INSTRUCTION FOR
OPERATION & MAINTENANCE

RECIPROCATING COMPRESSOR

(KSDWNL-2, 400HP OXYGEN GAS COMPRESSOR)

CUSTOMER : BOC INDIA LIMITED

PROJECT NAME : O2 COMPRESSOR FOR SESA GOA PROJECT

ITEM NO. : 2.0 FOR 100TPD ASU

KwangShin
Dependable Compressors

KWANGSHIN MACHINE INDUSTRY CO., LTD.
180-12, OKOG-RI, CHILWON-MYON, HAMAN, GYEONGNAM, KOREA.

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CHAPTER I. SPECIFICATION OF COMPRESSOR

RECIPROCATING COMPRESSOR DATA SHEET

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1	CUSTOMER	BOC India Limited			PREPARED BY :
2	PJT. NAME	O2 Compressor For Sesa GOA Project			PREPARED BY :
3	M/O NO.	SR11006	ITEM NO.	2.0 For 100 tpd ASU	REVIEWED BY :
4	SERVICE	Oxygen Gas Compressor			REVIEWED BY :
5	NO. REQ'D	WORKING 1	STAND-BY 0	TOTAL 1	APPROVED BY : W.H.KIM

6	(OPERATION CONDITIONS)						
7	NO. OF STAGE(S)		TWO (2)				
8	GAS HANDLED	(Mol.%)	Oxygen Gas (O2 : 92,N2 : 4,Ar : 4,Vol.%)				
9	BAROMETRIC PRESSURE	(mmHg)	760				
10	CAPACITY (DRY)	(kg/hr)	4308.5				
11		(Nm^3/hr)	3000.0				
12		(Am^3/hr)	2719.7				
13	(SUCTION CONDITIONS,CYLINDER FLANGE SIDE)						
14	STAGE		(1ST)		(2ND)		
15	PRESSURE	(kg/cm^2. G)	0.190 (1.2Bar.A)		2.50		
16	TEMPERATURE	(℃)	20		40		
17	RELATIVE HUMIDITY	(%)	DRY		DRY		
18	MOLECULAR WEIGHT	(kg/mol)	32.2		32.2		
19	Cp/Cv	(K1)	1.40		1.40		
20	COMPRESSIBILITY	(Zs)	1.00		1.00		
21	(DISCHARGE CONDITIONS,CYLINDER FLANGE SIDE)						
22	PRESSURE	(kg/cm^2. G)	2.65		6.12 (6.0Bar.G)		
23	TEMPERATURE	(℃)	125		107	(COOLER OUT : 40℃)	
24	Cp/Cv	(K2)	1.40		1.40		
25	COMPRESSIBILITY	(Zd)	1.00		1.00		
26	INTER STAGE PRESS. DROP	(kg/cm^2. G)	0.15		0.00		
27	COMPRESSION RATIO	(Rc)	3.011		2.025		
28	BHP OF EACH STAGE	(kw)	160.0		110.6		
29	TOTAL BHP	(kw)	270.6				
30	ROTATIONAL SPEED OF COMP'R (rpm)		460				

31	(OTHER CONDITIONS)										
32	COMP'R TYPE	☐ "D" TYPE	■ "WNL" TYPE	☐ "L" TYPE	☐ "C" TYPE	☐ "W" TYPE	☐ "OPT" TYPE				
33		■ NON-LUBRICATED	☐ LUBRICATED								
34		■ WATER COOLED	☐ AIR COOLED								
35	DRIVER	■ V-BELT	TYPE : 8V	PCS : 13	LENGTHS : C = 1820 mm),	235 inch.					
36			COMP' PULLEY DIA. : 1000 mm		MOTOR PULLEY DIA. : 467 mm.						
37		☐ DIRECT BY COUPLING			COUPLING DIA. : mm						
38	COMP'R ROTATION (view comp'r pulley side)	■ CW	☐ CCW								
39	ELECTRIC MOTOR SPEC.	TYPE	TEFC		MANUFACTURER	BY PURCHASER'S SCOPE					
40		SPEC.	300 kw	415 volts	3 phase	50 Hz	6 poles	985 rpm			
41		STARTING METHOD	☐ DIRECT ON LINE START		☐ Y-△	☐ REACTOR					
42		INSULATION CLASS	■ B(temp.)	■ F	LOCATION	■ INDOOR	☐ OUTDOOR				
43	CAPACITY CONTROL	■ SUCTION VALVE UNLOADER : FINGER		■ ON AIR/POWER FAILURE : UNLOADER							
44		■ START-STOP	■ 2-STEP	☐ 3-STEP	☐ 5-STEP	■ BY-PASS CONTROL					
45		☐ CONTROL PANEL (BY PURCHASER'S SCOPE		☐ BY PURCHASER'S INSTRUMENT							
46	COMP'R LOCATION	■ INDOOR	☐ OUTDOOR	☐ UNDER ROOF							
47	ELECTRIC AREA	■ NON-HAZARDOUS	☐ HAZARDOUS	☐							
48	CONTROL POWER	■ AC 110 volts	1 phase	50 Hz							
49	PAINTING COLOR (Munsell No.)	■ MANUFACTURER'S STANDARD (2.5G 6/2)	☐ N-6 (LIGHT GRAY)								
50	APPLICABLE CODE	■ MANUFACTURER'S STANDARD	■ KS,JIS	■ ANSI,ASME							
51	REMARKS										
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3	SERVICE	Oxygen Gas Compressor		

	(CYLINDER DATA)				
5	STAGE	(1ST)	(2ND)	-	-
6	NO. OF CYLINDER PER STAGE	2	1		
7	SINGLE / DOUBLE ACTING	DOUBLE	DOUBLE		
8	CYLINDER LINER YES / NO	NO	NO		
9	CYLINDER LINER WET / DRY	-	-		
10	OUTSIDE DIA. LINER (mm)	-	-		
11	BORE (mm)	450	380		
12	STROKE (mm)	200	200		
13	PISTON DISPLACEMENT (m^3/hr)	3485.4	1239.0		
14	VOLUMETRIC EFFICIENCY (%)	78.03	81.18		
15	NO. OF PISTON RING PER STAGE	2*2PCS	3PCS		
16	NO. OF RIDER RING PER STAGE	2*2PCS	2PCS		
17	NO. OF SUC. / DIS. VALVE PER STAGE	6/6*2PCS	6/6PCS		
18	TYPE OF VALVES	PLATE	PLATE		
19	PISTON SPEED (m/s)	3.067	3.067		
20	ROD DIAMETER (mm)	55	55		
21	ROD LOAD-C (kg)	3917	4165	(Max. 7500)	
22	ROD LOAD-T (kg)	3850	3960	(Max. 7500)	
23	DESIGN PRESS. (kg/cm^2. G)	6.0	8.0	(GAS SIDE)	
24	DESIGN TEMP. (℃)	180	180	(GAS SIDE)	
25	HYDRO. TEST PRESS. (kg/cm^2. G)	9.0	12.0	(GAS SIDE)	
26	SUCTION FLANGE SIZE	8"*2	8"	(CYLIN.SIDE)	
27	RATING / FACING	M/STANDARD	M/STANDARD	(CYLIN.SIDE)	
28	DISCHARGE FLANGE SIZE	8"*2	8"	(CYLIN.SIDE)	
29	RATING / FACING	M/STANDARD	M/STANDARD	(CYLIN.SIDE)	
30	TYPE OF MAIN BEARING	■ SPHERICAL ROLLER B/R		□ METAL B/R	

	(COMPRESSOR MATERIALS)			
32	CYLINDER (S)	GC250 "Cr"Coating	VALVE SEAT (S)	STS431
33	CYLINDER LINER (S)	NONE	VALVE GUARD (S)	STS431
34	PISTON (S)	GC250 "Ni"Coating	VALVE PLATE (S)	STS420J2
35	PISTON RING (S)	BRONZE FILLED PTFE	VALVE SPRING (S)	STS631
36	RIDER RING (S)	BRONZE FILLED PTFE	CRANK SHAFT	SF540A
37	DIAPHRAGM	NBR	CROSS HEAD (S)	GC250
38	PISTON ROD (S)	STS420J2"Tc"Coating	CONNECTING ROD	SC480

39	COMP'R PACKING	■ NON-LUBRICATED	□ BUFFER GAS SYSTEM			
40		■ SELF COOLED	■ PACKING CASE MATERIAL : CS			
41		■ BRONZE FILLED PTFE	□ BRONZE	□ CARBON	□ METALLIC	□ TBM
42	DISTANCE PIECE	□ STANDARD	□ EXTRA LONG SINGLE COMPARTMENT	■ TWO COMPARTMENT"C"		
43	LUBRICATION	□ SPLASH SYSTEM				
44		■ PRESS. SYSTEM	OIL PUMP DRIVEN			
45			■ COMP'R SHAFT FOR MAIN PUMP			
46			■ ELECTRIC MOTOR FOR AUX. PUMP			
47			□ MANUAL FOR START			
48		CRANK CASE OIL CAPACITY 65 (ℓ)		□		
49		□ ELECTRIC HEATER (W/THERMOSTART)		□ STEAM		

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3	SERVICE	Oxygen Gas Compressor		

(ACCESSORIES)

■ SNUBBER (CS)

TYPE ■ VOLUME BOTTLES □

Q'TY: ■ SUCTION ■ DISCHARGE

3 □ EACH STAGE SUCTION & DISCHARGE

■ SUCTION LINE FILTER (TEMPORARY TYPE)

TYPE ■ DRY □ OIL BATH ■ INDOOR □ OUTDOOR

■ 10" ANSI 150LB SO.RF

Q'TY: 1 SET

■ UNLOADER SYSTEM,GAUGE BOARD

□ MAGNETIC TYPE ■ FILTER & REGULATOR

□ MANUAL TYPE ■ PRESSURE SWITCH

■ SOLENOID VALVE

■ LUBRICATION

□ CYLINDER PART □ LUBRICATOR

□ CHECK VALVE

□ INTER PIPING

■ CRANK CASE PART ■ LEVEL GAUGE

■ GEAR PUMP

■ OIL COOLER

■ OIL FILTER (DUAL)

■ OIL STRAINER

■ INTER PIPING

□ RECEIVER TANK

TYPE : □ VERTICAL □ HORIZONTAL

VOLUME : m^3

MAT'L :

SIZE (ID x L x TH'K) :

Q'TY :

■ 1ST INTER COOLER (M/S)

TYPE : SHELL / TUBE Q'TY : 1 SET(S)

SHELL DIA. : 14" SHELL MAT'L : A53Gr.B

TUBE SIZE (OD x L x TH'K) 15.88 X 2500 X 1.24

TUBE MAT'L :C1220T-1/2H TUBE Q'TY : 191 PCS

■ AFTER COOLER (M/S)

TYPE : SHEEL/TUBE Q'TY : 1 SET(S)

SHELL DIA. : 12" SHELL MAT'L : A53Gr.B

TUBE SIZE (OD x L x TH'K) 15.88 X 2500 X 1.24

TUBE MAT'L :C1220T-1/2H TUBE Q'TY : 147 PCS

■ OIL COOLER (M/S)

TYPE : SHEEL/TUBE Q'TY : 1 SET(S)

SHELL DIA. : 6" SHELL MAT'L : A53Gr.B

TUBE SIZE (OD x L x TH'K) 9.53 X 600 X 0.89

TUBE MAT'L :C1220T-1/2H TUBE Q'TY : 72 PCS

■ CHECK VALVE

TYPE LIFT Q'TY : 1 SET(S)

SIZE ■ 6" ANSI 150LB SO.RF

■ BED

FOR ■ COMMON BED Q'TY : 1 SET(S)

■ MOTOR SLIDE BED Q'TY : 1 SET(S)

■ GUARD

FOR ■ V-BELT Q'TY : 1 SET(S)

□ DIRECT COUPLING Q'TY : SET(S)

■ PROCESS & UTILITY PIPING

■ SUCTION □ INTER STAGE

■ DISCHARGE (up to check valve)

■ COOLING WATER ■ OIL ■ INSTRUMENT AIR

■ THE OTHERS ■ ANCHOR BOLT & NUT ■ COUNTER FLANGES ■ NAME PLATE

(SAFETY VALVE)

LOCATION	□ COOLING WATER LINE	■ 1ST DISCH.LINE	■ 2ND DISCH.LINE	□ N2 PURGE LINE
SIZE		LATER	LATER	
SET POINT (kg/cm^2. G)		4.5	6.8	
Q'TY :		1EA	1EA	

(CONSUMPTION OF COOLING WATER)

SERVICE	COMP'R	INTER COOLER	AFTER COOLER	OIL COOLER	JACKET COOLER
CAPACITY (ton/hr)	3.90	9.21	7.200	0.62	
INLET TEMP. (℃)	30	30	30	30	
OUTLET TEMP. (℃)	39	39	39	39	
PRESSURE (kg/cm^2. G)	3.0	3.0	3.0	3.0	
TOTAL (ton/hr)	20.93				

(ELECTRIC SERVICE)

	kw	volts	phase	Hz	poles
MAIN DRIVER	300	415	3	50	6
AUX. OIL PUMP	1.5	415	3	50	4
CONTROL	0.5	110	1	50	-
OIL HEATER					
SPACE HEATER	0.3	110	1	50	-

(ALARM & SHUT DOWN)

■ LUBE OIL PRESS. LOW	■ ALARM	□ SHUTDOWN
■ LUB. OIL PRESS. LOW.LOW	□ ALARM	■ SHUTDOWN
■ SUCTION PRESS. LOW	■ ALARM	□ SHUTDOWN
■ DISCHARGE PRESS. HIGH	■ ALARM	□ SHUTDOWN
■ DISCHARGE TEMP. HIGH	■ ALARM	■ SHUTDOWN
■ COOLING WATER FLOW LOW	■ ALARM	□ SHUTDOWN

REMARKS :

This manual is designed to describe the structure, function and operating method of single-stage and two stage "Kwangshin Machine Industry Co. LTD." water-cooling compressors of Y model which are drawing attention from each and every field for their superior capability without any failure for a long period.

The first one is single stage which transmits compressed gas through 1 set Discharge pipes by 2 cylinder, and in the second one compressed gas at 1st-stage cylinder gets cooled by Inter Cooler and gets compressed at 2nd stage cylinder.

Non-Lubricated Compressors of KSDWNL has 3(three) cylinders are supplied for this project. Compressor has the shape of V at 90°of 3 cylinders. The 2nd and 3rd cylinders are assembled with tandem construction. With its little installation space, and extremely slight vibration, the compressor has the structure strong enough to endure long hours of operation.

The capability, failure and endurance of compressors depend on the drawing of machine it-self, properness of material that was used, and the precision of manufacturing technology.
However, daily maintenance and operation are also no less important.

We hope that every user can take a full advantage of our compressors with this manual as guideline of treatment or information for study.

Specification See attached RECIPROCATING COMPRESSOR DATA SHEET (3Pages)

CHAPTER II. INSTALLATION

II-1. General

The foundation, installation, grouting and piping instructions in this chapter are intended for use with the plans and diagrams that are prepared to suit a particular compressor installation. KWANGSHIN erecting engineers are available, and we recommend that they be used, to supervise the installation and start-up of the machine. Proper installation is important to the successful operation of the unit.

For installation purpose, there are two compressor mounting techniques that are commonly used.

① BLOCK-MOUNTED UNITS
compressor, driver and accessory equipment are mounted directly on a suitable foundation

② SKID-MOUNTED UNITS
Units are normally shipped to the installation site with the compressor and driver mounted on a rigid skid. Alignment, controls, accessories and on-skid piping are completed at the factory and the unit is available at the compressor site as a complete package ready for erection on a suitable foundation.

The instruction in this section cover the installation of both "block-mounted" and "skid-mounted" compressor units.

II-2. STORAGE

If the compressor is to be stored at any time and it is not resting on a foundation, it must be supported the full length to prevent any possible sag or distortion. It will also be necessary to protect the unit from the weather, either in a building or by a tarpaulin or similar covering.

Protection for longer than 6 month storage period can be provided as an equipment option. This additional protection is normally selected to suit the particular storage requirements and environmental conditions.

When a lubricated compressor cylinder is shipped, the main bores and gas passages are coated with a rust preventative oil. This oil should not be removed or wiped out of the cylinder until actual starting of the compressor. All of the cylinder openings must be completely closed so that dirt, rain or dust cannot be blown into them.

Non-lubricated compressor cylinders are preserved at the factory by (1) blowing out bores and gas passages with compressed dry air (2) charging dry nitrogen or dry air (3) hang desiccant bag one per M^3 of the box (4) covering the unit with vinyl (5) finally, pull out air and charge dry air or nitrogen inside of the vinyl and then tightly closing all openings.

Before storing the unit, it is important to check inside as well as outside the machine to be sure all finished surface and all exposed surfaces subject to corrosion are adequately protected.

During storage, periodically remove covers and check inside of the unit for condensation and for adequate protection of all internal surfaces. This should be done at least once a month and more often if conditions warrant it.

II-3. LOCATION

Where possible select a site for the compressor installation where the soil under and around the foundation will be firm and dry at all times. Inadequate soil conditions require special compensating measures in designing and constructing the foundation. Before making a final decision on the compressor site, study the foundation plan, installation drawings and piping diagrams.

II-4. BUILDING

It is normally a customer option as to whether or not the compressor is placed in a building and the building should then be designed to suit the particular installation. Generally, a building is

intended to provide adequate protection against the weather for the operators, compressors and auxiliary equipment ; it may be partially or completely enclosed, depending on the site requirements.

The building should be of ample size to provide sufficient working space around each unit. Refer to the compressor layout plan for minimum clearances required to remove compressor pistons and other parts. An overhead hoist, arranged so that it can be moved to a position over any parts of the compressor or driver, will greatly facilitate maintenance work requiring the removal of parts. Select a hoist with enough capacity to lift the heaviest part that may be removed during normal maintenance.

Good lighting is essential for proper operation and care of these units. In addition to daylight and overhead electric lights, outlets should be provided for drop light and extensions convenient to each machine.

Adequate ventilation is essential to safety in any compressor room. Pockets or areas any escaping gas can collect must be avoided. Remember that even the spark from a nail in a shoe can start a fire in a flammable atmosphere. Good ventilation around any compressor is of prime importance to the comfort and morale of the operators.

II-5. FOUNDATION SIZE AND DESIGN

Foundation requirements can vary from one installation site to another and will depend upon the soil condition, the gas to be handled, the forces to be absorbed and, in some cases, the climate. The KWANGSHIN, therefore, can suggest only general foundation design criteria to be adapted to the local conditions. So, have to consult with civil engineer who knows well as local foundation condition

1) GENERAL RULES FOR FOUNDATION DESIGN

A few general rules may aid in the design of a foundation :

Keep the height of the foundation block as low as possible. The greater the height of the block the greater the rocking effect will be ; consequently, the greater the chance of excessive vibration.

When two or more compressors are to be installed, it is preferable to arrange the units with the crankshaft parallel (not in line) and to have one continuous reinforced mat under all compressor foundation block.

2) FOUNDATION CONSTRUCTION

Build the forms for pouring the foundation so that the top of the foundation will be at the proper to allow for grout placement under the compressor base or skid ; the recommended grout thickness is shown on the foundation drawing. Be sure that the forms provide for any pockets or depressions in the foundation.

The foundation bolts must be located according to the plan supplied for the unit. To hold the bolt accurately in the position while the foundation is being poured, build a skeleton wood template with holes for the bolts to correspond to the bolt layout plan(foundation drawing).

Foundation for reciprocating compressors require adequate steel reinforcement. Cracks which would cause little or no concern in ordinary concrete construction are serious in foundation of this type, where they are subject to stresses which can cause the cracks to grew.

A good concrete mixture for compressor foundations are consists 1 : 2 : 4parts of cement : sand(clean and shape) : crushed stone. If crushed stone is not available, gravel may be substituted, using one part cement to four parts gravel together with the

sand. Make sure that the sand, gravel and stone are clean and contain no loam or clay. Impurities will weaken the foundation and may result in an expensive repair later.

After a final check on the location and height of all foundation bolts, the concrete can be poured up to the bottom of the template ; leave the top surface rough to assure a good bond for the grout. After pouring the foundation, cover it with burlap and wet it down twice a day to prevent its drying too rapidly. Allow three or four days to elapse before removing the forms and at least 3 weeks between pouring the foundation and operating the compressor.

II-6. SETTING AND LEVELING UNIT

The following procedure for setting and leveling the compressor can be applied to both block-mounted and skid-mounted units.

1. Roughen the top of the concrete foundation with a star chisel or chipping hammer to remove the surface layer of material which has a low strength ; the roughened and cleaned surface provides a better bond for the grout. Clean the surface of oil. grease, dirt and loose particles.

2. Prepare enough steel wedges to allow one being placed near each foundation bolt. The wedge must be thick enough to allow the recommended grouting space between the top of the foundation and the bottom of the unit.

   Note : skid-mounted units are leveled by means of setscrews provided in the skid base flange. A steel leveling plate made from 13mm thick steel plate, or equal material, and approximately 75mm square should be placed under each leveling setscrew to keep it from digging into the foundation and affecting level adjustments.

3. Lower the compressor frame over the foundation bolts and onto the steel leveling wedge.

4. Adjust the compressor frame is at its desired elevation and is level both longitudinally and transversely. Leveling the compressor as close to zero as possible, but never exceed 0.2mm/m, using the level on the frame vicinity of the crankshaft.

5. On block-mounted units, adjust the wedges under the distance piece support and outboard cylinder support(if used) so that these supports are carrying the distance piece and cylinder weight but are not placing an upward strain on the frame-to-distance piece or distance piece-to-cylinder bolting. In its final position, the weight of the compressor should be evenly distributed on the leveling wedges.

6. When the unit is level, place washers and nuts on the foundation bolts and snug them evenly against the frame base flange to hold the final position. At the same time, check with the level to make certain the machine does not shift on the wedges. Do not attempt to level the unit by tightening the foundation bolt/nuts as this can distort the frame(or skid base).

7. Install the driver

8. Recheck the equipment to be sure it is properly aligned and leveled. With the unit properly aligned, and with the foundation bolt/nuts pulled down only enough to hold the unit in position, grout in the machine as described in the procedure outlined in Section II-7.

II-7. GROUTING

There are numerous grouting materials and techniques that will provide satisfactory result. The following instructions describe the commonly used sand and cement grout mixture and may require modification when a commercial grouting material is being used.

Note : Commercial grouts include the non-shrink cement grout mixtures and the epoxy grouts. Epoxy type grouts in particular have received increased usage because of their oil resistance, high compressive strength and exceptional bonding characteristics. The final selection of a particular grouting material is the responsibility of the customer or his contractor.

1. The foregoing instructions for preparing the top of the foundation and for setting and aligning the equipment must be closely observed before grouting the unit.

2. Build a temporary dam of boards around the top of the foundation about 50mm higher than the bottom of unit. This will provide a sufficient head on the grout so that it will flow under the compressor frame or skid members and fill voids on the underside of the equipment.

3. Mark the locations of the level wedges, if used, so that they can be removed after the grout has started to set.

4. For proper bonding of the grout to the surfaces being grouted, it is particularly important that these surface be clean and free of all paint, oil and rust. Sand blasting of these surface is preferred ; however, properly performed wire brushing can be adequate. After sand blasting or wire brushing, thoroughly clean surfaces with solvent. For best results, complete the surface preparation just before grouting.

5. Before starting to grout, be sure that there are sufficient materials and help available so that the grouting can be completed without interrupt. Keep the top of the foundation wet for 6 to 8 hours prior to the time the actual grouting is started. Then, blow off the excess water with an air hose, paying particular attention to the foundation bolt holes. It is important that any puddles of water are removed.

6. If Portland cement grout is used, a good mixture is one part normal Portland cement to two parts of clean, sharp, well-ground sand. (It is important that the sand is free from silt or clay) To lessen shrinkage, use as little water as possible.

   Note : The strength of a cement grout is reduced, and shrinkage is increased, as larger amounts of water are used.

7. Crumbling grout affords poor support for a compressor installation. If low temperatures are likely to be encountered before the grout has thoroughly set, precautions must be taken to prevent freezing.

8. Place the grout quickly and continuously to avoid the undesirable effects of overworking. Pour the grout from one side only to assure complete filling of the space to be grouted and to avoid entrapping air.

9. When the grout placement is completed, have a batch of thoroughly mixed dry sand and cement(2 parts sand to 1 part cement) ready to pack in around the edges of the unit.

10. If the installation site is dry and warm, cover the exposed grout with wet burlap bags or similar material and wet thoroughly every few hours to keep it from drying too rapidly and developing surface cracks.

11. The distance piece support, cylinder support and driver are grouted in a similar manner.

12. After the grout has hardened sufficiently, remove the forms.

13. When the grout has set at least 24 hours, remove the leveling wedges and patch.

    CAUTION : It is important that the compressor is supported by the grout and not by the leveling wedges or setscrews.

14. After the grout has thoroughly set (usually about 5days), pull the foundation bolts down tight. Recheck all leveling points to be sure that the machine was not disturbed during the grouting period. If the unit does not show the level, remove it from foundation, chip off the grout and start over again.

15. Before starting the compressor, be sure the grout is thoroughly set and hard and then paint the whole foundation with a good water- and oil-resistant paint. Be careful to make a good paint seal between the unit and the grout so that any oil spilled cannot creep under the equipment to soften the grout. If any oil works its way into the grout, the alignment of the entire machine can be affected as the grout softens. Epoxy type paints are recommended because of their oil resistance and bonding characteristics.

    CAUTION : Do not operate the compressor until the foundation has thoroughly hardened.

CHAPTER III. CONSTRUCTION

III-1. FRAME

The frame is of cast iron and takes a form of box type. The frame forms with individually fitted distance pieces and through going studs over each main bearing a very rigid construction.

The inside of it forms the crankcase in which a crankshaft and connecting rods are provided. The bottom of it forms the oil tray in which lubricating oil is stored for lubrication of moving parts.

On both sides, the crosshead guides are mounted. On upper side of it are mounted one or more steel covers which enable easy inspection, cleaning, regulation, dismantling and exchange of the parts.

III-2. CRANKSHAFT AND CONNECTING ROD

The crankshaft is one piece forging and supported by main bearings.

The most adjacent bearing to the driver has collars on both sides and works as guide bearing so as to hold the position of crankshaft in the axial direction.

The connecting rod of forged steel has the crank-pin bearing in the big end (crank end) and the crosshead pin bearing in the small end (crosshead end).

The oil to the main bearings is supplied under pressure through the inlet pipes in the frame and the oil holes in the bearing housings.

The drilled passages in the crankshaft and connecting rods enable the oil supply from main bearings to crank-pin bearings and to crosshead pin bearings.

It is very important to keep these drilled holes always clean.

In case of checking or renewing main bearings, first remove the frame top covers, secondly the reinforced distance pieces over each main bearing and take off main bearing caps then the upper halves can be dismantled.

The crank-pin bearings are also precision symmetric metal.

To prevent the metal from turning in the big end, a guide lock is provided at the side of each metals.

The crosshead pin bearings are one piece bush and have oil grooves on the surface.

When the bearing clearance becomes large due to wear of metal, the bearing should be renewed.

The precision metals which have been machined in very precise

dimensions can be fitted with appropriate clearance by tightening the bolt with given tightening torque or giving elongation to bolt. Also, scraping for adjusting the bearing clearance is not allowed for these precision metals.

After taking out the metal which had been worn down, check the wear condition of the crankshaft carefully.
It is not reasonable that original new metals are fitted in the worn crankshaft.

When the crankshaft is re-machined because of its wear, the new another bearings, the inside diameter of which suits the outer diameter of re-machined crankshaft, should be used to give appropriate clearance between the metal and the crankshaft, of course this being very rare case.

In case of ordering the bearing applied to the small diameter shaft from us, please inform us of the re-machined diameter of shaft.

Depend on the conditions, re-machining the crankshaft outer diameter and Cr plating and to fit the original size.

III-3. CROSSHEAD AND CROSSHEAD GUIDE

The running surfaces of crossheads are lined with white metal.

The crosshead pin is fitted in the crosshead with forced fitting method. Proper clearance is given between crosshead pin and bush. Plate are fixed on the both ends of crosshead pin for stopped in it against axial movement.

When pulling out the connecting rod, for one thing, remove the frame top cover and besides remove the crankpin bearing cap of the connecting rod big end, and separate the connecting rod from the crosshead, then it can be taken out from the frame top.

Covers are provided on both sides of the crosshead guides and serve for checking of the crosshead and connection condition between the crosshead and the piston rod, and for disassemble of the crosshead pin.

III-4. STUFFING BOX COVER

Partition cover of crosshead guide which is so called as crosshead side stuffing box is provided with oil wiper(scraper) rings and gas sealing rings. (in case of two compartment construction)

The oil wiper ring minimize oil leakage from crankcase to distance pieces. The seal rings prevent the gas leakage into the crankcase.

Drains are taken out from the bottom of the compartment.

To prevent the gas leakage to the crankcase, the gas which has leaked out from stuffing box is ejected in the open air or safety area through piping.

In another case that the double compartment distance piece is applied, one more another partition cover is provided between the cylinder and the crosshead guide.

This partition cover provides gas sealing rings, and a longer distance than the piston stroke is provided between both partition covers.

III-5. COMPRESSOR CYLINDER

Compressor cylinder is provided with cylinder liner(when required), cylinder cover(upper and lower), cooling jacket, compressor valves and stuffing box.

Assembling and disassembling of the liner are facilitated by filling hot water into the cooling jacket and cooling the liner before disassembling with a jet of cold water or carbon dioxide snow (dry-ice), if necessary.

The cylinder covers are fastened to the cylinder by studs. The top cover has threaded holes for easy disassembling of it and is dismantled by using jack bolt, and this can transferred by eye-bolts.

Cylinders are designed as water-cooled type.

In case of wet gas, in order to ensure fast and complete possible draining of condensation products which might appear in the cylinder, the suction valves are fitted at the top side and the discharge valves at the bottom side of the cylinder.

The stuffing box is fitted on where the piston rod runs through the cylinder, and prevents the gas leakage from the cylinder.

Gas seals between cylinder body and bottom cover or top cover can made by gasket or O-ring.

When dismantling the cylinder cover for maintenance, caution should be paid whether the pressure in the cylinder is perfectly relieved.

III-6. COMPRESSOR VALVE

Both the suction and discharge valves consist of a valve seat, valve guard, valve plate and valve spring, fitted together by a center bolt and nut, the correct spacing being obtained by spacer placed around the bolt. Between valve seat and guard, the valve plate and one or two damper plates are fitted and the valve plate is set on the valve seat by a set of coil springs.

The valve guard, valve plate and damper plates are positioned by two guide pins.

The valve is fixed on the valve port in the cylinder by the valve cover through the valve holder or by the bolts fitted on the valve cover through the valve holder after the valve cover being secured by the studs for valve cover.

Gas tightness at the seating surface of valve in the valve port of cylinder can be secured by means of metal gasket, and O-ring is fitted between cylinder and valve cover for easy to maintenance and perfect gas tightness.

Wet gas operation, discharge valve located bottom side of cylinder. At any case of disassemble the valves which fitted at bottom side of cylinder, should be careful of the valve down. To prevent this kind of accident, snap rings are fitted at the top of valve. When disassemble and reassemble the valves, to be careful this snap rings located at the wright position.

Fitting of bottom side valve

A bottom side valve shall be fitted on a cylinder in the following order.

1) Prepare the valve seat gasket, valve and valve holder
2) Assemble the valve seat gasket, valve and valve holder in order and fit the snap ring.
3) Check the valve and gasket are fitted wright position.

4) Assemble the valve cover and to fasten the nuts. To be careful, the valve cover O-ring is not damaged.

Maintenance of Compressor Valve

Satisfactory operation of the compressor is largely dependent on the maintenance carried out on the compressor valves.
We advise to disassemble, clean and inspect the valves at the time past 500 operating hours after the compressor is started up.
After this first inspection, unless something is wrong, the interval of this inspection may be made be longer by yourselves considering the operating condition of the compressor.(The maximum interval is 4,000 hours)

All valve plates and valve springs to be preferably renewed for the preventive maintenance after 8,000 hours running even if they are not damaged.
The damper plates to be renewed after 16,000 hours running.

The inspection procedures of the valves are as follows.

a) Remove the valves from compressor
b) Dismantle the valves
c) Clean all parts with a cleaning fluid using a soft brush taking particular care to free the ports of the seat and the guard from all foreign material to insure full seat area in operation.
   Never use wire brushes or tools with sharp edges to clean the seats, guards d plates.
d) Check the condition of all components, especially for wear, damage to the seat face, the plates, and for fatigue of springs.
e) Repair all parts which can be remachined without disturbing strength factor.
f) Replace all parts which are worn or show any cracks.
   Valve plate which are worn on one side should never be used in reversed position, and maximum allowable wear is about 10% of the total plate thickness.

g) Every grinding or lapping of the valve seat face, in order to keep the dimension constant, the grooves have to be re-machined as well.

h) Reassemble the valve according to the following instructions and drawing.

i) Refer to Tightening torque table in the "Technical data"
Never loosely nor forcibly screw nut in order to adjust the split pin to the hole.
If not adjusting the split pin, re-machine the tail face of the nut, but never insert shims.

III-7. PISTON

Piston is provided with Bronze filled PTFE (TBC) piston rings and rider rings.

When fitting piston rings and/or rider rings on the piston, be sure not to enlarge the ring gap more than necessity.

As to clearances, refer to "Technical data".

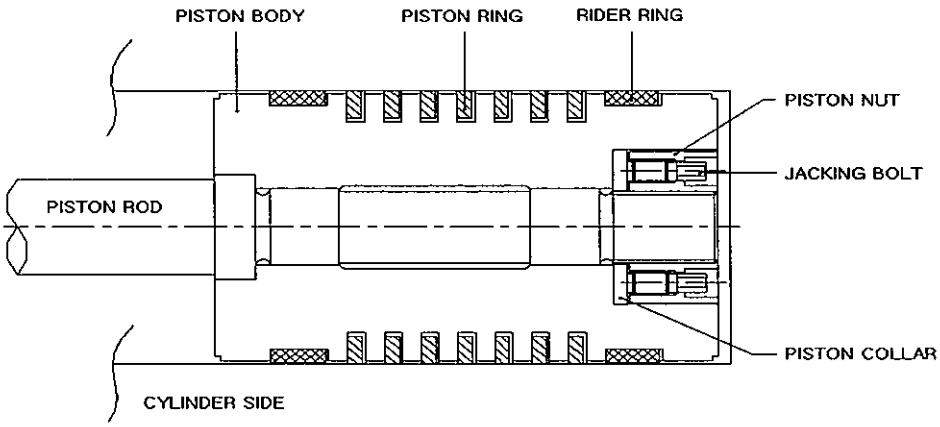
As to the connection of piston and piston rod, refer to the next page.

III-8. PISTON ROD

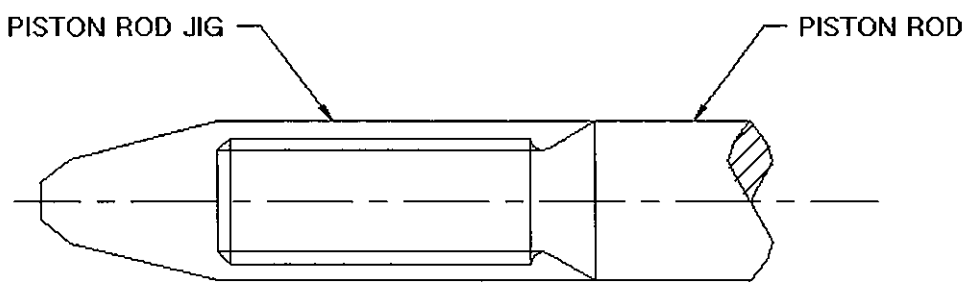
The piston rods are cr-plated with alloy steel.
When the piston is fitted on the piston rod, the piston collar should be placed the first in position(when hollow piston is provided).

After setting the piston and thrust washer, screw the piston nut by hand and tighten the multi-bolt(jacking bolt) securely.

As to the tighten torque for Multi-bolt refer to "torque table".



Before the piston rod is pushed through the stuffing box, the piston rod jig should be screwed the first onto the thread of the piston rod end to prevent the sealing rings in stuffing box as well as the thread of piston from being damaged.



Fastening of piston rod and crosshead (Double-nut design)

Fastening of piston rod and crosshead is the most important work in assembling and disassembling.

In case of assembling the piston rod to the crosshead, do it in following order ;

1) Move the crosshead to backward.

2) Fit the piston rod jig at the piston rod thread and slowly move the piston rod from top head of cylinder to stuffing box.

3) When piston rod jig pass through the oil wiper ring, remove the piston rod jig from piston rod and fasten the INNER & OUTER NUT at the piston rod.

4) Spin the piston rod till crank end clearance shall be our reference value.

5) To check the clearance between piston and cylinder head, disassemble the valve from cylinder and than insert feeler gauge or lead wire into the gap between piston and cylinder

6) Rotate the fly-wheel and check the thickness of feeler gauge or lead wire.

7) After set the bottom side clearance, fasten the OUTER NUT to crosshead face and tight fasten use special wrench supplied from KWANGSHIN and 2kg sledgehammer.

8) Fasten the INNER NUT like 7).

Fastening of piston rod and crosshead (Tow-nut design)

Fastening of piston rod and crosshead is one of most important work in assembling and disassembling.

In case of assembling the piston rod to the crosshead, do it in the following order ;

1) Slip the large round fastening nut on to the piston rod

2) Screw the small counter nut on to the screw thread of the piston rod end.

3) After the distance ring of the required thickness has been placed between the piston rod end and the crosshead, screw the large round nut on to the threaded part of the crosshead.

4) Tighten down the round collar of the small counter nut on the piston rod to the collar of the large round nut .
By this working, the piston rod end can be securely pressed on the recess of the crosshead through the distance ring.

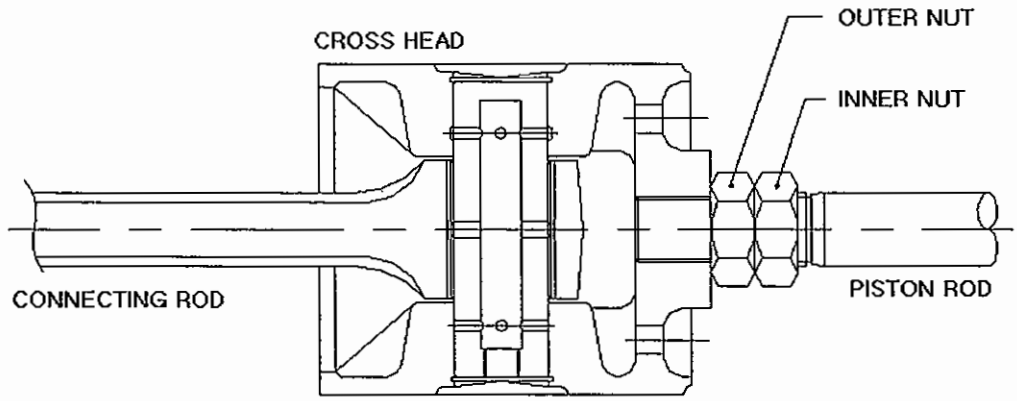
5) Finally, securely lock these nuts by the stop screw with wire.

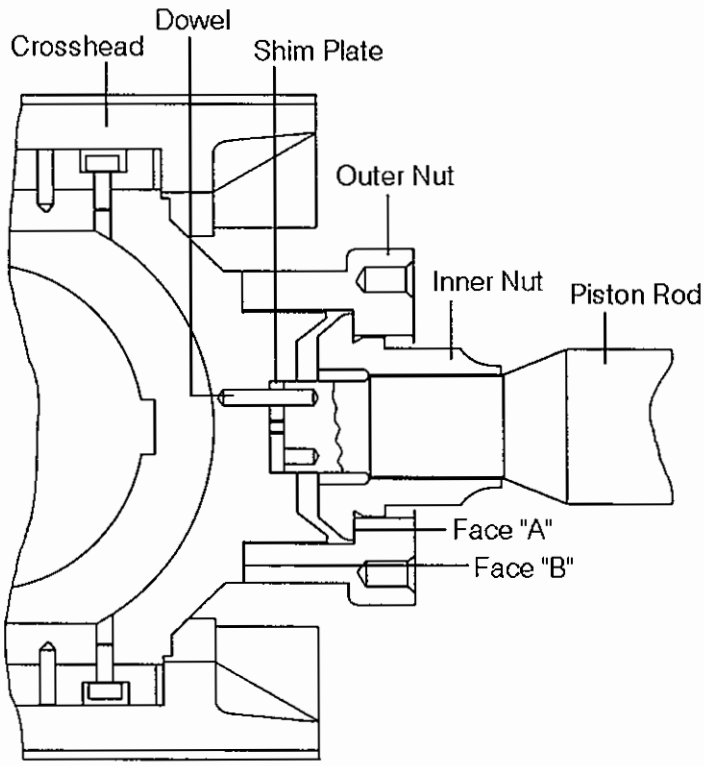
The Distance ring serves for adjustment of the clearance between the piston and the cylinder cover in both extreme piston positions.

For this clearance, refer to "technical data". This clearance is set in the factory by inserting a distance ring of correct thickness.

Generally, the thickness of the distance ring is not exactly the same for all cylinders, and therefore, they are not interchangeable.

After dismantling the suction valve from the cylinder, the piston clearance can be checked either by direct measurement with a feeler gage or by inserting a piece of lead wire between the piston and the cylinder cover and measuring the thickness of the wire after it has been flattened by the piston.


CROSS HEAD
OUTER NUT
INNER NUT
CONNECTING ROD
PISTON ROD


Dowel
Crosshead
Shim Plate
Outer Nut
Inner Nut
Piston Rod
Face "A"
Face "B"

III-9. STUFFING BOX

The stuffing box consists of several packing cases in which a pair of seal rings are inserted. The garter springs around the rings give them the required surface pressure on the piston rod.

The contact surfaces of each packing case operate the sealing of leakage gas. The sealing of gas between the bottom packing case and cylinder shall be kept by gasket.

The leakage gas from the stuffing box is vent to the flare-line, safety area through piping or connected with suction line in accordance with their gas property. And for compressed air, generally it is vent to atmosphere.

Constructions and materials of the stuffing boxed are varied with the specified operating conditions, pressure, temperature and property of handled gas. The followings are general guides in servicing and installing, and should be closely watched to keep the stuffing box in good order.

1) When assembling the stuffing box, always carefully clean up the packing cases, rings, springs and the piston rod surface.

   Dirts on the ring will cause sticking the rings, and dirts on the sealing face of packing case will result in incorrect alignment and cause the leakage between them.

   Inspect carefully the lube oil(if lubricated compressor is supplied) and vent holes in the gland and each packing case.

2) Care should be taken to assemble the seal rings and the packing case in the correct sequence. One or more types of the rings are arranged in grooves to give the best sealing effect according to the specified condition.

   In case of assembling the rings in the incorrect sequence, the

stuffing box will not seal the pressure. Incorrect sequence of the packing cases will result in the serious damage coming from the stop of oil feed.

Furthermore, care must be taken to arrange the pair of rings in correct direction in a groove. All ring segment ends are lettered or match-marked and accordingly, should be assembled. When water cooled type and/or oil feed type packing case is supplied, all cases must be assembled in accordance with their own match-mark.

3) Through tie bolts, screw the nuts securely and uniformly.

4) Clean the faces of the pocket in the cylinder on which the gasket of the stuffing box rests.

5) The rings, the wearing faces of the packing cases and the piston rod should be coated with lube oil on assemble for lubricated service.

6) If gas leakage occurs in operation, first check whether the tightening bolts are securely screwed, and secondly check the side clearances and the end gaps of the rings, the garter springs and the sealing surfaces of packing cases.

As the gas leakage from stuffing box can be ascertaind by by the surface temperature of the vent pipe, care must be taken to the increase of this temperature, because high temperature means much leakage.

7) LUBRICATED STUFFING BOX (Not Applicable)

If the stuffing box is lubricated, lube oil for it is supplied by the lubricator.

The amount of lube oil supplied to it should be controlled by considering the running condition, i.e., it shall be increased in

initial running and lessened as little as possible in normal running by checking the wearing condition of packing rings.

The lube oil pipes must be correctly connected so that the oil is securely supplied to the lubricating points.

8) WATER COOLED STUFFING BOX

Whether the cooling water is flowing through the stuffing box or not can be checked by sight glass. Clean the coolant passages of gland and packing cases in case that they are clogged.

It is preferable to clean it at regular intervals which must be decided according to the condition of coolant.

The followings are considerable to prevent the coolant passages from being clogged.

(1) The cooling water for stuffing box must be clean and fresh water.

(2) If necessary, supply a filter at the cooling water inlet.

(3) As a general rule, these inlet valves should not be throttled.

Check the packing of coolant passage and renew, if necessary.

9) ASSEMBLY OF STUFFING BOX AND GLAND PACKING

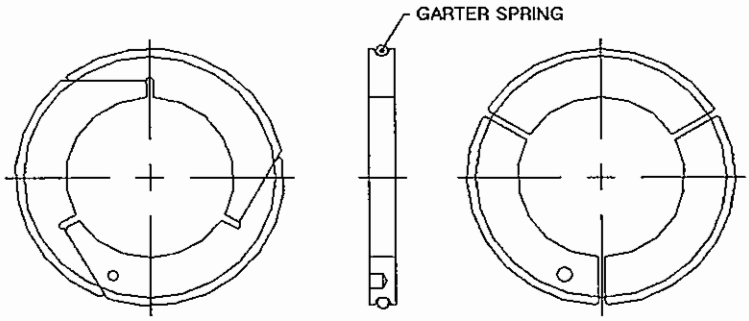
Gland packing is pared with 2 or 3 types of rings such as below.

Stuffing box locate crank end side of cylinder.

RADIAL RING is installed toward the high pressure side (pressure side) and TANGENTIAL RING is installed toward the distance piece side.

When piston rod insert to the stuffing box, have to use piston rod jig to prevent damage at the gland packing.

Even if it is winter season, after the lube oil temperature should be rasied above 20℃ as minimum by means of electric heater or steam heater, the compressor should be started.



Supply and renewal of oil

The lube oil is little by little consumed due to lubrication of gland packings or oil wiper rings fitted on the partition cover of crosshead guide. Therefore, check every day the oil level by the level gage attached to crankcase and keep always the level between maximum and minimum.

Regularly(every 4,000hrs.), check the property of oil(the inferior degree of oil, the amount of mixed water, etc.).

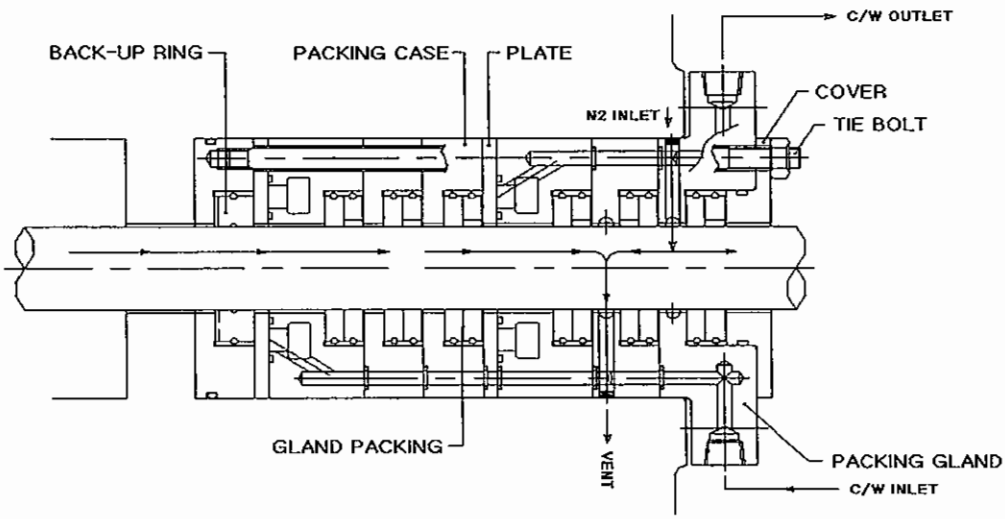
(1) to examine whether the oil is able to continue to use or not,
(2) to know the renewal time, and
(3) to know the abnormal change of oil to be the omen of big accident.

The renewal interval should be synthetically decided by the property of oil, the running condition of compressor, the handling gas, the result of oil analysis, etc.

But, for the first 2,000hrs running, it is preferable to renew the oil in crankcase, afterwards, renew all of the lube oil at the time of regular overhauling such as every one or two years.

As to the kind and brand of oil, refer to "Lubricant List".

CYLINDER AND STUFFING BOX LUBRICATION



The compressor cylinders and piston rod stuffing boxes are lubricated by the mechanical force feed lubricator.

The amount of lube oil can be controlled by the regulating knob on lubricator and the oil supply can be checked through the sight glass of lubricator.

The amount of lube oil supplied to cylinders and stuffing boxes should be controlled to increase it in initial running and, afterward, to lessen it in normal running by the operating condition of compressor.

When the compressor is started after long stoppage, sufficiently prime the lube oil to the cylinders and stuffing boxes by the priming handle and fill up the oil in the pipes.

As no feed of the oil must cause serious damages, the oil tank should be filled up regularly with the oil.

III-10. CYLINDER COOLING

a) Forced water-cooled cylinder

In case that the cooling water controlled its temperature is supplied for the cylinder cooling, keep to the following ;

① For wet gas, the inlet temperature of cooling water should be maintained above 6~10℃ than the process gas inlet temperature by the reason of protecting the gas from condensing.

② As a general rule, also during the stoppage of compressor, the cooling water maintained its temperature should be continuously supplied into the cylinder jackets.

③ Also in case of starting the compressor after long stoppage, after the inlet temperature of cooling water is maintained above 6~10℃ than the process gas inlet temperature, the compressor should be started.

III-11. PNEUMATIC BARRING DEVICE (Not Applicable)

a) GENERAL

The pneumatic barring device, or "rig", is used to turn over the compressor for maintenance purposes and at any other time when exact positioning of the running gear is required. The air-operated actuating cylinder is equipped with a dog which engages with the teeth of the barring wheel on the crankshaft. A manually operated three-way valve is used to direct the air supply alternately to one end and then the other end of the double-acting air cylinder. This results in a "ratchet-like" turning of the barring wheel and crankshaft as the actuating piston is operated in both directions. A positive engagement catch is provided to hold the barring device away from the machine when it is not in use.

b) INSTALLATION

The mounting location and foundation bolt plan for the barring device are shown on the installation plans furnished with each compressor. Customer air supply and exhaust connections are also shown on the installation drawings. The instructions provided by the sub-manufacturer's of the various components used in the barring rig should be carefully read before installing and operating the device.

Set the skid-mounted, barring cylinder support plate over its foundation bolts, and align it with wedges. Check the engagement between the barring dog and barring wheel teeth with the set bolt nuts snugged down lightly. When the proper alignment is obtained, if it is floor-mounted, proceed to grout in the support plate. Tighten the nuts on the foundation bolts after the grout has set.

Make up the operating air connections at points A and B on the barring cylinder. Do not remove the port seals from the cylinder until ready to connect the lines. Connect the air supply line to the top of the three-way valve at point C ; a 5.0 kg/cm^2 supply pressure is normally specified.

c) OPERATION

To bar the compressor, pull the catch release and move the barring dog against the barring wheel. Operate the barring cylinder by means of the three-way air valve to jack against the barring wheel teeth and turn the crankshaft. When the actuating piston rod has been extended to its travel limit, reverse the hand valve to retract the piston and obtain a new "bite" with the barring dog. Continue with this ratchet-type action until the crankshaft has been turned the required amount. The jacket speed can be regulated by throttling the air flow to each end of the barring cylinder; globe valves are provided in the air lines for this purpose.

When the barring device is not in use, be sure it is pivoted to its vertical (disengaged) position and engage the barring cylinder catch. As a safety measure, a micro-switch is provided so that the compressor driver can not be started unless the barring device is in its vertical position. Shut off the air supply to the barring cylinder when the device is not being used.

d) MAINTENANCE

Routine maintenance of the barring device is normally not required. Cover is required to prevent malfunction caused by dust.

CHAPTER IV. OPERATION & TROUBLE SHOOTING

After foundations, installations, piping and wiring have been finished carefully,

1) Flushing the inside of crankcase and the lube oil piping.
2) Blow-off for cleaning the process piping, if necessary.
3) Mechanical running by air under no-load or low-load.
4) Load-up operation by process gas up to 100%-load.
5) All-round inspection

The above works are carried out under the manufacturer's attendance or guidance, and therefore the operations are left to CUSTOMER or END USER.

In this chapter, necessary cares during this operation will be described.

IV-1. PREPARATIONS FOR STARTING

On starting the compressor after installation work being completed, or overhauling, or long stoppage, the following inspections and preparations should be performed.

a) In foundations, installations, piping, wiring, etc., such abnormality as mentioned below must not be found.
   (1) Cracks of foundation
   (2) Slack of foundation bolts
   (3) Slack of piping connections
   (4) Breakage or earth of electric wire

b) Compressor proper and fittings to be in good order. Confirm that the minor modifications have been finished, if any.

c) No slack of bolts and nuts all parts should be found.

d) Check the lube oil level in crankcase whether oil has been filled up to nearly center line of level gauge.
   Mobil Rarus #425 is used as standard for crankcase oil.
   (See attached Lubricant List)

e) If cylinders are lubricated, fill up the lubricator reservoir with oil. In that case, take care not to confound this oil with the crankcase oil.

f) Inspect the lube oil filter and clean it, if necessary.

g) Supply cooling water to the lube oil cooler, compressor cylinders and stuffing box, if water-cooled.

   In that case, the valves of pipeline should be fully opened. As a general rule, these valves are not be throttled. And make sure that cooling water is flowing through the equipment by sight glass at the outlet.

h) If thermo-syphon coolant system or static-filled coolant systems are provided, fill up to nearly center line of the tank level gauge.

i) Supply cooling water to the gas cooler.

j) If suction valve unloaders or clearance pockets are equipped for the capacity control, the formed should be set under the unload condition, and the latter shoulder be fully opened.

k) By-pass valve of gas pipeline should be fully opened. Open the drain valves and eliminate the drains. Then, shut the drain valves.

l) Turn the crankshaft by bar in order to make sure that all moving parts are run freely. The turning of the compressor should be done under the condition of leaving the pressure in the cylinder.

m) Turning the compressor, prime the lube oil to compressor by the priming pump. And confirm the lube oil to be supplied to moving parts.

If the motor-driven priming pump is equipped, this pump should be driven continuously until starting of compressor. At the same time, the lube oil pressure should be confirmed.

n) Even if it is winter season, raise the lube oil temperature above 20℃ as minimum by means of steam or electric heater.

o) If cylinders are lubricated, turn the lubricator by hand cranking for 20 to 30 times. And check whether oil is filled in the pipes up to cylinders. This can be confirmed by disconnecting the line at the non-return valve on cylinder.

p) Confirm whether any tool does not remain forgotten around compressor or any people do not remain near the compressor.

q) Confirm all safety devices to be in operating condition.

IV-2. STARTING OF COMPRESSOR

a) On no alarm condition, start the main driver.
If the shaft-driven main lube oil pump and the motor-driven oil pump for priming or the spare are equipped, after the main drive has reached the rated speed, stop the motor-driven oil pump. In case that the motor-driven oil pump is supplied for the spare, after stopping it, set the motor switch in the position of "Auto".

b) Check the lube oil pressure in order to confirm the feed condition of the crankcase oil force-red to the main, crank-pin and crosshead-pin bearings.
If cylinders are lubricated, confirm the oil feeds to cylinder and stuffing box by sight glasses of the lubricator.

c) After main driver runs up to normal speed and all parts are confirmed in good order, load up the compressor.

d) In case that the capacity control devices are equipped, load up the compressor gradually, as increasing the capacity by loading on the top side of cylinder and then setting the clearance pocket valve closing, and the loading on the crank side, at the same time on each stage.

e) When starting the compressor after long stoppage (more than a week), or overhauling, confirm whether abnormal conditions do not exist in any parts of compressor during no-load running, and then load up.
Especially, attentions should be paid for lube oil pressure, bearing and lube oil pump temperatures, sound of moving parts and the reading of am-meter.
In no-load running, suction gas temperature gradually increases, because of gas being blown back to suction side through unloaded suction valve and heated by friction.
Accordingly, a period of no-load running by suction valve unloaders or by-pass through no gas cooler should be possibly shortened.

IV-3. INSPECTIONS AND CARES DURING OPERATION

a) Watch the gages to ascertain that they indicate normal figures.

(1) Suction and discharge gas pressures and temperatures :
In such case as the heating system of the gas being provided, attention should be paid for suction gas temperature so that it is kept at a uniform temperature to protect the gas from condensing.

(2) Lube oil pressure and temperature, and pressure drop across oil filter :
Adjust the lube oil temperature to keep it above 40℃ even in winter by the by-pass valve.

b) Watch the reading of am-meter for motor.

c) Regulate the temperature of cooling water.

(1) As a general rule, cylinder cooling water should be always full-flowed. In case of regulating the temperature by throttling the valves, the temperature difference between inlet and outlet should not exceed 5℃ as standard.

(2) Valves of cooling water to stuffing box should be fully opened.

(3) In such cases as the temperature-controlled hot water being supplied to the cylinder jackets to prevent the gas from condensing, care should be paid for the inlet temperature so that it is kept at a uniform temperature.

d) Watch the level of cooling water in the tank.

In such cases as thermo-syphon system or static-filled system, if the amount of coolant is lessened, the cooling effect for a cylinder is decreased for that.

Keep the level of coolant at the nearly center line of the level gauge of the tank.

e) Watch the level of lube oil.

① Check if oil in crankcase is keeping normal oil level (not lower than min. level and not higher than max. level), and if necessary, fill up the lube oil.

② If cylinders are lubricated, fill up the lubricator reservoir with cylinder oil regularly.
No feed of oil must cause serious damages.

f) Watch the sound and vibration of moving parts.

Abnormal sound and vibration are the first sign causing a serious damage. In such a case, the compressor should be stopped at once and inspected.

g) Make sure that the compressor valves are acting normally. Watch the temperature of valve cover, the gas temperature, the flow capacity of gas, the moving sound of valves, etc.

In case of temperature rising of valve cover or gas, check whether the bolts of valve keeper have been tightened sufficiently or not, as the insufficient tightening causes such troubles.

h) Drain off frequently and regularly, and watch the amount and color of drain.

Take care of black drain. Black drain means the abnormal wear of cylinder liner and piston rings in most cases.

i) When the relief-valve is blown, before re-starting of the compressor, check each part, and trace the cause, if any.

j) Watch the amount and temperature of leakage gas from stuffing box (rod packing) and compartment adjacent to the cylinder.

k) Inspect that all foundation bolts are tight, and there is no leakage from gaskets and pipe connections

All checking points as mentioned above should be checked and all

running conditions should be noted in an operation diary.

Daily checking also should be made regularly.

IV-4. STOPPING OF COMPRESSOR

Cares and procedures when compressors are stopped are as follows

a) Unload the compressor by opening the suction valve unloaders or the by-pass valves.

When stopped, the compressor shall be under the condition of no cmoressing in the cylinders.

b) Then stop the main driver

c) Close the main valves in the discharge line.

d) Close the main valves in the suction line.

e) Relieve the pressure in the cylinders and gas to be replaced by Nitrogen.

f) Shut and drain off the cooling water, if the freezing temperature is expected or the shutdown is expected long.

But, it is not necessary that ethylene-glycol solution for thermo -syphon or static-filled coolant system is drained off.

g) Drain off all the drains in the same case as mentioned above.

h) Abnormal points to be checked and repaired during stoppage.

i) Management in case that the long stoppage is expected:

① After the cylinders have been cooled, all liquid in the cylinders should be drained off to prevent the cylinder inside from corrosion during the stoppage.

It is preferable to coat the rust preventive oil on the cylinders.

② Run the compressor for about five minutes every week under

an unloaded condition to prevent the parts from being rusty or corrosion.

In such case as an unload running being impossible, the compressor to be turned at least five revolutions by barring device, while the oil primed with the priming lube oil pump and the cylinder lubricator.

③ In such case that the process gas piping, in which corrosive gases are handled, is overhauled and left open to atmosphere, the piping ends to be fitted with blind flanges and the inside of the piping to be filled up with nitrogen to prevent it from being rusty or corrosion.

None of this work may cause a serious trouble.

④ Close the main stop valve in suction and discharge lines, and take off or lock the handle.

⑤ Take off the instruments which are liable to damage.

IV-5. TROUBLE SHOOTING GUIDE

In order to find the abnormal conditions during running, it is very important to be well aware of normal conditions, to record the data regularly and to be familiar with every sound from compressor and auxiliaries.

Don't overlook even a small abnormal phenomenon, because it must result trouble.

Generally, the trouble of compressor occurs hardly from single cause, but from several complicated causes.

The following are the abnormal phenomena which appear on ordinary compressors and must be watched carefully

1) Abnormal pressure

a) Low suction pressure

Causes	Remedies
Increased resistance in suction pipe line	Check the pipe line and fittings(valve, etc.).
Excessive capacity of compressor	Decrease the compressor capacity by the capacity control device.
Overcooling in the fore stage gas cooler	Decrease the flow of cooling water.
Leakage from suction pipe line	Check the pipe connection.
Low process gas pressure	Inspect process side.

b) High suction pressure

Causes	Remedies
Faulty suction compressor valve	Check and renew valves.
Increased leakage from piston rings.	Renew piston rings.
Leakage from the back of cylinder liner.	Tighten cylinder liner correctly.
High pressure gas flow into suction pipe line.	Close and check the by-pass valve.
Insufficient cooling in the forestage gas cooler.	Increase the flow of cooling water, clean tubes.
Shortage of compressor capacity.	Increase the compressor capacity by the capacity control device.

c) Low discharge pressure

Low suction pressure	See above.
Increased leakage from piston rings and stuffing boxes.	Check piston rings and stuffing boxes.
Leaky discharge pipe line	Check leakage from valves and other fittings.
Faulty suction and discharge compressor valves	Check and renew valves.
Excessive capacity of next stage compressor	Check the next stage capacity control device.
Drain valves or by-pass valves are not perfectly closed.	Close valves perfectly.

d) High discharge pressure

Increased resistance in discharge pipe line	Check the pipe line and fittings(valve, etc.).
Faulty suctin compressor valves of the next stage	Check and renew valves.
High suction pressure	See above.
Insufficient cooling in the forestage gas cooler	Increase the flow of cooling water, clean tubes.
Low suction pressure	Care about over-load.
Vibration of gas in suction and discharge pipe line	Change the piping layout.
Increased resistance at discharge compressor valve	Check the valve lift and the spring force.

2) Abnormal temperature

a) Low suction temperature

Low process temperature	Check the process side.
Over cooling in the gas cooler	Decrease the flow of cooling water
Excessive capacity of compressor	Decrease the capacity by the capacity control device.

b) High suction temperature

Faulty suction compressor valve	Check and renew valves.
By-pass valves are not perfectly closed	Close valves perfectly.
Heating of the suction pipe line	Remove the cause, cool the pipe, if necessary.

c) Low discharge temperature

Causes	Remedies
Low suction temperature	See above
Leaky discharge pipe line	Check leakage from valves or other fittings
Low discharge pressure	See above

d) High discharge temperature

High discharge pressure	See above
High suction temperature	See above
Low suction pressure	See above
Increased resistance in the discharge pipe line	Check the pipe line and fittings(valve, etc.).

3) Abnormal sound

a) Knocking sound in crankcase

Loose main bearing or crank pin bearing.	Check the bearing clearance, renew or adjust the bearing.
Loose tighten bolt of bearing.	Tighten the bolt correctly.
Faulty angle between piston center and crank pin, crosshead pin or crankshaft.	Re-machine to get 90°.

b) Knocking sound at crosshead guide

Loose crosshead pin bearing	Check the bearing clearance, renew, if necessary.
Loose nut for piston rod and crosshead	Tighten correctly and lock the nut perfectly.
Increased clearance between crosshead and crosshead guide	Check the clearance, readjust or renew, if necessary.
The uneven wear of crosshead guide or guide shoe	Readjust or renew guide shoes and rebore guide, if necessary.

c) Knocking sound in the cylinder

Causes	Remedies
Dropping pieces into the cylinder	Take out the pieces and insert the inside of cylinder.
Piston touches the top or the bottom of cylinder	Check and adjust the top clearance.
Loose tightening nut of the piston	Tighten correctly and lock the nut perfectly.
Loose tightening of cylinder liner	Tighten correctly.
The valve or piston of clearance pocket is not fixed perfectly	Check and fix the valve or the piston.
Increased clearance between piston rings and ring grooves	Check ring grooves and, if necessary, renew piston rings or piston.
Water hammer phenomenon	Drain off perfectly and check that discharge valve is in good order.
Breakage of suction or discharge compressor valve	Renew broken parts.
Improper working of suction valve unloader	Check and adjust it.

4) Abnormal sound in pipe line

a) Knocking sound in pipe

Resonant vibration of gas at the sudden change sections of the piping.	Remove the parts, change the layout.
Resonant vibration of gas at the branch or junction parts of the pipe.	Make the flow smooth at the parts, change the layout.

b) Abnormal sound by the vibration of the pipe

Causes	Remedies
Vibration of pipe	Strengthen the supports or change the pipe layout.
The pipes touch each other	Strengthen the supports or change the pipe layout.
Wrong pipe support	Supports pipes tightly.

c) Abnormal sound from Non-return valve

Non-return valves in poor order	Check and renew the valves, if necessary.

d) Abnormal sound in shell & tube type cooler

Baffle plate loosened	Make the baffle plates rigid.
Clattering sound from the tube and baffle plate	Strengten the shell of the cooler and tighten anchor bolt firmly.

e) Leakage sound from pipes and pipe connections

Cracked pipes	Mend by welding or remove the parts
Insufficient tightening of flange bolt	Tighten sufficiently
Breakage of gaskets	Renew the gaskets
Leakage from valves	Inspect and re-grind valves

5) Abnormal vibration

a) Vibration of the foundation

Resonance between the ground and the foundation block	Take measure to avoid the resonance.

b) Abnormal vibration of compressor

Causes	Remedies
Insufficient support of the foundation	Reinforce the foundation
Loose foundation bolt	Tighten correctly.
Loose connection studs of each parts	Tighten correctly.
Eccentric center fo fly-wheel shaft due to the excessive clearance of the bearing	Check the clearance, modify correctly and renew the bearings, if necessary.

c) Abnormal vibration of cooler

Vibration of gas in pipe	Strengthen the support
Resonance of pipe	Take measures to avoid the resonance
Vibration of pipe line	Reinforce the support

6) Abnormal consumption of power

a) Much consumption since running-in period

Causes	Remedies
Too much capacity	Check operation condition in comparison with design ones.
Too much resistance in pipe line	Inspect valves, check the piping.
High suction and discharge pressure	Inspect the process side
Too high viscosity of lube oil	Feed the suitable oil

b) Increased power consumption during running

Causes	Remedies
High suction and discharge pressure	See above
Increases resistance in gas passage	Inspect the pipe line and fittings (valve, etc.)
Increases resistance of compressor valves	Check and adjust the lift of valves.
Insufficient cooling in gas cooler	Increase the flow of cooling water, clean the tubes.
Increased friction loss of the moving parts.	Inspect the moving parts, such as bearings, crosshead guide, check the lubricating oil pressure.

IV-6. CARES OF AIR RUNNING

No one can say that no danger for gas explosion exists at all during air running under existing petroleum lube oil.
The following attentions should be paid for air running:

a) Air circulation running to be absolutely avoided.

b) Before air running, inspect whether carbon deposit adheres to the high temperature zone (discharge valves, discharge snubbers, discharge pipings, gas coolers, etc.) or not. Carbon deposits to be taken off as much carbon deposits eventually cause fire and perhaps explosion.
Thickness of the carbon deposit layer should be below 1mm.

c) During air running, frequently drain off the accumulated lube oil from the points where it tends to accumulate, especially from discharge snubbers, bends in discharge pipings, ect.

d) Care should be paid for temperature rise of the points where oil and carbon deposit tend to accumulate, especially discharge snubbers, and bends in discharge pipings, all the while of air running.

The temperature rise should be watched by any alarming system for high temperature such as temperature switch. The alarming temperature to be set at about 15 to 25℃ higher than normal air temperature.
It is preferable to keep the air temperature as low as possible.

e) Cylinder oil must have excellent oxidation stability and less carbonizing property. Feed rate of the cylinder oil to be reduced to a half of normal one.

f) Such partial load running as air velocity in the piping being slow should be avoided.

g) Of course, it is preferable to shorten the duration of air running.

IV-7. CAPACITY CONTROL

1) The capacity of compressor can be controlled by using the suction valve unloaders which are provided on all suction valves.

   The suction valve unloaders are of pneumatic type and can be manually operated from the local control panel.

2) Capacity control step

capacity		100 %	0 %
N o . 1 cylinder	H.E		
	C.E		

H.E : Head end
C.E : Crank end
B.C : By-pass control

S : suction valve unloader
F : fixed pocket valve open

* WARNING : Running under the condition of zero capacity should not be continued for longer hours, and it should be limitted only at start and stop.

IV-8. COMPRESSOR SAFETY DEVICE

1) The following safety devices are furnished with the compressor.

   a) Lube oil safety valve
   b) Cooling water thermal relief valve
   c) Other safety devices provided are listed in the attached "INSTRUMENT LIST"

2) Emergency Stop

   The compressor is provided with some protective devices to prevent serious damages from any troubles.

   When lube oil (crankcase) pressure drops to predetermined value, the compressor is stopped automatically.

   As there may be erroneous operations of instrument itself in case of emergency stops, the cause should be examined taking this into consideration.

   The compressor must be instantly stopped and checked in case that the following running conditions have been noticed:

   a) abnormal knocking sound
   b) abnormal vibration
   c) crack or damage of pipe and violent gas blow

   Immediately after stopping the compressor for checking

   a) close the main stop valves in gas line and purge the process gas in the compressor cylinder under the unloaded conition,

   b) operate the lub. oil pump, and

   c) turn the compressor, at least three rounds.

3) Troubles and Checkings.

a) Low lube oil pressure

Causes	Remedies
Clogged filter	Clean (Check inside)
Trouble of lube oil pump	Repair
Breakage of pipe	Repair
Leakage of oil from joint	Repair

b) High lube oil temperature

Fouling of shell side or tube side of lube oil cooler	Clean
Clog or fouling of cooling water passage in the oil cooler	Clean
Seizure of any moving part in crankcase	Check bearings and crosshead shoes and repair, if necessary.

c) High discharge gas temperature

As to causes and remedies for it, see "Trouble Shooting Guide" in chapter IV-5.

CHAPTER V. MAINTENANCE

V-1. MAINTENANCE SCHEDULE (As a general guide)

The following instruction for the maintenance schedule is to be understood as a general guidance for efficient maintenance of the compressor and may be altered by operators or people in charge of maintenance work in accordance with the experience at site based on the actual results of the operation. Especially in the case of contaminated gases, it is preferable that the maintenance intervals are shortened.

As a rule, it is not recommended to disassemble the compressor for inspection or maintenance except when data in the daily records indicate that readjustment or replacement of certain parts is called for or when distinguished troubles occur on the compressor parts.

We advise to record a number of operating data at regular intervals.

a) temperature and pressure of lube oil
b) pressure drop across lube oil filter
c) temperature and pressure of handling gas
d) average load
e) gas analysis

In addition to the above data, operator should bear in his mind the conditions of lube oil, handling gas and cooling water, drains from individual parts, and sound under normal operating conditions of the compressor.

The abnormal value of above data, the lube oil consumption, the gas leakage from stuffing box, etc. will often indicate the omen of accident or replacement of parts.

1) Daily Maintenance

a) Fill systematically the above mentioned operating data in records (several times daily).

b) Check cooling water supply.

c) Check lube oil level by sight glass. If necessary, replenish the oils.

d) Check pressure difference across lube oil filter.

e) Drain off all condensate from individual parts and inspect the colors.

f) Check the oil dropped out of stuffing box.

g) Check the sound around the compressor valve for normal conditions.

h) Sweep the compressor and around.

2) Every 500 hours

a) Check operation of safety devices.

b) Check gas, oil and water systems for leakage.

c) Inspect and clean lube oil filter, if necessary.

d) Check condition of lube oil.

Note : When starting the non-lubricating compressor for the first time, inspect the rider rings and piston rings after one week and 500 hrs of operation.

3) Overhauling schedule for parts

Part Name	Maintenance interval (Operating hrs)	Detail of maintenance
a) Cylinder		
cylinder or cylinder liner	8,000	Inspect the inside and measure the inside diameter.
gas passage in the cylinder	8,000	Inspect the condition of inside and clean the passage, if necessary
cooling water jacket	8,000	Take off the cover and clean out the dirt of jacket inside.
clearance pocket	8,000	Inspect the condition of inside and clean. Confirm the moving of handle and grease the thread.

Part Name	Maintenance interval (Operating hrs)	Detail of maintenance
b) Piston and Piston Rod		
Piston	8,000	Inspect the outside and measure the groove dimension and the outside diameter.
Piston Ring	Lub : 8,000 Non-lub : 4000	Inspect the ring condition and measure the amount of wear.
Rider Ring	Lub : 8,000 Non-lub : 4000	Inspect the sliding surface and measure the amount of wear.
Piston Rod	8,000	Measure the amount of wear and check the plated surface condition at the sliding section. Inspect whether the crack is observed.
	16,000	Examine the rod by Ultrasonic. (As a rule, the piston rod is worn down on the sliding section should be renewed.)
c) Stuffing box		
Gland packing	Lub : 8,000 Non-lub : 4000	Inspect the spring and contact surface to the piston rod. Measure the side clearance and the thickness of the ring.
Oil wiper ring	8,000	Inspect the spring and contact surface to the piston rod.
d) Compressor Valve		
valve seat	4,000	Inspect the seat face, if any damage is shown, re-machine and lap the seating area.
valve plate	4,000	Inspect the seat face and measure the thickness. Inspect the warp and breakage. (Renew after 8,000 operating hr.)

Part Name	Maintenance interval (Operating hrs)	Detail of maintenance
d) Compressor Valve		
damper plate	4,000	Inspect the warp and breakage. (Renew after 8,000 operating hrs)
valve spring		Inspect the warp and breakage. When a spring in a valve indicate damage, all springs as well as its spring in this particular valve must be renewed. (Renew after 8,000 operating hrs)
guide pin	4,000	Inspect the contact to valve plate or damper plate, and examine any breakage or damage.
valve cover gasket(O-ring)	4,000	Inspect cut off or hardened.
Suction valve Unloader	8,000	Inspect the condition of packing, diaphragm, spring, etc. (As a general rule, diaphragm packing should be renewed after one year operation.)
e) Crosshead		
crosshead	8,000	Inspect the sliding surface.
crosshead guide	8,000	Inspect the sliding surface and measure the clearance between crosshead and guide by feeler gauge.
crosshead pin	8,000	Examine the surface PT or MT. Measure the outside diameter.
crosshead pin bearing	8,000	Inspect the surface and measure the inside diameter.

Part Name	Maintenance interval (Operating hrs)	Detail of maintenance
f) Connecting rod		
crank pin bearing	8,000	Inspect the surface.(PT or MT) After assemble the bearing into the connecting rod, measure the inside diameter and the elongation of rod bolt.
rod bolt (big end bolt)	8,000	Inspect the surface.(PT or MT) Measure the free length of it. (The connecting rod bolt should be renewed after 20,000 running hrs. or 10 times of retightening)
g) crankshaft		
crankpin	8,000	Inspect the surface and measure the outside diameter.
	16,000	Inspect the surface.(PT or MT)
crank journal	16,000	Inspect the surface(PT or MT) and measure the outside diameter.
main bearing (sleeve)	16,000	Inspect the surface(PT or MT) and measure the inside diameter
main bearing (anti-friction)	16,000	Measure the bearing radial gap.
deflection of crank	4,000	By reason of confirming the alignment of crankshaft, measure the deflection. If bad alignment is appeared adjust and/or renew the main bearing or motor bearing
h) Crank case	8,000	Inspect the inside for dirts or foreign matters.
i) Lub. oil pump	8,000	Inspect the bearing, gear and their contact condition.
j) Lubricator	8,000	Check the working of its element and clean it. Also clean piping.

Part Name	Maintenance interval (Operating hrs)	Detail of maintenance
k) Lub. oil filter	4,000	Investigate the dust on the element, check the abnormal wearing. Renew after 4,000 running hrs.
l) Driver(motor)	8,000	According to instruction for it.
m) Crankcase lube oil	4,000	Analyze and examine the viscosity, inflammable point, etc.
n) Tightening bolt and nut	8,000	Inspect the tightening condition of all bolts. If loosened, tighten it firmly. If the anchor bolts are adjusted, after the working, measure the deflection of crankshaft and confirm its value.
o) Heat exchanger (L.O cooler) (Gas cooler) (C.W cooler) (C.W heater) (L.O heater)	8,000	Inspect the clogging condition and the corrosion or erosion condition inside the tubes. If necessary, measure the tube wall thickness.
p) Vessel & piping (suc. & disch. snubber) (separator) (disch. piping)	4,000	Inspect the carbon deposit and watch it not to accumulate more than 1 mm. If necessary, clean it by chemical cleaning. If accumulated more than 1 mm within 2,000 operating hours, clean up it every 2,000 operating hours.

CHAPTER VI. COMPRESSOR TECHNICAL DATA

GENERAL BOLT CONCLUSION TORQUE

NO.	MATERIAL / NORMAL SIZE	SCM435	S35C	SS41
1	10 x 1.25	4.1	2.6	2.2
2	12 x 1.25	7.2	4.5	3.8
3	14 x 1.5	11	7.1	6.0
4	16 x 1.5	17	11	9.0
5	18 x 1.5	24	15	13
6	20 x 1.5	34	21	18
7	22 x 1.5	45	28	24
8	24 x 2	58	36	31
9	27 x 2	84	53	45
10	30 x 2	116	73	62
11	33 x 2	155	97	83
12	30 x 3	111	69	59
13	33 x 3	149	93	79
14	36 x 3	196	123	104
15	39 x 3	252	157	134
16	42 x 3	317	198	168
17	45 x 3	394	246	210
18	48 x 3	483	302	257
19	52 x 3	618	386	328

Big End BOLT CONCLUSION TORQUE

(CONNECTING ROD BOLT)

Nominal Bolt Size	Length (mm)	Elongation		Tightening Torque(kg · m)
		최소(mm)	최대(mm)	
M18 x 1.5	123	8.61	9.84	15
M18 x 1.5	147	10.29	11.76	15
M22 x 1.5	174	12.18	13.92	30
M28 x 2	216	15.12	17.28	48
M28 x 2	236	16.52	18.88	48
M28 x 2	256	17.92	20.48	48
M34 x 2	248	17.36	19.84	70
M34 x 2	258	18.06	20.64	70
M34 x 2	268	18.76	21.44	70
M34 x 2	284	19.88	22.72	70
M38 x 3	322	22.54	25.76	105
M39 x 2	287	20.09	22.96	110
M48 x 3	349	24.43	27.92	170
M48 x 3	369	25.83	29.52	170

CHAPTER VII. ATTACHMENT

JOKWANG I.L.I CO.,LTD.

DATA SHEETS
FOR
QUOTATION

PRESSURE SAFETY & RELIEF VALVE SPECIFICATIONS

Doc.No. : SLQ006609

PROJECT NO. : M/O No:SR11006
(HULL NO)

PROJECT NAME : O2 COMPRESSOR FOR SESA GOA PROJECT

CLIENT : 광신기계공업

SITE :

Head Office & Plant

1650 - 8, SONGJEONG-DONG, KANGSEO-KU, PUSAN, KOREA
Tel : (051) 602 - 0200 Fax : (051) 831 - 0799
http://www.jokwang.co.kr

0	2011. 03. 24.	Quotation	김준희	김태훈	현상봉		

REV.	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D	APP'D	DATE
						CLIENT	

Pressure Safety & Relief Valve Specifications

Sheet No.	1	Rev.No.	0
Project No.	M/O No:SR11006		
Project	O2 COMPRESSOR FOR SESA GOA PROJECT		
Date	2011. 03. 24.	By	김준희
Checked	김태훈	Approved	현상봉

GENERAL	Item No.	1	
	Tag No.	2	PSV-1105
	Service Line	3	1ST Dis. Snu
	Number Required	4	1
	Nozzle Type, Full or Semi	5	Full Nozzle
	Design Type	6	
	A.Safety,Safety & Relief,Relief		Safety & Relief
	B.Conventional or Bellows		Conventional
	C.Full Bore, Low or High Lift		Full Bore Type
	Bonnet Type. Open or Close	7	Close
CONN	Size. Inlet / Outlet	8	2X3"
	Inlet. Rating / Facing	9	ANSI 150LB RF
	Outlet. Rating / Facing	10	ANSI 150LB RF
MATERIALS	Body / Bonnet	11	A216 WCB / A216 WCB
	Seat	12	A351 CF8(STELLITED)
	Disc	13	A276 304(STELLITED)
	Resilient Seat seal	14	
	Gasket	15	NON-ASBESTOS
	Spring	16	SWOSC
	Bellows	17	
ACCESS	Cap. Screwed or Bolted	18	Screwed
	Lever. Plain or Packed	19	None Lever
	Test Gag	20	No
	Paint Color	21	Silver
BASIC	Code	22	ASME sec. VIII
	Fire	23	No
	Other	24	
SERVICE	Fluid and State	25	O2+N2+Ar(G)
	Required Capacity	26	4308.5 kg/h
	Mol. Weight or Specific Gravity	27	32.2
	Viscosity	28	
	Operating / Set Pressure	29	2.65 / 6 Kgf/㎠g
	Operating / Blowout Temp	30	125 / 125 ℃
	Constant Back Pressure	31	Kgf/㎠g
	Variable Back Pressure	32	Kgf/㎠g
	Total Back Pressure	33	0 Kgf/㎠g
	Closing Pressure	34	Min. 5.4 Kgf/㎠g
	Hydrostatic Test	35	9 Kgf/㎠g
	Allowable Overpressure	36	10 %
	Compressibility Factor	37	1
	Ratio of Specific Heat	38	1.4
ORIFICE	Calculated Area	39	865.961 ㎟
	Selected Area	40	1134.115 ㎟
	Orifice Designation	41	J
	Valve Capacity	42	5643 kg/h
	Model No.	43	JSV-FF21
S.T	Lapping Tool	44	

CALCULATION

* Calculation of Area

A1 = W1/(C*K*(P*1.1+0.1)*√(M/(ZT))

=4308.5 / (27.03 *0.864 * (0.59 *1.1 + 0.1) * √ (32.2 / (1 *398))

= **865.961** ㎟

* Calculation of Capacity

W = A*C*K*(P*1.1+0.1)*√(M/(ZT))

=1134.115 *27.03 *0.864 * (0.59 *1.1 + 0.1) * √(32.2 /(1 *398))

= **5643** kg/h

W = Valve Capacity .....
W1 = Required Capacity ..... 4308.5 kg/h
P = Set Pressure ..... 0.59 MPag
A1 = Calculated Area ..... ㎟
A = Selected Area ..... ㎟
K = Coefficient of Discharge 0.864
C = Coefficient base on Ratio of Specific Heat 27.03
T = Absoulte Temperature..... 398
M = Molecular Weight..... 32.2
Z = Compressibility Factor..... 1

Remark

*Oil free

Pressure Safety & Relief Valve Specifications

J • K Since 1968

Sheet No.	1	Rev.No.	0
Project No.	M/O No:SR11006		
Project	O2 COMPRESSOR FOR SESA GOA		
Date	2011. 03. 24.	By	김준회
Checked	김태훈	Approved	현상봉

GENERAL	Item No.	1	
	Tag No.	2	PSV-1106
	Service Line	3	After cooler
	Number Required	4	1
	Nozzle Type, Full or Semi	5	Full Nozzle
	Design Type	6	
	A.Safety,Safety & Relief,Relief		Safety & Relief
	B.Conventional or Bellows		Conventional
	C.Full Bore, Low or High Lift		Full Bore Type
	Bonnet Type. Open or Close	7	Close
CONN	Size. Inlet / Outlet	8	1-1/2X2-1/2"
	Inlet. Rating / Facing	9	ANSI 150LB RF
	Outlet. Rating / Facing	10	ANSI 150LB RF
MATERIALS	Body / Bonnet	11	A216 WCB / A216 WCB
	Seat	12	A351 CF8(STELLITED)
	Disc	13	A276 304(STELLITED)
	Resilient Seat seal	14	
	Gasket	15	NON-ASBESTOS
	Spring	16	SWOSC
	Bellows	17	
ACCESS	Cap. Screwed or Bolted	18	Screwed
	Lever. Plain or Packed	19	None Lever
	Test Gag	20	No
	Paint Color	21	Silver
BASIC	Code	22	ASME sec. VIII
	Fire	23	No
	Other	24	
SERVICE	Fluid and State	25	O2+N2+Ar(G)
	Required Capacity	26	4308.5 kg/h
	Mol. Weight or Specific Gravity	27	32.2
	Viscosity	28	
	Operating / Set Pressure	29	6.12 / 8 Kgf/㎠g
	Operating / Blowout Temp	30	40 / 40 ℃
	Constant Back Pressure	31	Kgf/㎠g
	Variable Back Pressure	32	Kgf/㎠g
	Total Back Pressure	33	0 Kgf/㎠g
	Closing Pressure	34	Min. 7.2 Kgf/㎠g
	Hydrostatic Test	35	12 Kgf/㎠g
	Allowable Overpressure	36	10 %
	Compressibility Factor	37	1
	Ratio of Specific Heat	38	1.4
ORIFICE	Calculated Area	39	600.406 ㎟
	Selected Area	40	706.858 ㎟
	Orifice Designation	41	H
	Valve Capacity	42	5072 kg/h
	Model No.	43	JSV-FF21
S.T	Lapping Tool	44	

CALCULATION

* Calculation of Area

A1 = W1/(C*K*(P*1.1+0.1)*√(M/(ZT))

=4308.5 / (27.03 *0.864 * (0.78 *1.1 + 0.1) * √ (32.2 / (1 *313))

= **600.406** ㎟

* Calculation of Capacity

W = A*C*K*(P*1.1+0.1)*√(M/(ZT))

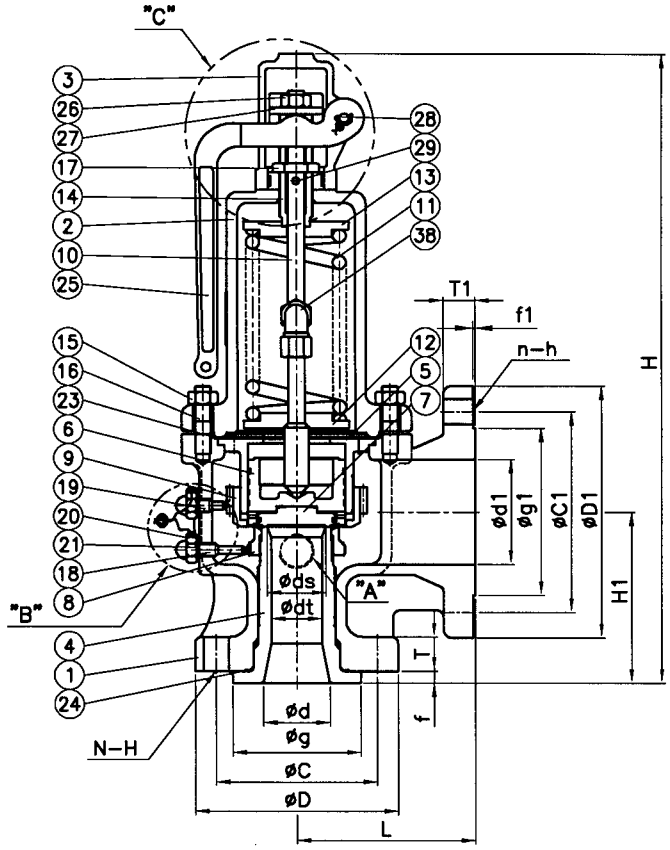
=706.858 *27.03 *0.864 * (0.78 *1.1 + 0.1) * √ (32.2 /(1 *313))

= **5072** kg/h

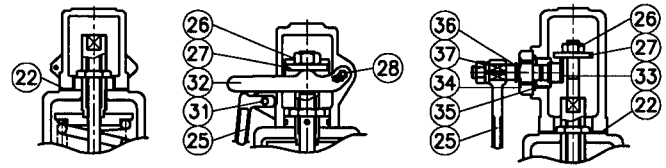
W = Valve Capacity .....
W1 = Required Capacity ..... 4308.5 kg/h
P = Set Pressure ..... 0.78 MPag
A1 = Calculated Area ..... ㎟
A = Selected Area ..... ㎟
K = Coefficient of Discharge 0.864
C = Coefficient base on Ratio of Specific Heat 27.03
T = Absoulte Temperature..... 313
M = Molecular Weight..... 32.2
Z = Compressibility Factor..... 1

Remark

*Oil free

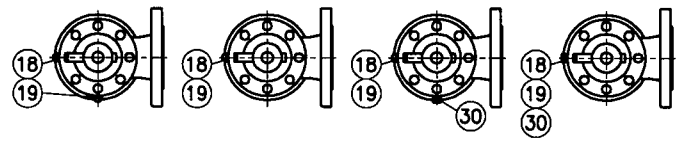


LEVER TYPE



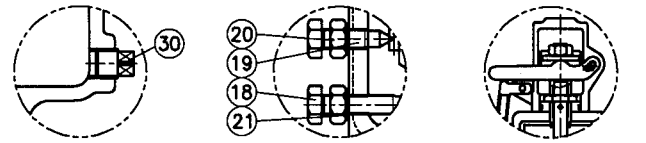
■NONE LEVER(CN) □PLAIN LEVER(CL) □PACKED LEVER(PL)

DRAIN PLUG & SET SCREW POSITION



1/2B-3/4B(Dt:11.5) 3/4B-1B 11/2B-4B 5B-8B

DETAIL VIEW



VIEW A:DRAIN PLUG
11/2B-4B: PT3/4"
5B-8B: PT1/2"

VIEW B:SET SCREW TYPE
5B-8B

VIEW C:PLAIN LEVER TYPE
4B-8B

DIMENSION

UNIT : mm

SIZE d x d1	dt	ds	L	H1	H(CN) ■	H(CL) □	H(PL) □	INLET FLANGE ANSI B 16.5 CL150 RF						OUTLET FLANGE ANSI B 16.5 CL150 RF						W.T (kg)	Q'TY
								D	g	C	T	f	N-H	D1	g1	C1	T1	f1	n-h		
1/2Bx1B	11.5	14.5	96	88	287	289	314	89	35	60.5	15	5	4-16	108	51	79.5	14.3	1.6	4-16	6.5	
3/4Bx1B	11.5	14.5	96	88	287	289	314	98	43	70.0	15	5	4-16	108	51	79.5	14.3	1.6	4-16	6.5	
3/4Bx11/2B	15	17.5	102	100	297	299	324	98	43	70.0	22	7	4-16	127	73	98.5	17.5	1.6	4-16	10	
1Bx2B	19	22	103	104	338	338	363	108	51	79.5	22	7	4-16	152	92	120.5	19.1	1.6	4-19	14	
→ 11/2Bx21/2B	30	35	120	119	389	406	414	127	73	98.5	24	8	4-16	178	105	139.5	22.3	1.6	4-19	23	
→ 2Bx3B	38	44	134	130	459	476	508	152	92	120.5	26	9	4-19	191	127	152.5	23.9	1.6	4-19	28	
21/2Bx4B	49	57	150	150	534	565	580	178	105	139.5	30	10	4-19	229	157	190.5	23.9	1.6	8-19	37.5	
3Bx4B	61	71	162	168	593	622	653	191	127	152.5	24	12	4-19	229	157	190.5	23.9	1.6	8-19	55	
3Bx5B	61	71	166	168	593	622	653	191	127	152.5	32	12	4-19	254	186	216.0	23.9	1.6	8-22	55	
4Bx6B	76	88	194	203	689	731	749	229	157	190.5	28	12	8-19	279	216	241.5	25.4	1.6	8-22	94	
5Bx8B	95	114	227	232	865	907	950	254	186	216.0	38	15	8-22	343	270	298.5	28.6	1.6	8-22	140	
6Bx8B	115	133	232	230	911	953	996	279	216	241.5	28	15	8-22	343	270	298.5	28.6	1.6	8-22	165	
8Bx10B	150	175	281	280	1089	1121	1160	343	270	298.5	46	15	8-22	406	324	362.0	30.2	1.6	12-25	317	

NO	PART NAME	MATERIAL	Q'TY	REMARK
38	VENT VALVE	BRASS	1	CL TYPE
37	SPRING WASHER	HSW	1	PL TYPE
36	SNAP RING	HSW	1	PL TYPE
35	O-RING	NBR	1	PL TYPE
34	GLAND NUT	A276 304	1	PL TYPE
33	CAM SHAFT	A276 304	1	PL TYPE
32	LEVER-2	A536	1	CL TYPE
31	PIN-2	A36	1	CL TYPE
30	PLUG	A36	1	11/2B-8B
29	CAP BOLT	A322 4140		CL TYPE
28	PIN-1	A36	1	CL TYPE
27	STEM WASHER	A36	1	CL,PL TYPE
26	NUT (STEM)	A194 8	1	CL,PL TYPE
25	LEVER-1	A536	1	CL,PL TYPE
24	SEAT GASKET	PTFE	1	CN,PL TYPE
23/22	BONNET GASKET/ CAP GASKET →	GRAPHITE / PTFE / NON ASBESTOS	1	CN,PL TYPE
21	SET SCREW GASKET	PTFE / NON ASBESTOS	2	CN,PL TYPE / CL TYPE
20	CAP NUT or NUT	A563	2	VIEW B
19	SET SCREW (UPP.)	A276 304	1	
18	SET SCREW (LOW.)	A276 304	1	
17	LOCK NUT(ADJUST SCREW)	A276 304	1	
16	STUD BOLT	A193 B7		
15	STUD NUT	A194 2H		
14	ADJUST SCREW	A276 410	1	
13	SPRING SEAT (UPP.)	A283 B	1	
12	SPRING SEAT (LOW.)	A283 B	1	
11	SPRING →	SUS 316 / SUS 304 / SUP 9 / SWOSC	1	
10	VALVE STEM	A276 410 / A276 304 / A276 303	1	5B-8B / 3B-4B / 1/2B-21/2B
9	ADJUST RING (UPP.)	A351 CF8	1	
8	ADJUST RING (LOW.)	A351 CF8	1	
7	DISC →	A276 316L (STELLITED) / A276 316 (STELLITED) / A276 304 (STELLITED)	1	
6	DISC HOLDER	A351 CF8	1	
5	DISC GUIDE	A351 CF8	1	
4	SEAT →	A351 CF3M (STELLITED) / A351 CF8M (STELLITED) / A351 CF8 (STELLITED)	1	
3	CAP	A536	1	
2	BONNET	A216 WCB	1	
1	BODY	A216 WCB	1	

DES	CHE	APP	DATE	2010.09.01
W.J.JUNG	K.H.KIM	W.S.BAEG	SCALE	N S

D.W.G NAME: CL150 FULL BORE TYPE SAFETY RELIEF VALVE

MODEL NO: JSV-FF21

JOKWANG I.L.I CO.,LTD.

D.W.G NO: JKS-A1321037 REV.: 0

LUBRICANT LIST

DOC. NO.	VP-10045-05
DATE	2011. 03. 15

M/O NO.	SR11006	ITEM NO.	2.0 For 100 tpd ASU	PJT. NAME	02 Compressor For Sesa GOA Project

NO.	GRADE (ISO or ASTM)	MAKER'S BRAND				INITIAL CHARGE (LITER)	REPLACEMENT CHARGE		MAKE UP		LOCATION TO BE USED
		SHELL	CALTEX	MOBIL	GULF		QUANTITY (LITER/SET)	INTERVAL	QUANTITY (LITER/SET)	INTERVAL	
1	ISO VG100	SHELL CORENA P100	RPM COMPRESSOR EP VDL	RARUS 427	ESSTIC 100	65ℓ	65ℓ	4000hr	DEPEND ON LEVEL GAUGE	500hr	CRANK CASE
2											

NOTE :
DE : DRIVE END
NDE : NON-DRIVE END

UTILITY CONSUMPTION LIST

ITEM NO.	2.0 For 100 tpd ASU	NAME OF EQPT.	KSDWNL-400HP O2 COMPRESSOR

JOB NO. : -
PLANT NAME : O2 Compressor SESA GOA Project
REQ. NO. : -
SELLER NAME : KWANGSHIN MACHINE IND. CO., LTD.
SHEET NO. : 1 OF 1

NO.	SYSTEM / EQUIPMENT	Q'TY	Q'TY PER OPERATION MODE			ELECTRICITY		INST. AIR (N ℓ/min)		N_2 (N ℓ/min)		COOLING WATER (T/H)		DEMI WATER (m3/hr)		FILTERED WATER (m3/hr)		REMARK
			C	I	S	C	I	C	I(T)	C	I(T)	C	I	C	I	C	I	
1	COMPRESSOR (MOTOR)	1	1			300kw						4.92						AC415V
2	CONTROL POWER	1	1			0.5kw												AC110V
3	AUX. OIL PUMP	1	1			1.5kw												AC415V
4	SPACE HEATER	1	1			0.3kw												AC110V
5	INTER COOLER	1	1									11.84						
6	AFTER COOLER	1	1									9.26						
7	OIL COOLER	1	1									0.80						

NOTE : (*T) : OPERATING HOURS PER 24 HOURS
C : CONTINUOUS OPERATION
I : INTERMEDIATE OPERATION
S : STAND-BY

* MOTOR : AC415V 3PH 50HZ
* UPS : UNINTERRUPTED POWER SUPPLY
* IPS : INTERRUPTED POWER SUPPLY

NOTE

1. THE MARK " ▼ " DE NOTES TERMINAL POINT BETWEEN OWNER & KWANGSHIN

CUSTOMER ▼ KWANGSHIN

SYMBOL	DESCRIPTION
⋈	GATE VALVE
⋈	NEDDLE VALVE
⋈	CHECK VALVE
⋈	GLOBE VALVE
⋈	SAFETY VALVE
⋈	SOLENOID VALVE (3-WAY)
⋈	PRESSURE CONTROL VALVE
⋈	SUCTION LINE FILTER (#40)
⋈	GEAR PUMP
⋈	ELECTRIC MOTOR
⋈	UNLOADER
⋈	OIL STRAINER
⋈	REGULATOR & FILTER
PG	PRESSURE GAUGE
PS	PRESSURE SWITCH
PT	PRESSURE TRANSMITTER
PDI/PDS	PRESSURE DIF. GAUGE/SWITCH
TG	TEMPERATURE GAUGE
TE	TEMPERATURE ELEMENT
LG	LEVEL GAUGE
FS	FLOW SWITCH
FC	FLOW CONTROL VALVE
SG	SIGHT GLASS
◯	LOCAL MOUNTED
⊖	LOCAL GAUGE BOARD
▭	DCS & MCC
———	GAS MAIN LINE
———	COOLING WATER LINE
- - - - -	ELECTRIC LINE
—×—×—	CAPILLARY TUBE LINE
—//—//—	LUB. OIL LINE
—//—//—	TUBING LINE

PG 1103 · TG 1103 · INTER COOLER · SET. PRESS. 5.0 Kg/Cm²G PSV 1107 · PAH 1102 · TG 1102 · PS 1102 · PG 1102 · SET. PRESS. 6.8 Kg/Cm²G PSV 1102 · DISCHARGE SNUBBER · 3/8" SS304 · XA 1101 · XA 1102 · SV 1101 (50%) · SV 1102 (50%) · PG 1108 · 1/2" · 1/2" INSTRUMENT AIR INLET · DEW POINT −40°C at 1Atm.A · 4 ~ 6 Kg/cm2.G · ANSI 150LB SW.RF · TAHH TAH · TE 1101 · TI 1101 · TI 1102 · TE 1102 · PAHL 1102 · PAHL 1101 · A · PG 1105 · PT 1102 · 2ND. CYLINDER · 1ST. CYLINDER · 1ST. CYLINDER · SG 1101 · SG 1102 · SG 1103 · SET. PRESS. 5.0 Kg/Cm²G PSV 1105 · SET. PRESS. 5.0 Kg/Cm²G PSV 1106 · SET. PRESS. 5.0 Kg/Cm²G PSV 1104 · MCC · LG 1101 · M · 300KW, 415V, 3PH · PI 1103 · PAL 1103 · PALL 1103 · PG 1107 · PT 1103 · MAIN OIL PUMP (SHAFT DRIVEN) · AUX. OIL PUMP 0.5kw, 110V, 1PH · AL DPAH 1101 · DPS 1101 · DPG 1101 · SET 0.7KG/CM²G · F1 OIL FILTER F2 · PG 1106 · SG 1103 · OIL COOLER · TG 1105 · TAH TI 1110 · PG 1108 · TE 1110 · TAHH TAH TI 1103 TE 1103 · SET. PRESS. 5.0 Kg/Cm²G PSV 1108 · SET. PRESS. 6.8 Kg/Cm²G PSV 1103 · PG 1104 · AFTER COOLER · TG 1104 · C.V (CV-50-3) · 6"-GO-UN-1075-ADBS1A-S2 O2 GAS OUTLET ANSI 150LB SO.RF · 1" N2 PURGE GAS OUTLET ANSI 150LB SO.RF · 4"-CWS-UN-12Y-ADBA1A C.W SUPPLY ANSI 150LB SO.RF · 4"-CWR-UN-12Y-ADBA1A C.W RETURN ANSI 150LB SO.RF · FS 1101 · TE 1109 · FAL 1101 · TAH 1109 · TG 1101 · PG 1101 · PS 1101 · PAL 1101 · PT 1101 · PIC 1101 · SET. PRESS 3.0 Kg/Cm²G PSV 1101 · SUCTION SNUBBER · 10"-GO-UN-1073-ADAS1A-S2 O2 GAS INLET ANSI 150LB SO.RF · 1" N2 PURGE GAS INLET ANSI 150LB SO.RF · A · PV 101 · (V-50-2A) · (V-50-2B) · (V-50-2C) · F.O · 6" · 10" · 8" · 4" · 3" · 2" · 1-1/2" · 1-1/4" · 1" · 3/4" · 3/8" · 1/2"

REV.	DESCRIPTION	DRAWN	CHK'D	APP'D	APP'D	DATE
5	FOR APPROVAL	B.J.JIN	-	K.P.JANG	H.C.JANG	11'06.08
4	FOR APPROVAL	B.J.JIN	-	K.P.JANG	H.C.JANG	11'05.16
3	FOR APPROVAL	B.J.JIN	-	K.P.JANG	H.C.JANG	11'05.03
2	FOR APPROVAL	B.J.JIN	-	K.P.JANG	H.C.JANG	11'04.24

BOC INDIA LIMITED

Dependable Compressor
KWANGSHIN MACHINE INDUSTRY CO., LTD.

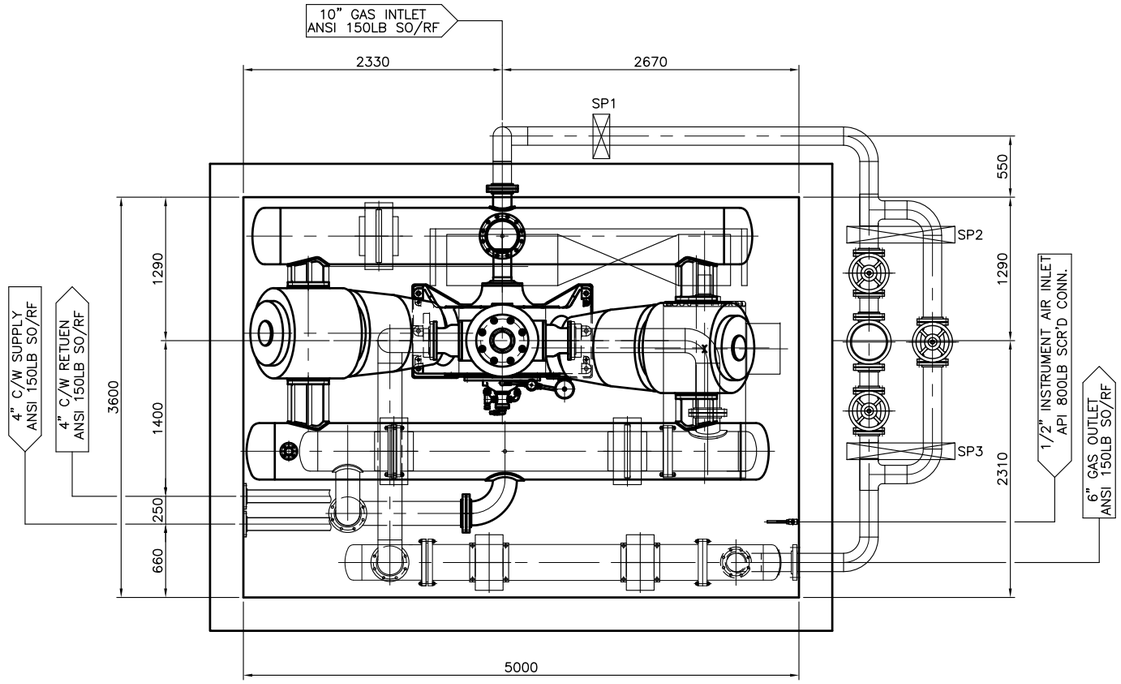
TITLE

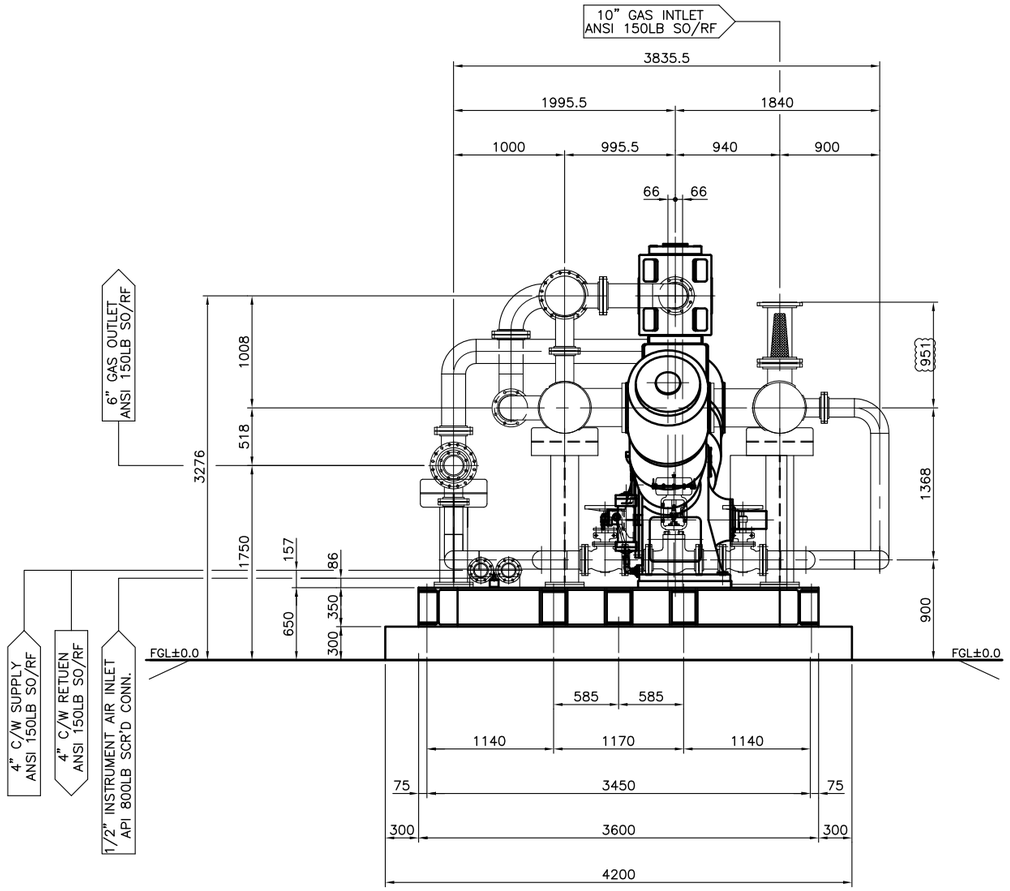
PIPING & INSTRUMENT DIAGRAM

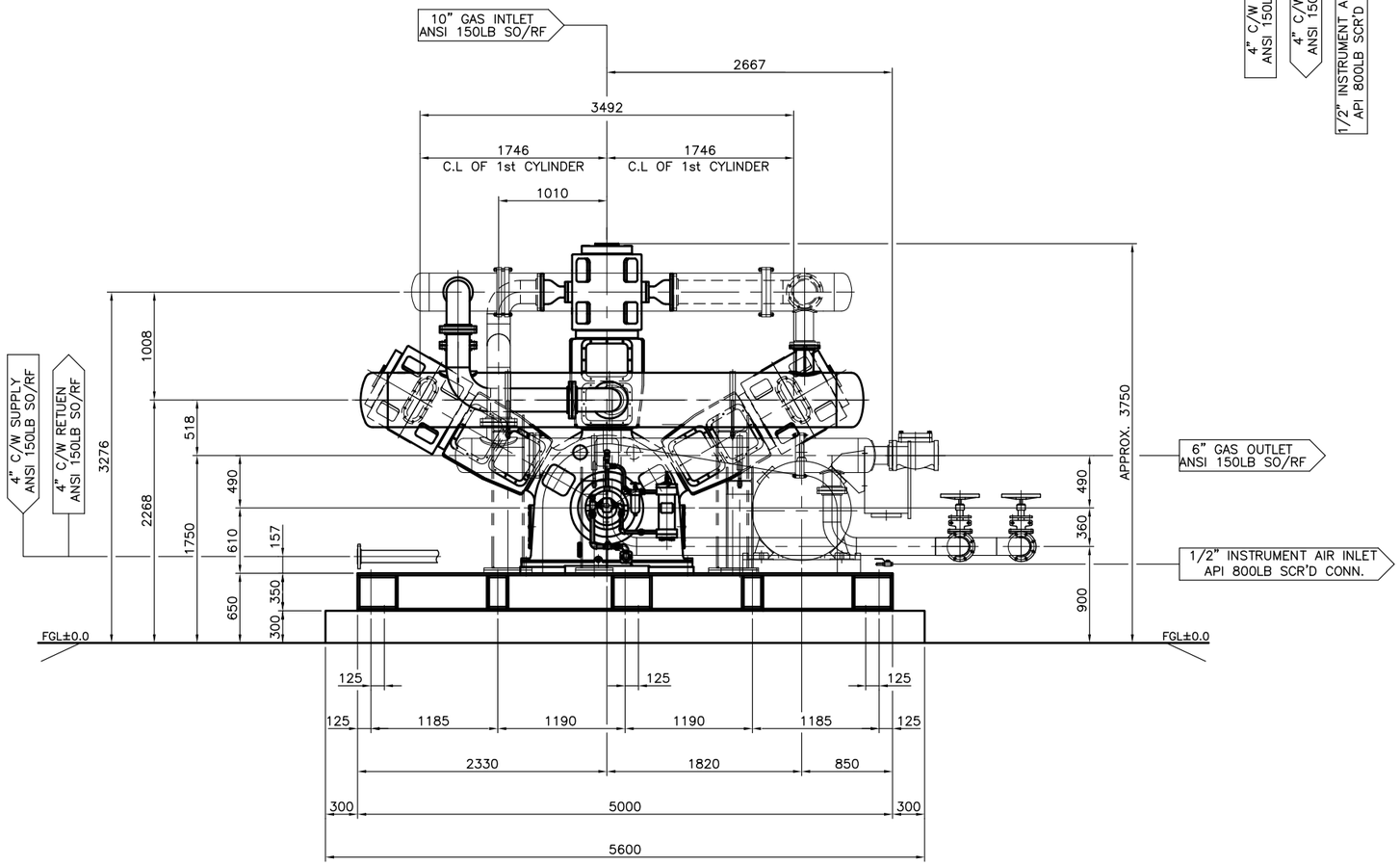
SCALE	NONE	P.J.T NAME	O2 COMPRESSOR FOR SESA GOA PJT.
ITEM NO.	DRAWING NO.		REVISION
4034	PI-11006-001		5

A B C D E F

1 2 3 4 5 6 7 8







REV.	DESCRIPTION	DRAWN	CHK'D	APP'D	APP'D	DATE
4	FOR APPROVAL	B.J.JIN	–	J.Y.KIM	H.C.JANG	11'05.16
3	FOR APPROVAL	B.J.JIN	–	J.Y.KIM	H.C.JANG	11'05.03
2	FOR APPROVAL	B.J.JIN	–	J.Y.KIM	H.C.JANG	11'04.24

BOC INDIA LIMITED

Dependable Compressor
KWANGSHIN MACHINE INDUSTRY CO., LTD.

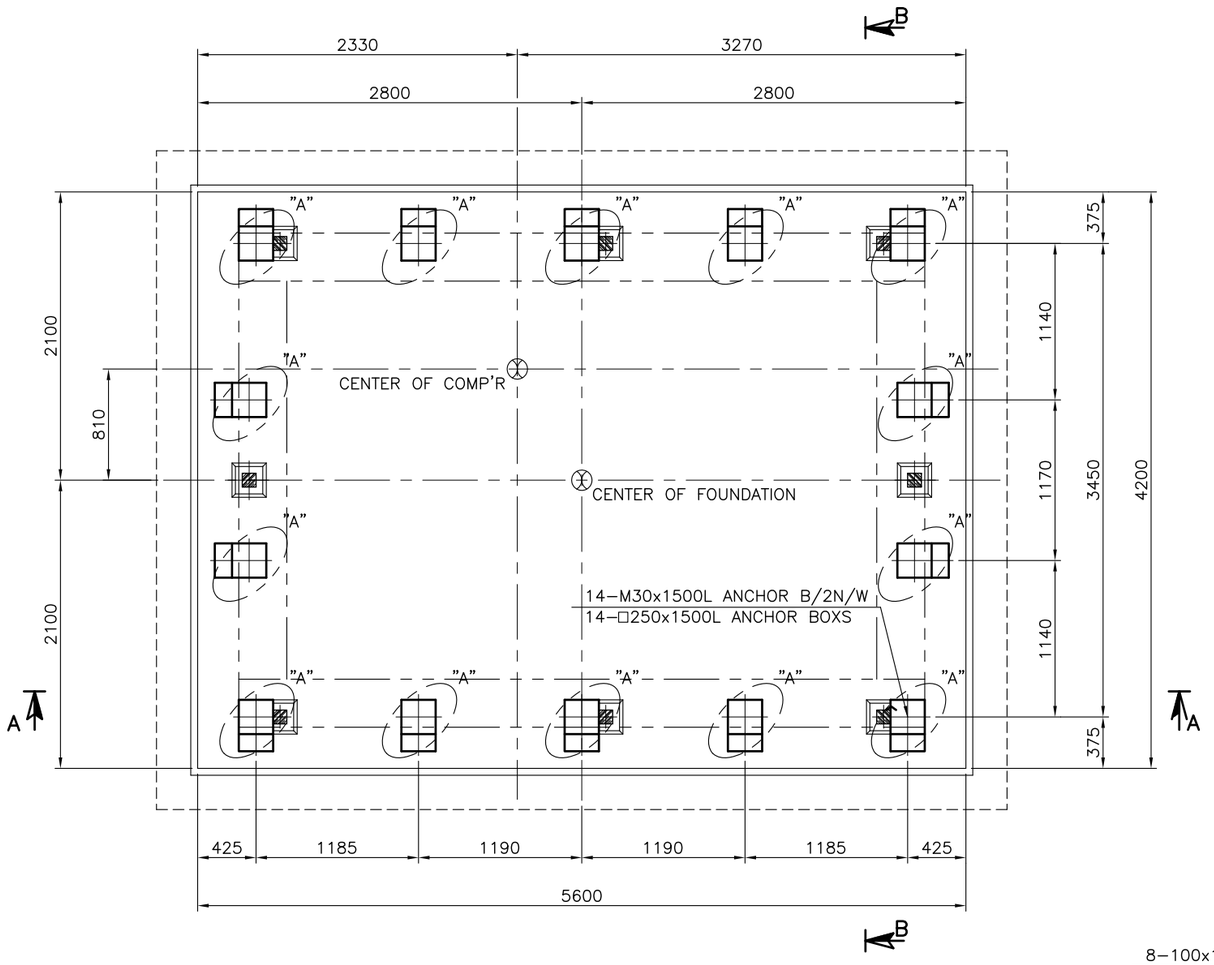
TITLE

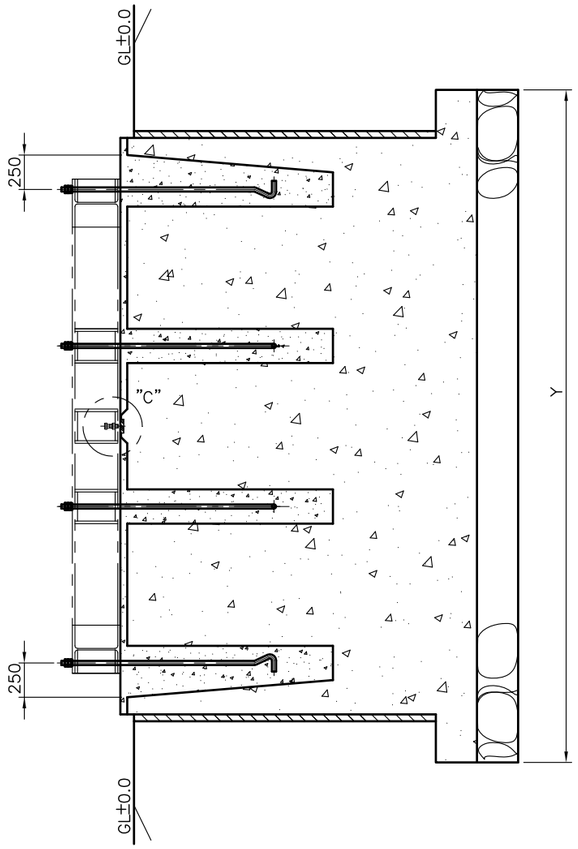
OUTLINE DRAWING

SCALE	NONE	P.J.T NAME 02 COMPRESSOR FOR SESA GOA PJT.	
ITEM NO.	DRAWING NO.		REVISION
2.0 FOR 100 tpd ASU	OD-11006-002		4

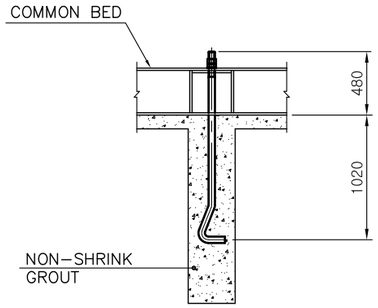
A B C D E F

1 2 3 4 5 6 7 8

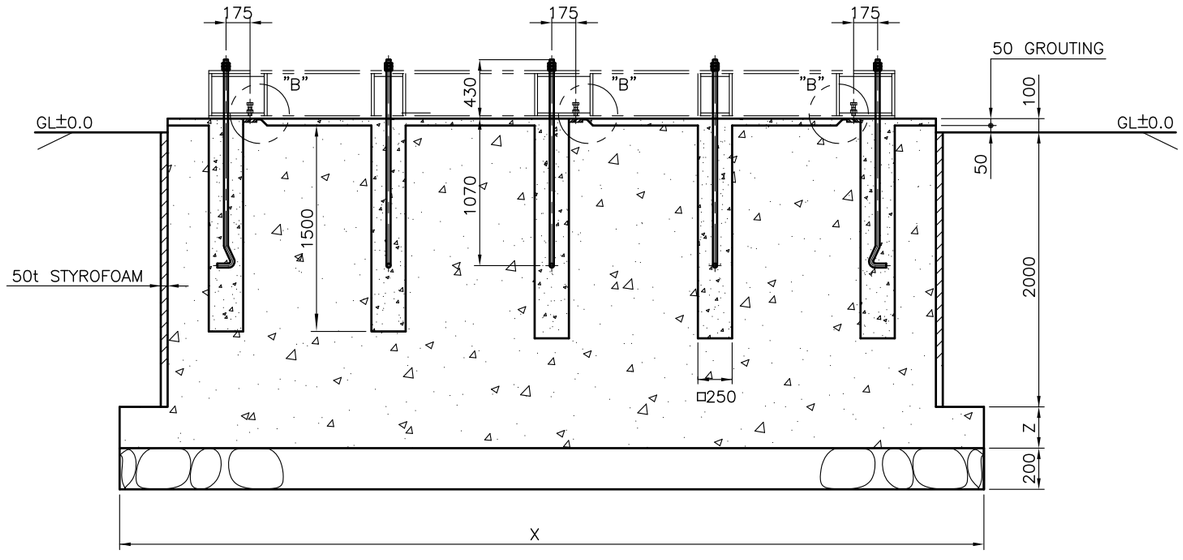




SECTION "B – B"



DETAIL : "A"



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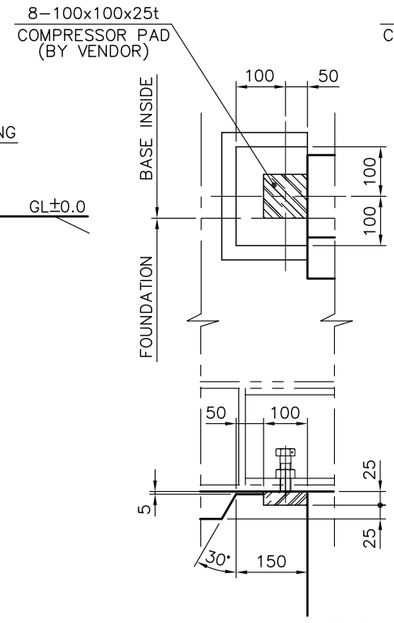
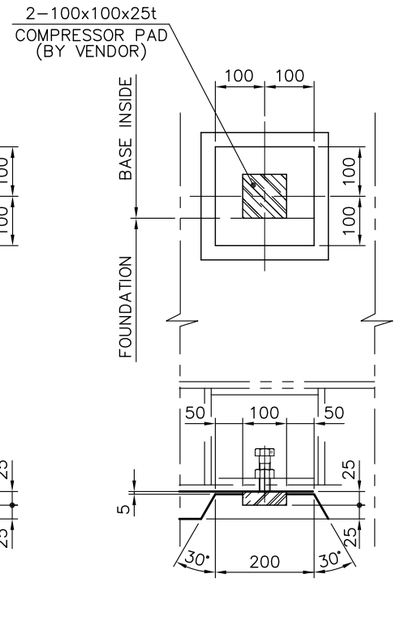


DETAIL : "B"



DETAIL : "C"

NOTE

COMPRESSOR & COOLER		: 10700 Kg
MOTOR & COMMON BED		: 7800 Kg
DYNAMIC LOAD	VERTICAL	: 3646 Kg
	HORIZONTAL	: 2343 Kg

THE EMPTY SPACE OF THE COMMON BASE SHALL BE FILLED WITH CONCRETE

DICIDE THE LENGTH OF X , Y , Z BY CONSIDERING THE LOCAL CONDITION

REV.	DESCRIPTION	DRAWN	CHK'D	APP'D	APP'D	DATE
2						
1						
0	FOR APPROVAL	B.J.JIN	–	K.P.JANG	H.C.JANG	11'04.06

BOC INDIA LIMITED

Dependable Compressor
KWANGSHIN MACHINE INDUSTRY CO., LTD.

TITLE

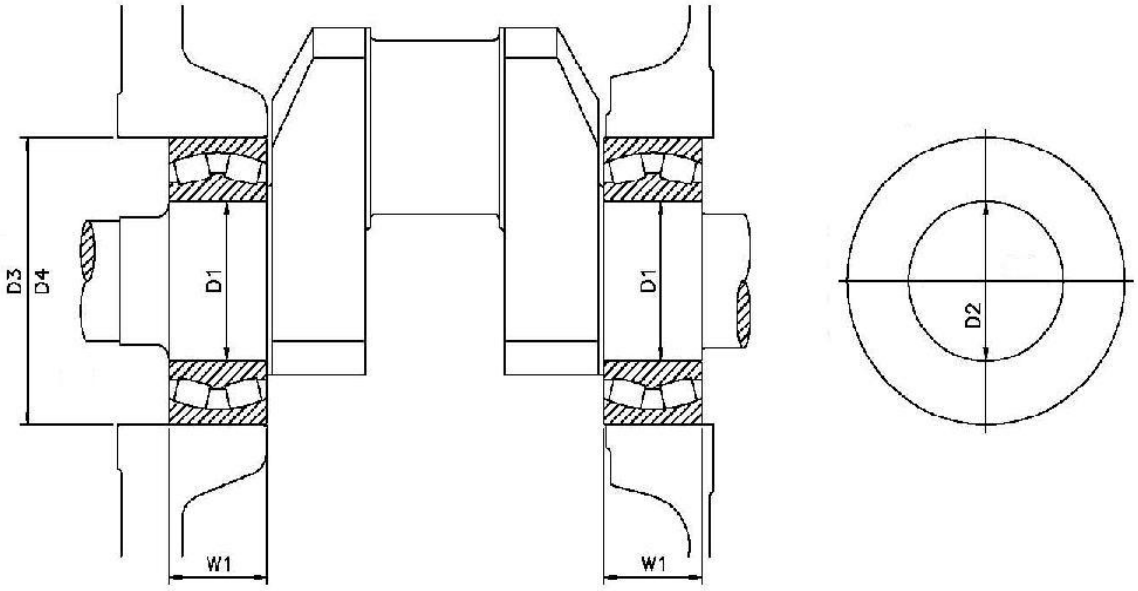
FOUNDATION DRAWING

SCALE	NONE	P.J.T NAME 02 COMPRESSOR FOR SESA GOA PJT
ITEM NO.	DRAWING NO.	REVISION
2.0 FOR 100 tpd ASU	FD-11006-003	0

A B C D E F

1 2 3 4 5 6 7 8

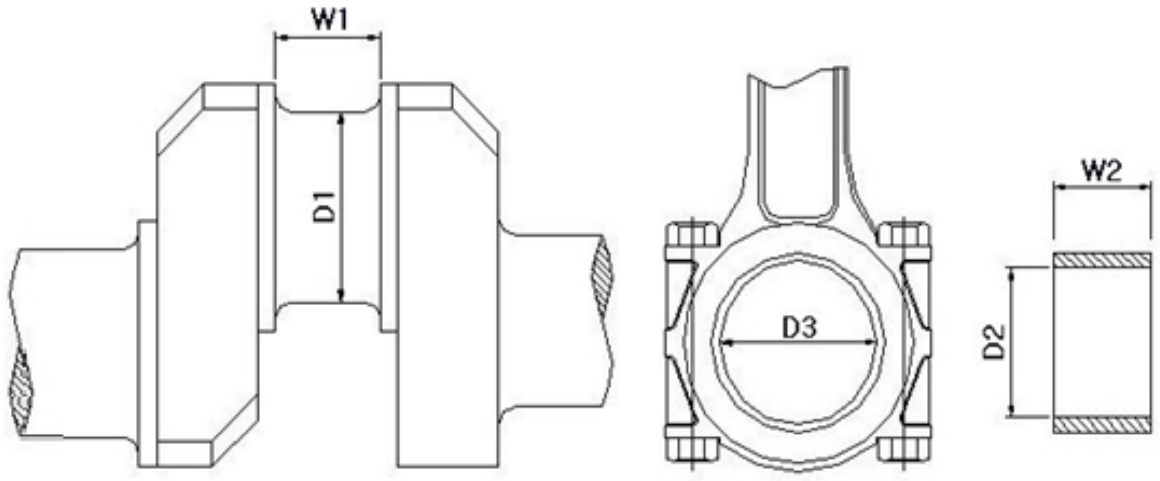
Main Bearing(Spherical Roller Bearing)



Unit : mm

Name	기준치 (Design)		허용한계 (Use Limits)	비 고 (Remarks)
	치 수 (Dimension)	틈 새 (Clearance)		
Main Bearing의 폭(W1) (Width of Main Bearing)	108 / 88			#22330CA/ 23134C (Maker:NTN)
Crank Journal의 내경(D4) (Width of Crank Journal)	280	+0.02 −0.01	280.2	
Main Bearing의 외경(D3) (O.D of Main Bearing)	320 / 280			#22330CA/ 23134C (Maker:NTN)
Main Bearing의 내경(D2) (I.D of Main Bearing)	150 / 170			#22330CA/ 23134C (Maker:NTN)
주축의 외경(D1) (O.D of Journal)	150 / 170	+0.033 +0.015	149.7 / 169.7	
Journal의 진원도 (Ovalness of Journal)	< 0.03			

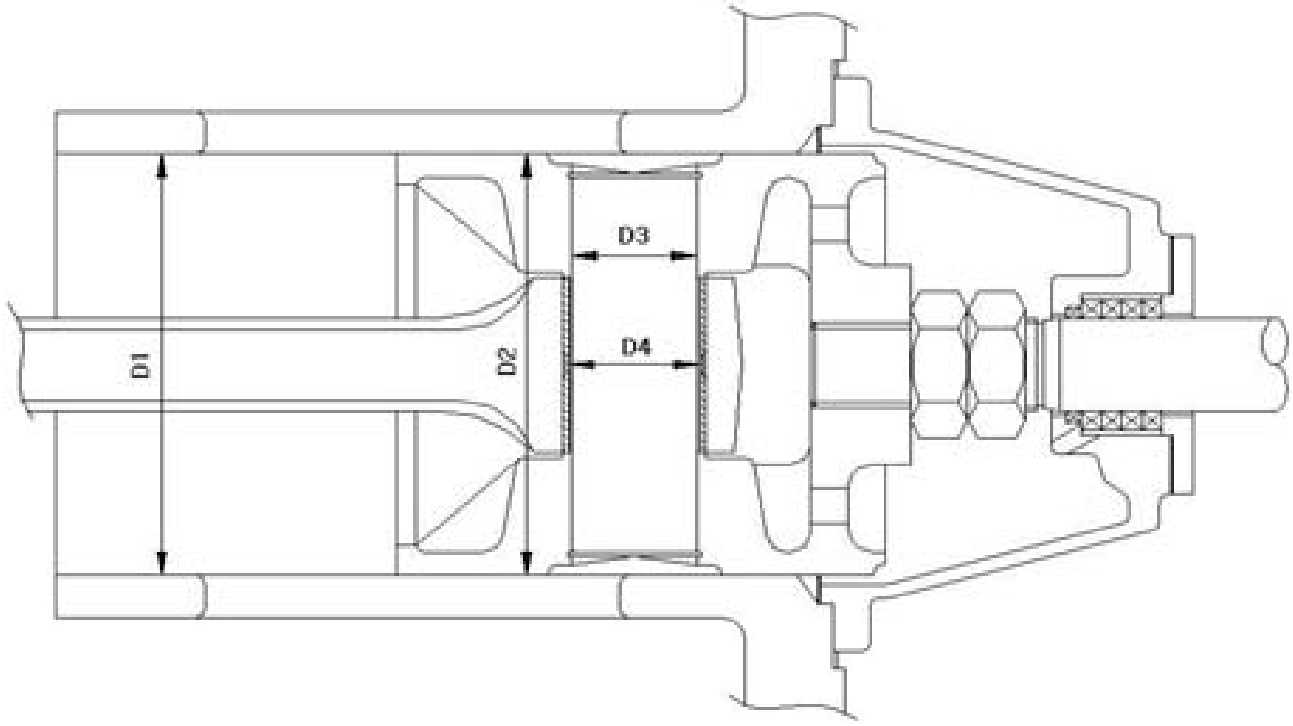
Crank Pin Bearing (Metal)



Unit : mm

Name	기준치 (Design)		허용한계 (Use Limits)	비 고 (Remarks)
	치 수 (Dimension)	틈 새 (Clearance)		
Crank Pin의 폭(W1) (Width of Crank Pin)	199	+0.1 0	199.5	
Crank Pin Metal의 폭(W2) (Width of Crank Pin Metal)	65	0 −0.1	64	
Metal의 내경(D2) (I.D of Metal)	160	+0.17 +0.14	161	
Crank Pin 외경(D1) (O.D of Crank Pin)	160	0 −0.025	159.7	
Crank Pin의 진원도 (Ovalness of Crank Pin)	< 0.03			

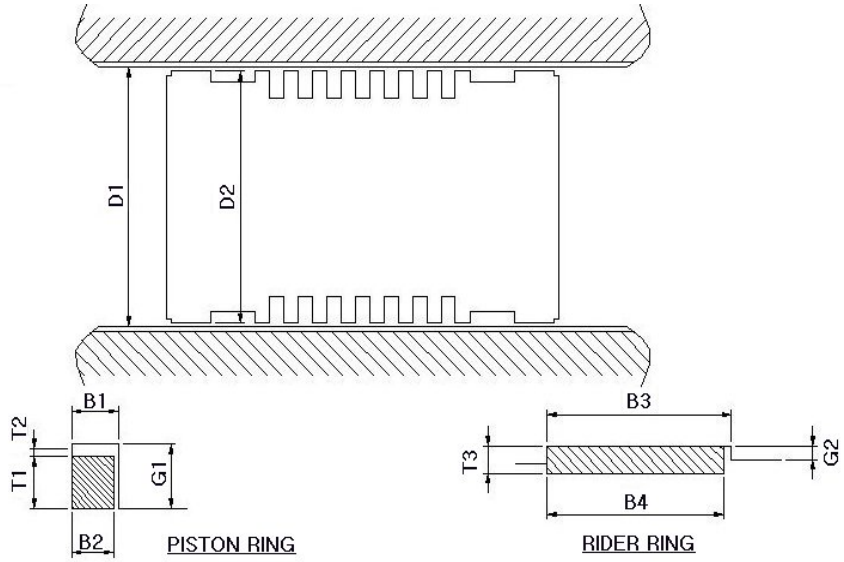
Cross Head



Unit : mm

Name	기준치 (Design)		허용한계 (Use Limits)	비 고 (Remarks)
	치 수 (Dimension)	틈 새 (Clearance)		
Cross Head Guide의 내경(D1) (I.D of Cross Head Guide)	270	+0.036 0	270.15	
Cross Head의 외경(D2) (O.D of Cross Head)	270	−0.19 −0.22	269.4	
Cross Head Pin의 외경(D3) (O.D of Cross Head Pin)	90	0 −0.02	89.9	
Cross Head Side의 내경(D4) (I.D of Cross Head Main Metal)	90	+0.06 +0.04	90.1	
Piston Rod의 외경(D5) (O.D of Piston Rod)	55	0 −0.030	54.92	
Cross Head Pin Metal의 내경(D6) (I.D of Cross Head Pin Metal)	90	+0.11 +0.09	90.2	

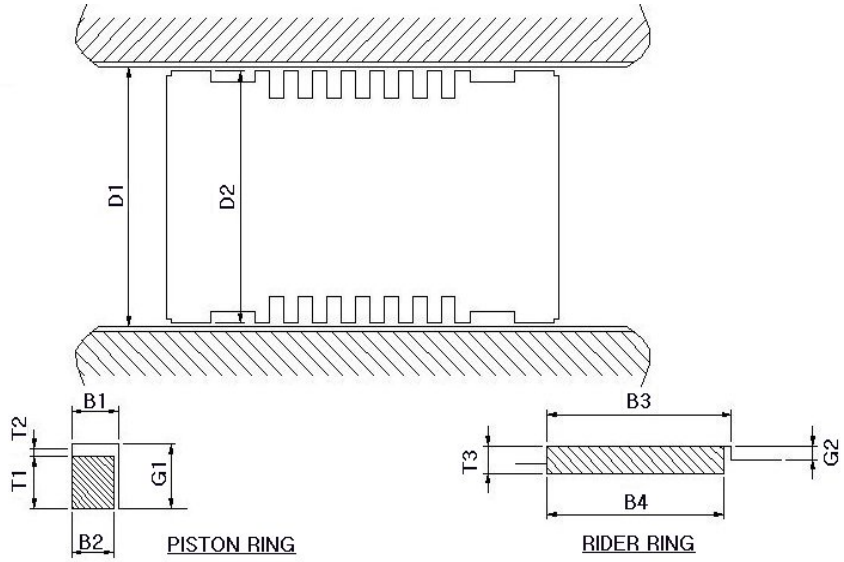
1st Cylinder and Piston



Unit : mm

Name	기준치 (Design)		허용한계 (Use Limits)	비 고 (Remarks)
	치 수 (Dimension)	틈 새 (Clearance)		
실린더의 내경(D1) (I.D of Cylinder(Linder))	450	+0.010 −0.010	450.25	
Piston의 외경(D2) (O.D of Piston)	444.8	5.2	444.3	
Piston Ring홈의 폭(B1) (Width of Piston Ring Groove)	14.3		14.8	
Piston Ring의 폭(B2) (Width of Piston Ring)	14		13.3	
Piston Ring 홈의 깊이(G1) (Depth of Piston Ring Groove)	20.5		19.5	
Piston Ring의 두께(T1) (Thickness of Piston Ring)	20		15.4	
Rider Ring 홈의폭(B3) (Width of Rider Ring)	50.8		51.8	
Rider Ring의 폭(B4) (Width of Rider Ring)	50		49.2	
Rider Ring 홈의 깊이(G2) (Depth of Rider Ring Groove)	9.9		9.15	
Rider Ring의 두께(T3) (Thickness of Rider Ring)	11.95		10.4	

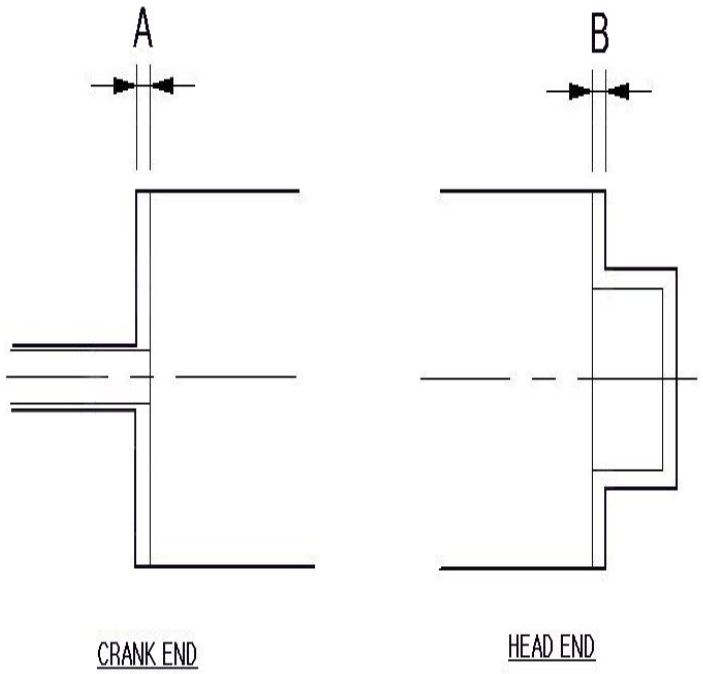
2nd Cylinder and Piston



Unit : mm

Name	기준치 (Design)		허용한계 (Use Limits)	비 고 (Remarks)
	치 수 (Dimension)	틈 새 (Clearance)		
실린더의 내경(D1) (I.D of Cylinder(Linder))	380	+0.090 −0.090	380.25	
Piston의 외경(D2) (O.D of Piston)	375	5	374.5	
Piston Ring홈의 폭(B1) (Width of Piston Ring Groove)	12.3		11.8	
Piston Ring의 폭(B2) (Width of Piston Ring)	12		11.3	
Piston Ring 홈의 깊이(G1) (Depth of Piston Ring Groove)	20.5		19.5	
Piston Ring의 두께(T1) (Thickness of Piston Ring)	20		15.4	
Rider Ring 홈의폭(B3) (Width of Rider Ring)	40.6		41.6	
Rider Ring의 폭(B4) (Width of Rider Ring)	40		39.2	
Rider Ring 홈의 깊이(G2) (Depth of Rider Ring Groove)	9		8.25	
Rider Ring의 두께(T3) (Thickness of Rider Ring)	11		9.5	

Piston End Clearance



Unit : mm

Name	틈 새 (Clearance)		비 고 (Remarks)
	상 부 (Head End)	하 부 (Crank End)	
1st/2nd 실린더 (Cylinder)	4.0~5.0	1.5~2.5	