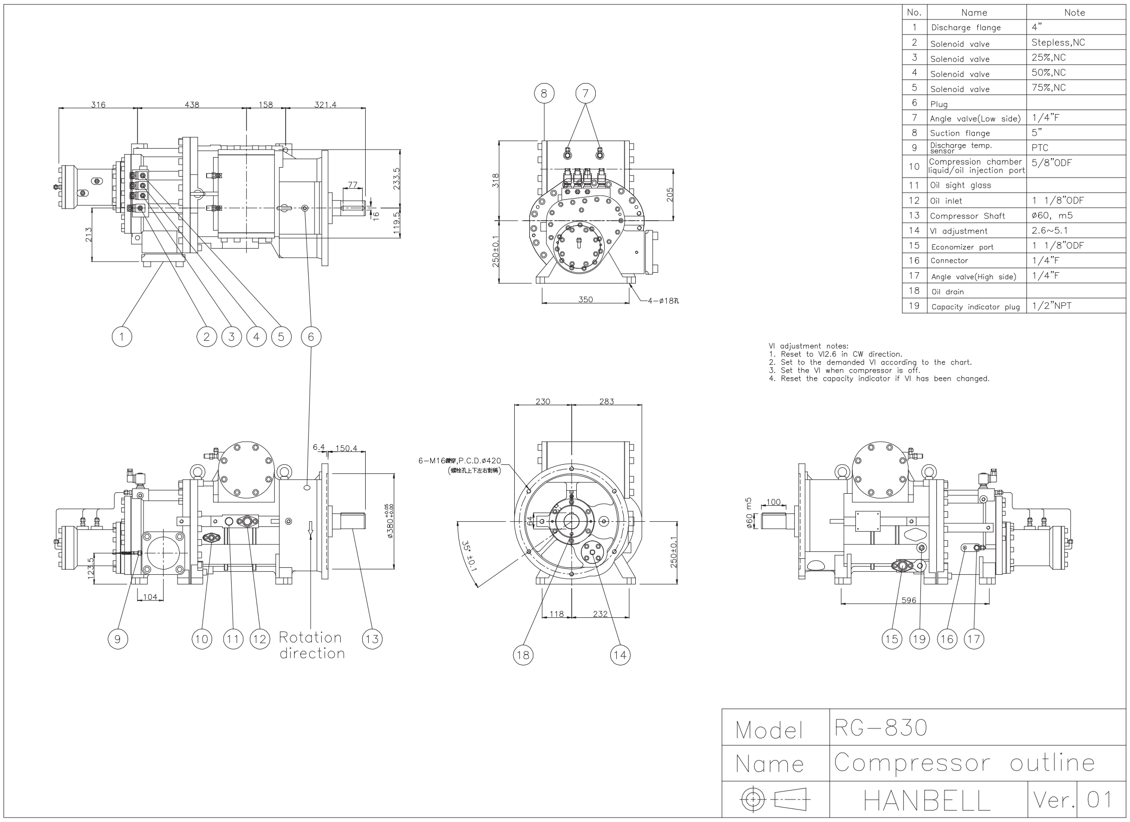
No.	Name	Note
1	Discharge flange	2"
2	Solenoid valve	Stepless,NC
3	Solenoid valve	25%,NC
4	Solenoid valve	50%,NC
5	Solenoid valve	75%,NC
6	Plug	
7	Angle valve(Low side)	1/4"F
8	Suction flange	3"
9	Discharge temp. sensor	PTC
10	Compression chamber liquid/oil injection port	5/8"ODF
11	Oil sight glass	
12	Oil inlet	1 1/8"ODF
13	Compressor Shaft	ø45, m5
14	VI adjustment	2.6~5.1
15	Economizer port	1 1/8"ODF
16	Plug	
17	Angle valve(High side)	1/4"F
18	Oil drain	
19	Capacity indicator plug	1/2"NPT

Fig. 2.3 RG-200 outline drawing



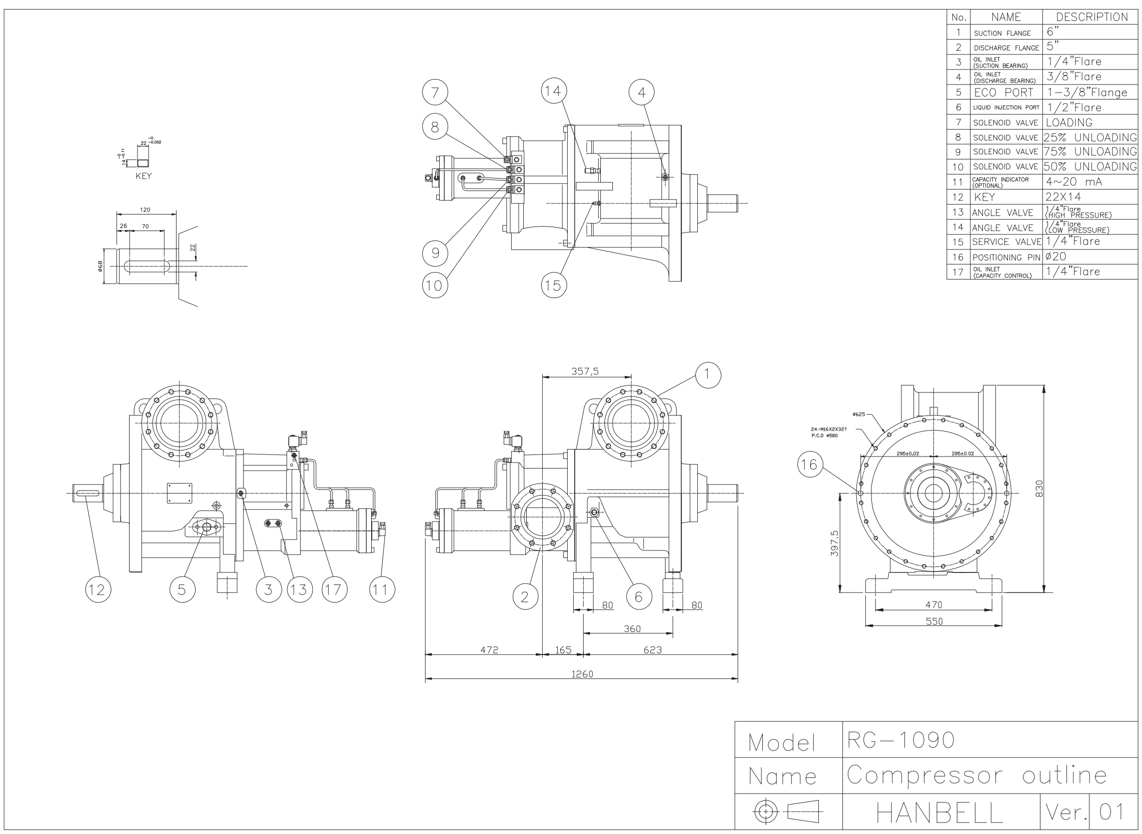
No.	Name	Note
1	Discharge flange	2 1/2"
2	Solenoid valve	Stepless,NC
3	Solenoid valve	25%,NC
4	Solenoid valve	50%,NC
5	Solenoid valve	75%,NC
6	Plug	
7	Angle valve(Low side)	1/4"F
8	Suction flange	4"
9	Discharge temp. sensor	PTC
10	Compression chamber liquid/oil injection port	5/8"ODF
11	Oil sight glass	
12	Oil inlet	1 1/8"ODF
13	Compressor Shaft	ø55, m5
14	VI adjustment	2.6~5.1
15	Economizer port	1 1/8"ODF
16	Plug	
17	Angle valve(High side)	1/4"F
18	Oil drain	
19	Capacity indicator plug	1/2"NPT

Fig. 2.4 RG-410 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)	1/4"F
8	Suction flange	5"
9	Discharge temp. sensor	PTC
10	Compression chamber liquid/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	2.6~5.1
15	Economizer port	1 1/8"ODF
16	Connector	1/4"F
17	Angle valve(High side)	1/4"F
18	Oil drain	
19	Capacity indicator plug	1/2"NPT

Fig. 2.5 RG-830 outline drawing



No.	NAME	DESCRIPTION
1	SUCTION FLANGE	6"
2	DISCHARGE FLANGE	5"
3	OIL INLET (SUCTION BEARING)	1/4"Flare
4	OIL INLET (DISCHARGE BEARING)	3/8"Flare
5	ECO PORT	1-3/8"Flange
6	LIQUID INJECTION PORT	1/2"Flare
7	SOLENOID VALVE	LOADING
8	SOLENOID VALVE	25% UNLOADING
9	SOLENOID VALVE	75% UNLOADING
10	SOLENOID VALVE	50% UNLOADING
11	CAPACITY INDICATOR (OPTIONAL)	4~20 mA
12	KEY	22X14
13	ANGLE VALVE	1/4"Flare (HIGH PRESSURE)
14	ANGLE VALVE	1/4"Flare (LOW PRESSURE)
15	SERVICE VALVE	1/4"Flare
16	POSITIONING PIN	ø20
17	OIL INLET (CAPACITY CONTROL)	1/4"Flare

Fig. 2.6 RG-1090 outline drawing

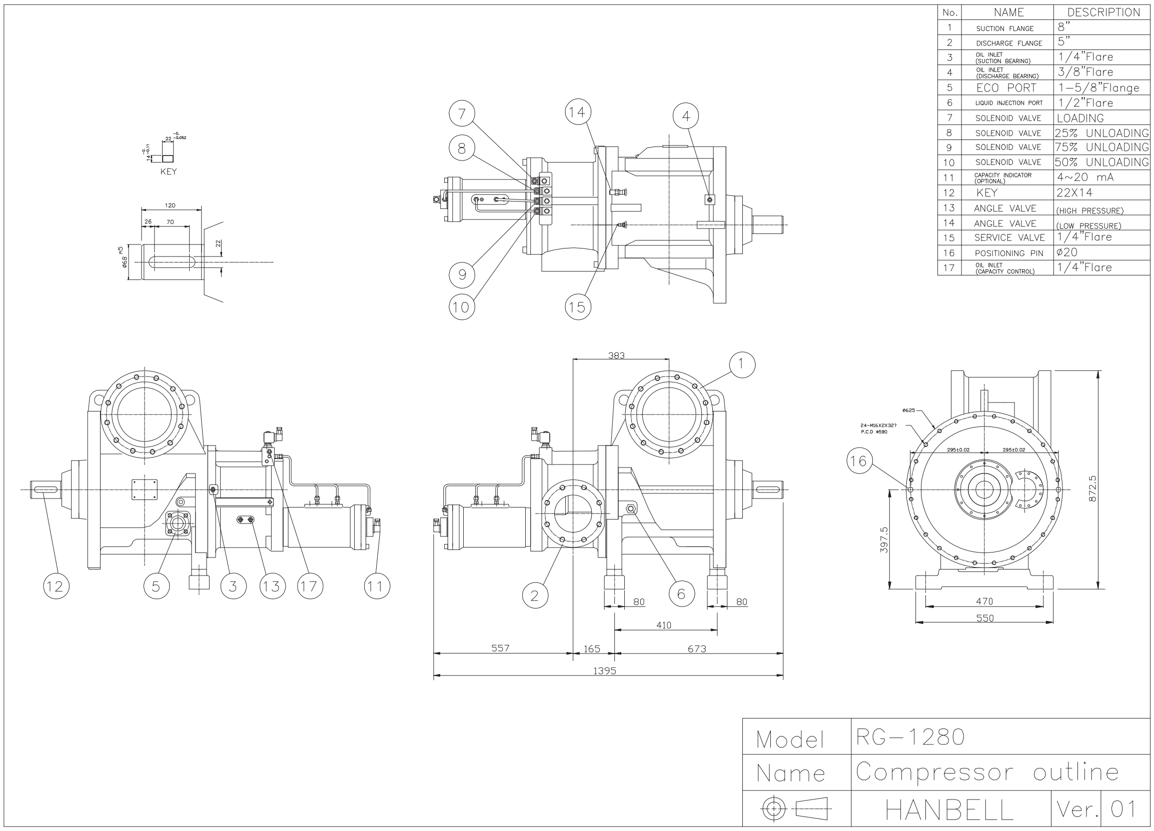


Fig. 2.7 RG-1280 outline drawing

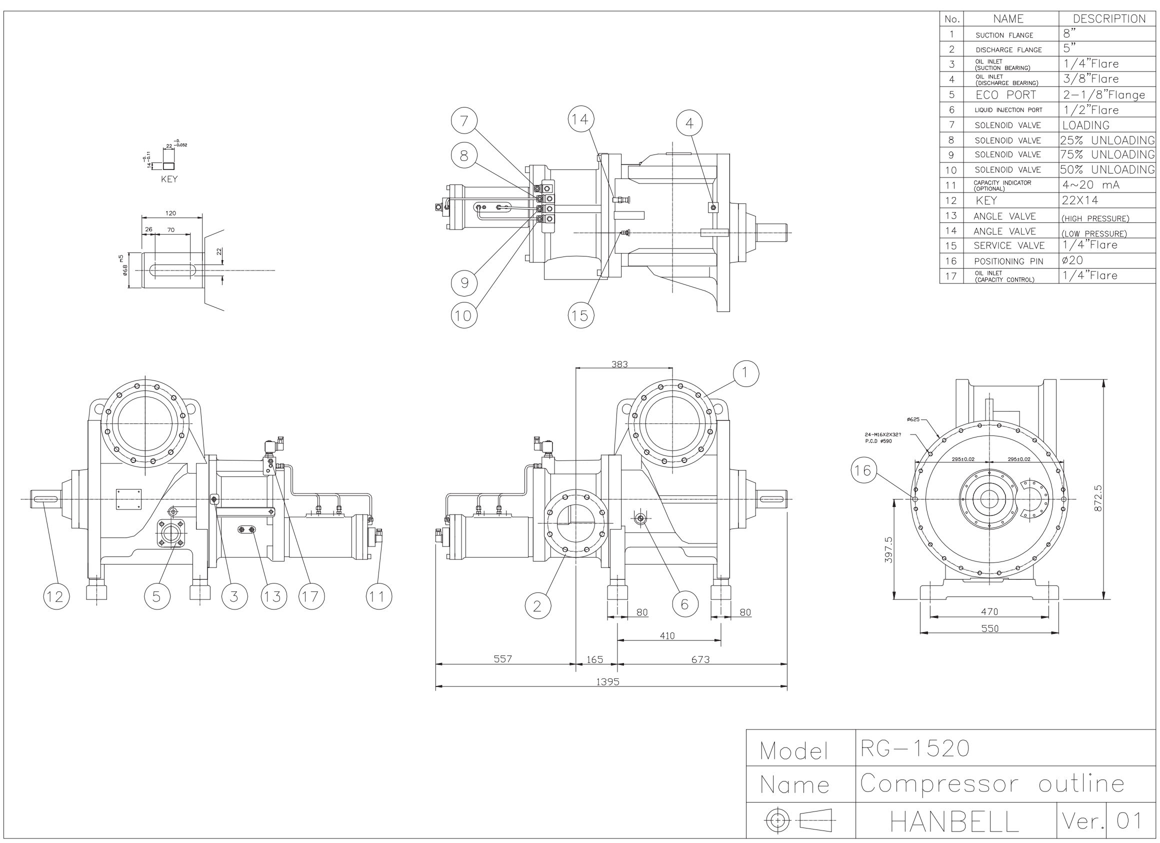
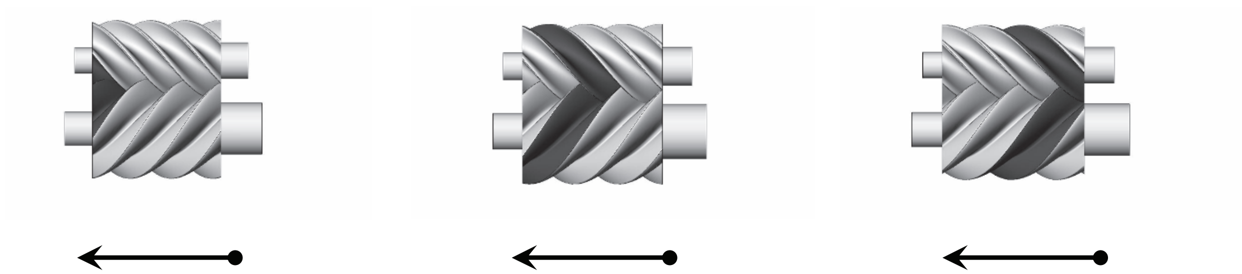


Fig. 2.8 RG-1520 outline drawing

2.5 Compression process

As shown in Fig. 2.9 below, during 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 of the male and female lobes. This lobe space increases to a maximum size (suction and sealing process). As the rotors rotate further, the new meshing on the suction side closes the V-shaped lobe space. The lobe space is then constantly reduced by continuing intermeshing of the lobes (compression process).

The reduction in lobe space takes place on 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, the vapor is discharge to the high-pressure side and flows to the oil separator where the high-pressure gas will be separated from the lubrication oil. The size and geometry of the discharge port determine the so called "internal volume ratio (Vi)" of the compressor. This ratio must have a defined relationship to operating pressure ratio to avoid losses in efficiency due to under or over compression.



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

Fig. 2.9 Compression process

2.6 Capacity control system

The RG series open-type screw compressors are equipped with either 4-step capacity control system or continuous (step-less) capacity control system. Both of the capacity control systems consist of a modulation slide valve, piston rod, cylinder, piston and piston rings. The slide valve and the piston are connected by a piston rod. The principle of operation is using the oil pressure to drive the piston in the cylinder. The lubrication oil flows from the external oil separator through the oil filter to the main oil inlet port and then fills into the cylinder due to the positive oil pressure force which is bigger than the spring force plus the force from high pressure gas. The positive pressure differential causes the piston to move toward the loading direction in the cylinder. When the slide valve moves toward the loading direction, the effective suction volume increases in the compression chamber. This means the displacement of refrigerant gas also increases, as a result the refrigeration capacity also increases. However, when any of the step solenoid valve (for 4-step capacity control system) is opened (energized), the high pressure oil in the cylinder bypasses to the suction side, which causes the piston and the slide valve move toward the unloading direction, and then some of the refrigerant gas bypasses from the compression chamber back to the suction end. As a result, the refrigeration capacity decreases because of the reduction of displacement of refrigerant gas flowing in the system.

The piston spring is used to push the piston back to its original position, i.e. minimum load position in order to reduce the starting current for the next starting-up. If the compressor started at full load capacity it may result in over current start. The modulation solenoid valves are controlled by a micro controller or temperature switch to modulate the piston position smoothly with stable output of capacity.

If the oil filter cartridge or modulation solenoid valves are not working well in the capacity control system, this may result in the abnormality and ineffectiveness of the capacity control system. Before stopping the compressor, HANBELL strongly recommends that the unloading solenoid valve of step-less control system or minimum load solenoid valve of 4-step control system should be kept opened (energized) for more than 60 seconds so that oil pressure in the cylinder can be released. When starting the compressor next time, the slide is at its minimum load position for a light duty start.

2.7 4-step capacity control system

There are three normal close solenoid valves equipped on the compressor that control the compressor capacity from minimum capacity to full load (100%). For the compressor with 4 steps capacity control, it is usual to use the sequence of 25%-50%-75%-100% to load the capacity of compressor and to use the sequence of 100%-75%-50%-25% to unload the capacity. If 25% capacity is essential to be kept running for a long time, pressure differential between suction and discharge port and high discharge temperature should be considered seriously to avoid insufficient oil supply or external cooling to compressor.

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.

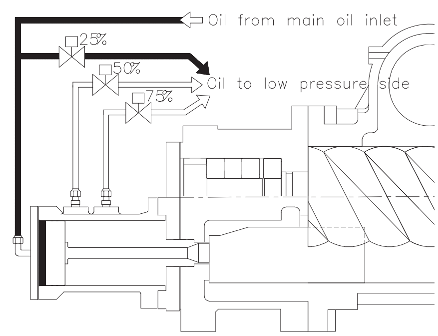


Fig. 2.10 Min% capacity

b. 50% capacity

When 50% solenoid valve is energized by the temperature controller, 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.

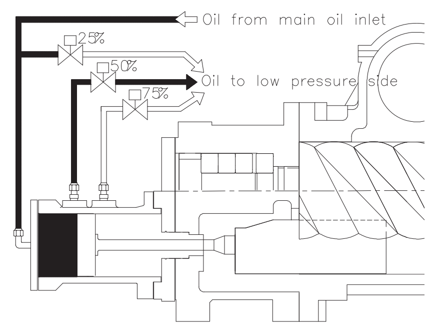


Fig. 2.11 50% capacity

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 on that position.

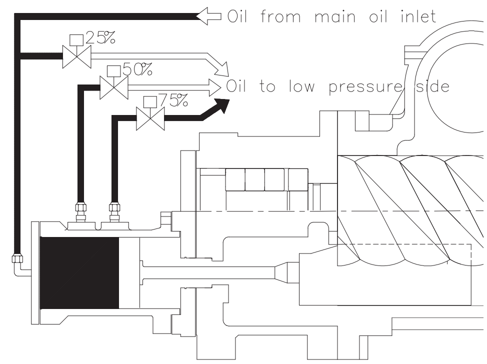


Fig. 2.12 75% capacity

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 end side of the compression chamber and the piston also reaches its dead end entirely where no bypass of compression gas occurred. So 100% load is achieved.

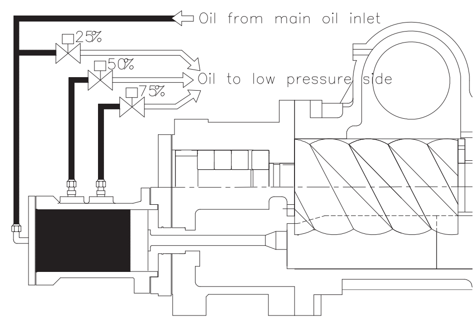


Fig. 2.13 100% capacity

2.8 Continuous (Step-less) capacity control system

In continuous (Step-less) capacity control system, 2 solenoid valves are equipped for the capacity control. These two solenoids are used to control the chiller by temperature controller or micro controller. 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 be injected continuously into piston cylinder and will not bypass through NC unloading SV so compressor keeps loading.

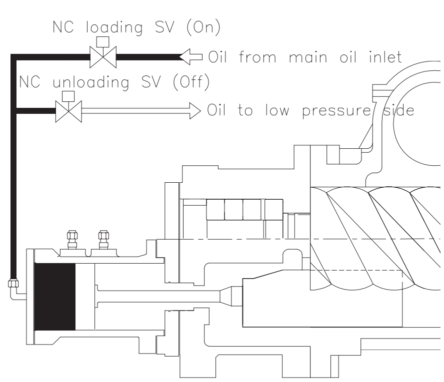


Fig. 2.14 Loading with NC loading valve

b. Unloading

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

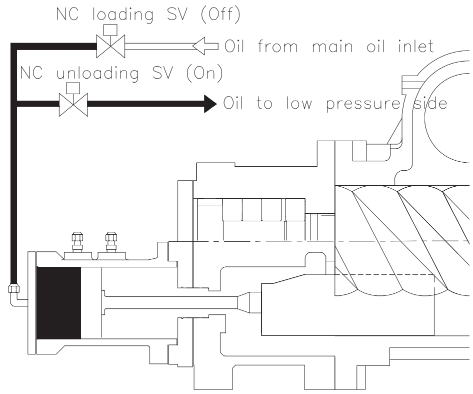


Fig. 2.15 Unloading with NC loading valve

c. Holding/Stable

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

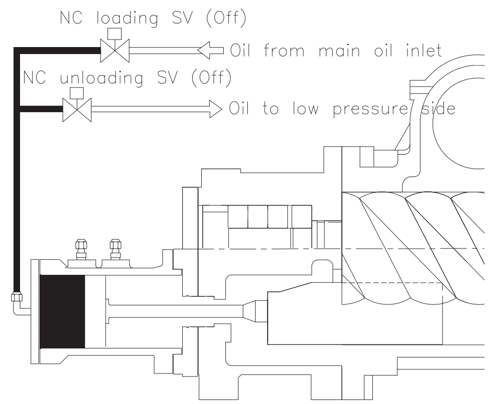
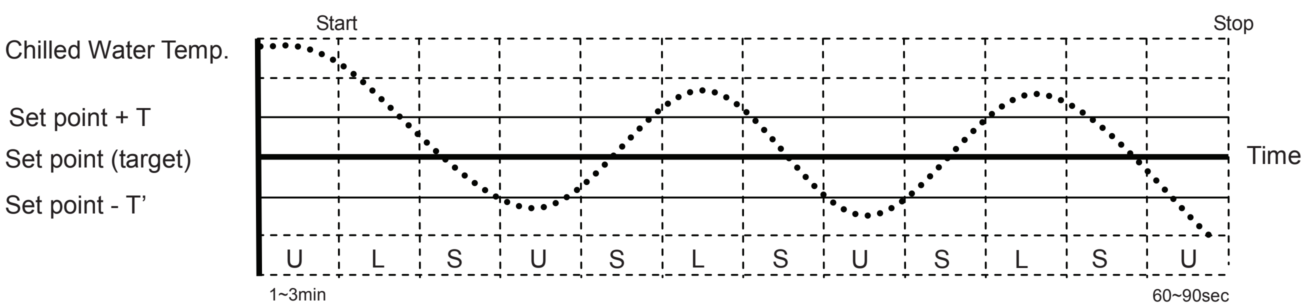


Fig 2.16 Holding with NC loading valve



••••• - Chilled water temperature

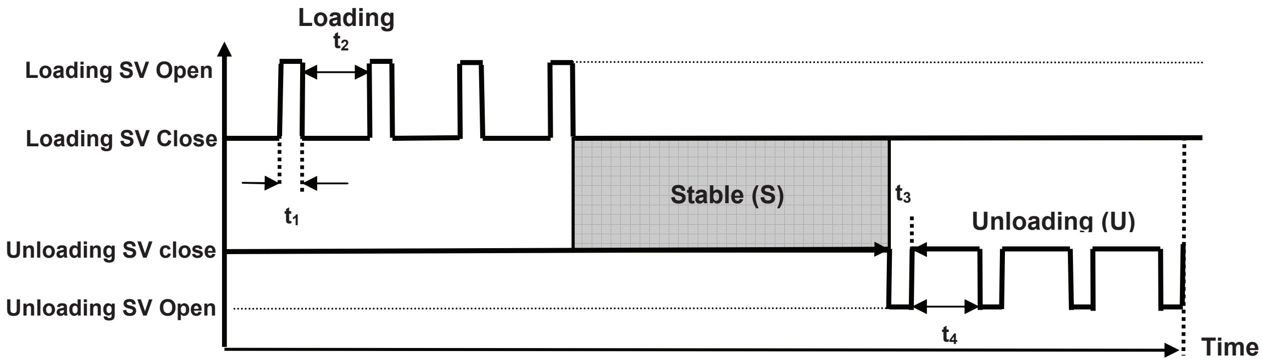
U - Unloading

S - Stable(holding)

L - Loading

Fig. 2.17 Continuous /stepless 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

Fig. 2.18 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 stepped + continuous capacity control system. If special solenoid valve for capacity control is specified, please contact Hanbell directly.

2.9 Dual capacity control system (Optional)

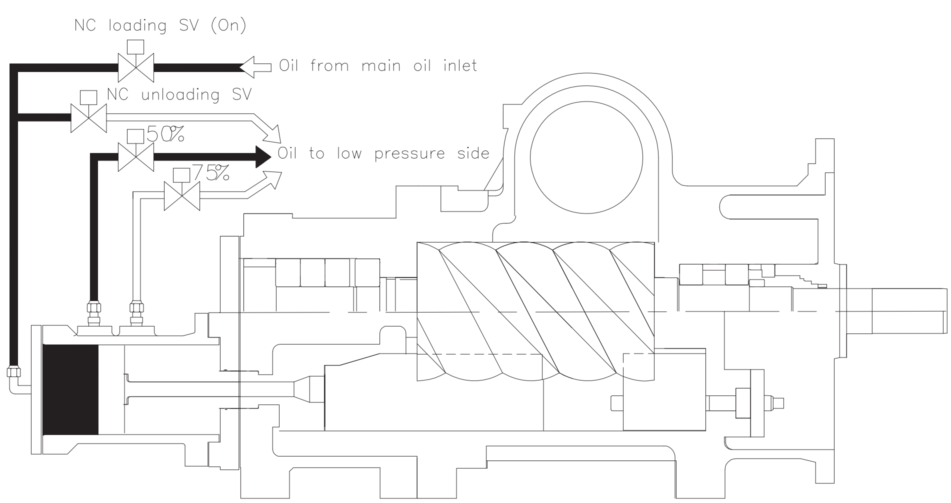


Fig. 2.19 Dual capacity control

Hanbell can provide compressors with dual capacity control for stock reason, system modification and special application (See above figure), and its control logic is as same as that in chapter 2.8 and 2.9.

2.10 Compressor volume ratio (Vi)

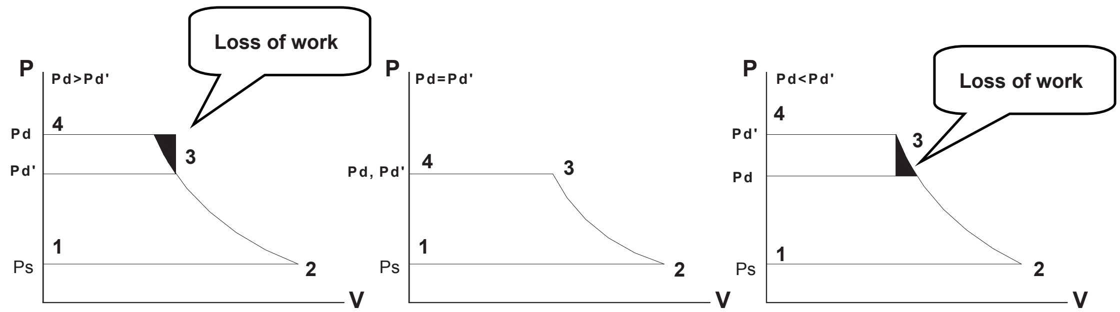
The Volume ratio (Vi) of the compressor can be defined as the ratio of suction volume of gas divided by discharge volume of gas of the compressor. The volume ratio directly affects the internal compression ratio or

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)**

Fig. 2.20 P-V Diagram

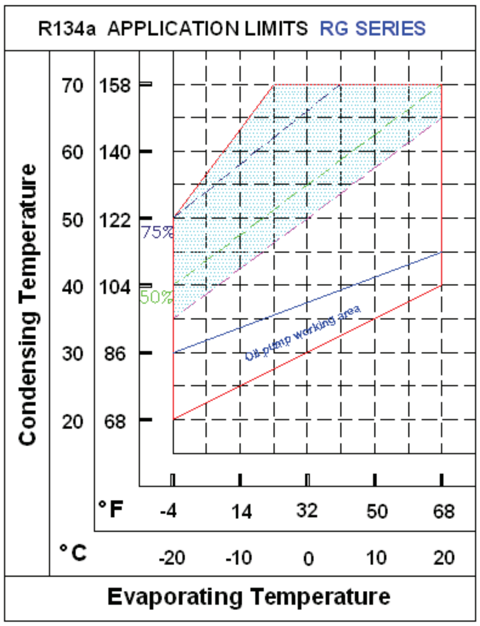
Where: **CR:** system compression ratio
Pi: internal compression ratio
Vi: internal volume ratio
Pd: system pressure (absolute pressure)
Pd': discharge pressure (absolute pressure)
Ps: suction pressure (absolute pressure)
Vs: suction volume
Vd: discharge volume
K: refrigerant specific heat ratio

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. When compressor running below 70% capacity, because the slide valve is partially inside the compression chamber and results the inappropriate Vi, the compressor will suffer higher discharge temperature. Therefore Hanbell does not recommend running the compressor under partial load in a long time.

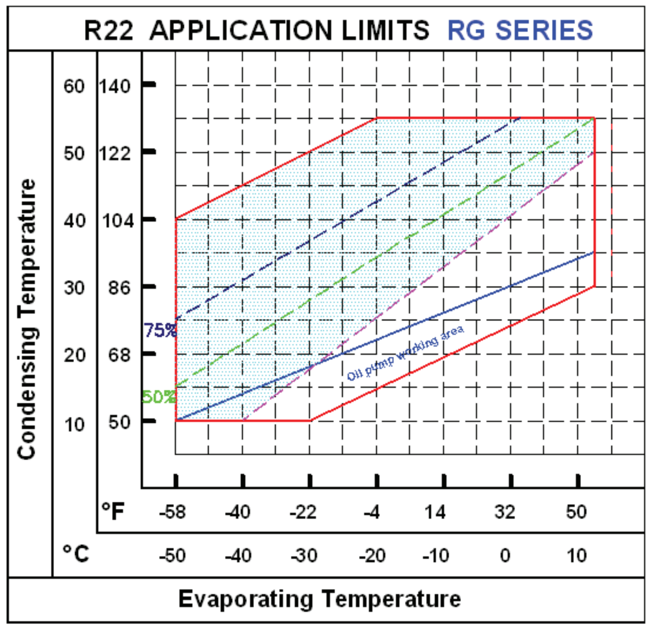
2.11 Application limits

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. Operating at extra low saturated suction temperature, may cause oil management problem, and operating at extra high saturated condensing temperature may shorten the compressor life due to insufficient compressor chamber cooling or oil supply for lubrication.

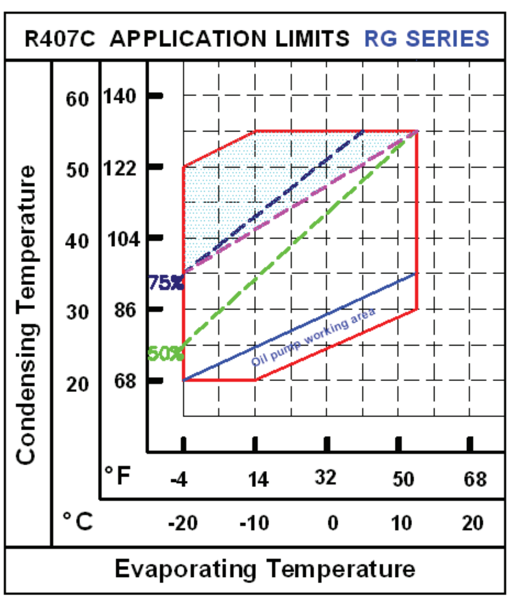
R134a Application Limits



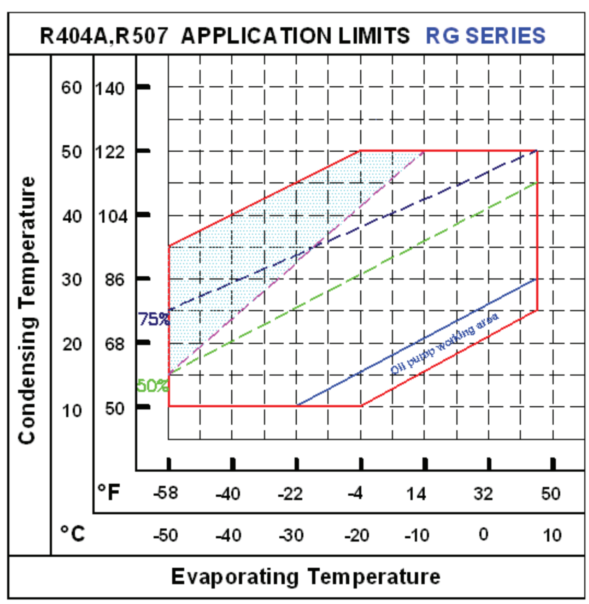
R22 Application Limits



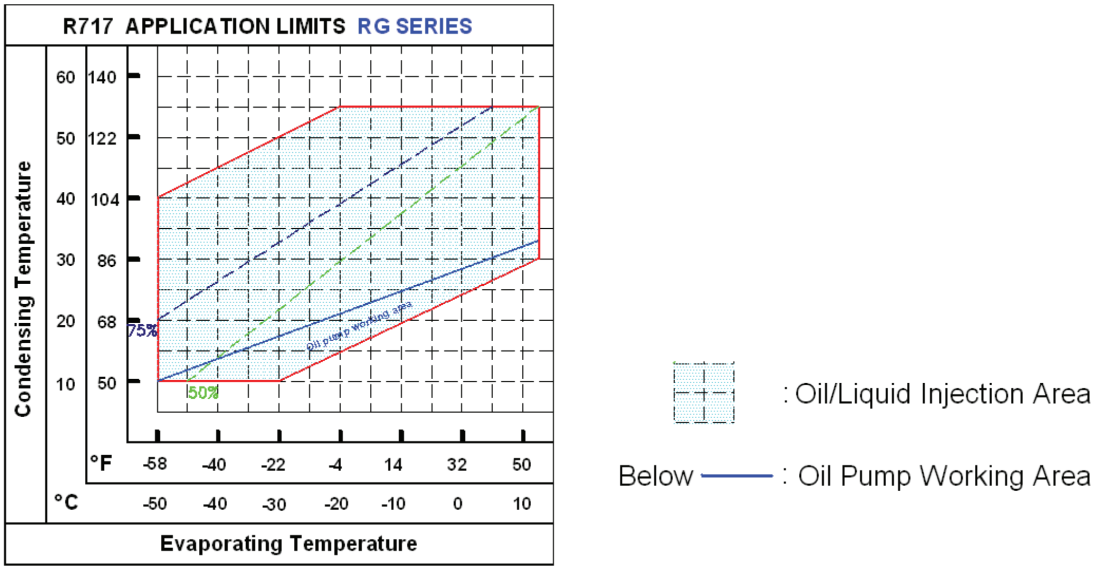
R407C Application Limits



R404A&R507 Application Limits



R717 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 the following additional cooling methods:
   (1) External oil cooler (2) Oil/Liquid injection to chamber
   Please refer to Hanbell selection software for calculation and chapter 6—system application for design reference.
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, R407C, R404A, R507A and 30°K for R22 and R717) to avoid liquid filling back to compressor and lubrication failure. According to EN12900, the minimum suction superheat is 10°K and liquid s ub-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. The design with positive pressure differential lubrication system in the RG series is available to omit an extra oil pump in most of applications. However, in some special applications ($P_{oil} - P_{suction}$ < 6 bar), it is still necessary to install an extra oil pump to the compressor for safety.

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 system. High oil carryover to the system will reduce the heat exchanger performance or simply block the pipe. For synthetic oil, it has high tendency to react with water, 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 more 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 recommended at 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). User should take notice on the oil level in the oil separator because if the oil return 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 find oil return problem in the system, a fine oil separator is highly recommended to be installed between the oil separator discharge port and condenser. Flooded chiller or DX type chiller with long distance piping is also recommended to be installed with a fine oil separator to reduce the oil carryover into system.

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.

3.1 Lubricant table

Tables below show the recommended lubricant with different kinds of refrigerant or gas.

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℃	mm^2/s (cSt)	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	–	–	–
DIELETRIC 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℃	mm^2/s (cSt)	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		℃	–	–	–	–
DIELETRIC STRENGTH 2.5mm		kV	–	–	46.6	–

Applicable oil types (R717)

SPECIFICATION		UNITS	Shell Clavus G				CPI CP 1009		CPI CP 4600		Mobil Gargoyle Arctic		Mobil Gargoyle Arctic SHC				
			32	46	68	100	68	100	46	68	C Heavy	300	224	226E	228	230	NH68
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
VISCOSITY	40℃	mm^2/s	30	44	64	100	69	108	46.9	68.5	46	68	29	68	97	220	64
	100℃	(cSt)	4.6	5.6	6.9	8.7	9.1	12	7.9	10.4	5.4	6.5	5.6	10.2	13.7	25	8.5
FLASH POINT		℃	195	210	226	220	226	266	246	248	195	208	230	266	255	260	211
POUR POINT		℃	-48	-42	-40	-36	-39	-12	-60	-51	-42	-36	-54	-45	-45	-39	-54
T.A.N		mg KOH/g	<0.04	<0.04	<0.04	<0.04	–	–	–	–	0.01	0.01	–	–	–	–	–
COPPER STRIP		100℃/3hr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1B
MOISTURE		ppm	–	–	–	–	–	–	–	–	<50	<50	–	–	–	–	<100
FLOC POINT		℃	<-50	<-50	<-50	<-50	–	–	–	–	-36	-31	–	–	–	–	–
DIELETRIC STRENGTH (2.5mm)		kV	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

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 dry air or 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. Be noted that the compressor is charged with 0.5~1 **bar** nitrogen, so release the inner pressure before loosing any parts on the compressor is very important.

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.

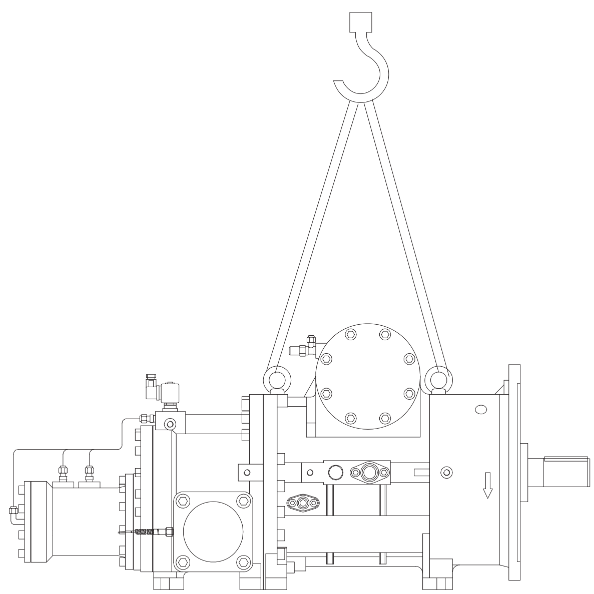


Fig. 4.1 Lifting compressor with steel rope

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.

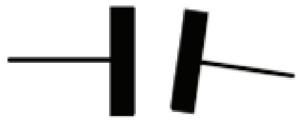
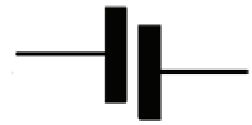
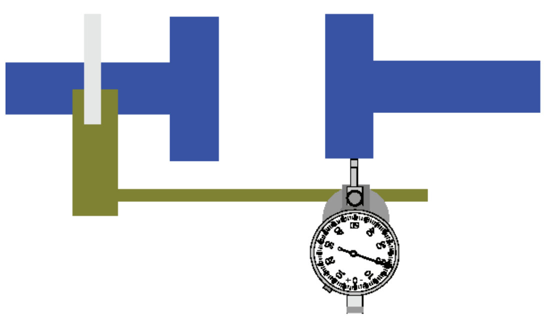
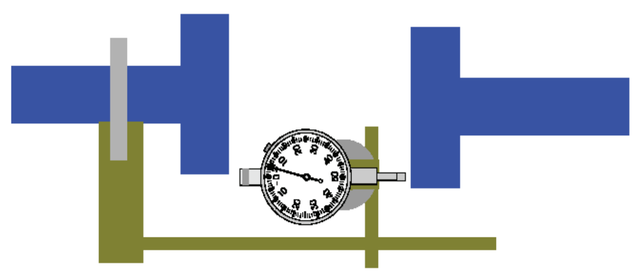
Angular Misalignment	Offset Misalignment
	
Less than 0.03 mm per 100mm	Less than 0.03 mm

Fig. 4.2 Requirement for centering work

To do the shaft alignment, user 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. In some cases coupling has been installed separately on the motor shaft and the compressor shaft. User 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

Fig. 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 the rigid base.
b. The compressor should be installed horizontally.
c. Use slim metal below compressor and motor for centering 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 standard above (Refer to Fig. 4.2) to finish the centering work.

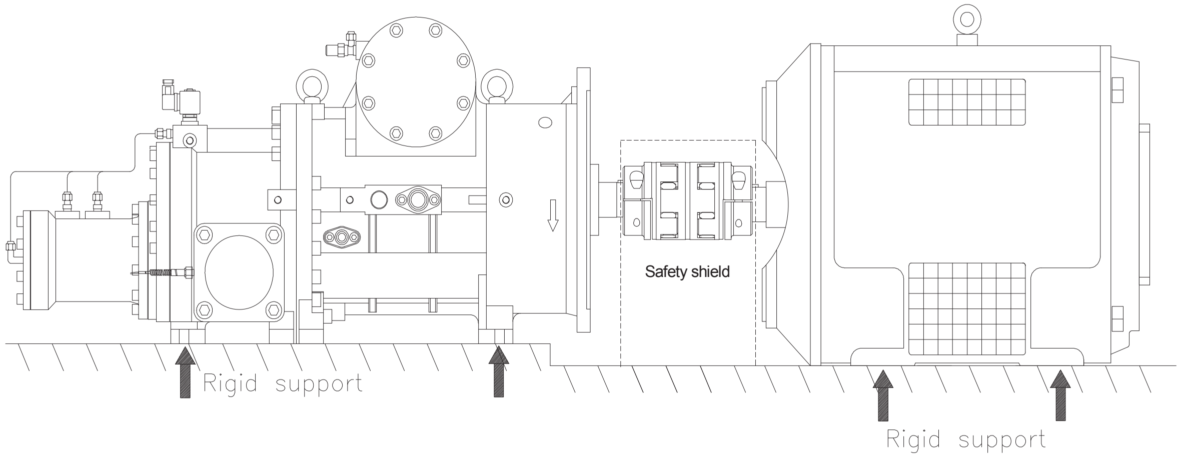


Fig. 4.4 Centering work without coupling housing

4.3 Shaft alignment with coupling housing

Using a coupling housing can help user save centering time. Hanbell provides several options for customers.

Option 1 - Customer needs a coupling housing from Hanbell, but wants to use their own couplings.

In this case, Hanbell needs 2D drawing of 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 ship 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 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.

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 centering work.

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 fig. 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.

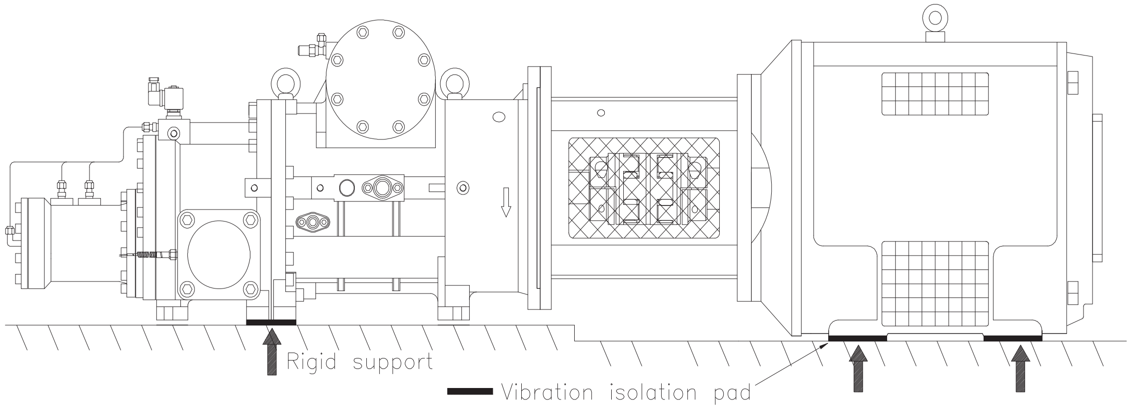


Fig. 4.5 Centering work with coupling housing

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% to 30% safety factor to achieve motor 's 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 whether the moisture and air or other contaminants are 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 charge 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 Ch 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. If the system has an oil pump, open the stop valve between the oil pump and the compressor after the oil charge and start the pump to get oil in all piping. 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 to the difficulty of start-up 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 can't be mixed.

4. Check oil level during the commissioning and add oil by 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. Because the return gas passes the strainer from the inside space to the outside space, residue accumulates on the inside surface by the time of running.

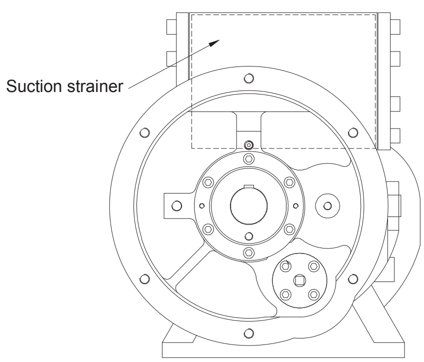


Fig. 4.6 Position of suction strainer

The suction strainer is located on the top of compressor as shown in the Fig. 4.6. 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. For a retrofit case, 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 Adjusting of volume ratio (Vi)

Vi adjusting is important to prevent losses in compressor efficiency due to over or under compression. For RG-200 to RG-830, volume ratio can be adjusted by simply rotate the Vi adjusting rod. Fig. 4.7 below shows you how the Vi change can be made. Each HANBELL RG compressor has been adjusted to the requested Vi. Unless different Vi setting is needed, it is not necessary to modify it.

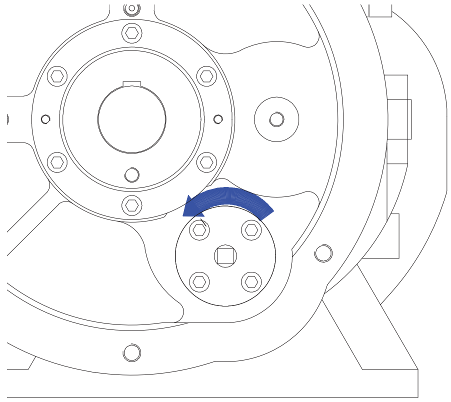


Fig. 4.7 Rotate Vi adjusting rod counterclockwise to increase Vi ratio

In the case of ignorance about the original Vi setting, user can rotate the adjusting rod clockwise or counter clockwise to make Vi to 2.6 or 5.1 separately. Follow the reference table 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 is off. The recommended Vi setting can be obtained by using Hanbell selection program.

Note:

1. Incorrect Vi setting will cause unwanted system vibration and higher power consumption.
2. Remember to recalibrate the capacity indicator after Vi modification

Table 4.1 Vi regulation

Turns	0	2	4	6	8	10	12	14	16	18	20
Vi (RG-200)	2.6	2.86	3.21	3.63	4.22	5.1	----	----	----	----	----
Vi (RG-410)	2.6	2.77	2.95	3.17	3.43	3.73	4.11	4.55	5.1	----	----
Vi (RG-830)	2.6	2.76	2.92	3.09	3.2	3.5	3.74	4.01	4.33	4.71	5.1

4.7 Vacuum the compressor

The vacuum of compressor can be achieved by connecting the vacuum pump to the suction side connector and discharge side connector on the compressor. 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, the resistance of PTC sensor increases to a trip point and 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 sec 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)

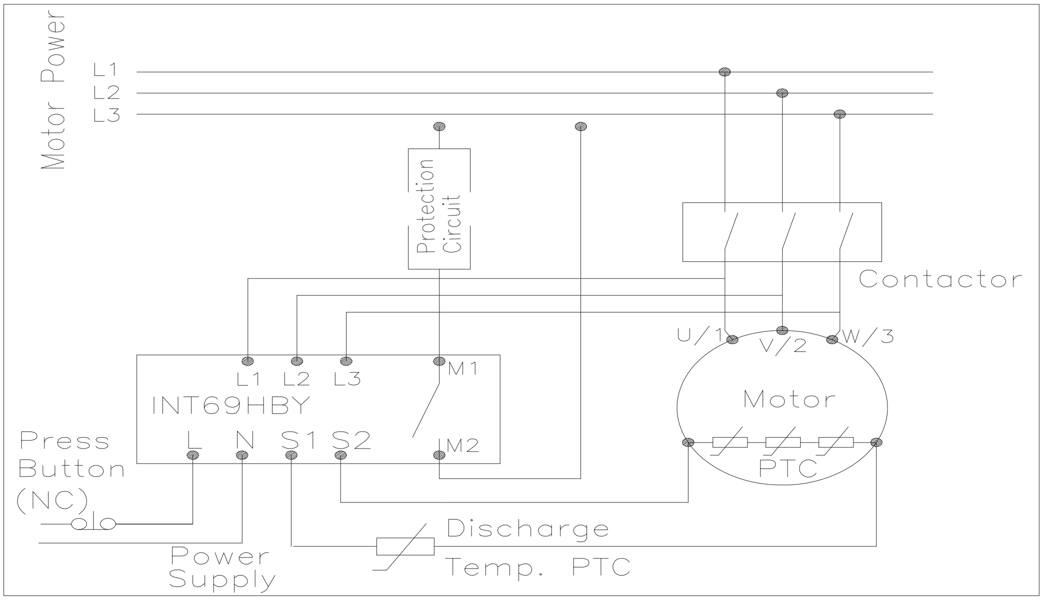


Fig. 4.8 INT69HBY connection diagram

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. In the case of low pressure differential (P_{oil} – Ps <6 bar), oil pump is required to ensure a sufficient oil supply for bearing lubrication, rotor sealing, mechanical seal and capacity control.

4.11 Accessories

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% Continuous	●
2	Fixed Vi =2.2, 2.6, 3.0, 4.8 or Variable VI	●
3	Suction coupling bushing / flange	●
4	Discharge coupling bushing / flange	●
5	Liquid / oil inject port	●
6	Economizer port	●
7	Suction check valve (RG-200~RG-410)	●
8	Suction stop valve (RG-200~RG-410)	●
9	Screw in discharge temperature sensor	●
10	Suction check valve (RG-830~RG-1520)	Δ
11	Discharge check valve (RG-200~RG-1520)	Δ
12	Suction stop valve (RG-830~RG-1520)	Δ
13	Discharge stop valve (RG-200~RG-1520)	Δ
14	Capacity indicator	Δ
15	Liquid injection expansion valve	Δ
16	Liquid injection solenoid valve	Δ
17	External oil separator	Δ
18	Coupling	Δ

2. Description of accessories

a. Capacity indicator

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

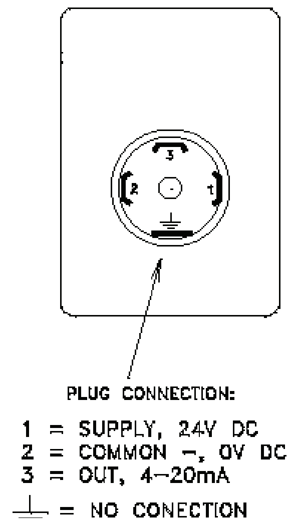
Ambient Temp------------------- -20 to +70 ℃ (electronic)

Temp. range sensor------------ -40 to +120 ℃

Temp. Coeff.---------------------- Better than 0.01% FS/℃

Vibration-------------------------- IEC 68-2-6

Pressure-------------------------- Max 100 bar



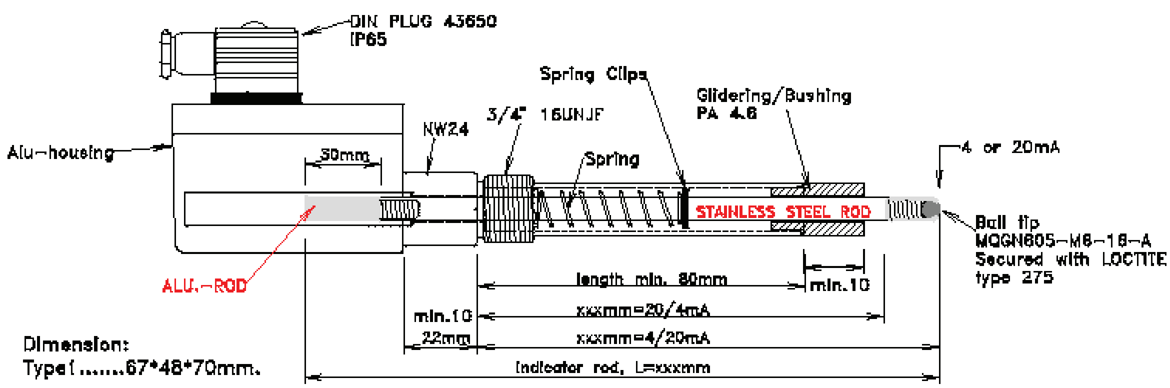
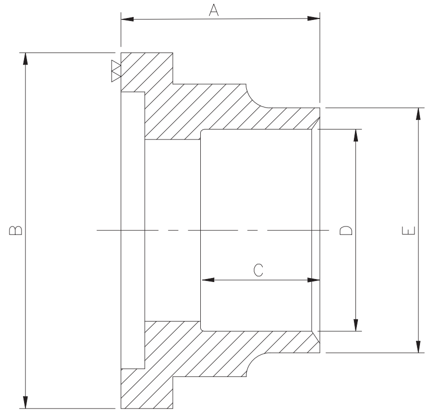


Fig.4.9 Construction of capacity indicator

Note: The instruction of calibration can be referred in 5.2.

b. Suction and discharge connection bushings

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 Flange Bushing		Standard Suction Flange 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-830	4″	4 1/8”	5″	5 1/8”
RG-1090	5″	5 1/8”	6″	---
RG-1280	6″	---	8″	---
RG-1520	6″	---	8″	---

Fig. 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-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-1090	Discharge	Steel	5"	75	174	35	141.3	154
	Suction	Steel	6"	75	215	40	166.7	196
RG-1280 RG-1520	Discharge	Steel	6"	75	215	40	166.7	196
	Suction	Steel	8"	75	260	40	218	241

c. Suction and discharge stop valves

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-1090	5″	6″
RG-410	2 1/2″	4″	RG-1280	6″	8″
RG-830	4″	5″	RG-1520	6″	8″

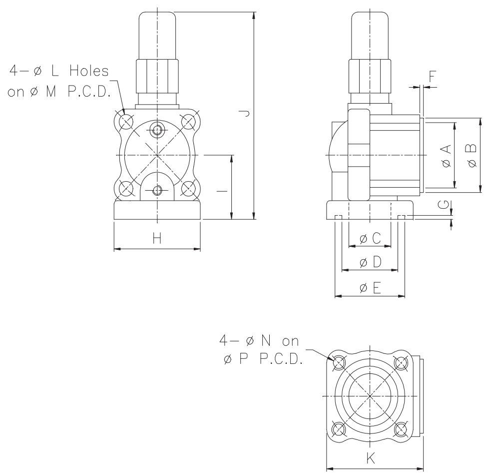


Fig. 4.11 Dimensions for 2"~4" stop valves

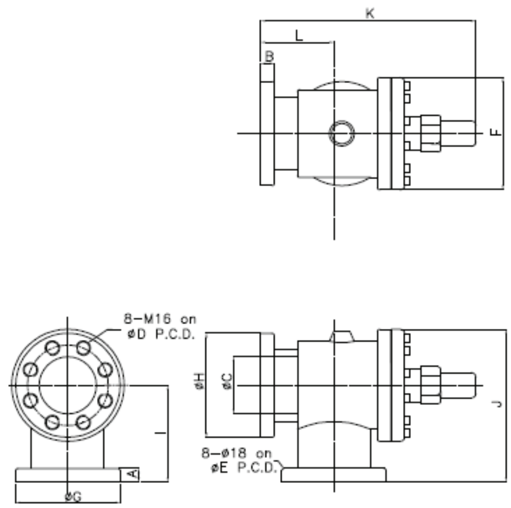


Fig. 4.12 Dimensions for 5" stop valve

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

Note: Please contact Hanbell for specification of 6" and 8" stop valves.

d. Suction and discharge check valves

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 Fig. 4.13 & 4.14 below. Users can contact Hanbell representative to get more information on the suction and discharge check valves.

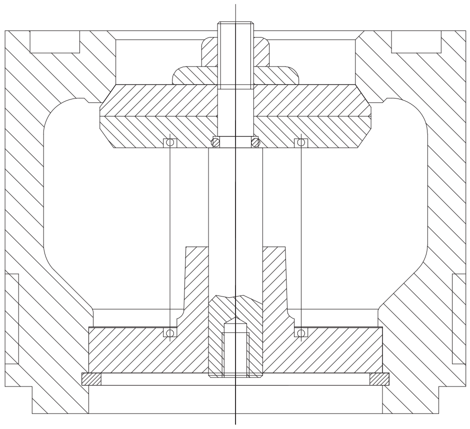


Fig. 4.13 Suction check valve

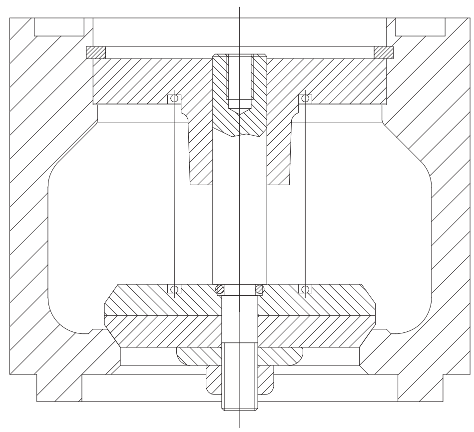


Fig. 4.14 Discharge check valve

e. Oil heater/ Oil temperature sensor

Oil heater is used to maintain the oil temperature in the oil separator during shutdown cycles. It can help to get a safe start-up especially when the ambient temperature is low. Oil heater should be energized only when the compressor unit is not in operation and should not be energized when there is no oil in the reservoir. The selection of oil heater depends on total quantity of oil.

Oil temperature sensor is used to detect the oil temperature and control the oil heater. When oil temperature reaches the setting value, oil heater should be off to save the energy. The oil heater and temperature sensor operate with each other regardless whether the compressor is operating or not. Hanbell recommends keeping oil temperature above 30 ℃ for a safe and easy start-up.

f. Oil level switch

Hanbell recommends installing an oil level switch on the external oil separator to ensure oil supply to the compressor. To prevent from oil level switch trip caused by oil foaming or surging in the sump, a time delay around 15 ~ 30 seconds is recommended before shutting down the compressor.

Max. contact capacity= 50VA DC/AC

Initial contact resistance=150mΩ(Max.)

Switching voltage = 600V DC

Max. voltage = 300V DC/AC

Max. current = 0.5A DC/AC

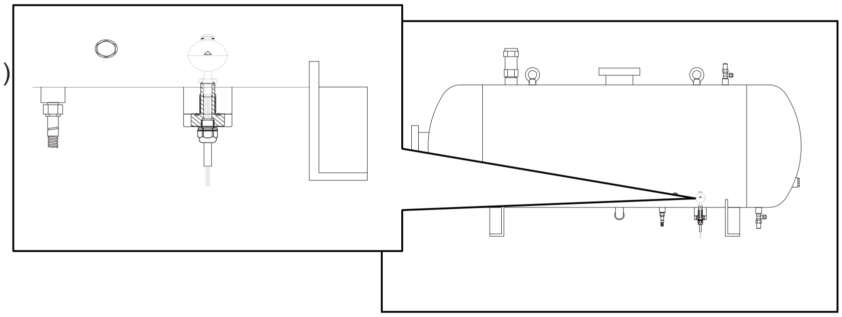


Fig. 4.15 Oil level switch on an external oil separator

g. Oil filter

Oil filter is often used in the oil line to reach proper oil filtration. Oil cleanliness is vital to the compressor life and system operation. Therefore, selecting a suitable oil filter becomes very important. Hanbell recommends using a 15 μm filter cartridge to have a qualify oil supply to the compressor system. When designing the oil circuit, having pressure differential check design on oil filter can help users to know the condition of filter cartridge and clean or replace the filter cartridge regularly to ensure a qualify and sufficient oil supply.

h. Oil flow switch

Oil flow switch is widely used on external oil circuit. With the installation of oil flow switch, user can ensure sufficient flow rate of lubricating oil. Specifications are shown below.

Specification:

Type	Size	Process connection d1	Setpoint range(H_2O, 20℃)		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

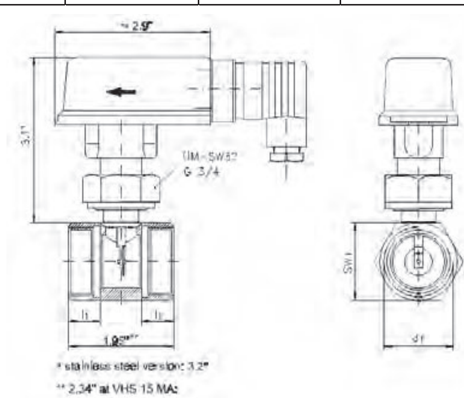


Fig. 4.16 Outline drawing

Material options:

Type	Material		
	Upper section	Paddle system	Pipe section
VHS .. M-MS	Brass	Brass	Brass*
VHS .. M-VA	Stainless steel	Stainless steel	Stainless steel
VHS .. MK	Brass	PPO Noryl GFN3	Brass*
VKS .. M	PPO Noryl GFN3	PPO Noryl GFN3	Brass*

i. Oil pump

When pressure differential between the main oil inlet port and the suction side is less than 6 kg/cm^2, it means using an oil pump for the oil circuit becomes important. Please select a proper oil pump according to its working pressure range ($P_{oil} - P_{suction}$ should between 6 kg/cm^2 and 15 kg/cm^2) and nominal pump rating (Please refer to the selection program to get the oil flow volume as reference).

j. Motor

The motor selection should base on motor's working environment, application method, maximum motor power and practical needs. User can refer to Hanbell selection program to get the maximum motor power. Normally a safety factor (1.2~1.3) is recommended to add when choosing a motor.

k. Oil separator

For the application with HFC or HCFC refrigerant, 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:

(Ⅰ) Technical data：

Model	Type	Oil volume (Liter)		Range of application based on displacement (m^3 /hr) (Recommended - HFC/HCFC)	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： Units: mm

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

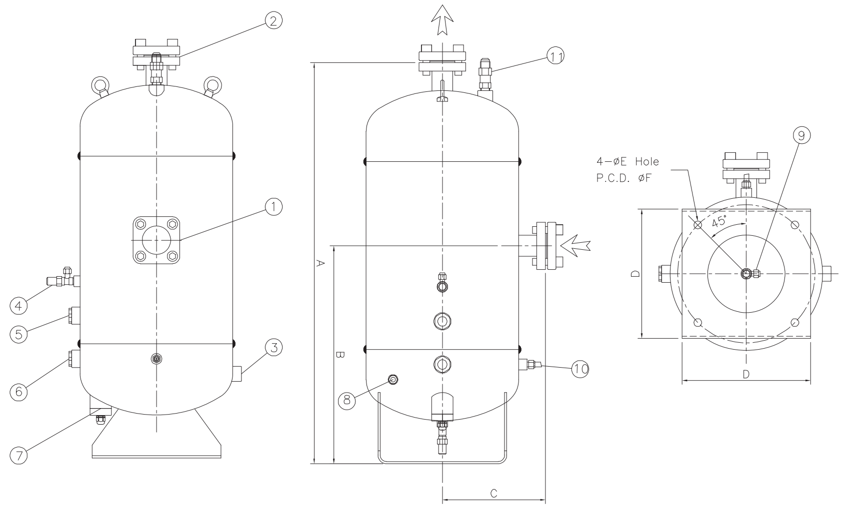


Fig. 4.17　Vertical -OS40, OS50, OS65

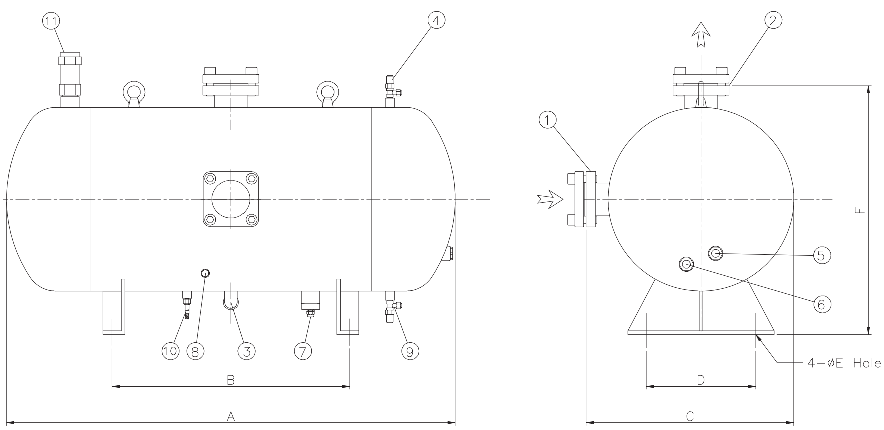


Fig. 4.18　Horizontal I -OS80

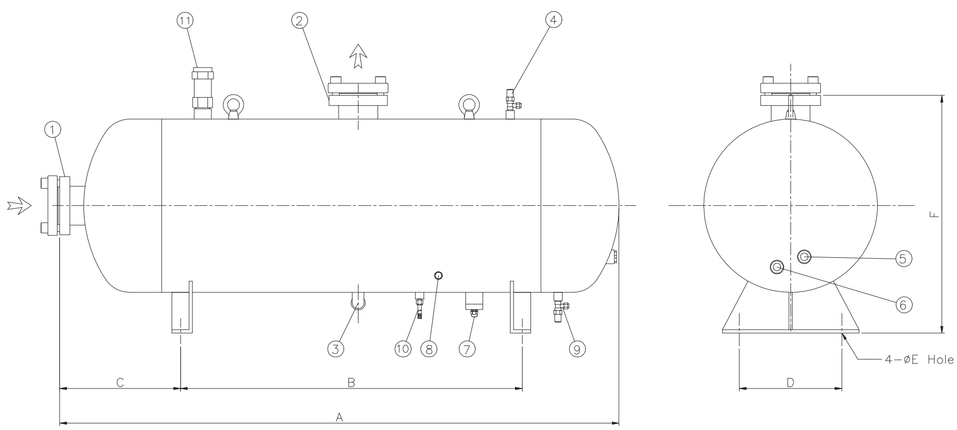


Fig. 4.19　Horizontal OS100, OS125, OS150

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

I. 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.

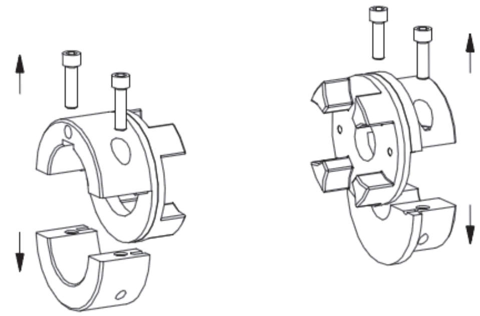
In contrast to other flexible couplings, the intermediate members of which are subject to bending stress and are therefore prone to earlier wear, the flexible teeth of these couplings are subject to pressure only. This gives the additional advantage of the individual teeth being able to accept considerably higher loads. The elastomer parts show deformation with load and excessive speeds.

Product characteristics

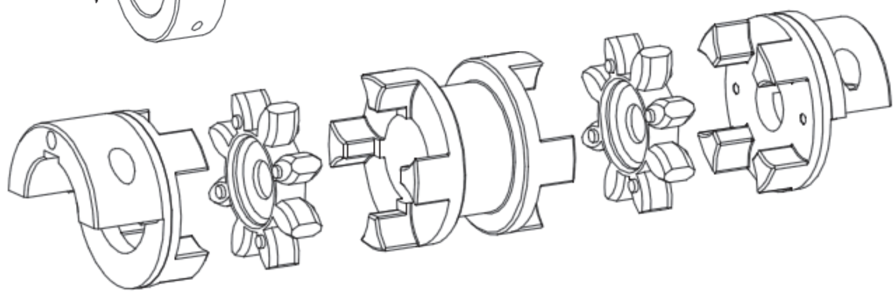
- Assembly/disassembly through 4 screws only
- Compensates for high shaft displacements due to double-cardanic
- Remains torsionally symmetric in case of shaft displacements
- Reduced vibration and noise
- Low restoring forces - Increase of the total lifetime of all adjacent components (bearings, seals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

Assembly procedure

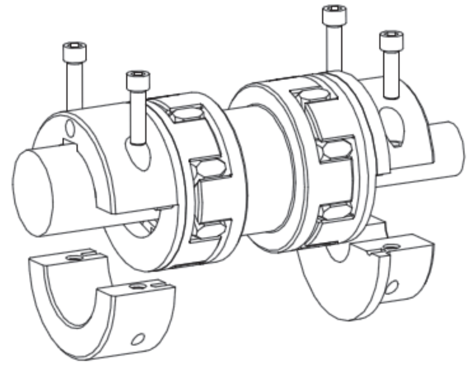
Step 1: Disassembly of shells

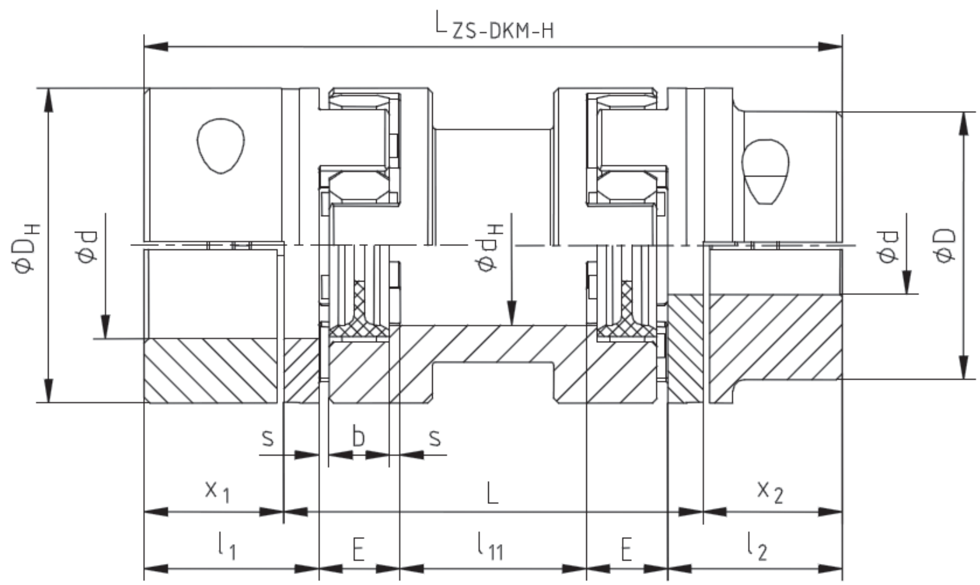


Step 2: Assembly of hub bodies, spiders and middle spacer



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)	Dismountable Length L (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	100	39	50	26	26	M10 69 Nm
RG-410 ROTEX48	525	1050	5600	60	100	45	56	22	28	M12 120 Nm
RG-830 ROTEX65	940	1880	4250	80	140	60	75	40	35	M12 120 Nm
RG-1090 RG-1280 RG-1520 ROTEX75	1920	3840	3550	90	140	67.5	85	25	40	M16 295 Nm

5. Operation and troubleshooting

5.1 Before commissioning of compressor

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 representative's review before start-up. Please refer to p. 41 for the pre-start check list.
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 25% solenoid (N.C.) to reach it. The table below lists the recommended energizing time for 25% solenoid.

Model	RG-200	RG-410	RG-830	RG-1090	RG-1280	RG-1520
25% solenoid energizing time	10 min	15 min	15 min	20 min	20 min	20 min

9. Turn the compressor coupling by hand to check any abnormality.

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's pressure test.
3. Don't add refrigerant to the leak test gas (N_2 or air) as leak indicator.

5.2 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. 42) and use it to record all working parameters. The data is extremely important as reference for the diagnosis when system encounters unexpected errors.

4. Press the compressor start button. Check the screw rotor rotation direction or pressure variation in suction and discharge side. 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” flare angle valve (refer to position 17 at RG-200~RG-830 2D drawings). The main oil line solenoid should be energized when motor starts. In the case of using oil pump, oil pump should be started at the same time when the motor starts. The oil pressure at main oil inlet port should be 6 kg/cm^2 higher than the suction pressure at all time 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. The red LED on capacity indicator will light up constantly (ON) for some seconds. When the red LED flash, it indicates ready for 100% calibration.(if applicable)
7. 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.
8. Check the oil pressure at main oil inlet port which should be at least 6 kg/cm^2 higher than the suction pressure. If this pressure differential can’t be achieved within 30 seconds, user should consider using an oil pump for the compressor. Oil pump can be switched off when pressure differential is reached.
9. Check the oil supply situation 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, user should stop the compressor immediately. The oil pump (if it is designed in) and oil return solenoid should be closed at the same time 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.
10. For step-less capacity control, check Ch 2.8 for loading and unloading procedures. For 4-step capacity control, run compressor at each step for at least 3 minutes. Check Ch 2.7 for details.
11. When loading the compressor, debris or unwanted particle might enter the compressor because of the increasing of flow velocity. User should stop the compressor if any abnormal situation (leakage of oil or gas, abnormal noise, vibration) is found.
12. When the compressor capacity reaches 100% position, push the calibration bottom once again. The red LED will light up constantly for some seconds. When the red LED is off, the calibration is done.(if applicable)
13. After the calibration of capacity indicator, the initial slide valve position read by capacity indicator should be 25%. Please check it during the unload process or next start-up. If the value is different, do the calibration for capacity indicator again by the procedures mentioned above.
14. The calibration of capacity indicator should be performed again if the compressor Vi is changed. User should follow the step 5, 6 and 12 for calibration.
15. For 4-step capacity control, the capacity indicator is not necessary to be installed.
16. 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 valve is found.
17. When the system reaches its operating condition and runs stably, user should finish the compressor

commissioning report (refer to p. 43) and send it to Hanbell for compressor warranty purpose.

18. 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.
19. Check the movement of slide valve. Unload the capacity from 100% to 50% gradually. For 4-step capacity control, unload compressor to 75% and operate the compressor at 75% for at least 3 minute then unload the compressor to 50%. When the slide back to 50%, run compressor for at least 3 minutes before next action.
20. Load and unload the compressor gradually and measure all working parameters. Write them down on the operating log sheet.
21. For high speed operations (> 60 Hz), oil pressure should be higher. Proper oil injection is also necessary.

Note:

1. Don't start the compressor when the system is vacuumed.
2. Danger or severe damage to compressor is possible if the compressor is flooded with oil during standstill.
3. Don't touch the compressor surface during compressor operation to avoid burns.
4. Don't remove any parts of compressor before release the compressor inner pressure.
5. The discharge temperature of compressor is recommended to be controlled at 80 ℃ for R22 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.
6. The supply oil temperature should be kept below 50 ℃ for ammonia application and 60 ℃ for R22 and HFC application.
7. The oil level in oil separator might slightly drop after the start-up. A lower level happened by gas or air 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.
8. During the commissioning, user should listen if any abnormal noise comes from compressor's bearing seat or compression casing. User should stop the compressor immediately when irregular, high tone and metallic noise is heard.
9. 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. Therefore, resonance should be often the cause of vibrations.
10. 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.
11. 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.
12. 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.

13. Oil/liquid injection can be used to maintain discharge temperature. Please refer to chapter 6 — System application for details
14. Check sight glass on liquid line to see the supply condition of refrigerant.
15. Check suction gas superheat not only at 100% capacity, but also 75%, 50% and 25% capacity to ensure sufficient superheat for system operation.
16. Avoid slugging compressor with liquid refrigerant. Make certain that adequate superheat or properly sized suction accumulator is applied to avoid dumping liquid refrigerant into compressor. Keeping liquid injection valves properly adjusted and in good condition to avoid flooding compressor with liquid.

5.3 System adjustment

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

Liquid/Oil injection to chamber

Liquid/Oil injection to chamber is widely used for the controlling of discharge temperature. In the case of using Liquid/Oil injection to chamber for the discharge temperature control, the Liquid/Oil line should be controlled by a liquid line solenoid (Normally Closed type). The liquid line solenoid is suggested to be energized when the discharge temperature reaches 80 ℃ (HFC and HFC application) or 75 ℃ (Ammonia application). On the Liquid/Oil line, there should be a regulation valve after the solenoid to adjust the injection flow rate. Before the start-up of compressor, user should completely close the regulation valve. When the system is running and the discharge temperature exceeds the set-point, the N.C. solenoid will be energized and user can open the regulation valve gradually to see the variation of discharge temperature. Try to adjust the regulation valve to the position that the discharge temperature starts to decrease to the setting point then keep the valve at this position for a while. When the discharge temperature down to 75 ℃ (HFC and HFC application) or 70 ℃ (Ammonia application), the liquid line solenoid can be off to stop the injection. Normally the discharge temperature will start to increase after the stop of Liquid/Oil injection. Therefore, user should observe the working situation for some time to ensure the proper work of Liquid/Oil injection.

Note: The adjustment of Liquid/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 (Normal Close Type) should be energized after the slide valve reaches 50% position and should be energized all the time during the compressor working period. Running compressor without sufficient cooling might cause severe damage to compressor.
3. Before stop the compressor, the controlling program should unload the slide valve to its initial position (minimum capacity). ECO line solenoid should be off when the slide valve position is below 50%.

Discharge bypass line

Discharge bypass line is widely used to reduce the pressure differential between low and high pressure side. In this kind of application, the discharge check valve is normally installed on the oil separator outlet which can isolate the high pressure side (condenser) from the oil separator side. Because a suction check valve is usually installed on the compressor’s suction port, the pressure in oil separator and compressor will be equalized in the end. Using a discharge by pass line which connects the oil separator and the suction pipe line can reduce the pressure in the oil separator to ensure a light-duty-start of the compressor.

Oil cooler

Oil cooler is often used to control the oil temperature at desire setting. The proper oil temperature can ensure the oil viscosity and lubricity and can provide necessary help for chamber cooling and discharge temperature control. Because the oil temperature in the beginning of system running is not high (normally around 20 to 30 ℃), oil cooling will not be necessary during this period. By pass the oil at oil cooler can help to increase the oil temperature faster to the desired temperature and having system stabilized. When the oil temperature reaches the setting, oil cooler can start to work to control the oil temperature for the system.

Oil cooler should be installed as close as possible to the compressor and preferably below the level of compressor / oil separator to avoid gas pads or any drainage of oil into the oil separator during standstill.

Oil filter

Oil filter is usually installed on the oil line. User should consider installing a pressure differential protector which helps to monitor the pressure drop between both sides of oil filter. When oil pressure drop reaches 1 to 1.2 kg/cm^2, this means the oil filter is clogged by debris or dirt and user should clean it to ensure sufficient oil supply to compressor. Insufficient oil supply leads to severe damage to internal moving parts and malfunction of capacity control.

Oil pump

When pressure differential between main oil inlet port and suction side is less than 6 kg/cm^2, it means using an oil pump for the oil circuit becomes important. The oil pump should start and stop simultaneously with the compressor to ensure sufficient oil supply.

Oil return valve (for fine/secondary oil separator)

In the case of using fine/secondary oil separator, an oil return line from the bottom of fine/secondary oil separator to compressor's suction side is very important. The control of oil return valve can be simply by a solenoid valve with a regulation valve or using a floating ball as a trigger and be opened only after the compressor starts. User should adjust the flow volume during the initial start up to ensure a steady oil return to the system.

Pressure regulation valve

Pressure regulation valve is suggested to be installed on the exit of the external oil separator when oil pump is not applied in the system. With its help, the oil pressure can be built up quickly to ensure sufficient oil supply to compressor. User should use suction pressure as reference and make sure the valve opened when the discharge pressure is 6 kg/cm^2 higher than the suction pressure. This is essential especially in the low condensing temperature condition.

5.4 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 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/Liquid injection line should be closed 3 to 5 seconds before the compressor stop. 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/liquid 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 kept 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 the cooling water in the condenser and oil cooler must de drained completely.

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

5.5 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
Vibration at piping	Harmonic resonance of piping due to improper piping design	Check piping design, add muffler, use copper pipe or contact Hanbell
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
Low suction pressure	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
	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
	Refrigerant floods back	Check system design and correct system suction superheat
Oil level in oil reservoir drops continuously	Discharge superheat is low	Increase the discharge superheat
	Liquid compression in compression chamber	Check suction superheat and improve it
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 10K
	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)

Symptom	Cause	Countermeasures
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
Oil pressure fluctuates	Liquid injection overfeeding or refrigerant flood back from system	Make necessary adjustments or corrections
Abnormal oil temperature rise	Insufficient cooling water	Improve cooling water supply
	Scale builds up in oil cooler resulting in insufficient heat exchange	Clean oil cooler tube

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

Compressor Prestart Checklist

<u>Mechanical checks</u>

Leak test is done	☐ Yes	☐ No
Leak test pressure	☐ 6 kg/cm^2	☐ ____ kg/cm^2
Leak test gas	☐ Yes	☐ No
The compressor unit is not pressurized	☐ Yes	☐ No
The compressor unit is evacuated now	☐ Nitrogen	☐ Dry air
All bolts, nuts, screws are tightened	☐ Yes	☐ No
All hand/stop valves are checked	☐ Yes	☐ No
All check valves are confirmed (direction)	☐ Yes	☐ No
Check the piping of economizer (if it is designed in)	☐ Yes	☐ No
Check the piping of oil/liquid injection (if it is designed in)	☐ Yes	☐ No
Check refrigerant level in receiver	☐ Yes	☐ No
Check oil level in oil separator	☐ Yes	☐ No
Oil brand and model	☐ Yes	☐ No
Check thermosyphon receiver refrigerant level (if it is designed in)	☐ ____________________	
Confirm the supply of cooling water (if it is designed in)	☐ Yes	☐ No
Add grease to electric motor	☐ Yes	☐ No
Check the rotating direction of main motor and oil pump motor	☐ Yes	☐ No
Check safety valve setting pressure and functioning	☐ Yes	☐ No
All oil lines are full of oil	☐ Yes	☐ No
Pre-setting values of all control/ protection equipment have been	☐ Yes	☐ No
noted and recorded for reference.	☐ Yes	☐ No

Signature of mechanical contractor: ______________________________

<u>Electrical checks</u>

Power supply to main motor	☐ ______V ______phases _____Hz		
Auxiliary power supply	☐ ______V		
Starting method	☐ Y-Δ	☐ Part winding	☐ Direct start
Motor breaker size	☐ ______A		
Independent conduit for control wiring (110V/220V)	☐ Yes	☐ No	
Size of current transformer	☐ ______		
Check all point-to-point wiring between the micro and motor starter	☐ Yes	☐ No	
Check the control logic and setting on protection devices	☐ Yes	☐ No	
Check the function of transmitters at control panel	☐ Yes	☐ No	
Check the function of protectors	☐ Yes	☐ No	
Check the activation of solenoid valve with control panel	☐ Yes	☐ No	
Check the insulation value of motor	☐ Yes	☐ No	

Signature of electrical contractor: ______________________________

Compressor Operating Log Sheet

Safety Set-points:

High discharge pressure Stop load _____ Force unload _____ Alarm _____ Delay _____ Shutdown _____ Delay _____

High discharge temperature Stop load _____ Force unload _____ Alarm _____ Delay _____ Shutdown _____ Delay _____

Low suction pressure Stop load _____ Force unload _____ Alarm _____ Delay _____ Shutdown _____ Delay _____

Low discharge temperature Stop load _____ Force unload _____ Alarm _____ Delay _____ Shutdown _____ Delay _____

High motor Amps Stop load _____ Force unload _____ Alarm _____ Delay _____ Shutdown _____ Delay _____

Low motor Amps Shutdown _____ Delay _____

High oil temperature at oil cooler exit Alarm _____ Delay _____ Shutdown _____ Delay ____

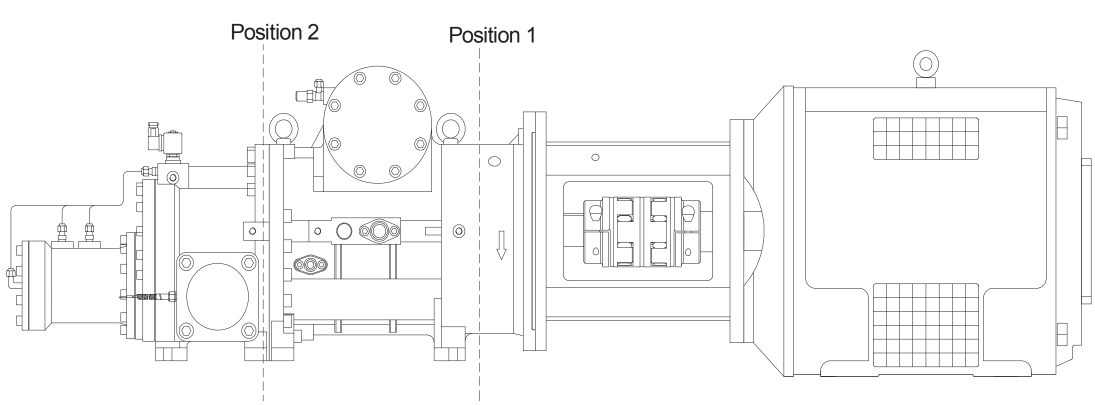
Low oil temperature at oil cooler exit Alarm _____ Delay _____ Shutdown _____ Delay ____

Low separator oil temp. Alarm _____ Delay _____ Shutdown _____ Delay ____

Low separator oil level Alarm _____ Delay _____ Shutdown _____ Delay ____

Low oil pressure differential Alarm _____ Delay _____ Shutdown _____ Delay ____

Date						
Compressor running hours						
Room temperature						
Suction temperature						
Suction superheat						
Suction pressure						
Discharge temperature						
Discharge superheat						
Discharge pressure						
Oil temperature (at oil separator)						
Oil level						
Oil temperature (at oil cooler exit)						
Oil filter pressure drop						
Oil pressure (at main oil inlet)						
Cooling water temperature						
Slide valve position						
Volume ratio (Vi)						
Motor ampere						
Seal leakage (Drop/Min.)						
Vibration at position 1 (H/V/A)						
Vibration at position 2 (H/V/A)						



Compressor Commissioning Report

Refrigeration/Chiller system is designed by: ______________________ Date: ________

End user: ____________________ Contact name: ____________ Phone: ________

End user add.: ________________________________ Email: ________

Unit General Information

Compressor model: ______________________ Compressor S/N: ______________

Capacity control: ☐ Step-less ☐ 4-Step Vi setting: ______________

Motor brand: __________ Frame size: ________ H.P. ________ RPM: ________

Service factor: __________ Voltage: ________ Hz: ________ FLA: ________

Serial #: ____________ Bearing type: ☐ Antifriction ☐ Sleeve

Oil pump: Brand: __________ Model: ________ Serial:________ (if apply)

Motor for oil pump: Brand: __________ Model: ________ Serial:________ (if apply)

Service factor: ______ RPM: ________ H.P.:________ (if apply)

Voltage: __________ Hz: ________ FLA:________ (if apply)

System design condition SCT/SST:______________ Evaporator type: ______________

Refrigerant/Gas: ______________________ Condenser type: ______________

Oil type: ____________________________ Injection to chamber: ☐ Oil ☐ Refrigerant

Oil separator type: ☐ Main oil separator ☐ Main oil separator + secondary oil separator

Y–Δ setting: __________ Sec Part winding setting: ________ Sec

Starting current: ________ A Δ current: ________ A (end of starting)

Oil filter size: ______________________ μm ECO: ☐ Yes ☐ No

Oil cooler type: ______________________ Oil cooler brand: ______________

System operating condition (at 100% load)

Motor current: R: ______ S: ______ T: ______ Power consumption: ______ kW

Motor voltage: R-S: ______ S-T: ______ R-T: ______ Over load setting: ______ A

Measured operating temperature : Suction ______ ℃ Discharge ______ ℃

Measured operating pressure: Suction ______ kg/cm^2g Discharge ______ kg/cm^2g

Measured oil pressure (at main oil inlet) ______ kg/cm^2g

Measured oil pressure (at oil injection to chamber port) ______ kg/cm^2g (if apply)

Measured refrigerant pressure (at liquid injection to chamber port) ______ kg/cm^2g (if apply)

Oil cooler temperature: Inlet ______ ℃ Outlet ______ ℃

Water temperature for water cooled condenser: Inlet ______ ℃ Outlet ______ ℃ (if apply)

Water temperature for water cooled oil cooler: Inlet ______ ℃ Outlet ______ ℃ (if apply)

Measured ECO temperature (at ECO port) ______ ℃ (if apply)

Measured ECO pressure (at ECO port) ______ kg/cm^2g (if apply)

Measured liquid line temperature: Before ECO ______ ℃ After ECO ______ ℃ (if ECO apply)

Signature by inspector: ______________

6. System Application

6.1 General design

Compressor is the heart of the chiller/refrigeration system. To ensure a long trouble free operation, the following design factors need to be considered during the design stage by the system designer.

a. Oil circulation

Compare with traditional reciprocating compressor using oil pump for oil circulation, Hanbell screw compressor uses pressure differential as the pushing force for oil circulation. To ensure the capacity control function and good oil supply to compressor, minimum 6 kg/cm^2g pressure differential between main oil inlet port and suction side is necessary. System designer should consider installing the necessary pressure sensors to get the pressure values at main oil inlet port and suction side and use them as reference to monitor the oil supply condition.

For compressor working with R22 and HFC refrigerant, a general oil circulation diagram can be referred to the figure below. The pressure drop at oil cooler and oil filter should be recorded as reference. Once the

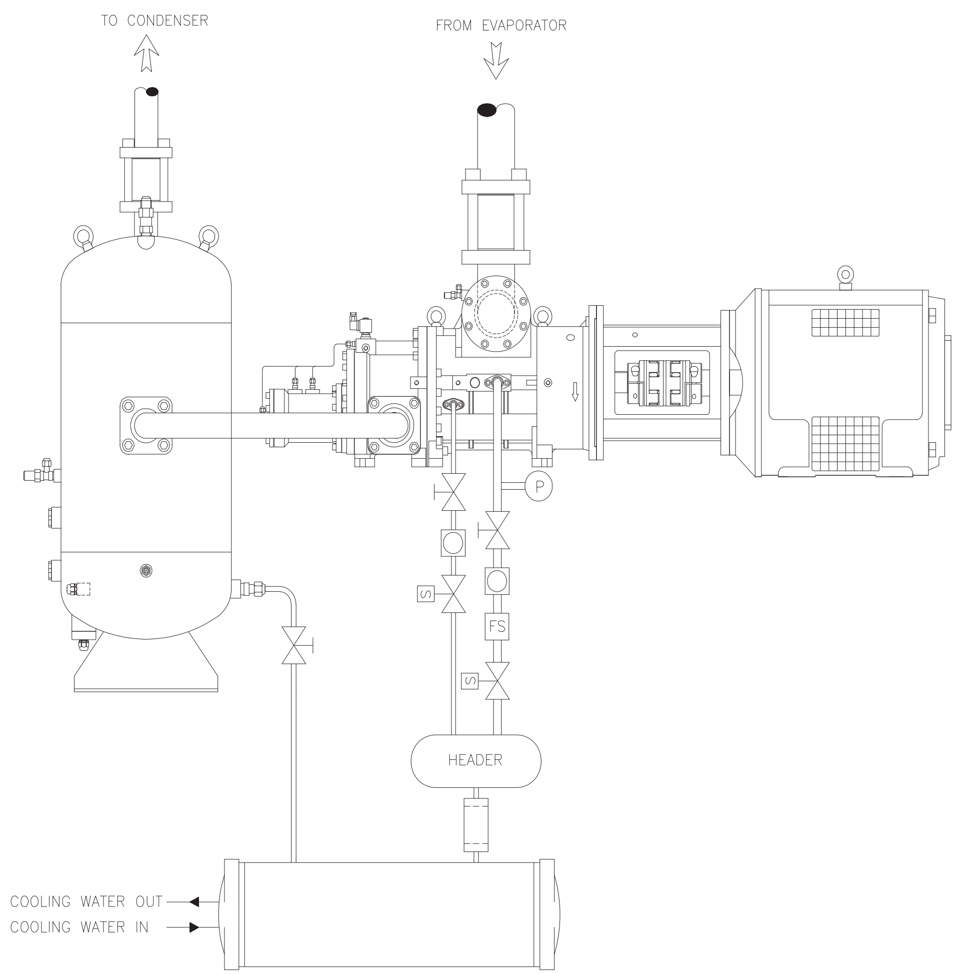


Fig. 6.1 Oil circulation design for R22 and HFC refrigerant

pressure drop increases more than 1 kg/cm^2, regular maintenance on oil cooler and oil filter should be executed to ensure good heat exchange at oil cooler and sufficient oil supply to compressor.

In the case of compressor working with R717, a secondary oil separator (fine oil separator) should be used. An oil return line from the bottom of secondary oil separator to the compressor's suction side is needed. The control algorithm of this oil line solenoid should follow the 2nd oil separator design and its mechanism.

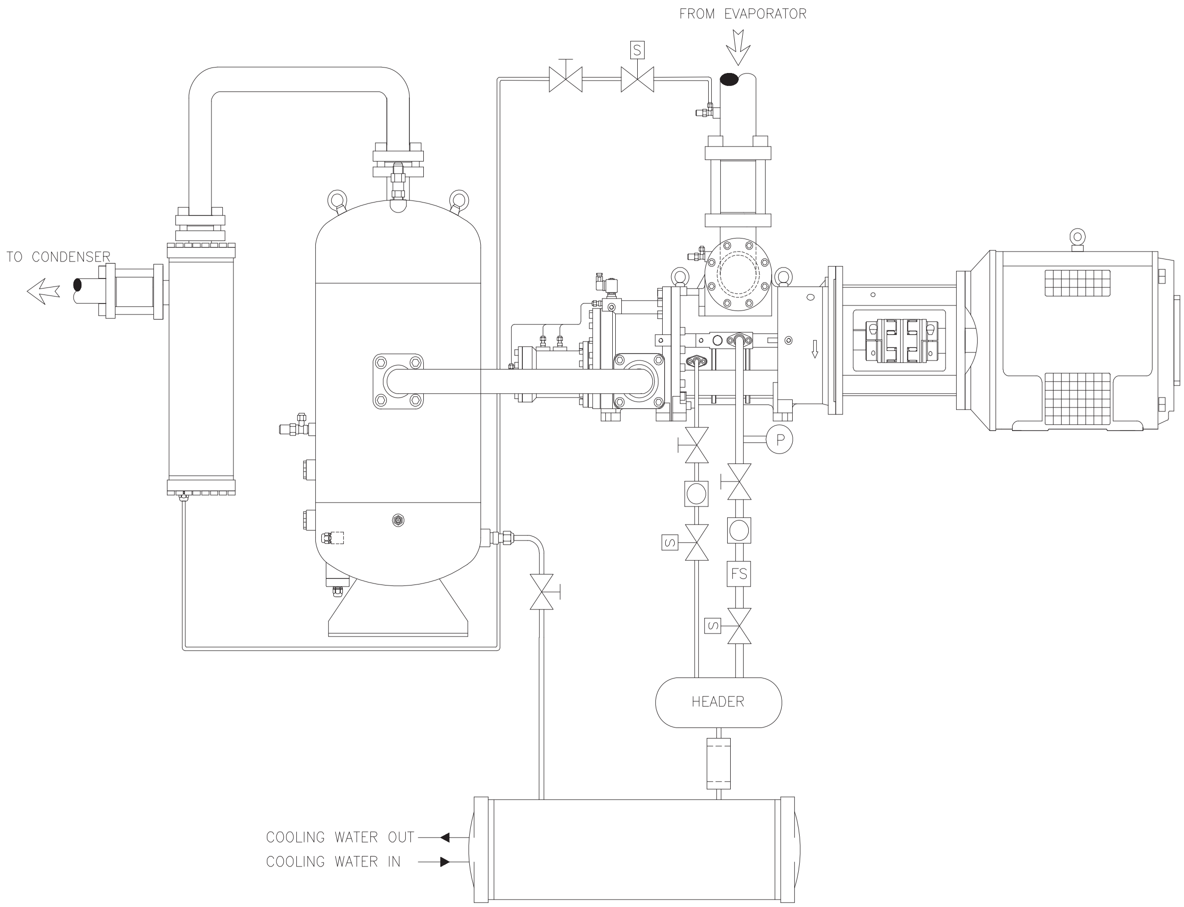


Fig. 6.2 Oil circulation design for NH3

If the oil pressure differential can't reach 6 kg/cm^2 between main oil inlet port and suction side, an oil pump should be assigned to build up the necessary oil pressure for oil circulation. User can follow Fig. 6.3 for design reference. In the oil pump section, 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

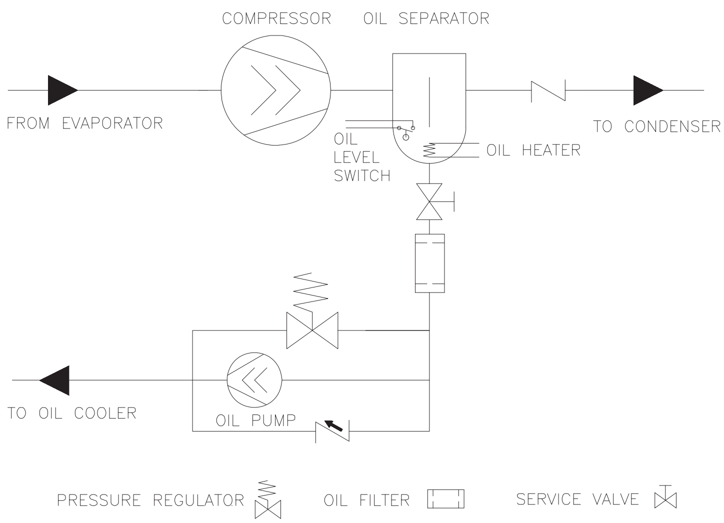


Fig. 6.3 Oil pump application

When the evaporator is far away from the compressor, system designer should consider designing proper suction line to help the oil flow back from the evaporator. From the outlet of the evaporator, the suction line should always drop vertically downward or run horizontally at a downward slope (1 cm per m) to a point where it then drops vertically downward. When the line comes to a risen part, a trapping technique similar to that for the discharge line is used. Please refer to Fig. 6.4 for details.

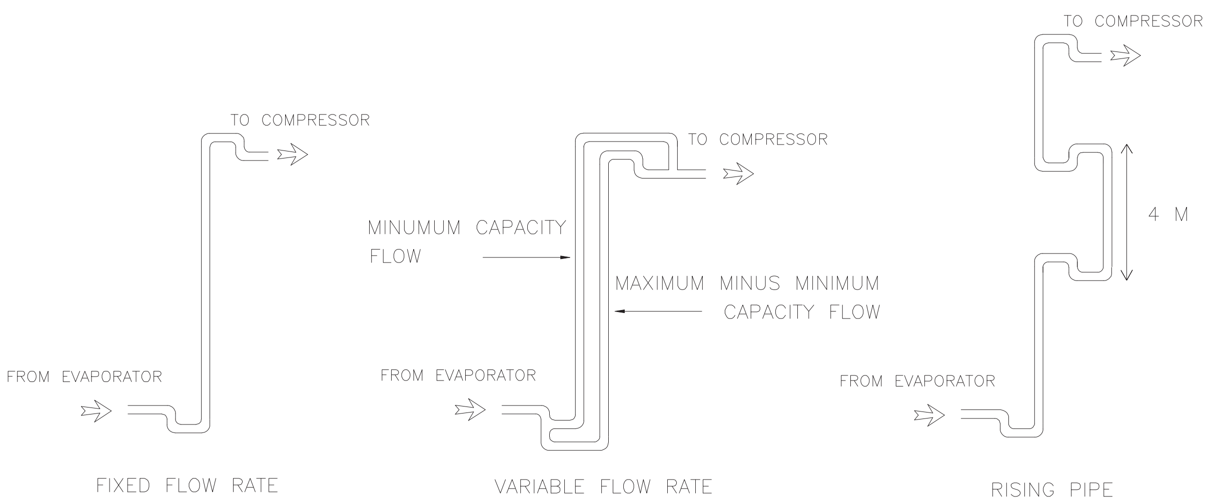


Fig. 6.4 Suction line design for risen part

For system with flooded evaporator at HFC and R22 application, a separate oil rectifier from the evaporator or the low-pressure receiver is required. Basically the oil/refrigerant mixture should be drawn off at several points in the oil-rich phase of the liquid level. Using means of heat exchange to evaporate the refrigerant fraction (e.g. in a counter flow with the warm refrigerant liquid) then feed back the oil via the suction gas line. Checking the oil level in the external oil separator is required to ensure sufficient miscibility (oil/ refrigerant) under the corresponding operating conditions in the evaporator or oil separator. When the oil circulation problem cannot be solved, a secondary oil separator is required to minimize the oil carryover to the system.

For R717 systems, because the density of R717 is lower than the oil, the oil can be drawn from the lowest point of the system. Oil shall be led back into the suction gas line regularly. Therefore, a separator which is designated for R717 application is preferable.

b. Piping arrangement

In the case of single compressor, the suction line design before compressor should have a sufficiently large volume and should not be angled towards the compressor. Please refer to Fig. 6.5 for details.

In the case of parallel compounding, the suction line runs below the level of compressor is recommended to provide the maximum possible safety. In system where liquid slugging cannot be avoided (e.g. system with long standstill under a pressure difference, hot gas defrost), the suction header shall able to take over the function of a liquid separator. Please refer to Fig. 6.6 to Fig 6.8 for design reference.

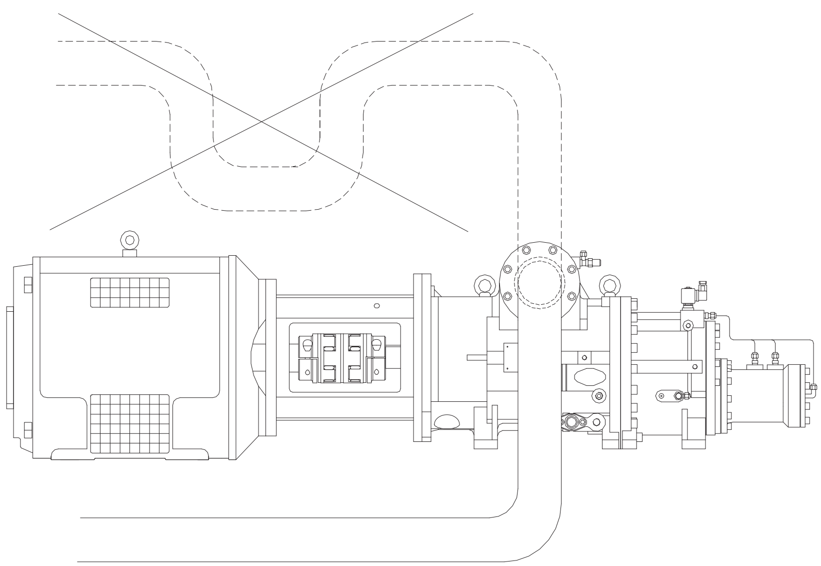


Fig. 6.5 Suction line design before compressor (single compressor)

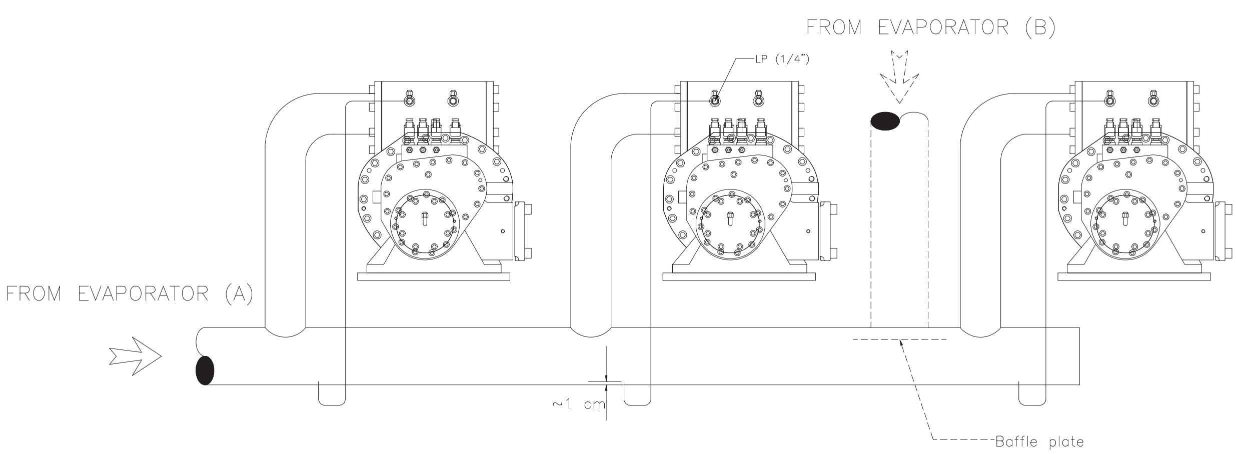


Fig. 6.6 Suction line design before compressors (parallel compounding)

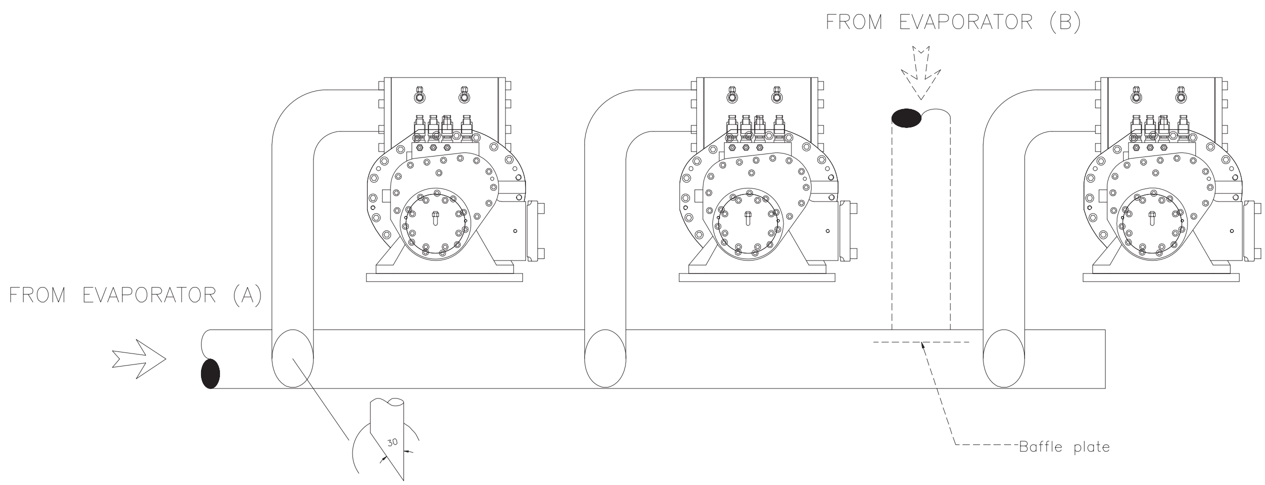


Fig. 6.7 Suction line design before compressors (parallel compounding)

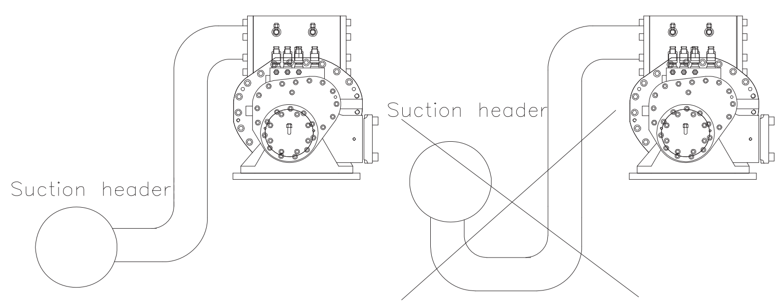


Fig. 6.8 Suction line design from suction header to compressors (parallel compounding)

When suction header has to be positioned above compressor level, the following design reference has to be considered for safe operation.

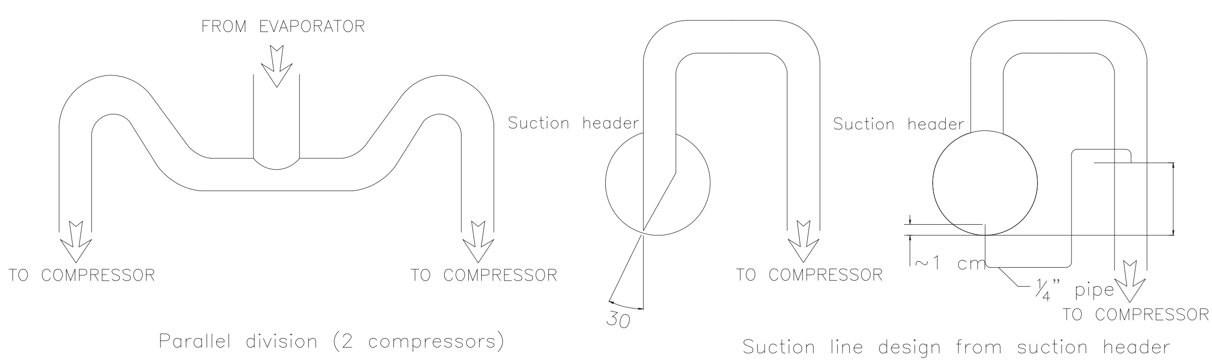


Fig. 6.9 Design reference when suction header runs above the compressors

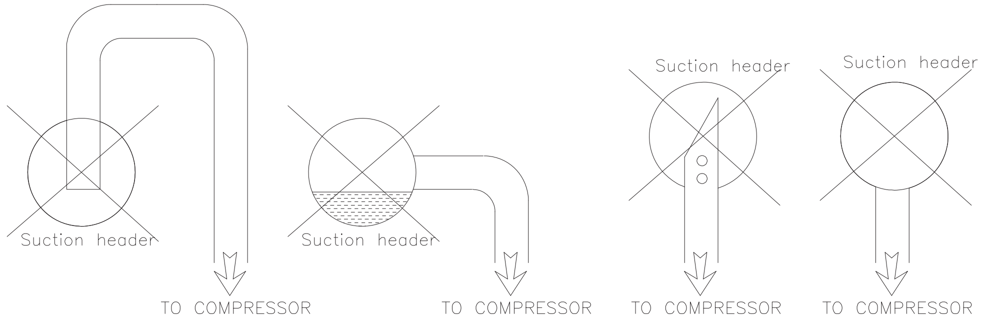


Fig. 6.10 Bad suction header design when suction header runs above the compressors

For oil separator, discharge gas and oil lines, the design concept is to ensure the compressor not being flooded with oil or liquid refrigerant during standstill because such a situation will lead to uncontrollable hydraulic pressures during start-up and in some cases comes to the bearings failure. For the safest arrangement, we recommend installing oil separator where the oil level is below the compressor outlet with inclining discharge gas line (> 1 cm per m). This design can ensure no oil flows back to the compressor during standstill.

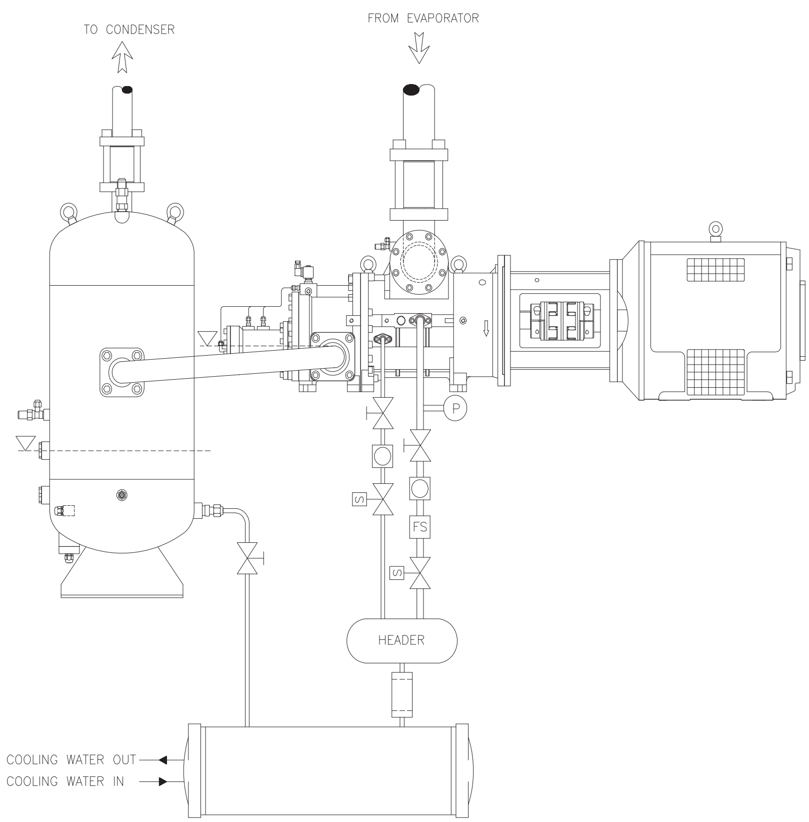


Fig. 6.11 Discharge gas line design when oil level in oil separator below the compressor level

Sometimes although the oil level in oil separator is below the compressor level, the inlet port of oil separator might above the compressor's discharge port. In this kind of situation, the discharge gas line should initially run downwards, so the oil or liquid refrigerant won't be accumulated in the compressor after the compressor stops. Please refer to Fig. 6.12 for details.

If the oil level in the oil separator above the compressor's oil inlet port, design a rise of oil line at the exit of oil separator port is a must and the discharge gas line should initially run downwards. This can ensure that the oil or liquid refrigerant won't be accumulated in the compressor after the compressor stops. (Fig. 6.13)

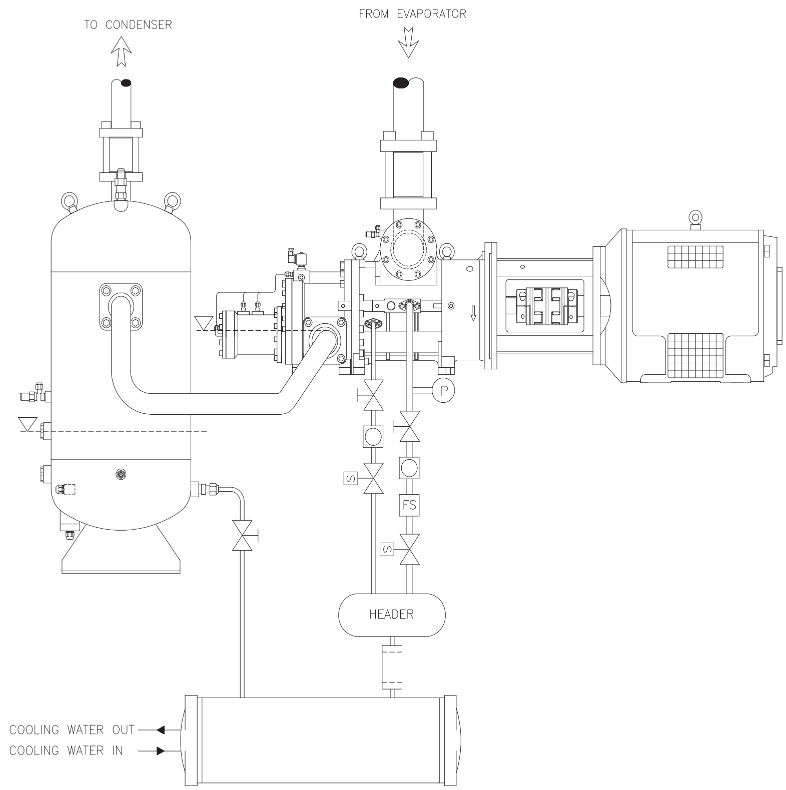


Fig 6.12 Discharge gas line design when inlet port of oil separator above the compressor level

Note: Because R404A and R507A have high vapor density, it is recommended using a muffler in the discharge line after the compressor to avoid resonant vibrations.

For oil cooler, if it's water-cooled version, install the oil cooler below the level of compressor oil inlet or raise the oil line between the cooler and compressor (Fig. 6.13). If the oil cooler is an air-cooled version, the oil outlet of oil cooler should be below the sight glass of the oil separator and also below the injection point of the compressor (Fig. 6.14). In the case of air-cooled oil cooler above the oil separator and compressor, the oil in the oil cooler will drain into the oil separator during standstill. Thus, the oil separator will be overfilled and leads to higher oil carryover during next start. Therefore, using a check valve with small spring force at the exit of oil separator is very important to prevent the oil flowing back to the oil separator. Another way to ensure the fastest possible oil supply to the compressor on start up is using a by-pass line to supply the oil to compressor from oil separator directly.

For parallel circuit of compressors, a discharge header between the discharge line and the oil separator is very important. The discharge line should have sufficient falls to the discharge header to ensure free drainage in the future. Please refer to Fig. 6.15 to see the piping arrangement and design for parallel circuit. In order to protect the compressor away from backward running when it is not working, using a check valve at discharge

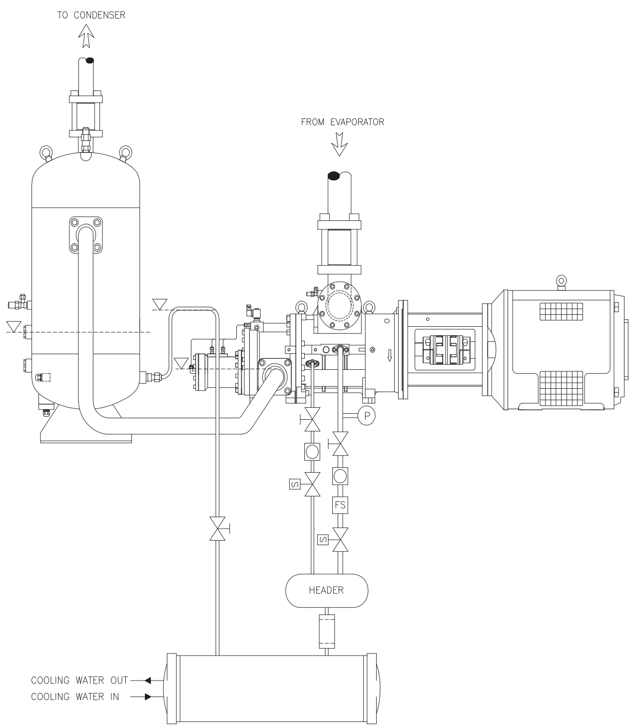


Fig 6.13 Discharge gas line and oil line design when oil level in oil separator above the compressor level

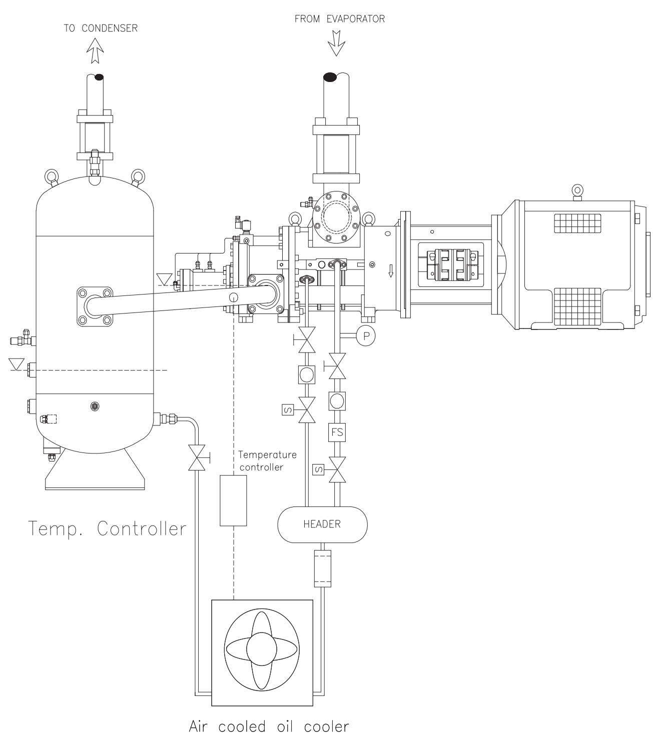


Fig. 6.14 Oil cooling by air-cooled version

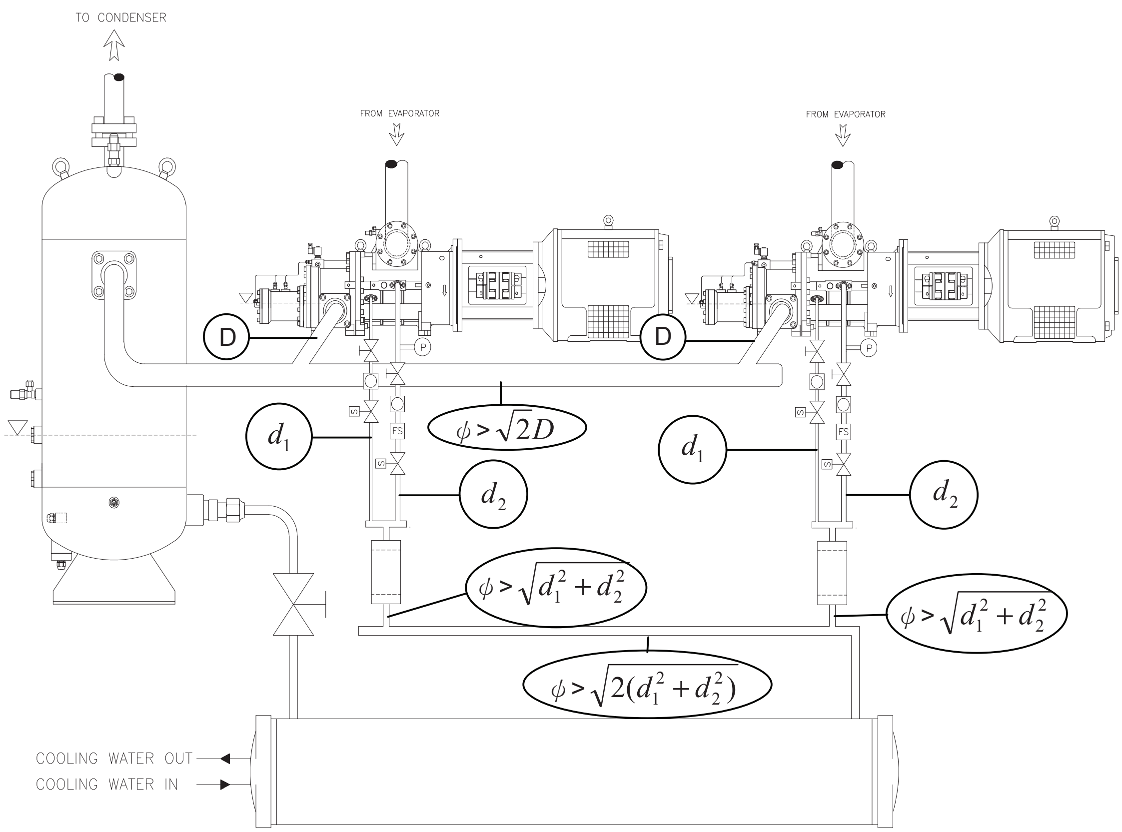


Fig. 6.15 Piping arrangement and design for parallel circuit

port is essential and important. To make the compressor easily exchangeable, the installation of stop valve will also be essential and important.

Note:

1. The individual pipe size to each oil inlet port should be equal or bigger than the correspondent port size on the compressor.
2. The individual pipe line length should not be longer than 3 m after the header to the correspondent port.
3. The oil main pipe (header) size shall refer to Fig. 6.15 to ensure minimum pressure drop and sufficient oil supply to each oil port.
4. For easier maintenance, it is recommended to use a regulation valve (ball valve) in the oil pipe line to each oil inlet port.

c. Temperature control

Temperature control is always critical for a long trouble free system running. With good temperature control, oil can work at proper working temperature which can help the oil to increase its reliability and stability. When the compressor has sufficient oil supply with good lubrication on bearings and rotors, long compressor life will not be too difficult to achieve.

When we talk about the temperature control, discharge temperature will be our first target. There is a general rule that keeps the discharge temperature at 80 ℃ at all operating conditions and at all capacity range. High oil temperature degrades oil properties fast. Also, slurry is easily formed under high working temperature and more problems come after. Therefore, system designer should calculate the cooling needs for all possible operating conditions and reserve safety factor (10%~15%) in case that the heat exchanger or any system component can't reach its 100% performance.

The most common way to control the discharge temperature is external oil cooling and liquid injection. According to the refrigerant or gas applied in the system, the following oil cooling methods can be applied to the system.

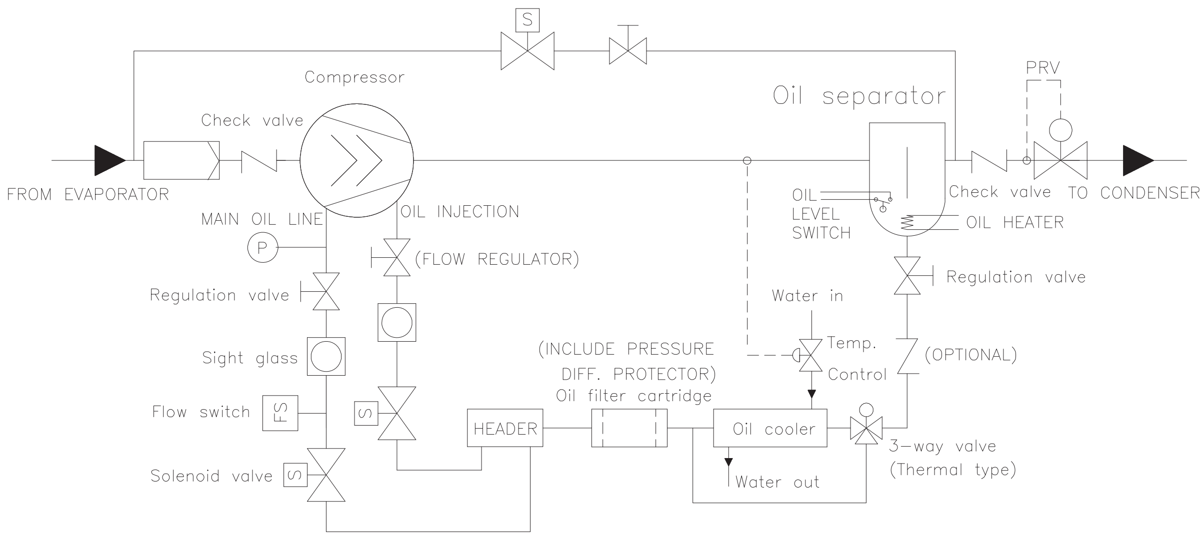


Fig. 6.16 Water-cooled oil cooler application

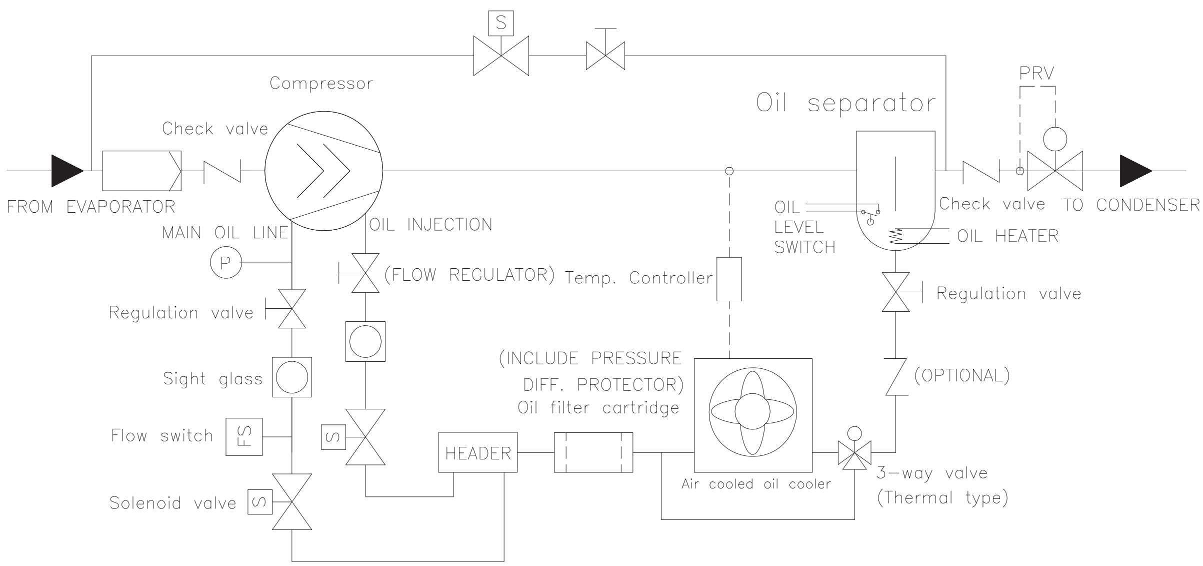


Fig. 6.17 Air cooled oil cooler application

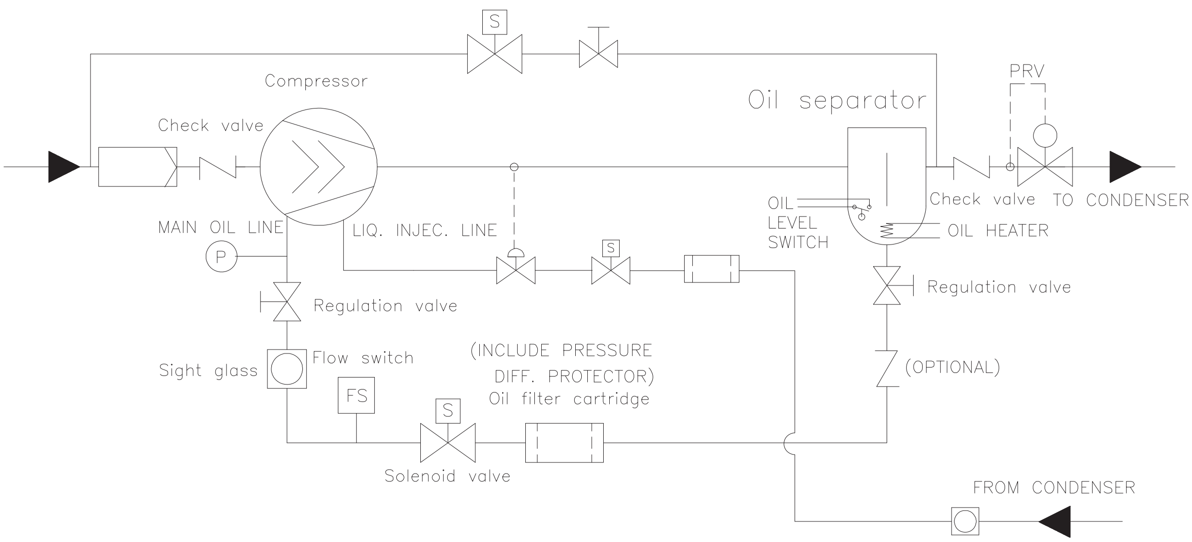


Fig. 6.18 Liquid injection oil cooling

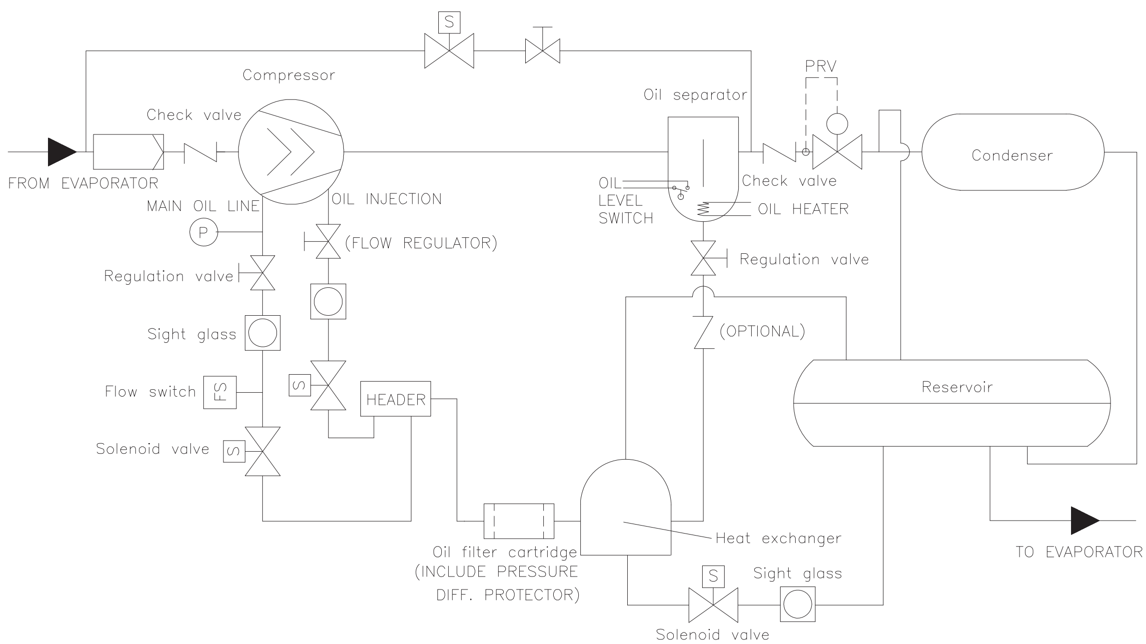


Fig. 6.19 Thermosyphon oil cooling

Note:

1. The oil cooler should be controlled according to the discharge gas line temperature. Using entry oil temperature as control reference should be confirmed by Hanbell for safety issue.
2. The oil cooler should be installed near the compressor to avoid long piping which will cause higher pressure drop.
3. The pressure drop in oil cooler should not exceed 0.5 bar during normal operation.
4. The arrangement of piping for oil cooler should avoid gas accumulation and ensure that the oil cooler is installed below the compressor and external oil separator.

5. The control algorithm of oil line solenoid valve should ensure no oil flows into compressor during the compressor off period.
6. Service valve (ball valve) is recommended to be installed after the oil cooler for service purpose.
7. For low ambient working temperature (below 20℃), an oil bypass line at oil cooler will be needed to ensure a quick warm up.

d. Liquid compression

Liquid compression can be classified as oil compression and liquid refrigerant compression. For oil compression it is extremely dangerous to the compressor because oil can't be compressed. If oil compression occurs, bearings need to suffer very big load which might cause severe damage to rollers and balls in bearing. Therefore, be aware of oil management and not to charge oil into compressor when the compressor is not running.

Liquid refrigerant compression is also a killer to short the compressor life. When liquid refrigerant flow into the compressor, the liquid refrigerant will wash out the oil where passed by. Those bearings might work without lubrication temporarily and causes wear on them. The same situation will occur at those rotors and higher possibility of mechanical contact between rotors can be predicted. This will also lead to scratches on rotors and become the origin of higher noise and lower volumentric efficiency for compressor. To avoid liquid's flooding back to compressor, system designer can use an accumulator and install it before the suction port or simply maintain good suction superheat to avoid liquid refrigerant compression.

e. Parallel system

In the rack or parallel system, oil management is extremely important. Due to open type compressor needs an external oil separator, sharing of a common oil separator becomes possible. Using parallel system can have the following advantages.

- Extend the capacity limitation to higher level with multiple compressors.
- The combination of compressors can be decided by actual needs. There is no need to use the identical one.
- Each working compressor can have its own working temperature by system design and arrangement.
- Maximize the usage of external oil separator.
- The start-up current can be lower at parallel system compare with the system with one bigger compressor.
- Extensive options of capacity control which helps compressors work safely.

The concept diagrams of twin compressor parallel system are shown below. They have slightly differences according to their operating condition and accessory application. Accessories installed on the system diagram are recommended for the safe operation and system protection. If other application and protection are considered to be installed, please contact HANBELL or local distributor/agent for more information or further confirmation.

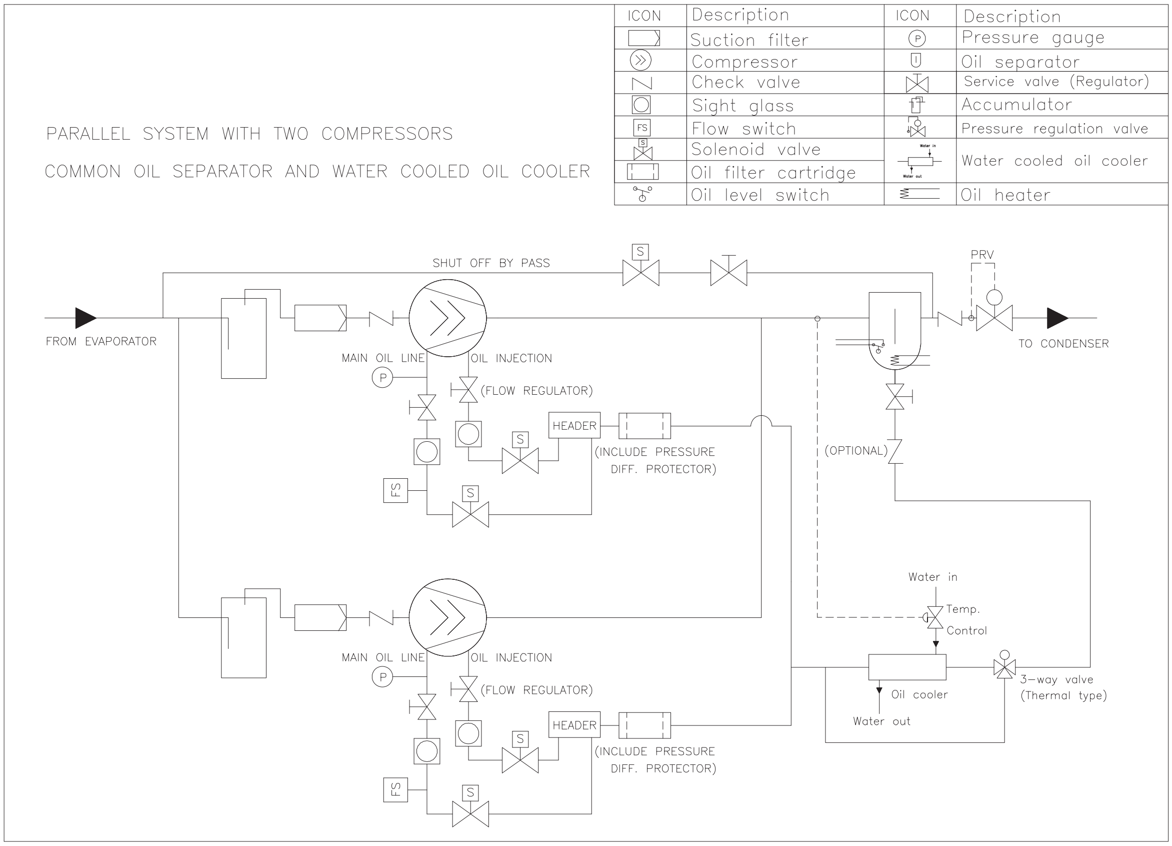


Fig. 6.20 Parallel compounding with common oil separator and water cooled oil cooler

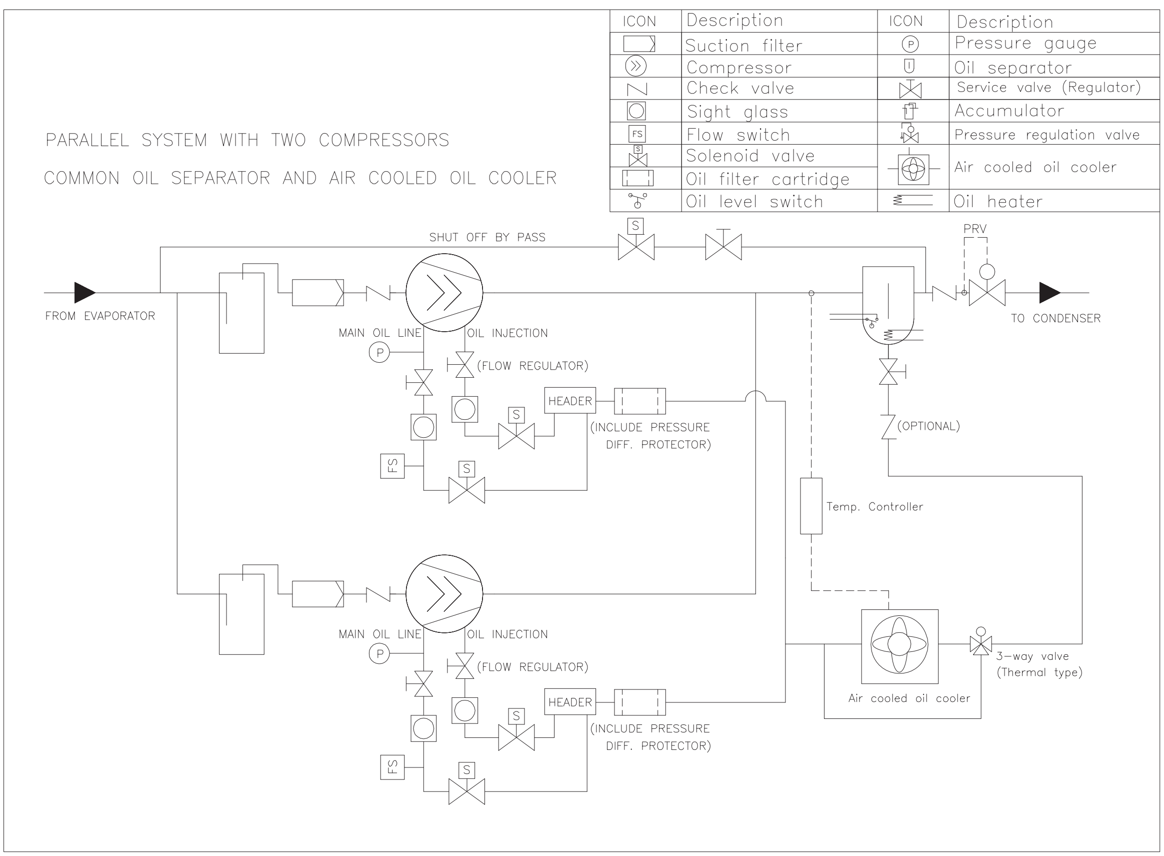


Fig. 6.21 Parallel compounding with common oil separator and air cooled oil cooler

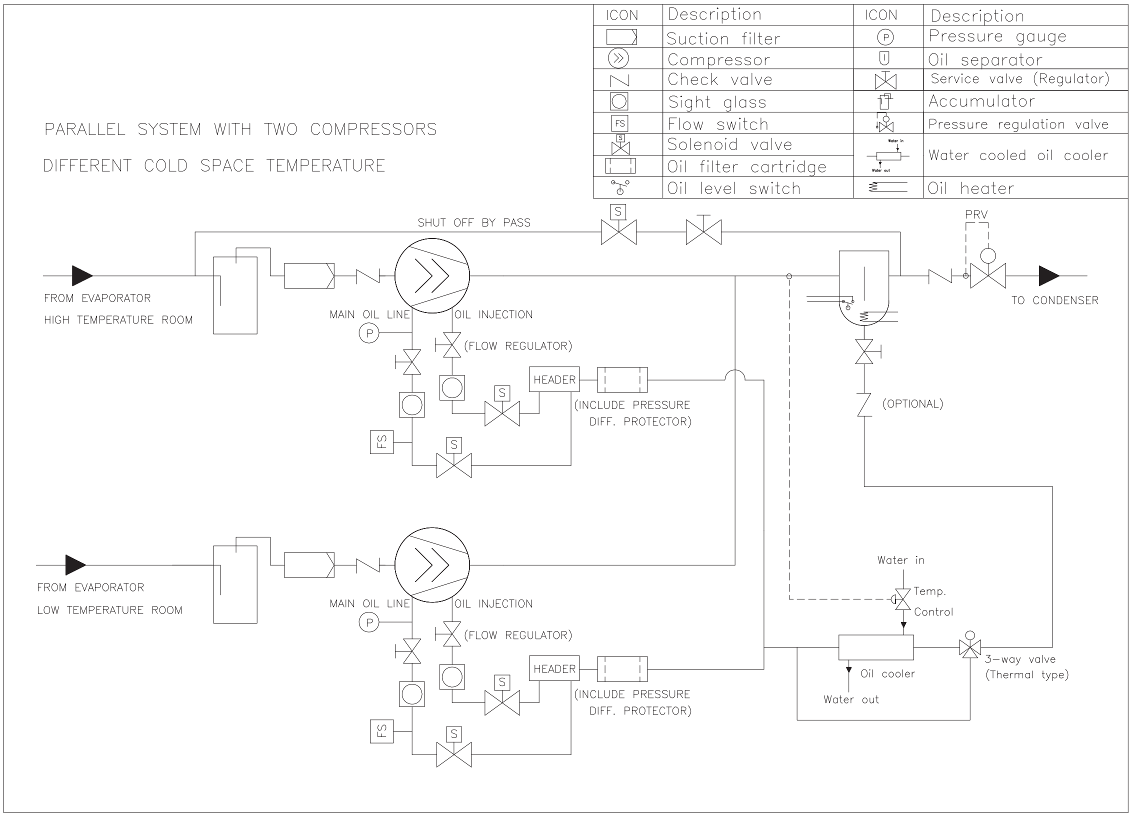


Fig. 6.22 Parallel compounding for different cold space temperatures

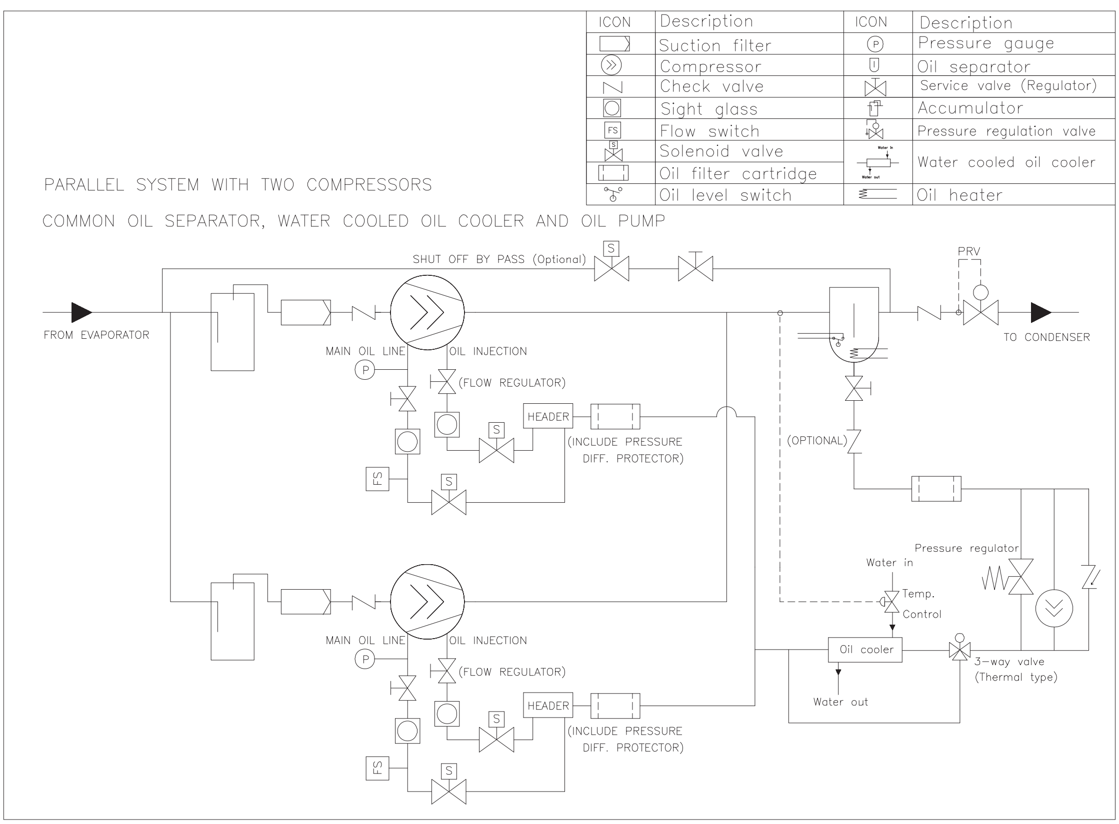


Fig. 6.23 Parallel compounding with common oil separator, water cooled oil cooler and oil pump

6.2 Specific design

When the evaporating temperature below -20 ℃, one stage system might not satisfy the customer's expectation. Not only for the poor system efficiency, but also for the component cost which is used for providing external cooling to compressor. In this kind of situation, using economizer or adopting 2-stage system will be a smart way to achieve the needs.

Economizer application

Economizer is an economical way to increase the system's cooling capacity and efficiency. Compare with using 2 compressors to achieve 2-stage compression, economizer achieves the same goal by subcooling liquid from the condenser through a heat exchanger or flash tank before it goes to the evaporator. The subcooling is provided by flashing liquid in the heat exchanger or flash tank and the flashing liquid vaporizes to an intermediate pressure level. The intermediate pressure gas flows back to the ECO port then is injected to the compression chamber. The power consumption of the compressor increases slightly compare to the additional work that takes place at a better level of efficiency especially at high pressure ratio application.

HANBELL screw compressor can be fitted with an additional middle connection for economizer operation. With this form of operation, refrigeration capacity and also system efficiency can be improved by means of a sub-cooling circuit or two-stage refrigerant expansion. Based on HANBELL extensive research, a special design of the Economizer connection has been developed so that the connection causes no additional back flow losses during compression. As a result, compressor capacity is fully retained in all operating conditions. Please refer to Hanbell selection software for the calculation of Economizer at different operating conditions.

a. Economizer by sub-cooler

With this form of operation, a heat exchanger (refrigerant sub-cooler) is used to cool down liquid refrigerant. The sub-cooling is achieved by injecting a small part of the refrigerant from the condenser into the sub-cooler. The superheated vapor is pulled into the compressor at the Economizer connection and mixed with the vapor from the evaporator, which has been already slightly compressed.

The sub-cooled liquid is at condensing pressure with this form of operation, the pipeline to the evaporator does not therefore require any special features, aside from insulation. The system can be generally applied. Figure 6.24 shows the system with Economizer, sub-cooler.

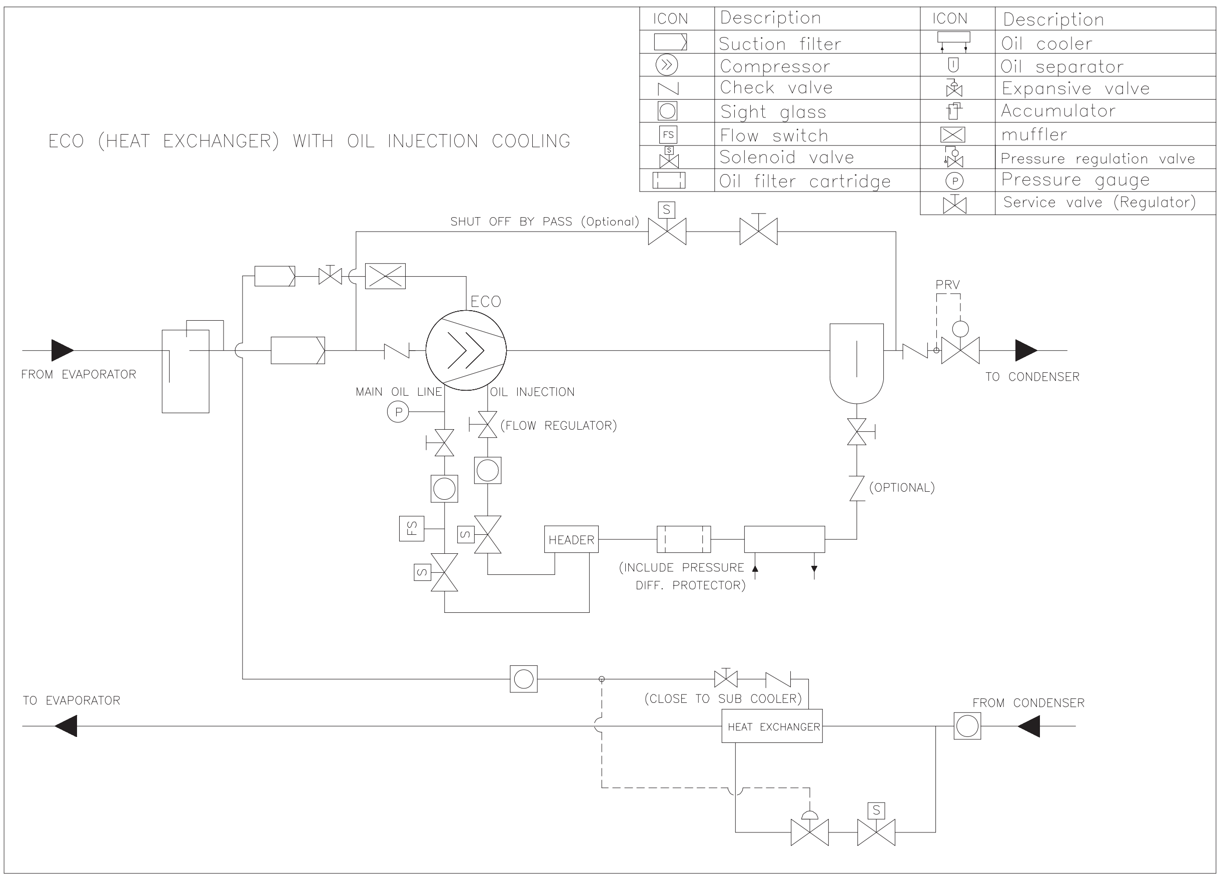


Fig. 6.24 ECO application by heat exchanger

b. Economizer by flash tank

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

This form of operation gives the most economical thermodynamic performance due to direct heat exchanging. As the intermediate pressure is reduced to the boiling point temperature, this system should only be used with flooded evaporators. Figure 6.25 shows the system with Economizer, flash tank.

Note:

It is strongly recommended to install a muffler or buffer before the economizer port because of nature of pulsation caused by screw compressor.

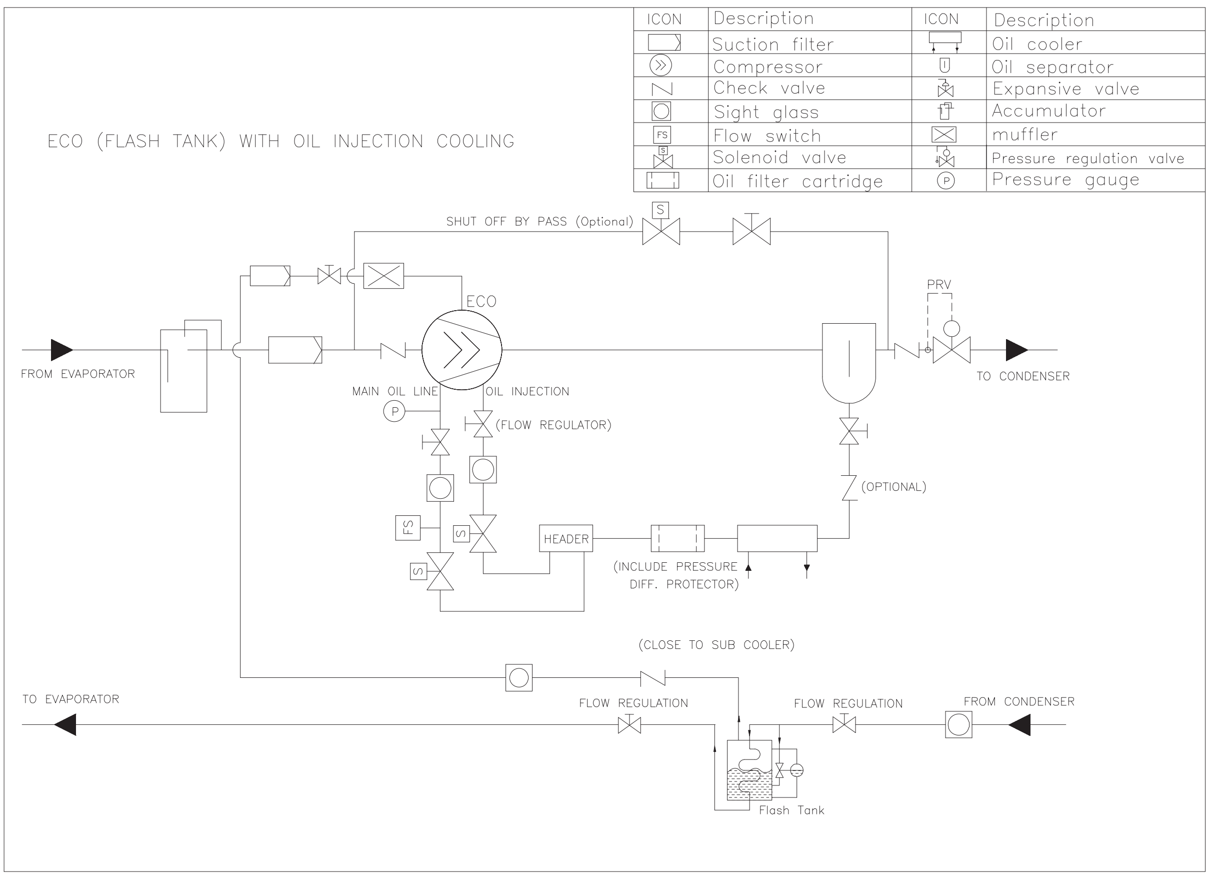


Fig. 6.25 ECO application by flash tank

2-stage system application

For low evaporating temperature or high pressure ratio operating condition, 2-stage system design can have better working efficiency and lower kW/TR. The drawing below is an example for design reference.

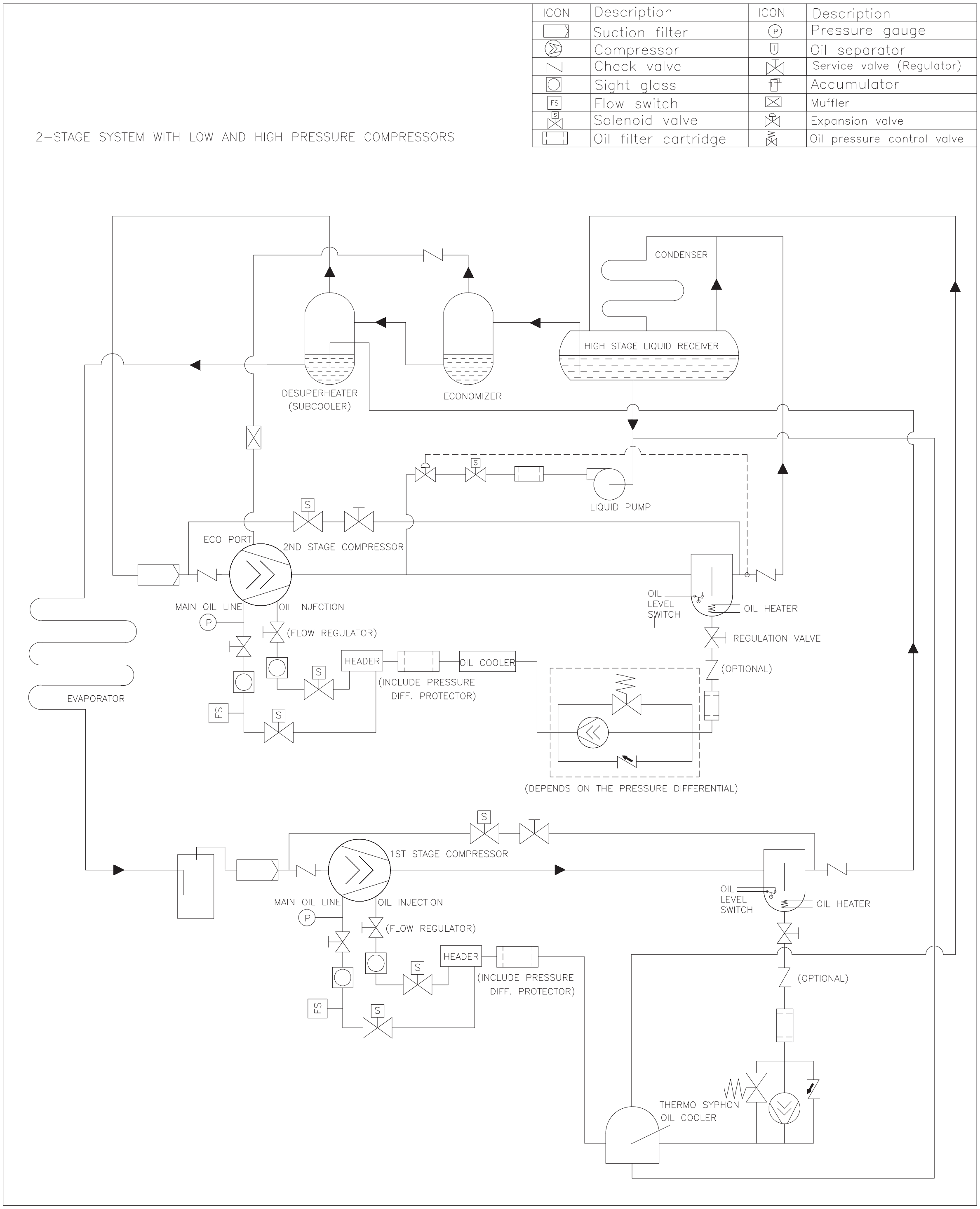


Fig. 6.26 2-stage system with separate low and high pressure compressors

7. 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 writing down its working parameters everyday. Most of time abnormal system condition can be found via comparing its working parameters with its daily operating data.

7.1 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. Oil filter

In the beginning of compressor operation, the oil filter might get clogged by debris and unwanted material. Therefore, checking it at the end of commissioning or after 200 hours of initial running can ensure good and sufficient oil supply to the compressor. A pressure differential protector should be installed to measure the pressure drop on oil filter. When the pressure drop reaches 1 bar or the value specified by filter manufacturer, user should stop the compressor and clean/replace the filter to ensure good oil circulation. Running a compressor for long period with improper filter pressure drop can starve the compressor of oil and lead to premature bearing failure.

b. 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.

c. 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.

d. Oil separator

Normally the debris or dirty matters are stopped by suction strainer before entering the compressor, so there should be no clogging or contamination in short time at oil separator. However, we still recommend checking it at the end of commissioning or after 200 hours of initial running to confirm its condition. If its condition is good, we can ensure a long continuous operation at oil separator.

e. 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 and motor's life. Check the oil acidity periodically and change the oil if the oil acidity value measured lower than pH6. Change the deteriorated drier periodically if possible to keep the 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.

7.2 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. 64 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

Oil plays a very important role for lubrication of internal parts. It is important to keep the oil in good condition for compressor and mechanical equipment. Therefore, periodical sampling and quality analysis are strongly recommended to know the oil quality. Besides checking oil at 200 hours of initial operation, user should check the oil every half year and replace it at least once every year depending on process condition.

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 wear 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 operatinging 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-830	RG-1090	RG-1280	RG-1520
Vibration value (mm/s)	3.0	3.8	3.8	3.8	3.8	3.8

e. Complete overhaul

The 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.

8. Selection program

Installation procedure

Step:

1. The selection program can be installed in the 32-bit operating system like Windows98, NT or the above edition (Windows ME, 2000, XP). The disk space should be at least 300MB above for program operation.
2. The best screen resolution setting should be 800x600 pixels or above.
3. Before the program installation, please close all running programs first.
4. To start the installation, please double click **“setup.exe”** and follow the instruction to finish the installation.
5. The software will decompress automatically.

ESP Operating Procedure:

Step:

1. Before using our selection software, please check any upgrade of selection software at Hanbell website

2. Enter the main window and it will present 「**RC**」, 「**RCF**」, 「**RC2-A**」, 「**RC2-B**」, 「**RC2-AF**」, 「**RC2-BF**」, 「**LA**」, 「**RV**」, 「**RC2-V**」, 「**RG**」 **and** 「**RT**」 buttons.

3. After selecting「**RG**」, it will present several function buttons:

   (3.1) choose the unit, 「**SI**」 or「**Imperial**」. **(default unit is SI)**

   (3.2) 「**PERFORMANCE**」button shows the performance sheet of the compressor

The above window is the operating mode of a compressor, just key-in the following condition and then click the「**Calculate**」 button.

- Refrigerant type
- With economizer (yes/no)
- Compressor model
- Cooling method (liquid injection to chamber/oil cooling)
- Power supply (default is 380V 3 50Hz)
- Partial load percent (%)
- Evaporating SST (℃,℉)(default is 0 ℃)
- Condensing SCT (℃,℉)(default is 40 ℃)

Showed the calculated performance data in the middle of the window.

In the lower part of the window, there are several kinds of buttons:

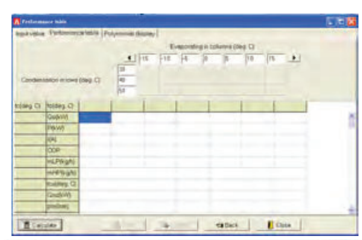
「**Calculate**」: Must click this key, to start the calculation

「**Tables**」: Calculate the coefficient of performance by means of polynomial or create the performance table

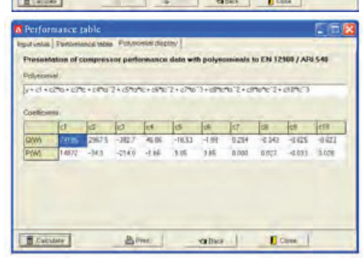
「**T.Data**」: Check RG series compressor technical data

「**Print**」: Print or output the performance data

「**Vi selection**」: Compare the performance data with different Vi value



(3.2.1) Click「**Tables**」 button and the default window will appear like right one. It can calculate the performance according to the SCT/SST setting.



(3.2.2) Click the polynomial display button and then click 「**Calculate**」. The polynomial coefficients can be gotten.

(3.3) 「***SELECTION***」 is for model selection. It helps customer to find a proper model for their application.

After clicking the 「***SELECTION***」button, the following data need to be input.
- Refrigerant type
- Cooling Capacity (KW)
- Evaporating SST
- Condensing SCT
- Power supply

The data shown in the middle of the window is the compressor model and its performance

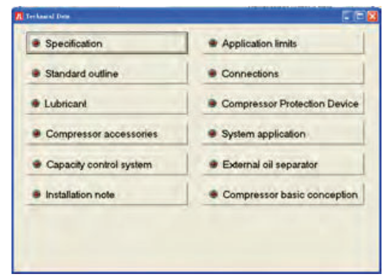
「**Calculate**」: Must click this button to start the calculation. After typing the required data, click this button and will show the compressor model and its performance.

「**T.Data**」: This bottom is the same as function key of technical data (3.4)

「**Print**」: Print or output the calculation result

(3.4) 「***T.DATA***」button is used to get the detailed technical information that the customer needs to know including specifications, dimensions, connections, accessories, and others.

After entering the 「***T.DATA***」 function, the following items can be refered:



◎**Specification**: Introduce the design specification of the RG series compressor.

◎**Standard outline**: Compressors outline drawing.

◎**Lubricant**: Introduce the suitable lubricant oil for various conditions, and features of viscosity, flash point, pour point, moisture, and floc point, etc…

◎**Compressor accessories**: It includes the standard and optional compressor accessories.

◎**Capacity control system**: Introduce the compressor capacity control system.

◎**Installation Note**: It shows the compressor handling, installation and pre-cautions before installing the compressors and some accessories.

◎**Application limits**: It shows the compressors operation limitation based on various refrigerant.

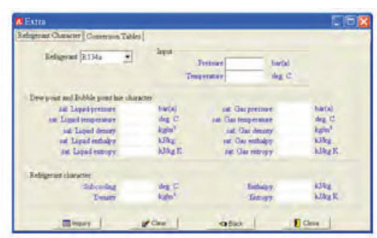
◎**Connections**: It shows the size of bushings.

◎**Compressor Protection device**: It introduces the compressor protection devices.

◎**System application**: It includes system application suggestion, piping drawings and illustrations.

◎**External oil separator**: Introduce oil separator (OS series), application, dimension, and outline, etc…

◎**Compressor basic conception**: Introduce Hanbell compressors design, concept and version.



(3.5) 「**EXTRA**」includes refrigerant's basic data according to (Pressure – Temperature) and unit conversion.

After entering the 「**EXTRA**」 function, it shows the following information:

「**Refrigerant Characteristic**」 (R22, R134a, R407C, R404A, R507A, R717)

「**Conversion Tables**」:

Temperature, Length, Area, Volume, Mass, Pressure, Specific Volume, Density, Velocity, Flow Rate, Power, Specific Enthalpy, Specific Entropy (specific heat)

(3.6) 「**ABOUT**」Shows the edition of this software and technical support.

(3.7) 「**EXIT**」Leave current window

9. Warranty

All HANBELL screw compressors are put through strict quality and performance testing prior to shipping from the factory. The screw compressors are manufactured from the finest quality material and are warranted for one year after the completion of installation and commissioning at the jobsite or up to18 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 reason: 1) damage 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) damage caused by modification of any part on or connected to the compressor, and/or

4) damage caused by the improper maintenance or repair by a non-authorized technician.

5) HANBELL will also not responsible for any accident, which may happen to personnel while installing, setting up, operating, maintaining, and/or repairing the compressor.