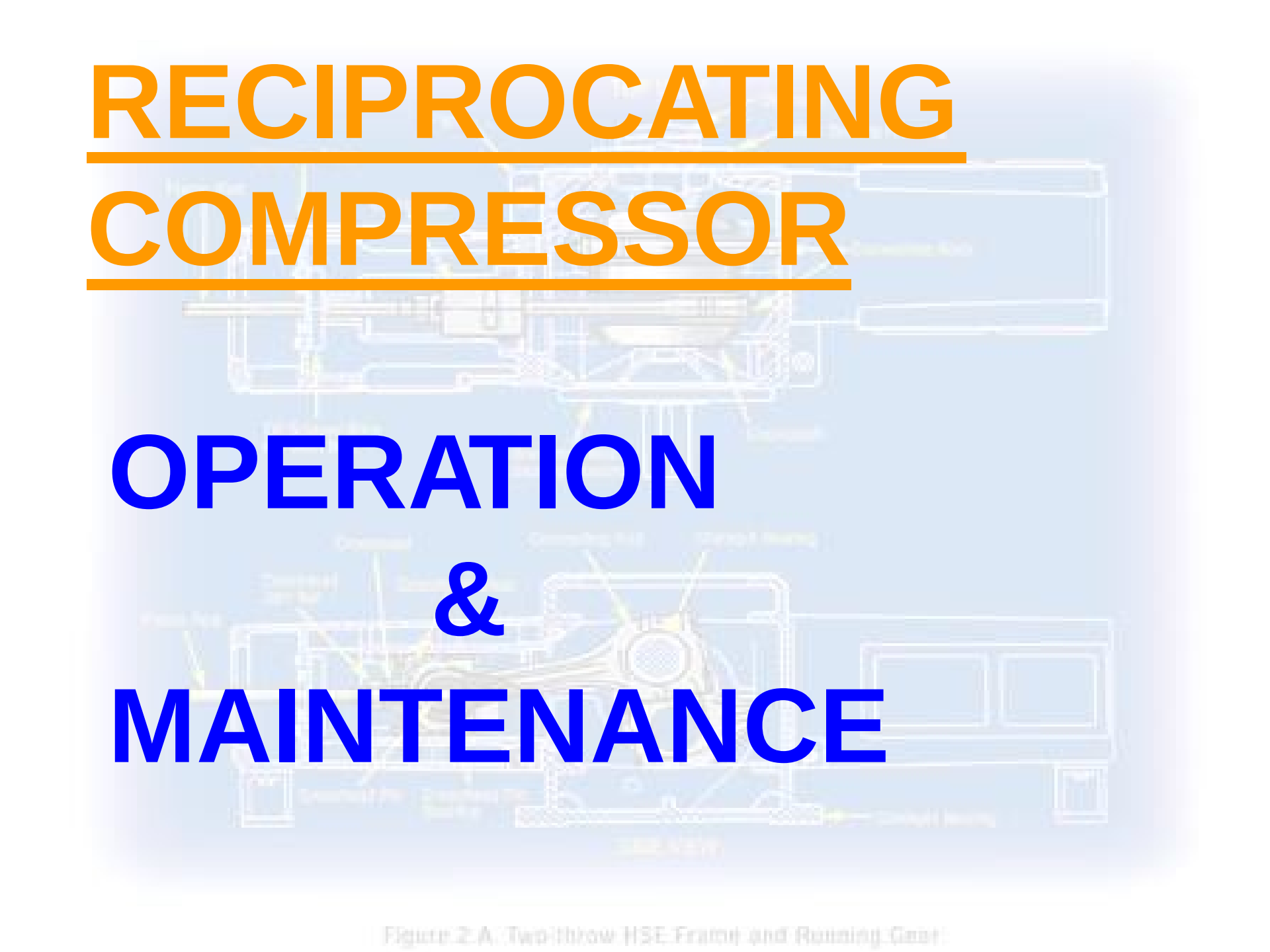
RECIPROCATING COMPRESSOR

OPERATION & MAINTENANCE



RECIPROCATING COMPRESSOR TRAINING FORMAT

- **Compressor Function**
- **Compressor Types**
- **Compressor Cycle**
- **Reciprocating Compressor Working**
- **Maintenance Aspects of major components**
- **General Maintenance Checks (**Discussion**)**
- **Common problems & Trouble Shooting**

What is meant by Compressing ?

Compressing is the process of adding energy to the fluid (liquid / gas) to move it from a one point to another
or raising its pressure or to transfer from a low pressure region to a higher pressure region.

Function Of A Compressor

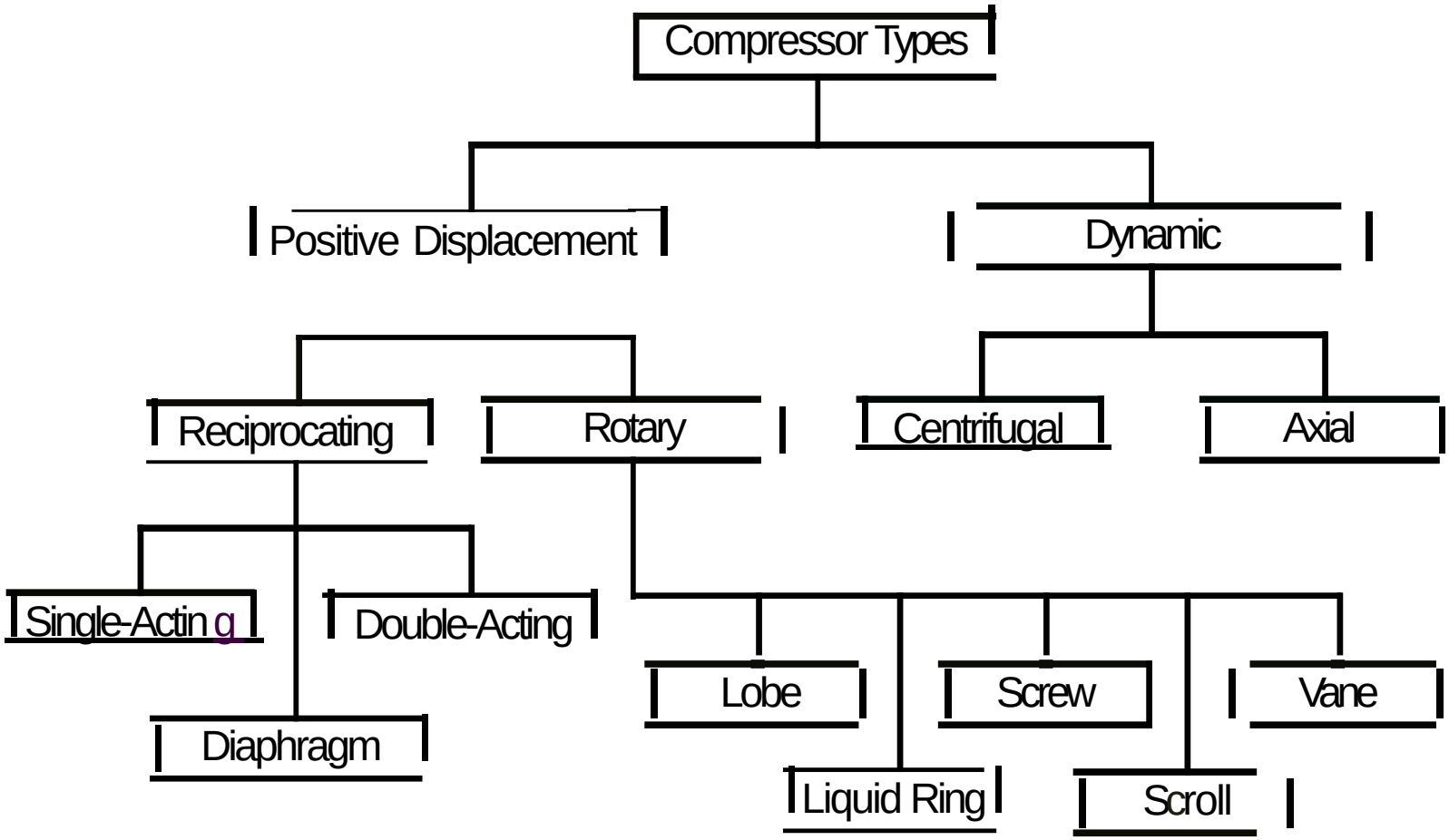
A compressor is a mechanical device that increases the pressure of a gas by reducing its volume.

Compressors are similar to Pumps

Compressors are similar to pumps:

- Both increase the pressure of a fluid
- Both can transport the fluid through a pipe
- As gases are compressible, the compressor also reduces the volume of a gas.
- Liquids are relatively incompressible, So the main action of a pump is to pressurize and transport liquids.

Classification Chart Of Compressors



BASSIC TYPES OF COMPRESSOR

Positive Displacement Compressor:

A type of compressor that delivers a fixed volume of air at high pressures. Common types of positive displacement compressors include piston/reciprocating compressors and rotary screw compressors.

Dynamic Compressor:

A type of compressor that delivers larger volumes of air at lower pressures. Common types of dynamic compressors include centrifugal and axial compressors.

Types Of Reciprocating Compressors

According To Action:--

Single acting compressors Double acting compressors

According To Number of stages:--

Single stage compressors Two stage compressors

Multistage compressors

According To Method of cooling:--

Air cooled Water cooled

According To Drive:--

Direct Drive Belt Drive Chain Drive

According To Orientation of cylinder:--

180*Orientated Cylinder 90*Orientated Cylinders

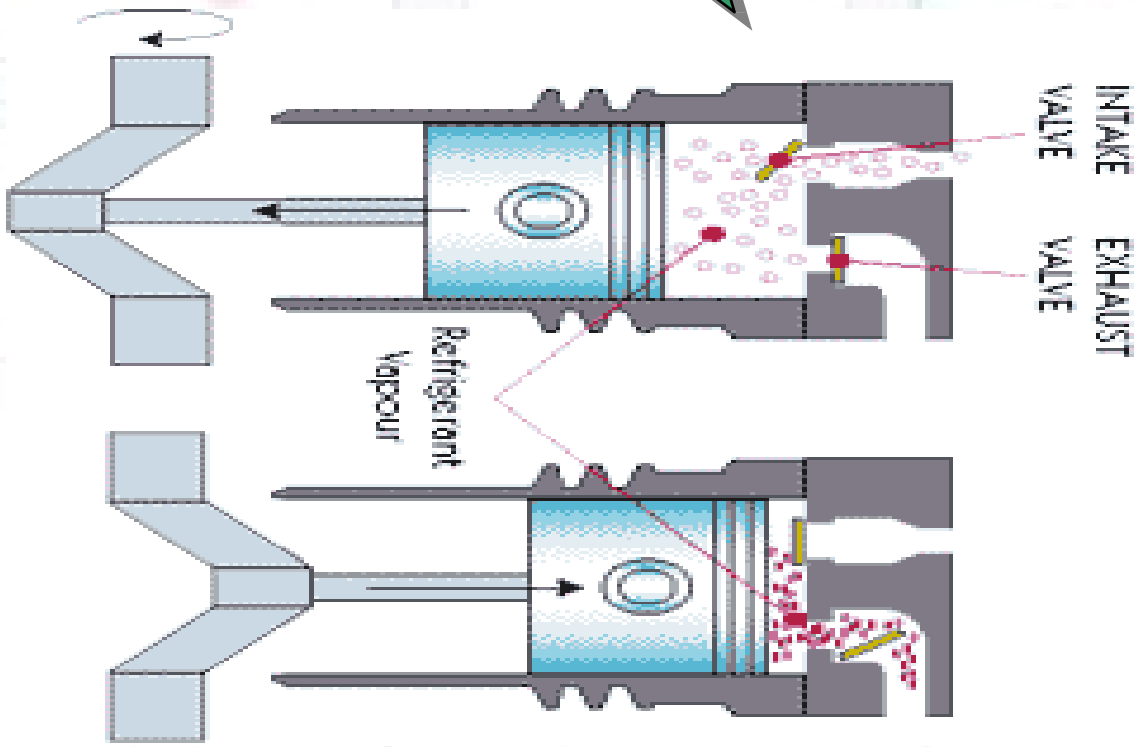
V Orientated Cylinders

According To cylinder Lubrication:--

Lubricated Cylinder Non Lubrication Cylinder

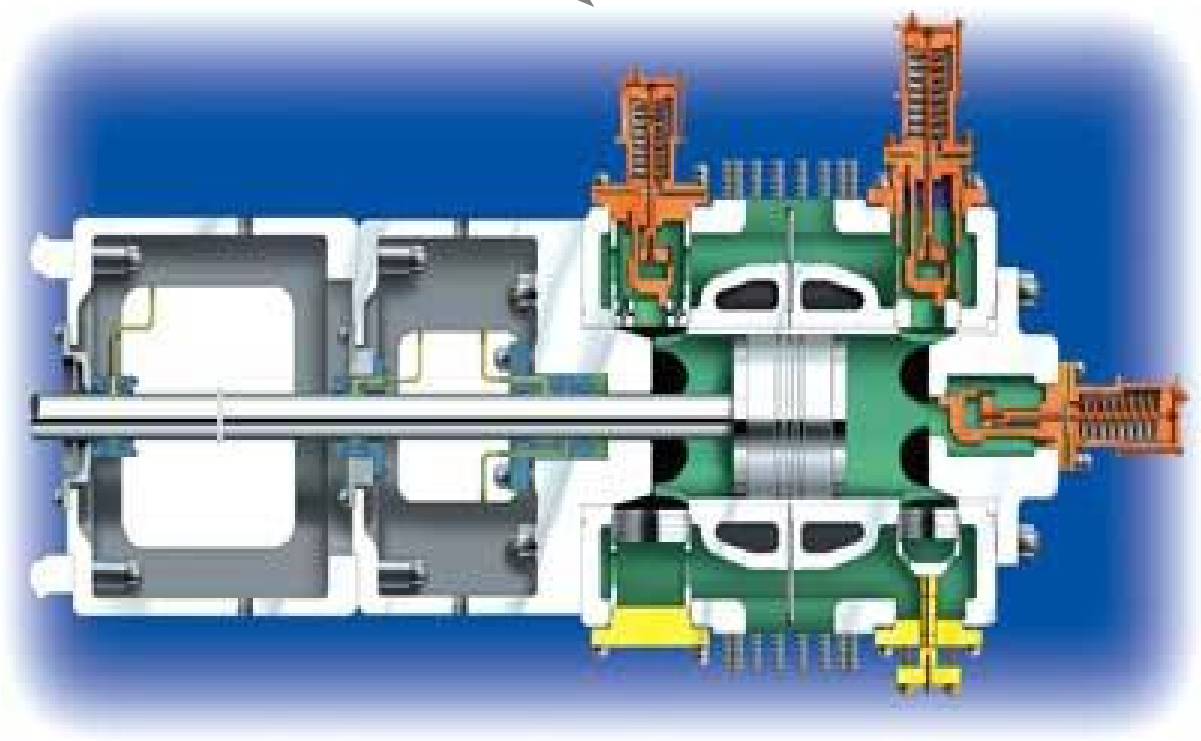
Single acting compressors

Single acting compressors is a machine which compresses Fluid (gas/air) in only one end of a cylinder



Double acting compressors

Double acting compressors is a machine which compresses Fluid (gas/air) in both ends of cylinder

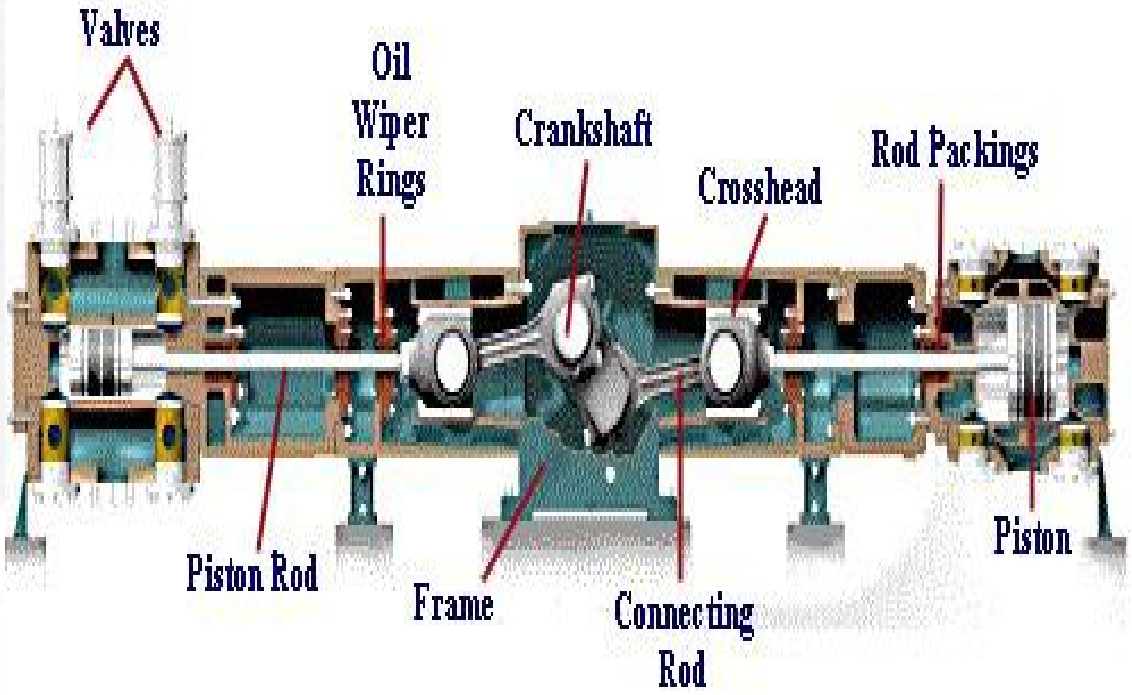


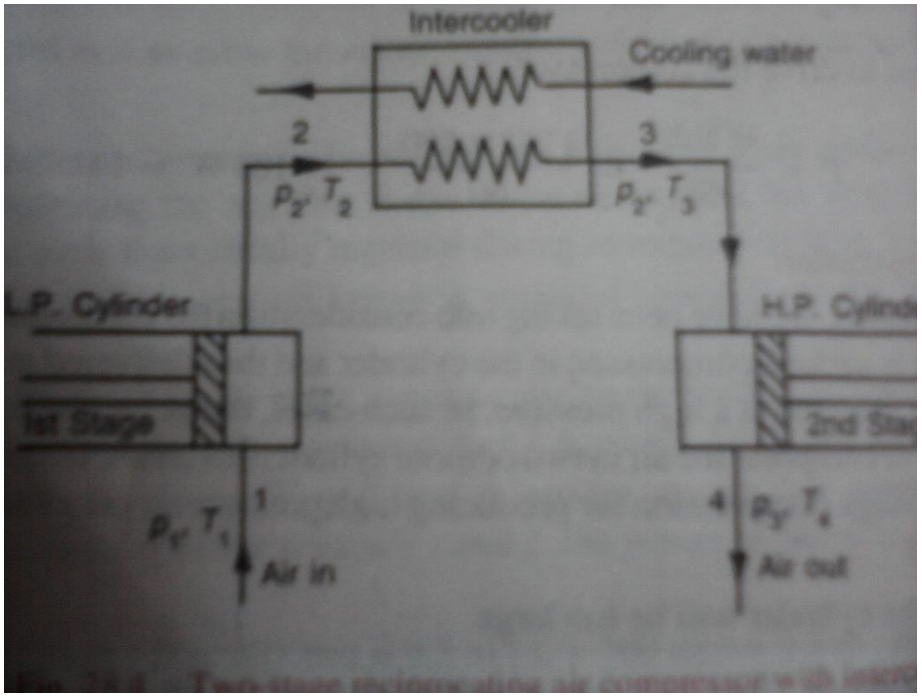
Single stage compressors

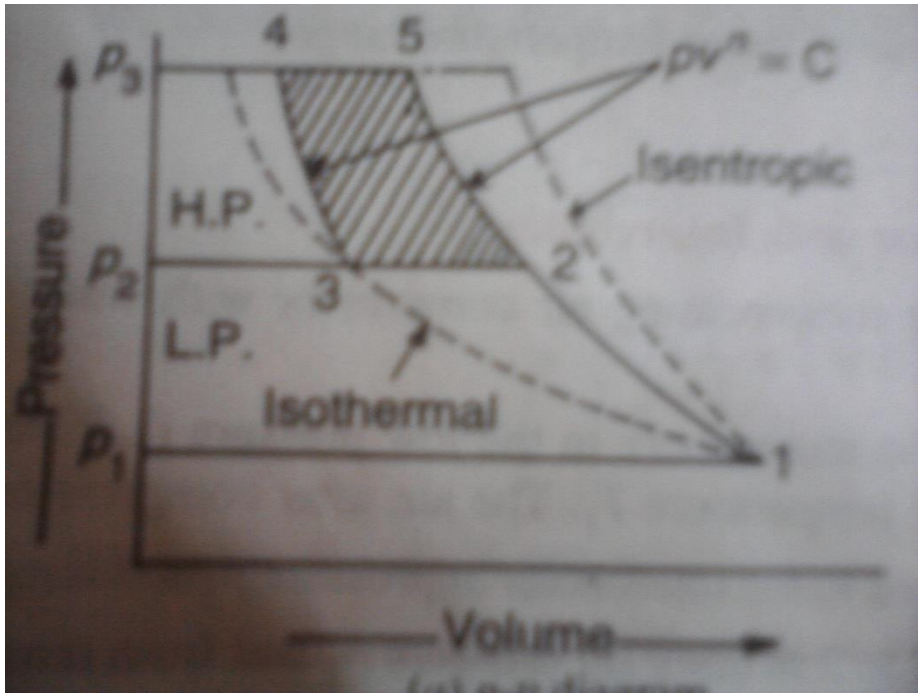
In Single stage compressors the air from atmospheric pressure is compressed to the desired discharge pressure in a single operation.

Two stage compressors

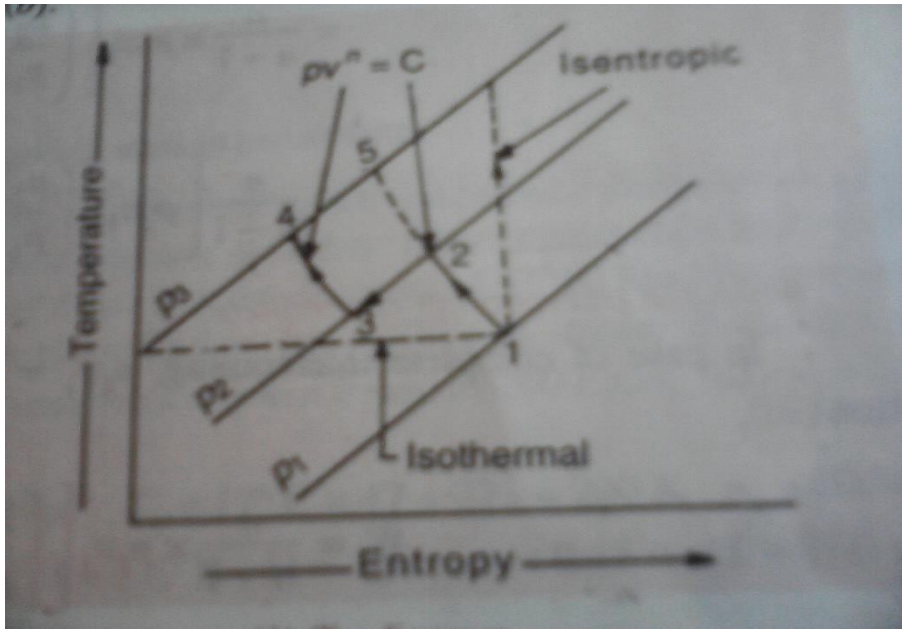
In this machine fluid (gas/ air) is compressed in two stages. In the first stage the fluid is compressed to an intermediate Pressure while in the second stage it is further compressed to the desired final stage





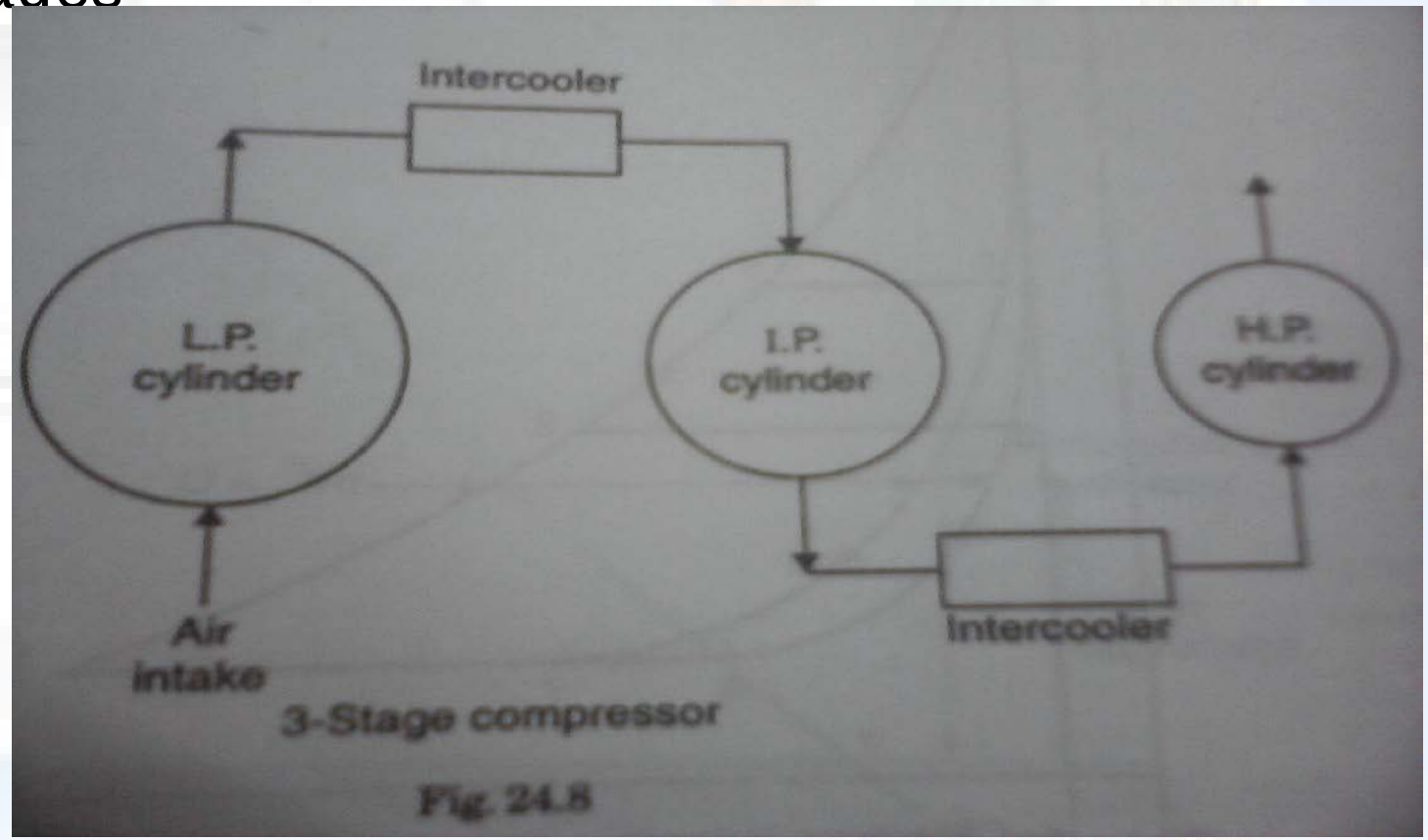


Two stage Reciprocating Compressor Cycle



Multistage compressors

This is a compressor which produces the desired final pressure through two or more stages



Orientation of cylinder

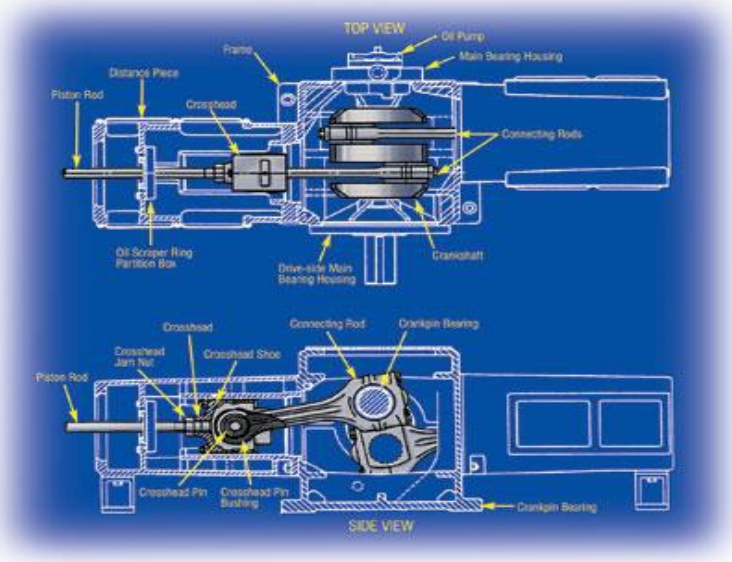
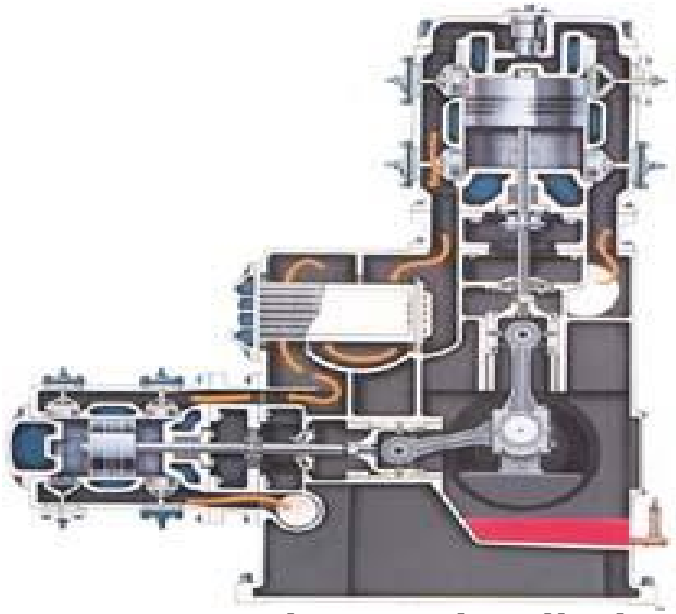


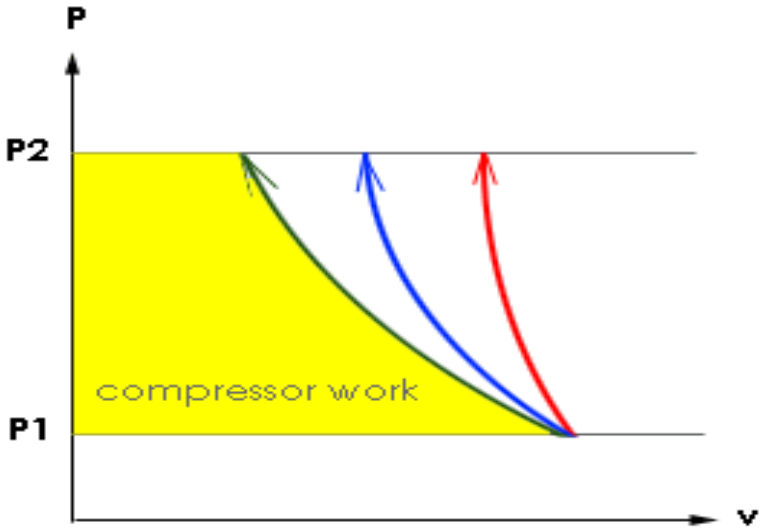
Figure 2 A. Two-throw HSE Frame and Running Gear

180* Orientated Cylinder

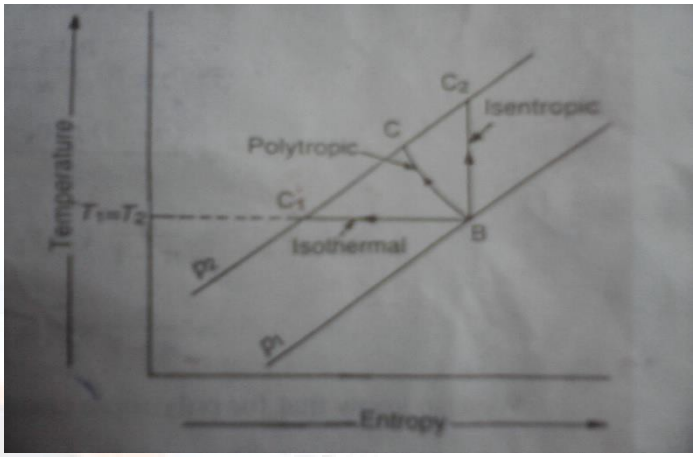


90* Orientated Cylinders

Compression Cycles



(P-V Diagram)



TS DIAGRAM

Air can be compressed in following ways.

→ Rember API

(1) Adiabatic compression.

(2) Polytropic Compression. **{Main Cycle}**

(3) Isothermal compression.

Isothermal Compression

ISO mean is equal or same and thermal mean is heat or anything related to temperature. Thus isothermal compression is compressing air with no change in temperature or at constant temperature.

As the pressure of air increases, the temperature also increases. So the heat produced during compression has to be removed at the same rate to keep the temperature constant. Thus to achieve same rate of heat exchange, the design of compressor must be such that it should move slowly thus we have more time to extract the same amount of heat as we receive it. The cylinder bore must be small and require a high standard of cooling. Thus during isothermal compression, the work input is the least and involves no temperature change.The isothermal compression process can be symbolically represented as PV = C.

Adiabatic or Isentropic Compression

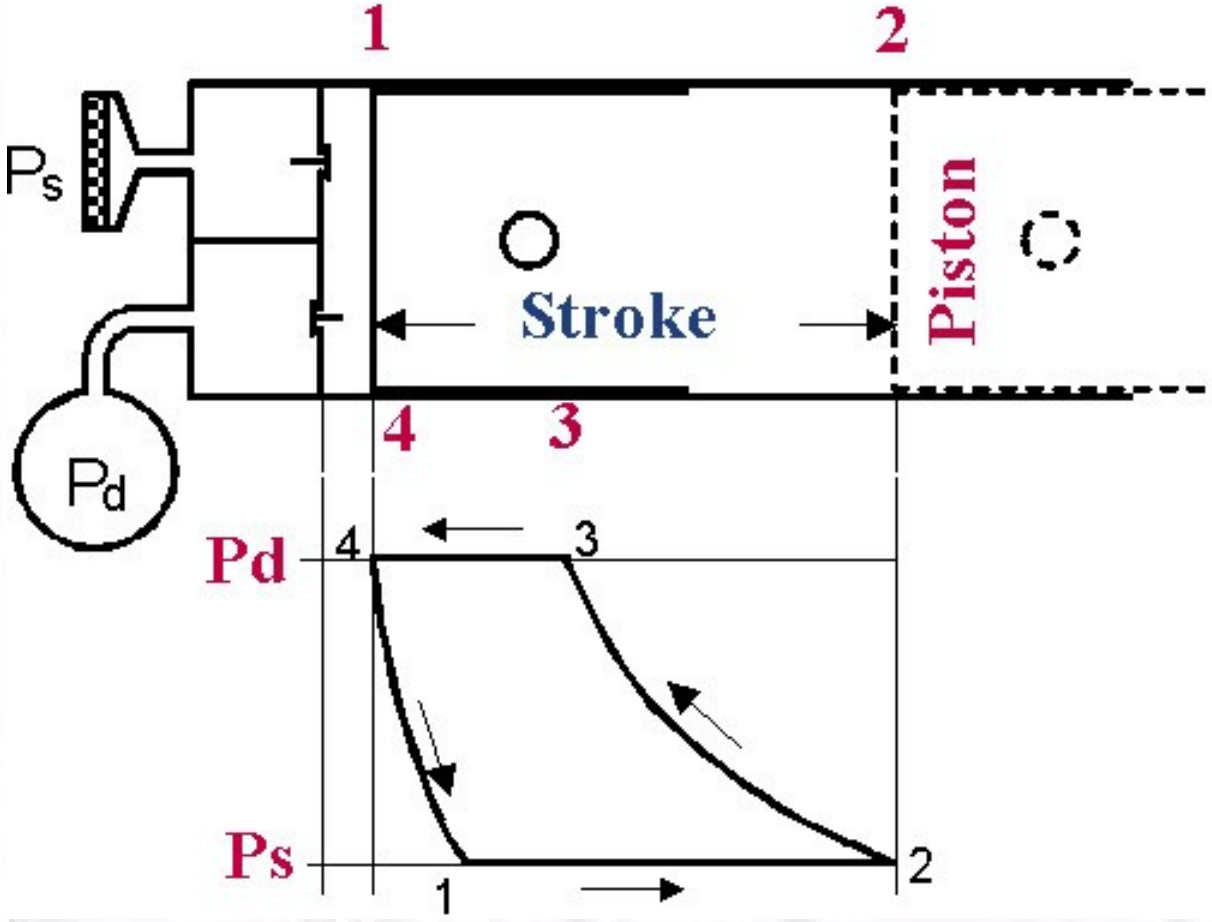
Adiabatic compression in simple terms means that no heat is given to or taken from the cylinder walls of the compressor. Also all work done in compressing the air is stored in the compressed air itself. Thus this process takes maximum energy input as no heat loss takes place through the cylinder walls. Theoretically, the compression process can be represented as

$$PV^{\gamma} = C.$$

Actual or Polytropic Compression

In the above two theoretical compression processes, there are huge practical constraints to achieve. Thus the actual compression process is termed as polytropic compression. From the curves shown in the figure, it is evident that the work done in adiabatic process is more than isothermal. So it is only isothermal compression which is desired in an air compressor. But in practice, isothermal compression is not possible to achieve. To achieve isothermal compression, if the piston movement in compressing air is slowed down and with small bore of the cylinder walls to extract the heat as received in the process of compression, then the desired air delivery rate would be a problem. This is the reason, compressors compress air polytropically. From the figure, it is evident that the polytropic curve is in between both extremes i.e., adiabatic and isothermal compression curves.

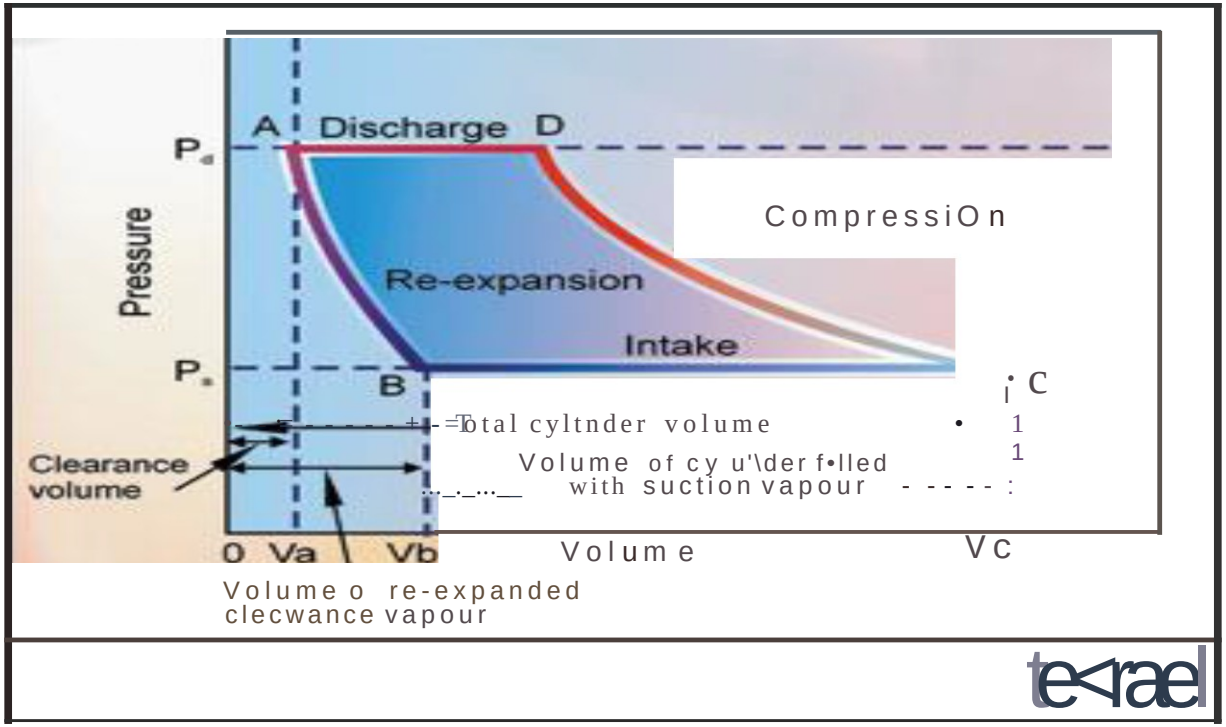
Working of Single Stage Reciprocating Compressor



(P-V Diagram)

- 1- Suction Valve Opens
- 2 – Suction of gas is complete. Compression begins
- 3 – Compression Is complete. Pushing of gas begins
- 4 - Compressed gas discharged.

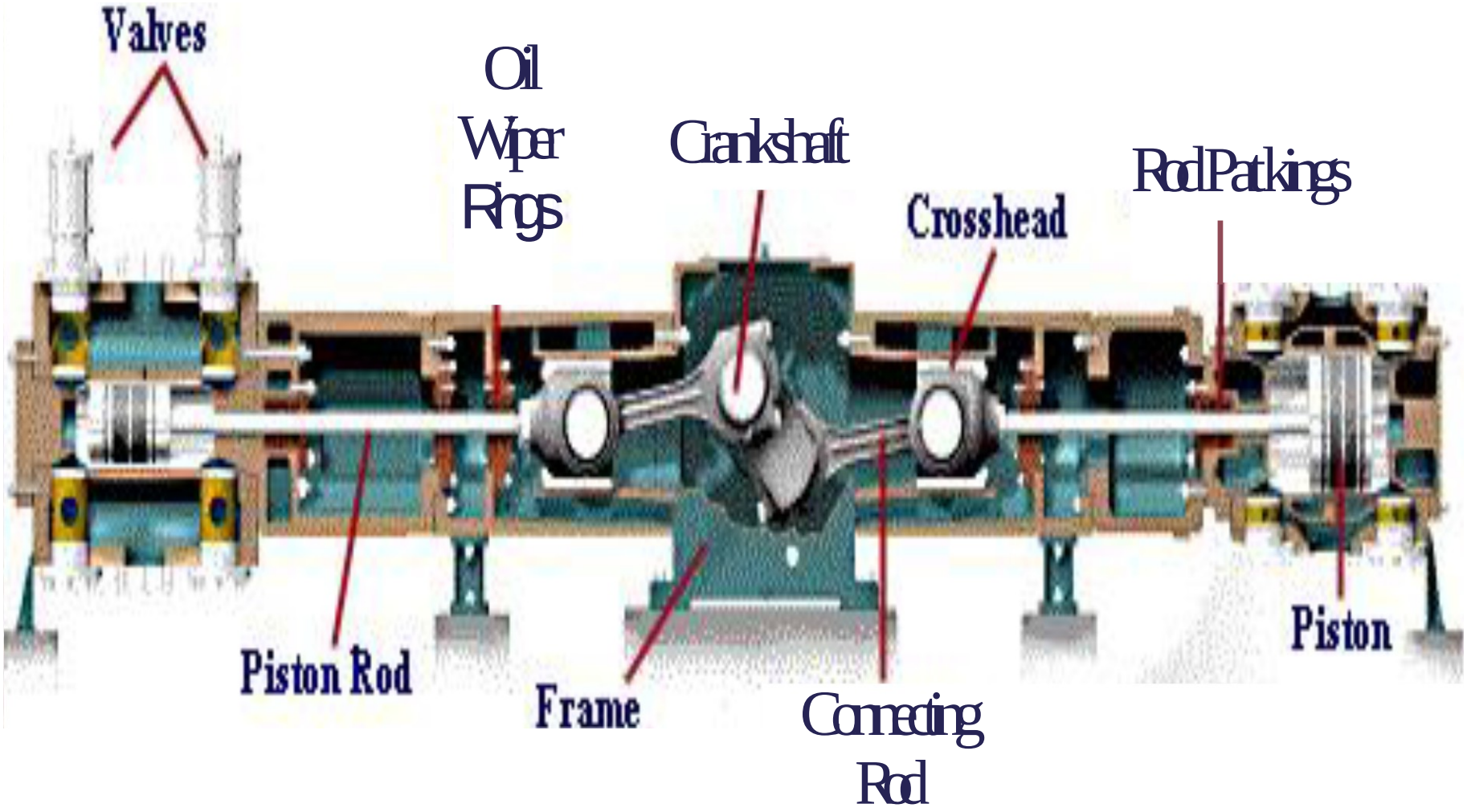
(P-V Diagram)


A
Discharge
D
Pd
Pressure
Compressi On
Re-expansion
Intake
Ps
B
Clearance volume
Total cyltnder volume
Volume of cy u'\der f•lled with suction vapour
0
Va
Vb
Volum e
Vc
Volume o re-expanded clecwance vapour

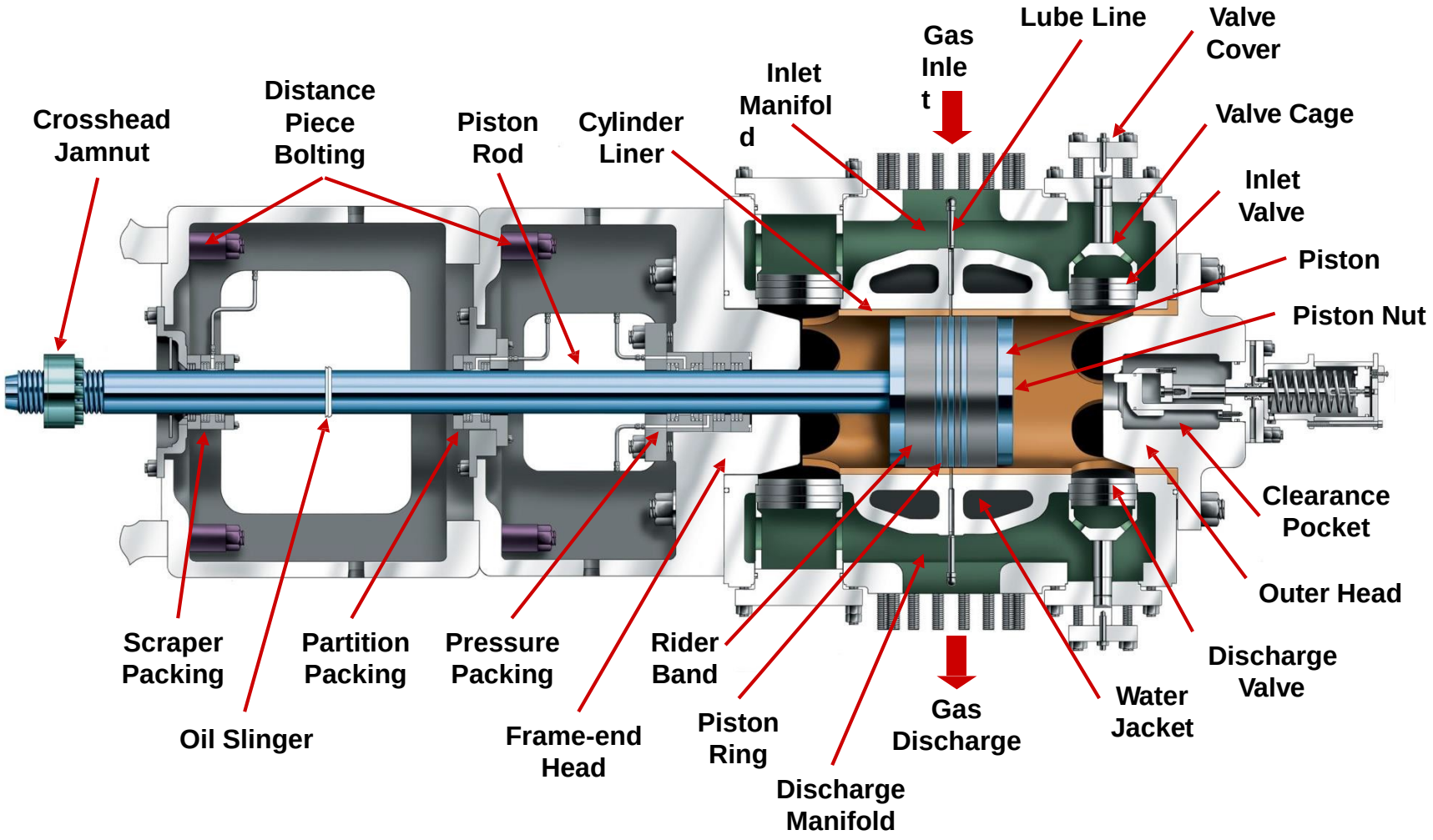
MAINTENANCE ASPECTS OF MAJOR COMPONENTS OF RECIPROCATING COMPRESSORS

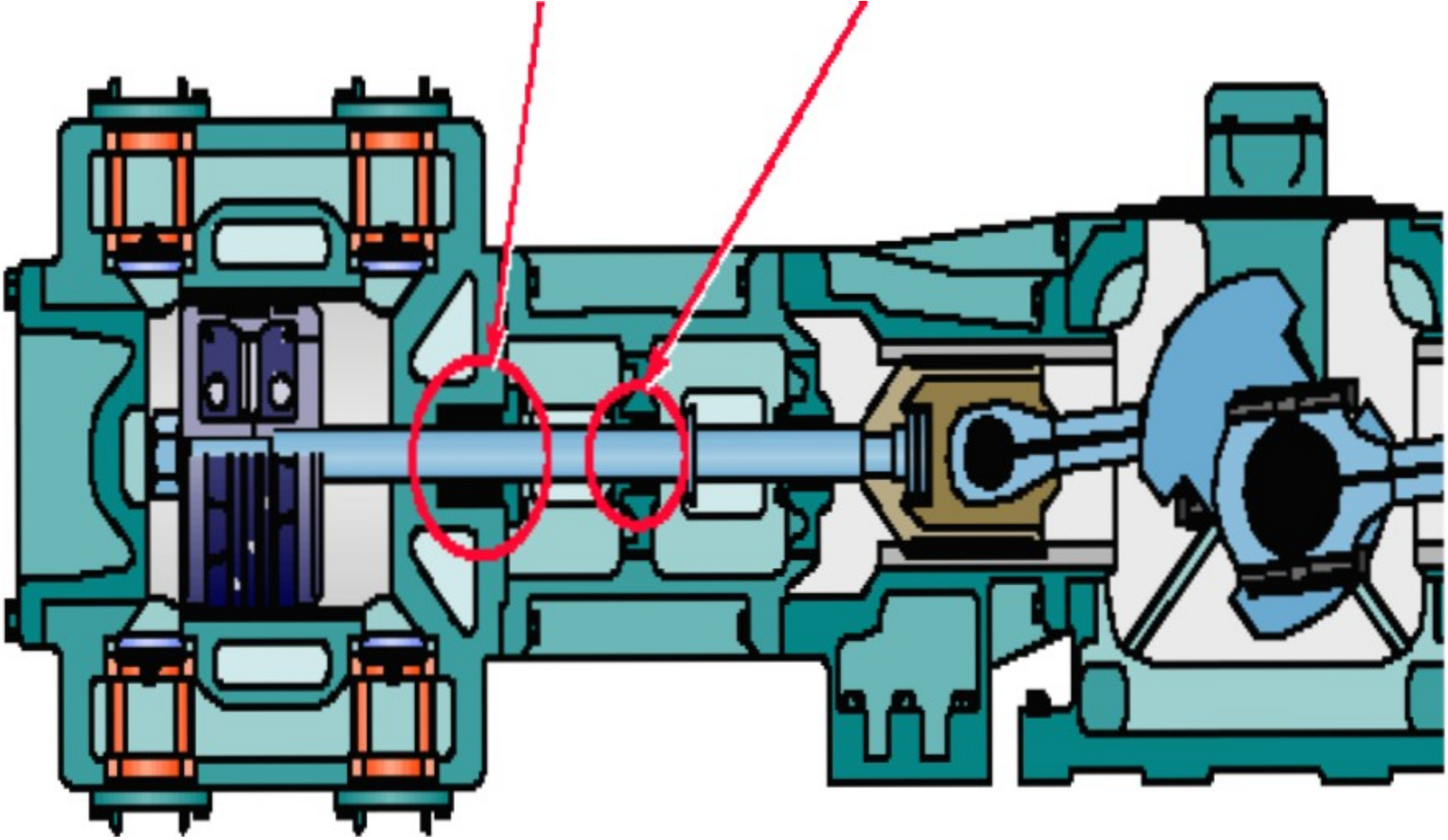
- FRAME
- CRANK CASE
- CRANK SHAFT
- CONNECTING ROD
- BEARINGS
- CROSS HEAD
- CYLINDERS
- PISTON & PISTON ROD
- PISTON RINGS & PACKING RINGS
- SUCTION & DISCHARGE VALVES

Compressor Parts



Compressor Cylinder Details





Double Acting Cylinder

Double Distance Piece

Crosshead

Crankcase

Frame

Frame is a rigid structure of cast iron (ASTM A40, A50)

- Transmitting loads to compressor foundation.

Basically it houses crank gear

IOCL 2010

- Crank shaft.
- Connecting rod big end bearings.
- Main bearings of crank shaft.
- In some machines cylinders are mounted Through Distance piece.
- Some times with integral cross head guides or may
- Separate bolted crosshead guide.

Maintenance Checks

1. Ensure tightening & locking of foundation bolts.
2. Ensure bearing housing concentricity with in limits.
3. Check cross head guides tightness.
4. Ensure all supports etc.

Crank case

- Crank case mean while is a part of frame.
- Crank case also known as “SUMP”.
- Crank case mainly contains “Lubricating Oil”.

Maintenance Checks

- Crank case is hydrodynamic tested to 1.5 times Of max. operating pressure of the lub. oil system

Crank shaft

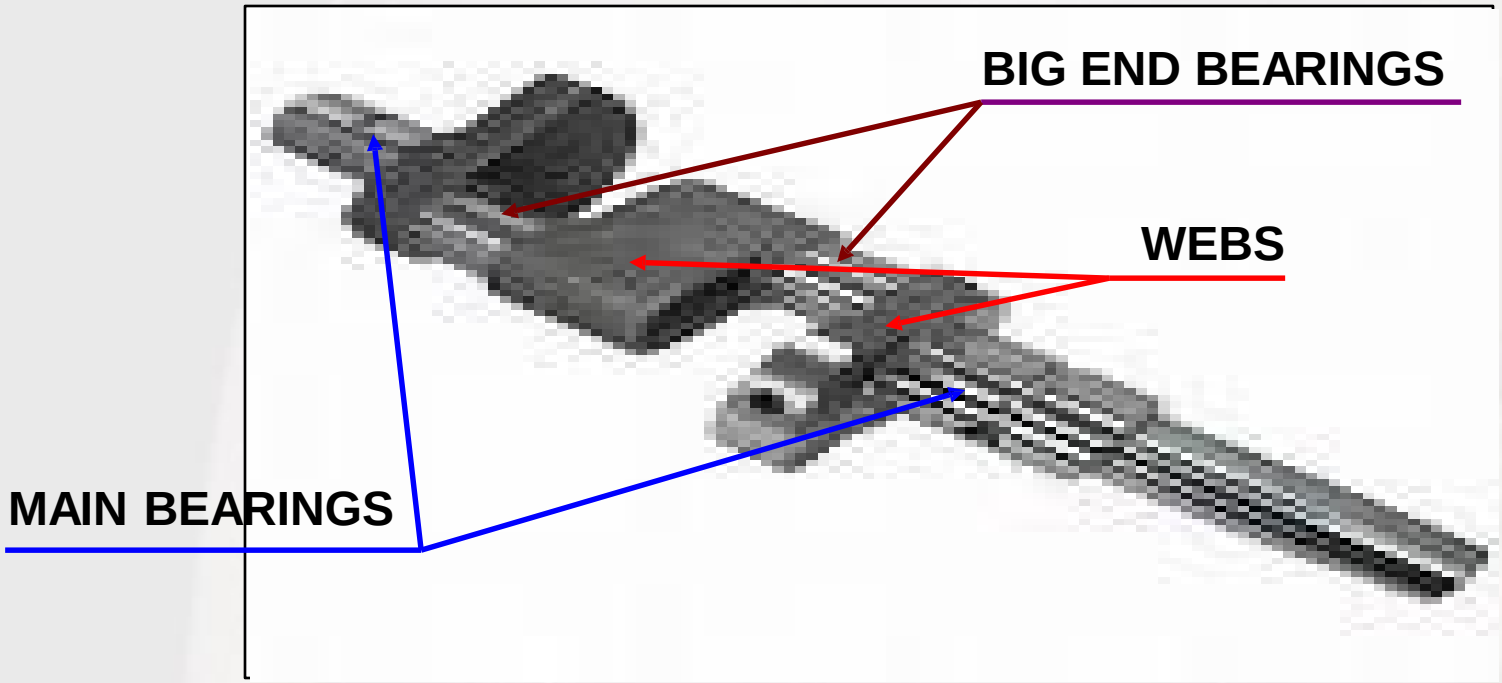
•The crankshaft translates rotary motion into reciprocating linear piston motion.

•The crankshaft has "crank throws" or "crankpins“ which accumulates the "big ends" of the connecting rods

•It typically connects to a flywheel, to reduce the pulsation characteristic of the compressor and to reduce the torsion vibrations often caused along the length of the crankshaft

• It is single piece forged carbon steel /carbon – vanadium steel.

Crank shaft



Maintenance Checks

- Check Crank shaft deflection.
- Check Wear of main / big end bearing.
- Check D.P. Test

Crankshaft Deflection

•The crankshaft is a huge bulky component which should remain as straight as possible.

•There is the requirement of measuring crankshaft deflections at regular intervals to ensure that the alignment of the shaft is within permitted limits and these deflections can be measured.

•As you can see from the picture a dial gauge is inserted between the crank-webs to find out the distance between them.

•If the deflection is measured after the specified interval, it is necessary that it is taken at the same point otherwise the reading will not give a real reflection about the degree of deflection.

•Normally a center punch is used to make markings so that each time the deflection is taken at the same point.

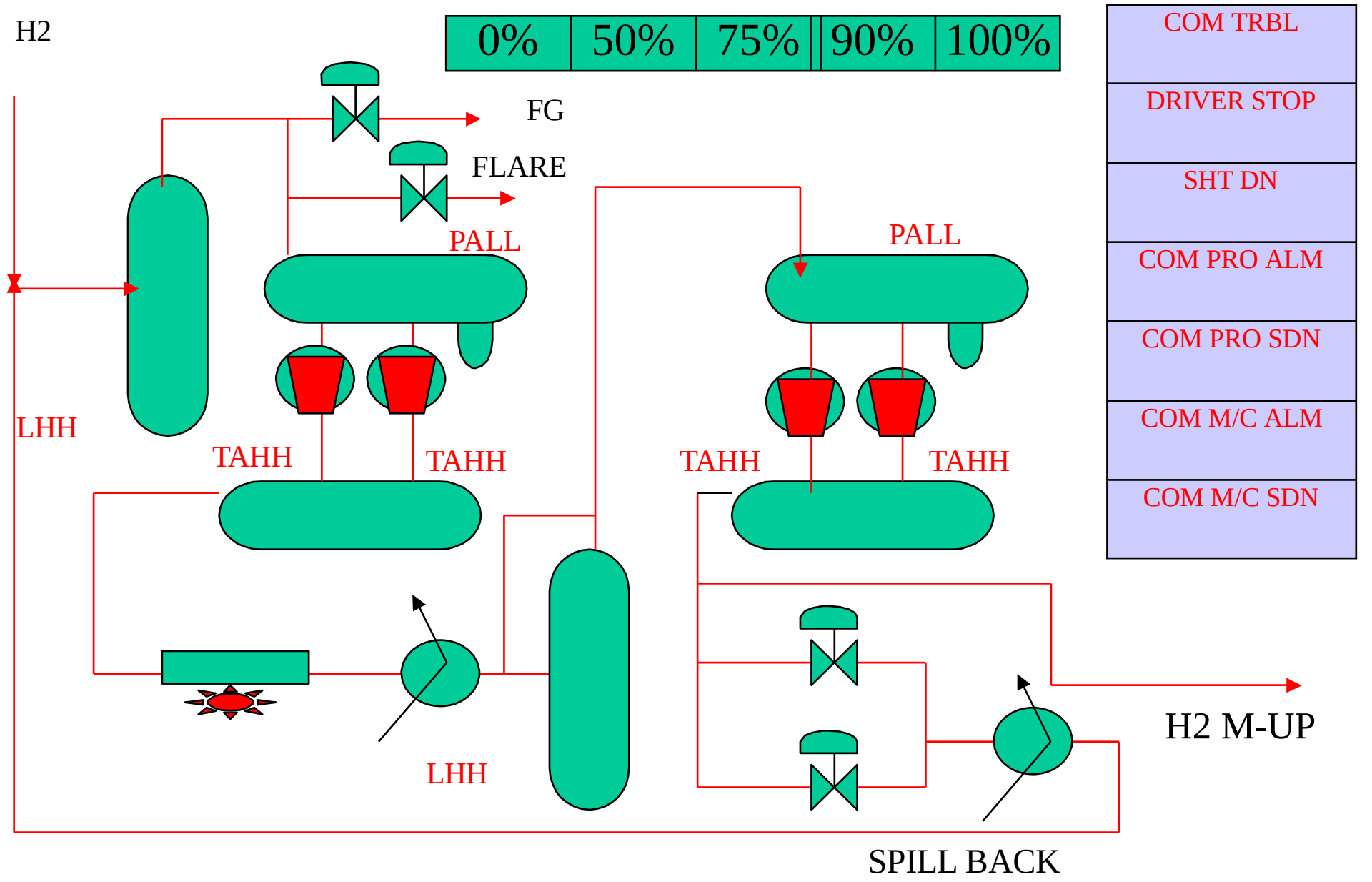
(cont.)

Reciprocation compressor

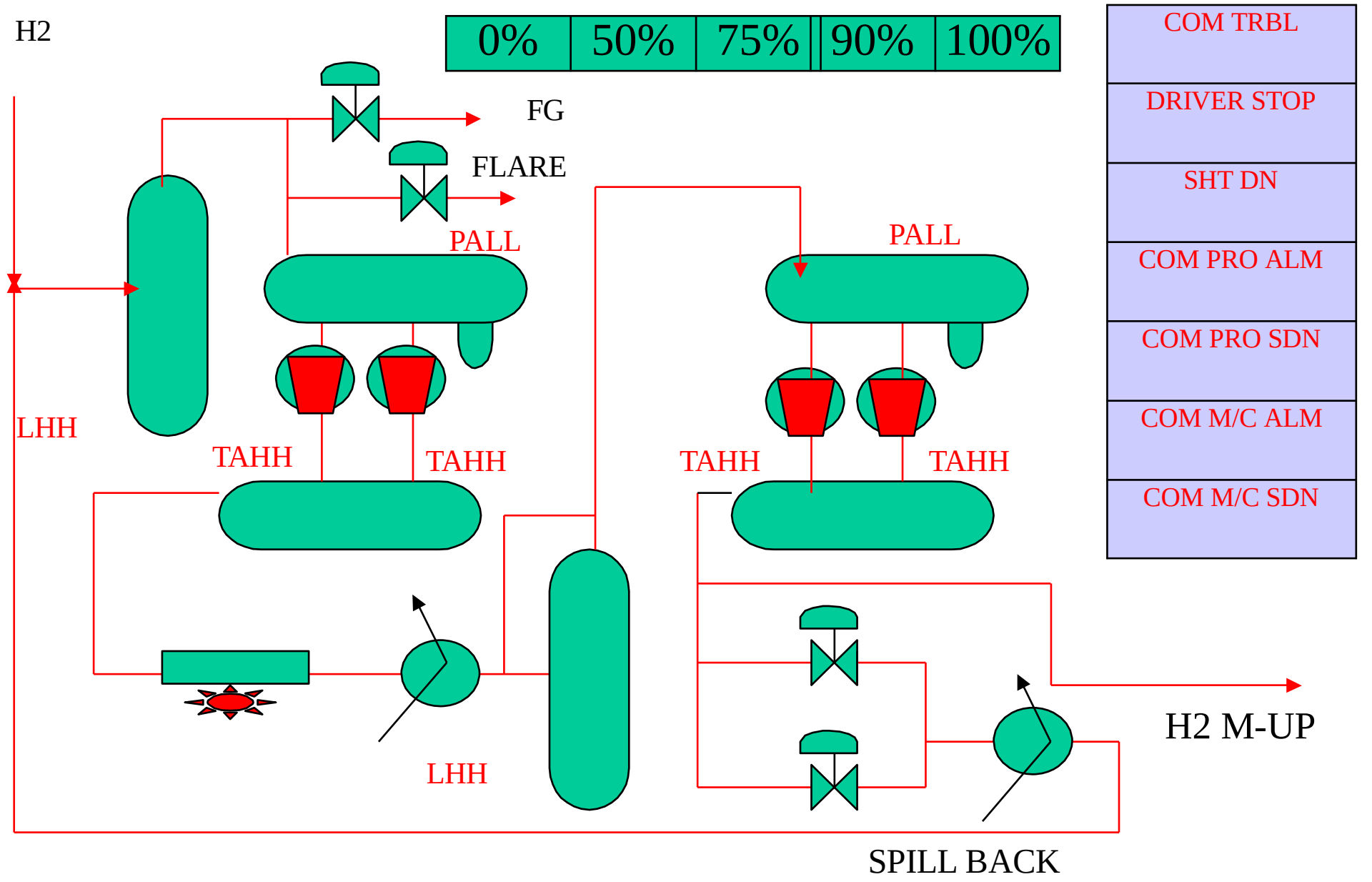
Components

- **Crank case**
- **Loader valve**
- **Piston**
- **Cylinder**
- **Flying wheel**
- **Driver**
- **Discharge loader**
- **Drop rod**
- **Frame oil**
- **Force lubricator**

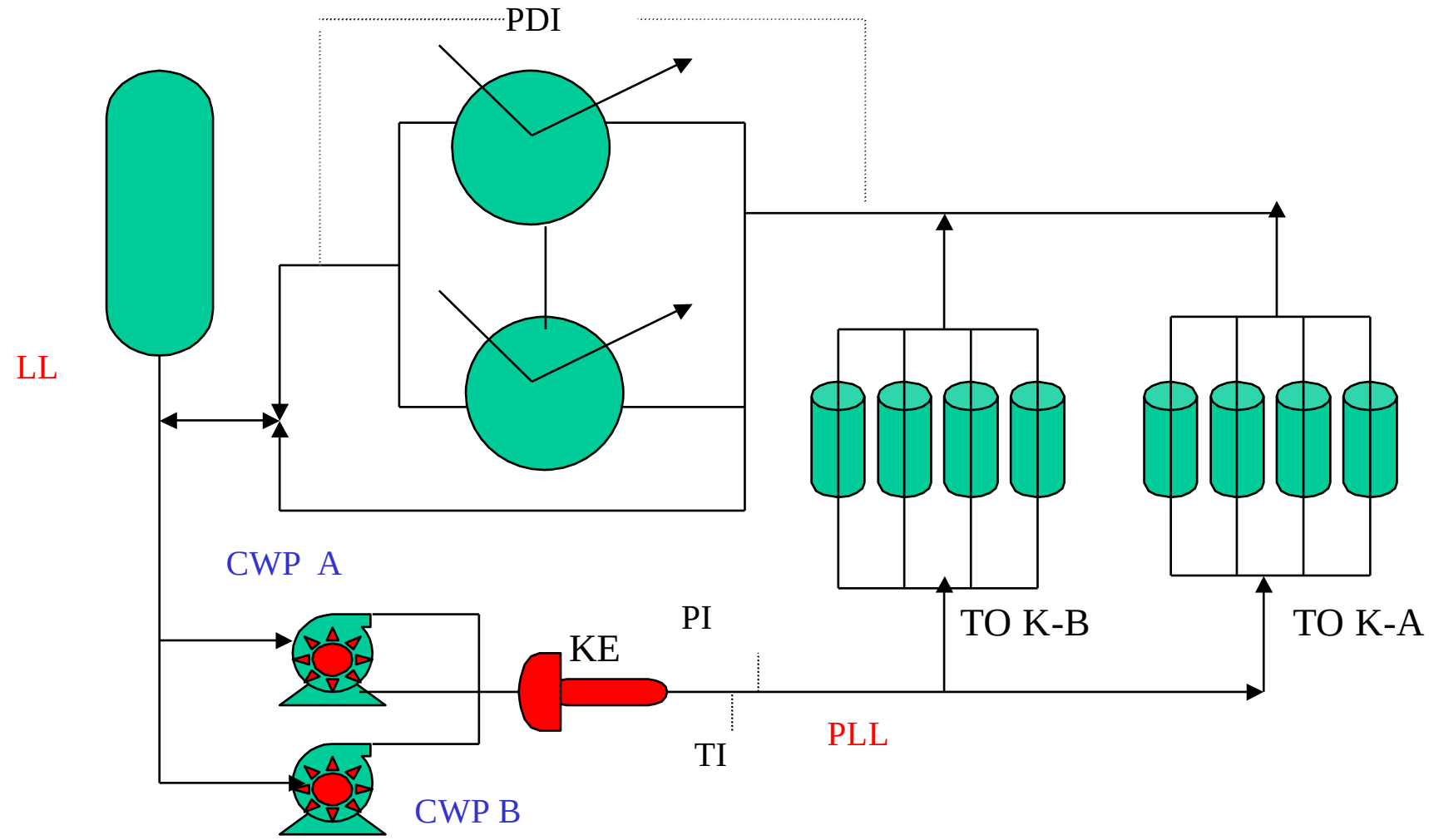
PFD OF Reciprocating Compressor



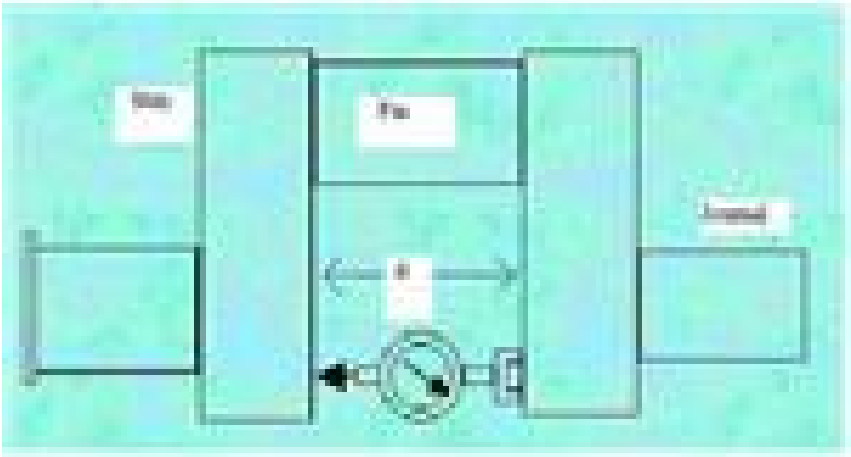
PFD OF Reciprocating Compressor

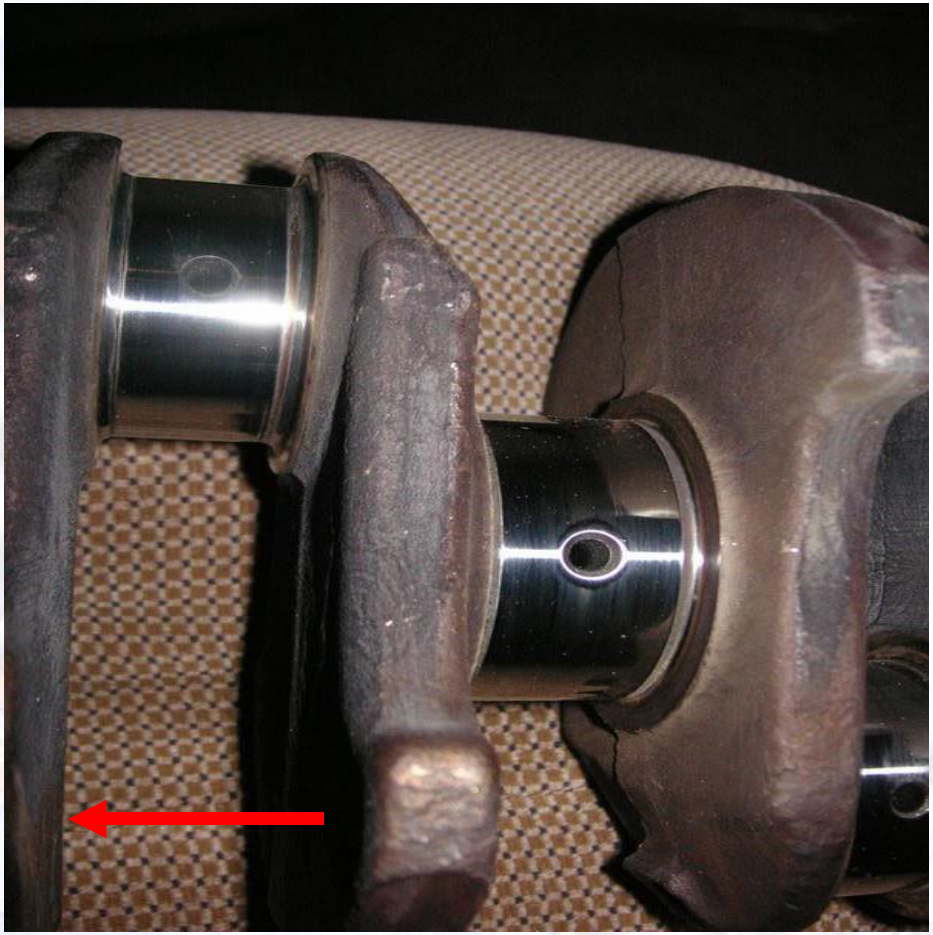


COOLING WATER SYSTEM



How to take Crankshaft Deflections?





REFRENCE READING CHECK HEAR

Wear Of Journal & Big End Bearing

•Maximum acceptable clearance for main bearing/ big end bearing
is 0.2% of the diameter of crank journal against initial average recommended clearance of 0.1% .
If this wear is higher, the crank shaft is to be ground to the next
Undersize, as per following table.

Diameter of journal (in mm)	Nos. Under sizing	difference between nominal diameter & subsequent under size (in mm)
<_100	2	0.5
<_ 190	3	0.5
<_ 300	3	1.0
<_ 405	4	1.0
>_ 405	5	1.0

Connecting rod

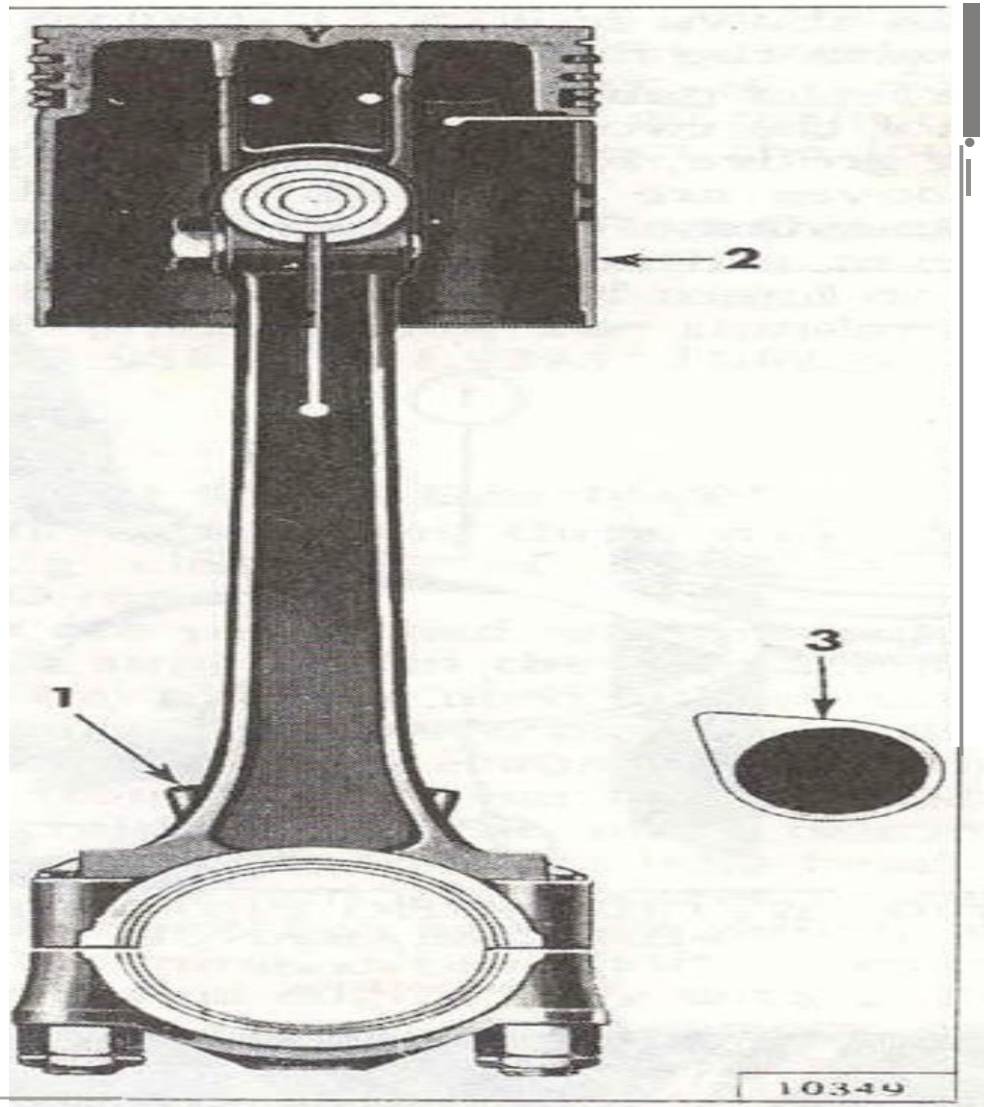
- This will connect the crank pin to the gudgeon pin of the cross head /piston.

- Portion on crank pin is called as “big end bearing” and generally in two pieces connecting together by bolts.

- Portion containing gudgeon pin is small end bearing usually single piece.

- It is normally die forged in carbon or alloy steel and shape is of I section for high load /weight ratio.

Connecting rod



F.:CY_ B

—CONNECTING ROD AND PISTON

1 ——
2 —— i : : . o s - c .... - -i=-w:-'\....-;- :-;:a,..T
3 —— ; -<..- l n . . ,,,,, , • Camshaft

t »c..:: s :.. .

Connecting rod

Maintenance Checks

- Ensure tightness of small end bush.
- Ensure the condition of big end bearing seat
- Check tightness & locking of tie bolts at big ends.
  for bearing rotation & burr etc.
- Check for ovalisation / wear of both ends.
- If Ovalisation /wear has crossed the permissible limits, new bearings are to be fitted.
- Permissible limits are 200% of the initial clearance.

- For example:- Journal nominal dia =100mm
  Initial recommended clearance = 0.1%
  $= \frac{100 \times 0.1}{100} = 0.1\text{mm}$
- Permissible limits $= 200 \times 0.1/100 =$ **0.2mm**

Bearings

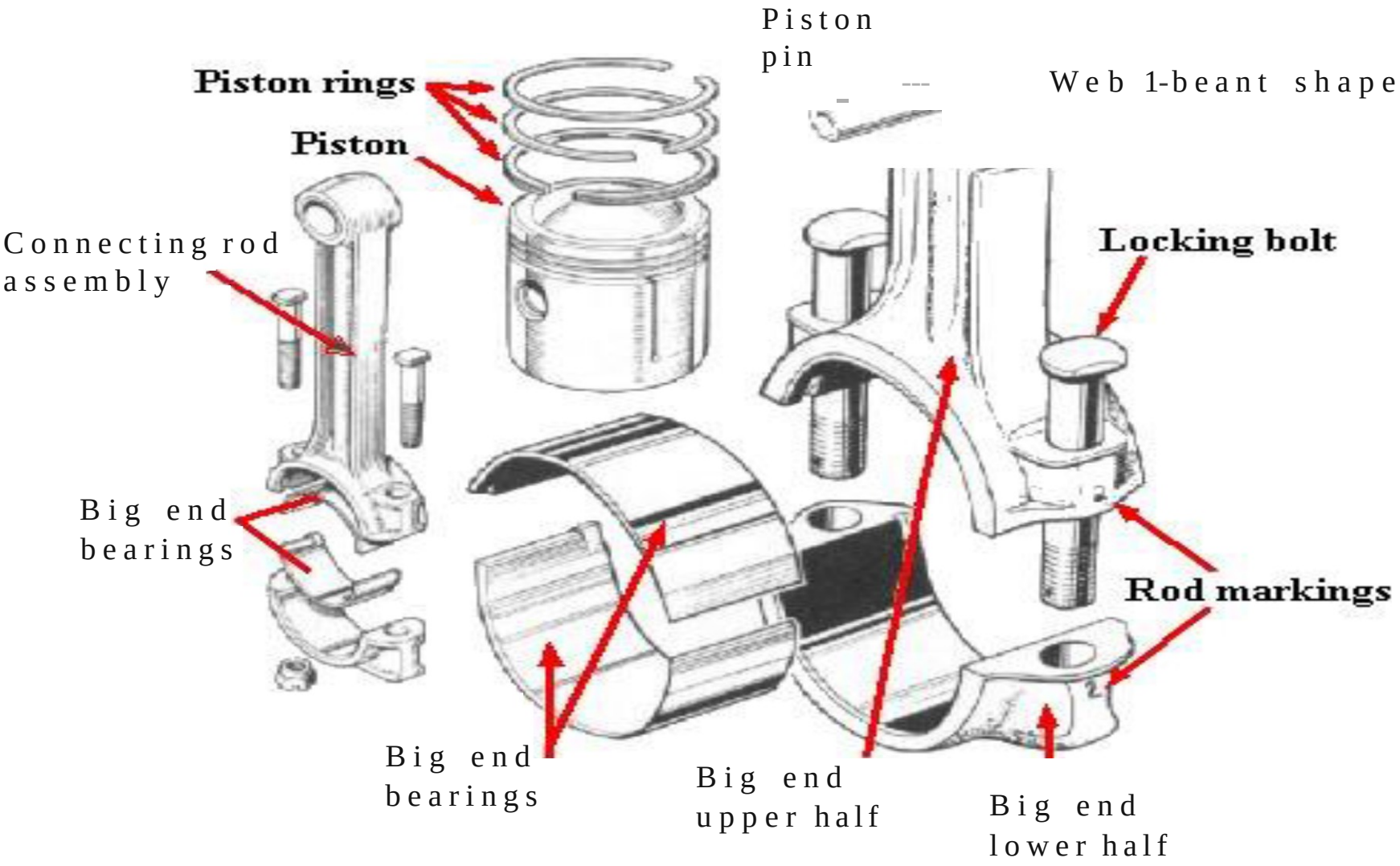
- The bearings supporting crank shaft are main bearings

- Connecting rod containing crank pin is called big end bearing and small end houses in cross head pin is called small end bush.

- All the bearings are sleeve type and working principal of hydro static lubrication.

- All the bearings usually of thin steel shell bearing with two halves having 3-4% of bearing dia with lining of white metal or combination of leaded bronze and white metal

Big End Bearing Bearings



Cross head

- It is the component which transforms the motion of connecting rod to the linear motion of the piston rod.

- Sliding surface of cross head is coated with white metal and sized according to kept connecting rod thrust to low value.

- It is of one piece construction with integral shoe of nodular cast iron or separate shoes bolted on a steel forged cross head body.

- Lubrication of sliding surfaces attained by feeding the crank case oil through cross head guides (separate lub. oil line)

Cross Head

- A cross head used in large reciprocating compressor to eliminate side ways pressure on the piston.

Maintenance Checks:-

Cylinders

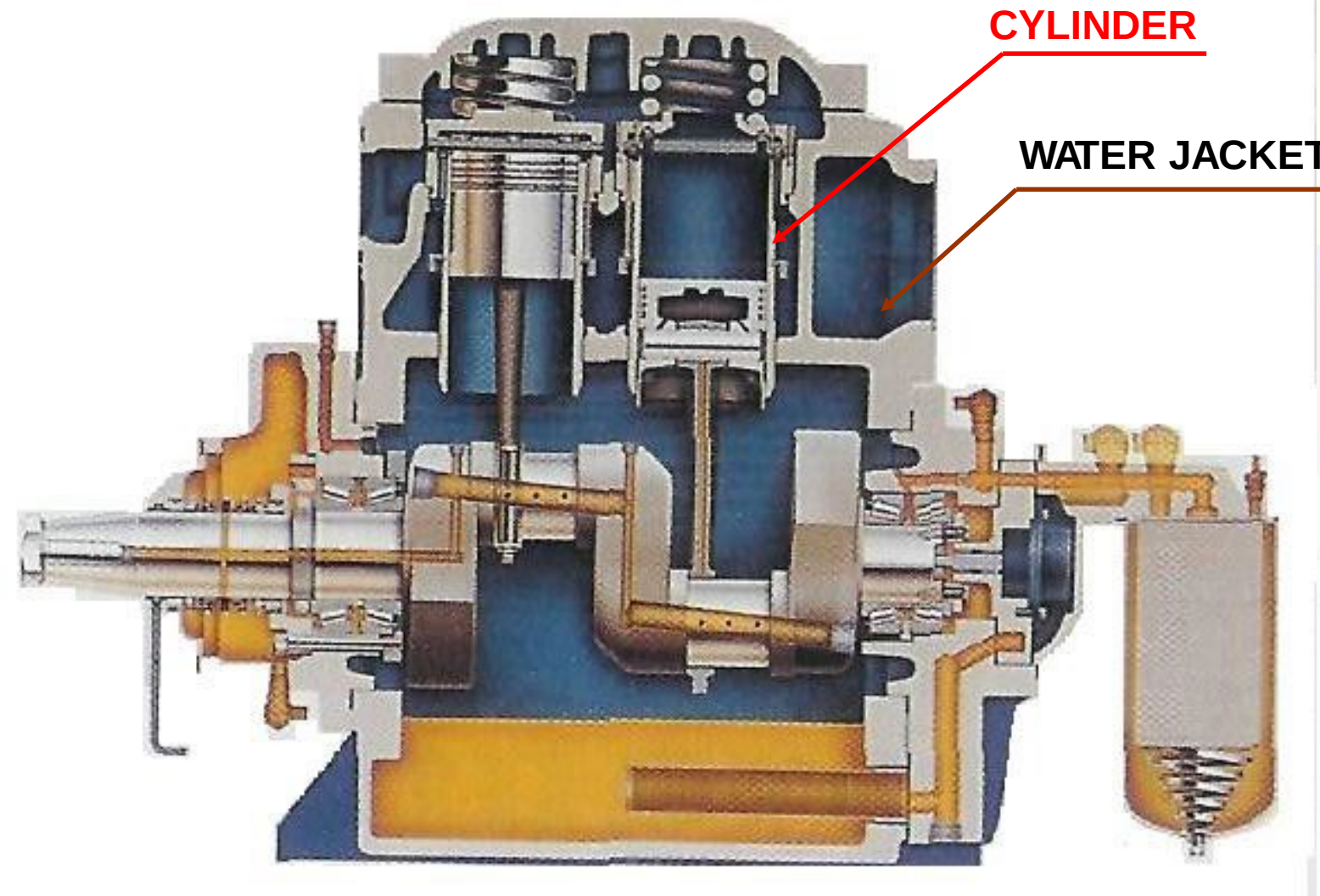
- The main purpose is to fulfill the process parameters without allowing any stresses in any point.

- Compressors cylinders are may be in cast iron(70ata),cast steel(120) or alloy steel (250ata).

- For cylinders made of steel ,it must have cast iron liner for suitable wearing surface.

- Cylinders cooling holes are to be provided for adequate cooling of the cylinders as well as reduce the thermal stresses because of wide variation of temperatures in suction and discharge ports.

CYLINDER

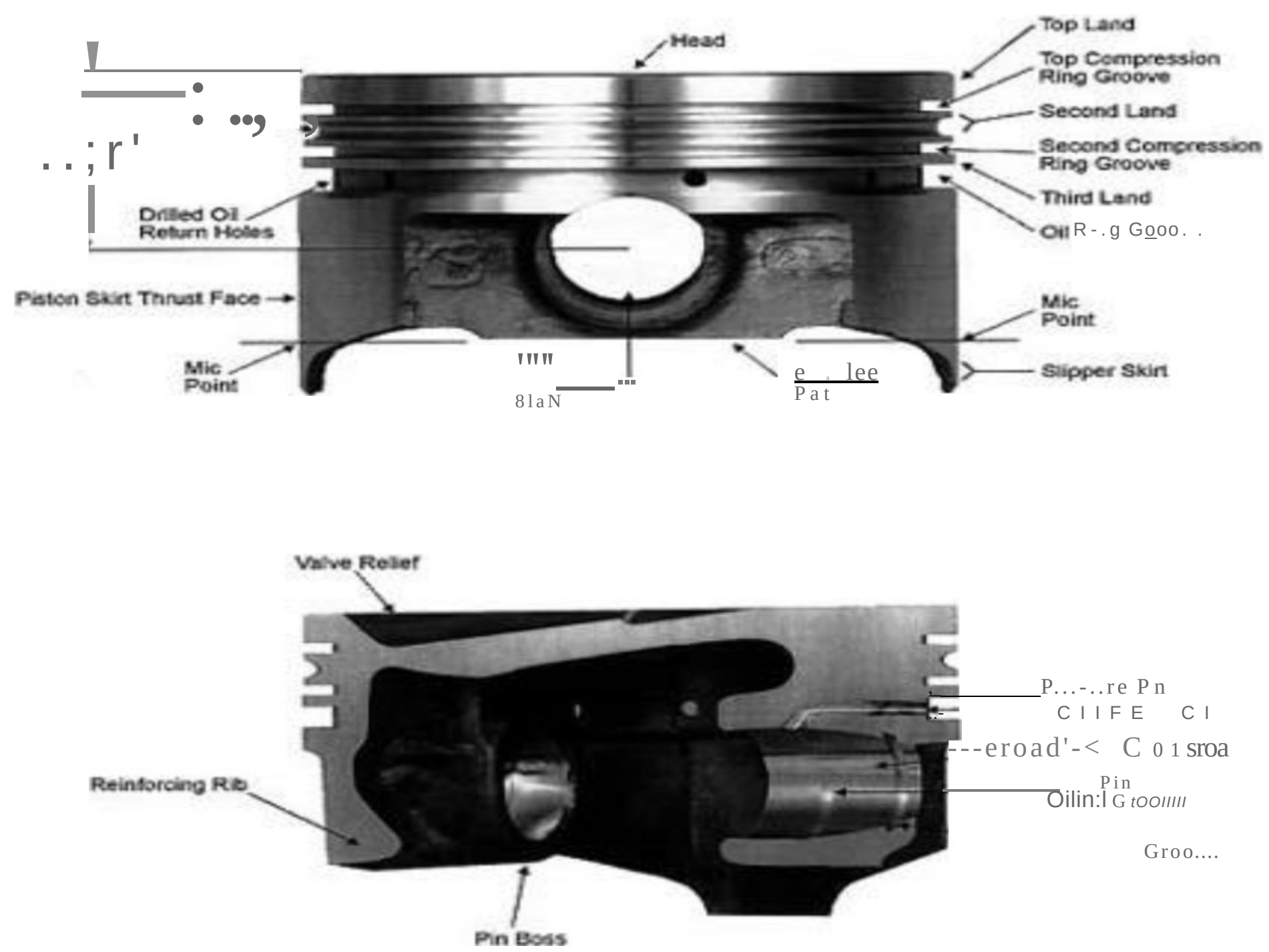


Piston & Piston Rod

- This is the component for transmit the motion of the cross head to the piston which finally compresses the gas in the cylinder.

- The pistons are made of ALUMINIUM ALLOY, CAST IRON ,STEEL based on the size of the piston and speed of the machine.

- Piston rod is invariably a forged carbon steel , alloy steel or stainless steel ,specifically surface hardened at packing contact zone.


Head
Top Land
Top Compression Ring Groove
Second Land
Second Compression Ring Groove
Third Land
Oil
Drilled Oil Return Holes
Piston Skirt Thrust Face
Mic Point
Mic Point
Slipper Skirt
Valve Relief
Reinforcing Rib
Pin Boss

Piston rings ,Rider rings and Rod packing

Piston rings

•The main function of piston rings is maintaining gas seal across the piston as piston ring is based on pressure difference.

•The conventional metallic piston rings are in cast iron or bronze having cut with suitable elastic preloading, so as to ensure proper sealing. These are mainly used for lubricated compressors

•Non-metallic piston rings such as filled PTFE rings are used for non lube application, the same offer's very low coefficient of friction. The filler material such as carbon graphite, glass bronze etc will increase the wear resistance of PTFE.

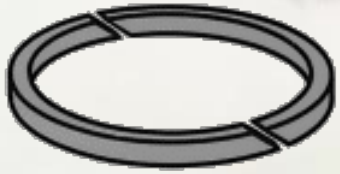
Rider Rings

The main purpose of Rider ring is to support the weight of piston. This provision helps the piston rings to perform only sealing function and avoid any direct metal to metal contact between sliding surfaces.
This is usually made of white metal band or PTFE ring .

Piston rings

Straight Cut

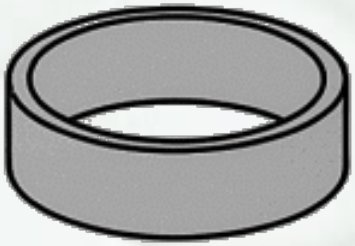
Angle Cut



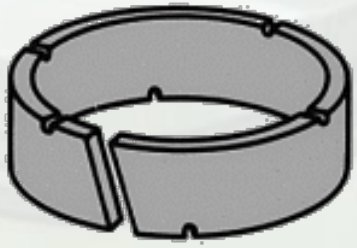
Two-piece

With relief groove to reduce wear

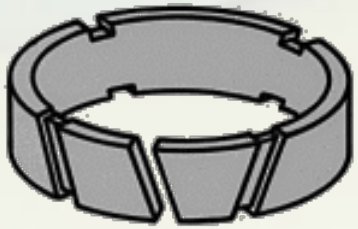
Rider Rings



Endless



Angle cut with Relief grooves



Angle cut with relief grooves to prevent spinning

Piston rings

Maintenance Checks:-

If the piston ring shows any sign of deterioration, they must be replaced.

The following checks are to be made on piston rings.:-

The end gap of the piston rings when mounted in the cylinder.

The side clearance between rings and grooves.

The general condition of the piston rings such as sliding surface.

Indiscriminate changing of all rings merely because they have been in the use for more than one or two years is not reasonable (refer fig. on next slide)

Packing rings

- Packing rings will prevent the gas leaking along the piston rod while reciprocating in and out of the cylinder.

- Packing rings are normally made of three pieces and kept with the help of garter springs.

- Bronze metallurgy is used for lubricated and high pressure applications.

- For non-lube applications filled PTFE packing rings are used.

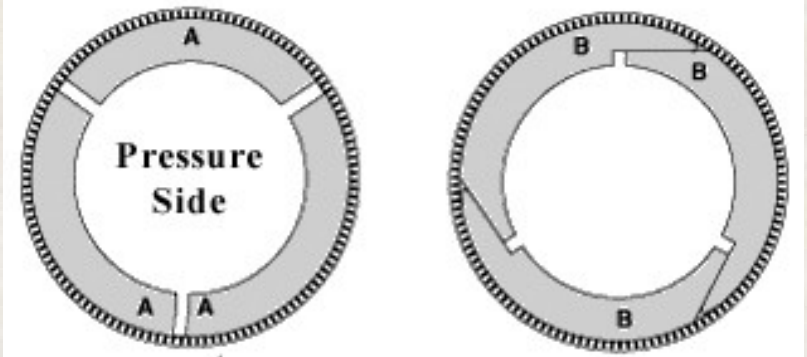
Continued …….

- The packing set consists of first three pieces radically split rings, which serves as pressure braking rings ,and also serves as the back flow of gas during suction stroke.

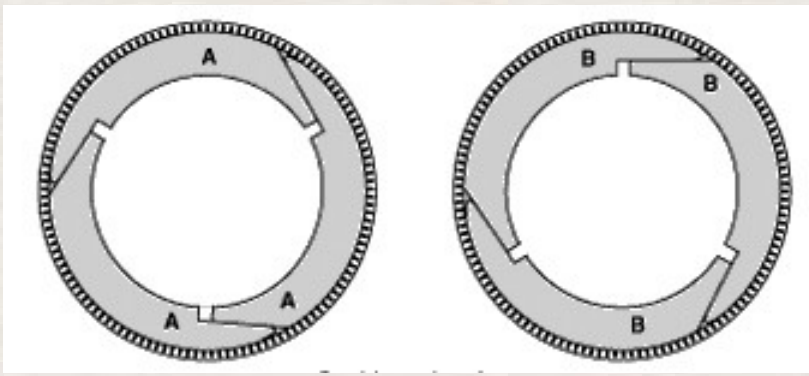
- Radically split rings are followed by suitable number of radial-tangential ring pairs for sealing against the flow of gases from cylinder.

- The lost one or two pairs followed by tangential rings able to seal in both directions. A suitable vent is provided before this ring in gland plate for vent out hazardous gases leaked up to this point.

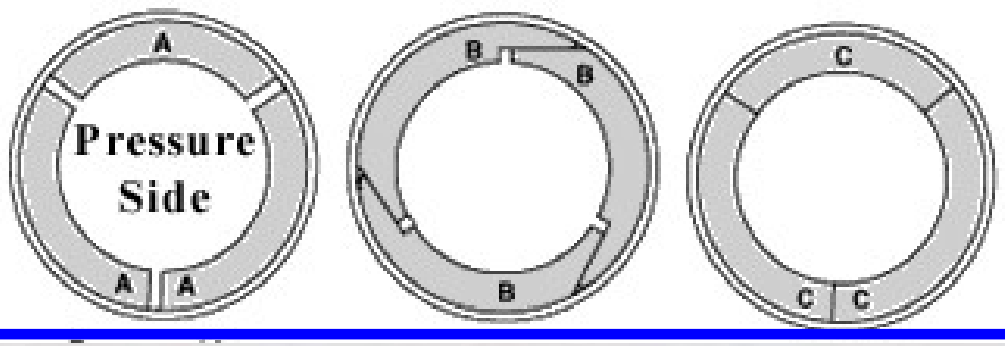
Packing rings



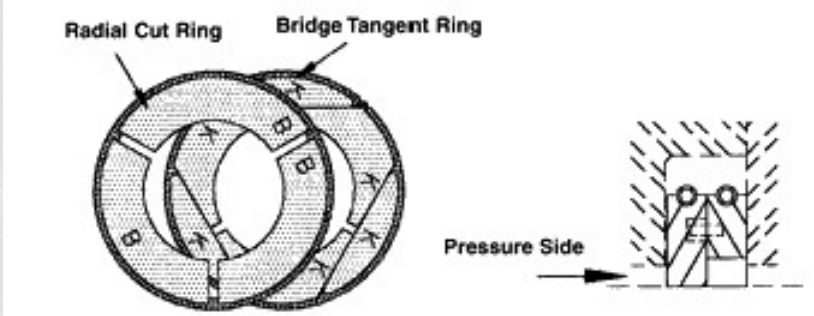
Radial Tangential Combination



2 Tangential Combination



Radial Tangential + Backup ring



Bridge Tangential – High P & T

Suction & discharge valves

The valves which allow the gas inside the cylinder during suction stroke is known as suction valves
The valves which allow gases out of the cylinder to the discharge manifold are called as discharge valves.

Compressor valve types include:-

- Plate valves
- Ring valves or Concentric valves
- Channel valves
- Feather valves
- Poppet valves
- Reed valves

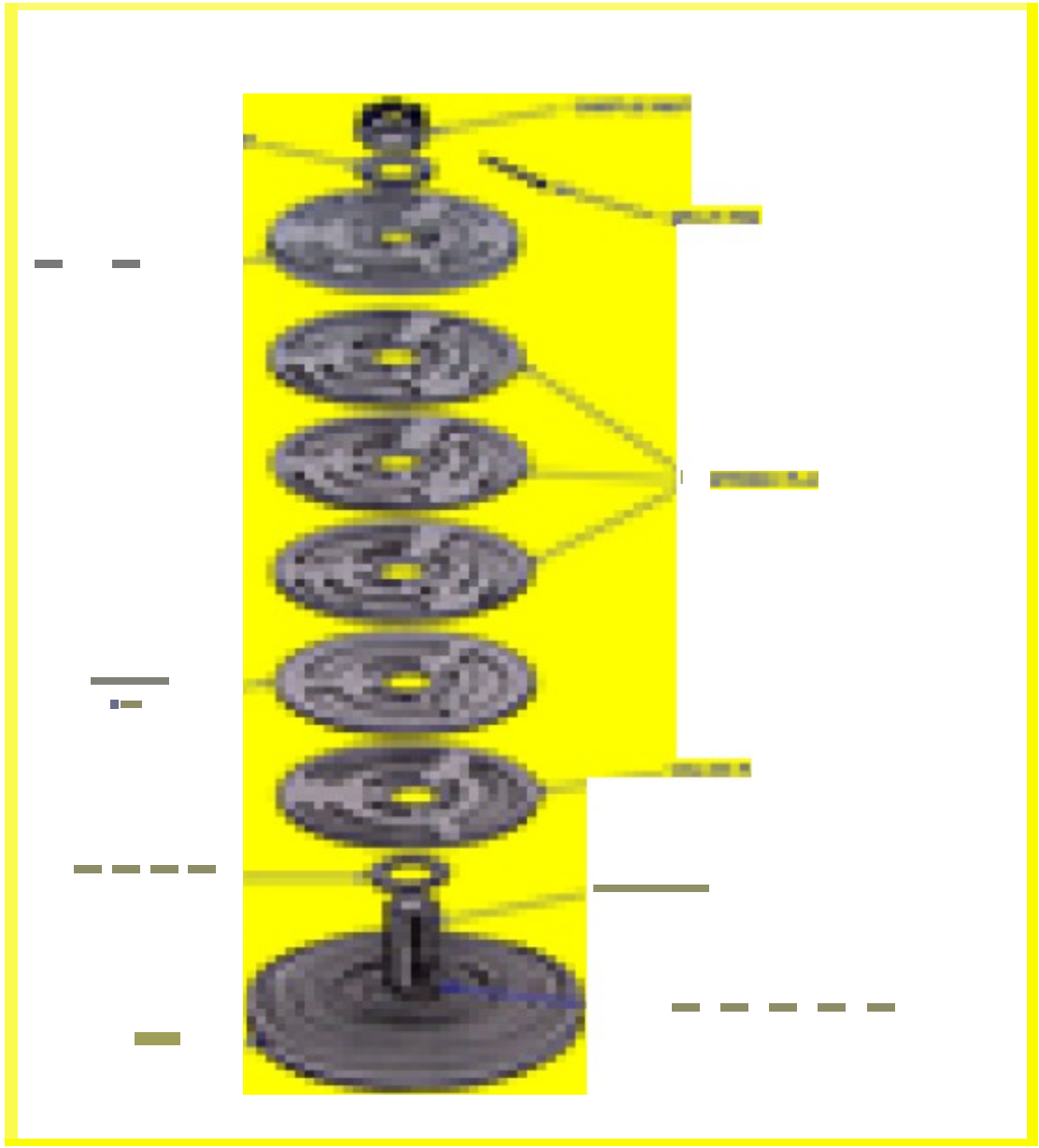
Continued …….

Plate
Valve

Plate valve with
Non Metallic Plate

Ring Valve

Channel
Valve



VALVES OVERHAUL PROCEDURE

•The compressor must be electrically isolated and depressurised before brought for overhaulingof compressors valves

•The suction and the discharge valves look similar; however the direction of the operation and the spring stiffness differs

•The suction valve springs are of lower spring stiffness than the discharge ones and they must never be mixed up

•Also when using new spare parts the part number must be carefully checked from the operation and maintenance manual to avoid mixing them up.

•When opened up the suction valves are found to be in clean condition while the discharge valves would have some degree
of carbonization.

•All the broken parts must be located to avoid any further damage to the machine.

• An exploded view of the compressor valve has been shown

Continued …….

1.Remove the split pin and open the castle nut.
2.Dismantle all the parts and soak in kerosene or clean diesel oil.
3. Clean all the parts with a soft brush. In case of a hard deposit a copper plate of washer can be used for the scraping action.
4.Check the valve plates and the valve seats for any damage and cracks. If any signs of fatigue cracks on the valve plates are present, then the valve plate must be replaced with new ones. The valve plate must never be turned over and used as it can lead to fatigue failure.
5.The valve plate and the valve seat must be separately lapped on a surface plate using fine and extra fine grinding paste.
6.Thereafter all the parts must be washed with diesel and cleaned with compressed air.
7. The valve should then be assembled, with the lapped surface of the valve plate and the valve seat facing each other.
8.After the assembly of the valve the operation of the valve should be checked by a soft wooden stick.

Valve Components

Sealing Element – Plate, Rings, Channels, Poppets
Material : Steels, Plastic Composites

- Opens and closes on pressure differential.
- Allows gas flow and prevents backflow

Damping Element - Coil springs, Cushion plates, Spring plates, Damping plates - Material : SS-410, Inconel, PH-17

- Cushion the motion of sealing element

Assembly Element - Bolts, Nuts, Retainer ring

- Clamp all the component of the valve as one assembly.

Valve Failure Modes

Wear and Fatigue

- Normal Wear
- Managed by proper design, materials, lubrication

Environmental

- Corrosive elements
- Foreign particles
- Liquid entrapments and carryover
- Improper (excessive or inadequate) lubrication
- Formation of carbon or other deposits

Abnormal mechanical action.

- Valve flutter
- lamming from delayed closings, other pulsations or improper lifts
- Multiple impacting from excess pulsations or Resonance
- Improper Flow pattern

Bumping Clearance

Clearance given so that the piston of the reciprocatingcompressor would not bump into its cylinder head.

Wear at the crankpin bearing

- crankpin bearing wears down due to use.
- This type of wear can be recognized when the compressor makes impact sounds running unloaded at the starting and stopping operations.
- Due to decrease in oil pressure over a period of time.

Incorrect thickness of the cylinder head gaskets

Wear on the main bearings

- Over all wear on the main bearings would lower the crank shaft and would thus lower the piston and increase the bumping clearances.

Significance of Bumping Clearance

The bumping clearance is something which must be adjusted very properly by decreasing and increasing it. If the bumping clearance is less and the piston would hit the cylinder head and mechanical damage would occur to both of them.

On the other hand if to keep safe, a few millimeters of extra clearance, the volumetric efficiency of the compressor would decrease and the compressor would struggle to fill up the air bottle.

In the case of excess bumping clearance when the compressor reaches the TDC a small amount of air remains in the clearance volume which is re-expanded and re-delivered thus lowering the volumetric efficiency. This would endanger your maneuvering and an accident is waiting to happen.

Check For Bumping Clearance

The bumping clearance can be checked by the following methods:

- In case a suitable opening is available the piston can be barred to the top dead centre and then feeler gauges can be put inside and the clearances checked at two three points.
- By inserting lead wire between piston & the heads
- Then the piston is slowly from TDC to BDC
- The thickness measured with the help of a micrometer. This measurement would give the bumping clearance.

- The caution which must be observed in these methods is that the clearances of the main and the crank pin bearing have not been taken into account. The correct method is thus that after turning the piston to top dead centre the piston connecting rod must be jacked up with the help of a crow bar. It is only after this hidden clearance has been accounted for, will the correct bumping clearance be found.

How to Adjust the Bumping Clearance

The bumping clearance once found to be incorrect would have to be adjusted. The methods of adjusting the bumping clearances are as follows:

- The cylinder head gaskets can be changed to a different thickness thus altering the bumping clearance.

- The shims between the foot of the connecting rod and the bottom end bearing can be changed thus changing the bumping clearance.
-

However after adjusting the bumping clearance the clearance should be checked once again to make sure that there is no error.

General Maintenance Checks

- TDC /BDC Checks
- Rider Ring Projections
- Piston Ring End Gaps
- Valve Condition
- Cylinder Dimensions
- Piston and Piston Rods
- Rod Packing Set and Oil Wiper Rings
- Packing Cases

Continued …….

- **Crosshead**
- **Connecting Rod**
- **Crankshaft**
- **Other Important Checks**

Intercoolers, Crankcase & Gear Box Oil Coolers, CWJ.
Lube Oil and Filters, Process Strainers
RV’s, NRV’s, Regulators
Pulsation bottles
Vents, Breathers, Tubing's
Lube Oil Pumps
Flywheel
Couplings
Motor
Instrumentation

OPERATION OF THE RECIPROCATING COMPRESSORS A PRECAUTIONARY ADVISES WITH ACTUAL SSTANDING OPERATING PROCEDURE IN USE IN THE PROCESS PLANT LIKE FCCU JUST FOR OVERVIEW

Start up of reciprocating compressor

•Ensure compressor returned from maintenance in totality and energized.

• Ensure all trip interlocks are checked and are healthy.

•Start cooling water circulation for jacket and remove trap air if any for proper circulation.

•Ensure force lubricator and frame oil level is normal.

•Ensure Lube oil circulation is normal

•Ensure heaters are energized and its cut off logic is working.

•Ensure loader valve position is at ‘0’ and physically valve are open condition.

•Take clearance from electrical and TPS for power.

•Ensure all spill backs are lined up and control valves are 100% open condition.

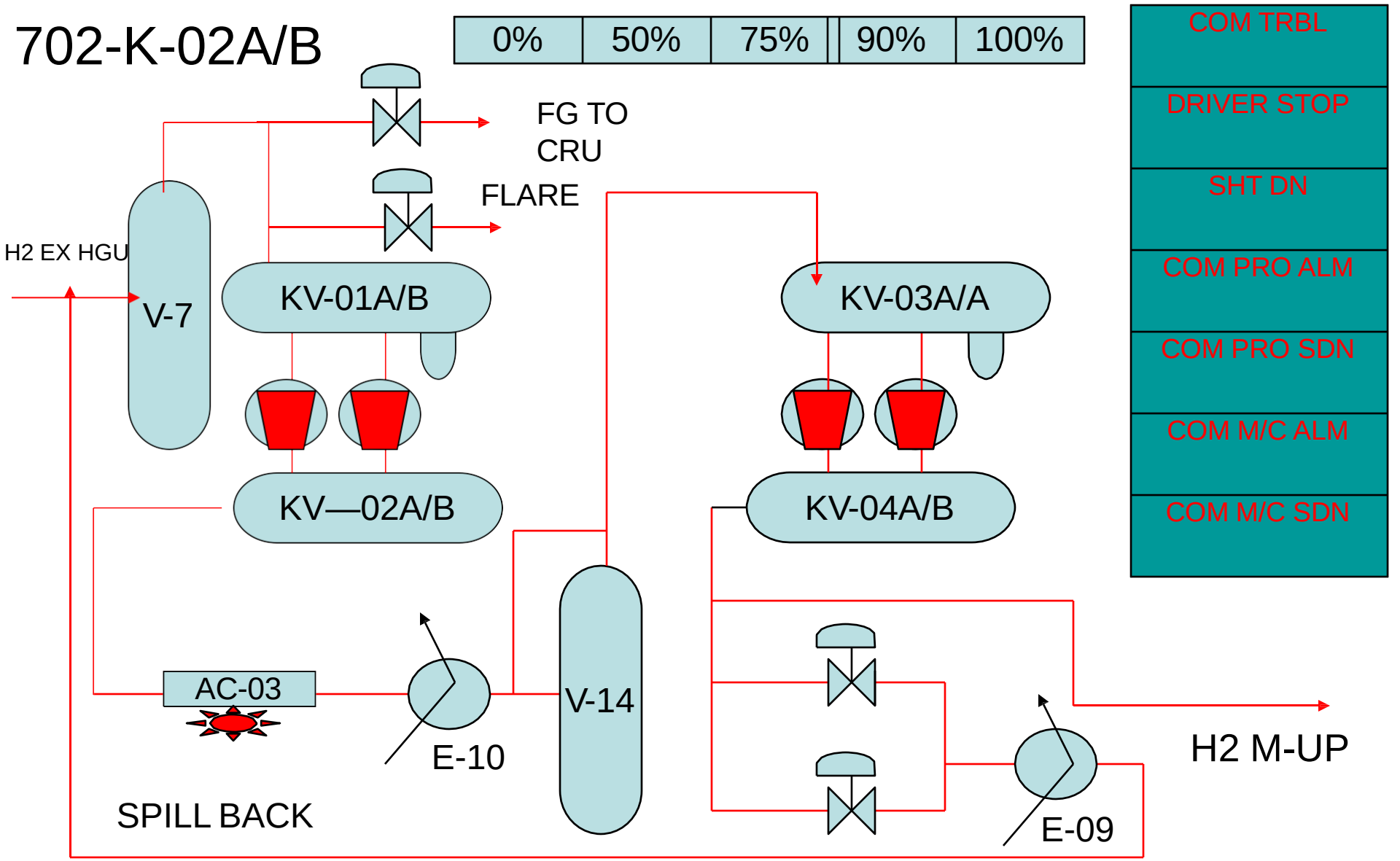
MAKE-UP GAS COMPRESSOR

- GENERAL DETAILES
- PROCESS FLOW DIAGRAM
- LUBE OIL SYSTEM
- COOLING WATER SYSTEM
- AUXILIARY EQUIPMENT
- START-UP PROCEDURE
- SHUTDOWN PROCEDURE
- GENERAL PRECAUTIONS
- GENERAL ARRANGEMENTS

MAKE-UP GAS COMPRESSOR

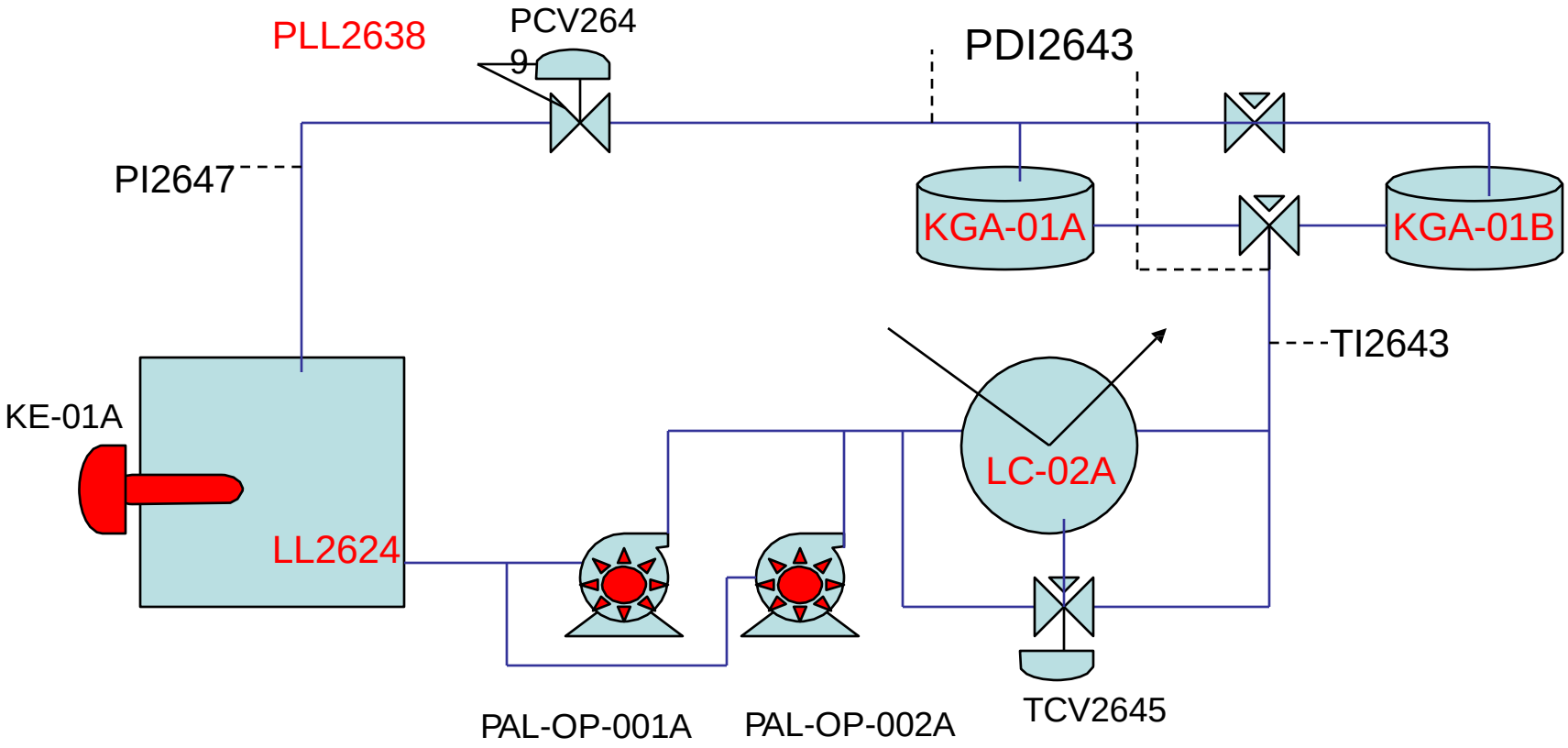
- TAG NO : 702-K-02A/B
- MAKE : THOMASSEN COMPRESSION SYSTEMS, NETHERLAND
- AREA : ZONE-1, GROUP II C
- RATED POWER : 5120 KW
- SPEED : 333 rpm
- RATED CAPACITY : 6388 Kg/hr
- SUCTION PRESS : 20.39/43.33 Kg/cm2
- DISCH PRESS : 43.33/96.88 Kg/cm2
- SUCT TEMP : 45^0C/45^0C
- DISCH TEMP : 132^0C/135^0C

PROCESS FLOW DIAGRAM



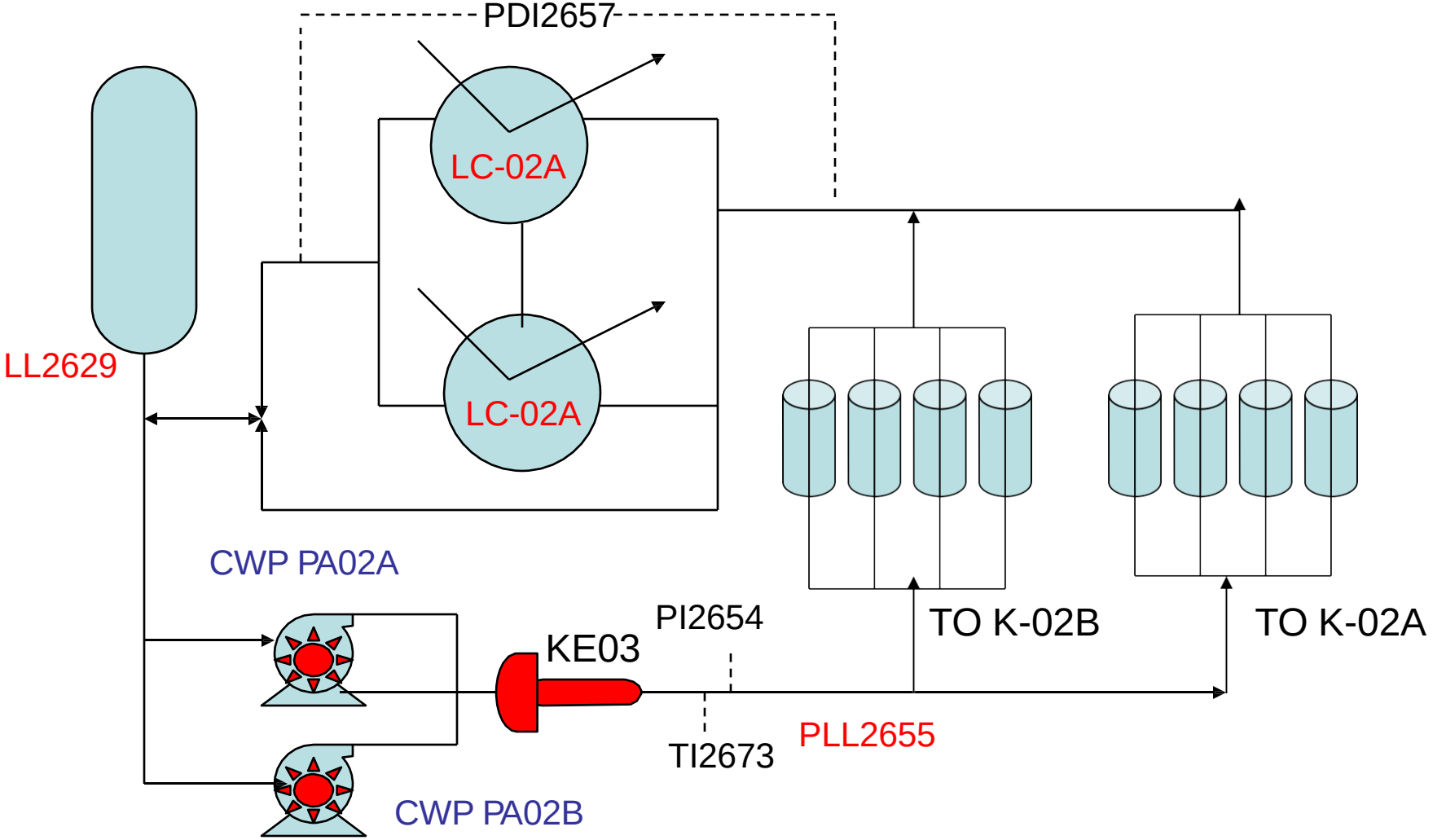
LUBE OIL SYSTEM

- LUBRICATION FOR K-02A
- FOR K-02B REPLACE TAGS 26 BY 27



COOLING WATER SYSTEM

- COMMON FOR K-02A/B



AUXILIARY EQUIPMENT

- **LUBE OIL COMPONENTS**

EQPT NO	DESCRIPTION	SUPPLIER
702-PA-LO-001A/B	LUBE OIL PUMP	ALBANY
702-PA-LOP-002A/B ALBANY	AUX LUBE OIL PUMP	
702-K-GA-01A/B	LUBE OI8L FILTER	INDUFIL
702-K-GB-01A/B	LUBE OI8L FILTER	INDUFIL
702-LC-02A/B	LUBE OIL COOLER	FUNKE
702-KE-01A/B	HEATER FRAME	ELTRON
702-K-LV-01A/B	LUBRICATOR	MANZEL

- **COOLING WATER COMPONENTS**

702-CWP-PA-02A/B BEGEMAN	COOLING WATER PUMP	
702-LC-01A/B	COOLING WATER OOLER	FUNKE
702-KE-03	COOLING WATER HEATER	ELTRON

- **DRIVER COMPONENTS**

BARRING DEVICE

- THE COMP IS EQUIPPED WITH BARRING DEVICE WHICH IS USED FOR MAINT PURPOSES AND TO CHECK FREE MOVEMENT OF COMP PARTS BEFORE STARTING. BARRING BEFORE STARTING PREVENTS COMP DAMAGE BY FOR INSTANCE ACCUMULATED LIQUIDS IN THE CYLINDERS AFTER A LONG STANDSTILL PERIOD DUE TO CONDENSATION. STANDBY COMP SHOULD BE BARRED ONCE IN A MONTH WITH LUBE OIL PUMP ON AND CYLINDER LUBRICATOR ACTIVATED IN ORDER TO PREVENT CORROSION.BEFORE BARRING CHECK FOR FOLLOWING

COMP DRIVER IN LOCKED OFF POSITION

FOR BARRING PRIOR TO STARTUP CYLINDER PRESS SHALL BE ATMOSPHERIC (UNLESS DESIGNED FOR PRESS CONDITIONS)

SUCTION VALVE UNLOADERS MUST BE SET TO UNLOAD OR THE BYPASS MUST BE FULLY OPENED.

COMP LUBRICATING AUX PUMP SHALL BE IN RUNNING CONDITION.

FOR MAINT COMP SHOULD BE GAS FREE.

AFTER BARRING LOCK BARRING DEVICE IN OFF POSITION.

HOW TO ENGAGE BARRING DEVICE ?

- OPEN THE VALVE BALL TO PRESSURISE THE PNEUMATIC SYSTEM
- RELEASE SPING LOADED MECH LOCKING DEVICE MANUALLY
- START THE MOTOR BY PUSHING THE BUTTON ON CONSOLE
- PUSH HE PNEUMATIC CONTROL VALVE UNTIL THE MECH LOCKING DEVICE CLICKS-ININ TOTAL ENGAGE POSITION.THE LIMIT SWITCH WILL BE ACTUATED WHEN THE BARRING DEVICE MOVES TOWARDS THE FLYWHEELTHIS SWITCH MUST BE USED AS AN INTERLOCK FOR START PREVENT ION OF MAIN DRIVER.
- THE COMP WILL NOW BE BARRED OVER
- STOP THE MOTOR BY RELEASING THE BUTTON ON THE CONSOLE(IN CASE OF AIR MOTOR LOCKING DEVICE WILL COME INTO OPERATION WHEN THE AIR PRESS IS RELEASED

HOW TO DISENGAEMENT BARING DEVICE

- PUSH THE PNEUMATIC CONTROL VALVE , UNLOADING THE MECH LOCKING DEVICE
- KEEP THE CONTROL VALVE IN THIS POSITION AND MANUALLY LIFT THE MECH LOADING DEVICE
- RELEASE PNEUMATIC CONTROL VALVE
- THE BARRIN DEVICE WILL NOW SLIDE BACKWARDSAND THE MECH LOCKING DEVICE CAN BE RELEASED AND WILL CLICK-IN WHEN THE OUTER POSITION IS REACHED.
- CLOSE THE BALL VALVE.

LUBRICATOR

- THE LUBRICATOR IS USED TO SUPPLY OIL TO THE COMP CYLINDERS AND/OR STUFFING BOXES.THE LUBRICATOR IS EITHER DIRECT DRIVEN WITH COMP OR DRIVEN BY AN ELECTRIC MOTOR.THE LUBRICATOR HAS A SEPARATE OUTLET FOR EACH LUBRICATING POINT.
- THE OIL TO THE EACH POINT IS VISIBLE IN THE SIGHT GLASSES OF THE LUBRICATOR.
- THE AMOUNT OF CAN BE ADJUSTED BY MEANS OF ADJUSTING SCREW.

INCORRECT ADJUSTED LUBRICATOR MIGHT LEAD TO INCREASE WEAR OR EXCESSIVE OIL CONSUMPTION.

START PERMISSIVE

- CHECK FOLLOWING TO GET PERMISSIVE

BARRING DEVICE
ZS2626

1ST STAGE SUCT DRUM
LAHH2502

2ND STAGE SUCT DRUM
LAHH2402

START PERMISSIVE
K2A PST

EMERGENCY STOP
HS2601

EMERGENCY STOP
HS2602

2ND STAGE DISCH TEMP
TAHH2601A

2ND STAGE DISCH TEMP
TAHH2601B

1ST STAGE DISCH TEMP
TAHH2603A

1ST STAGE DISCH TEMP
TAHH2603B

1ST STAGE DISCH PRESS
PALL2623

1ST STAGE DISCH PRESS
PALL2628

LUBE OIL PRESS LOW LOW
PALL2638

LUBRICATOR LEVEL LOW LOW
PALL2626

COOLING WATER PRESS LOW LOW
PALL2655

CAPACITY 0 % SELECTION
CAPAA

STARTUP PROCEDURE

- **PREPARATION FOR STARTUP**

VERYFY THAT OPERATION CLEARANCE FOR COMPRESSOR IS AVAILABLE FROM MECH/ELECT/INST.

VERIFY THE VALIDITY OF CERTIFICATES FOR ALL RELATED VESSELS/PSVS/TEMP & PRESS INSTRUMENTS AND SWITCHES SETTINGS FOR TRIPS.

CHECK LOGIC FOR START/STOP SEQUENCE & CAPACITY CONTROL ARE FUNCTIONING PROPERLY.

CHECK THE WIRING TO MOTORS,HEATERS & SWITCHES IS CORRECTLY CONNECTED. CHECK COVERS ON WIRING BOXES ARE PROPERLY CLOSED.CHECK MOTORS AND HEATERS ARE CORRECTLY FUSED.

VERIFY THE EXTENT OF MAINT IS COVERED AND SIGNED FOR ACCEPTANCE FOR FIELD SERVICE REPORT COMP. CHECK ALL COVERS AND GUARDS HAVE BEEN

STARTUP PROCEDURE

- OPEN COOLING WATER INLET VALVE AND CHECK CW PRESS.REMOVE TRAPPED WATER FROM CW SYSTEM BY VENTING FROM HPV. CHECK CW SYSTEM IS OPERATING LEAK FREE.
- CHECK OIL LEVEL IN FRAME OIL IS WITHIN MIN/MAX OF THE OIL INDICATOR.
- SWITCH ON OIL HEATER AND FOR PROPER ACTION
- START AUX OIL PUMP AND CHECK OIL PRESS AND LEAK FREE SYSTEM.
- TURN THE COMP CRANK SHAFT TWO COMPLETE REVOLUTIONS USING THE BARRING GEAR AND CHECK FOR FREE MOVEMENT.
- CHECK ALL DRAINS /VENTS OF THE PROCESS SYSTEM ARE CLOSED.PRESSURISE BLOCKEDIN PROCESS SYSTEM WITH INLET GAS.CHECK PROCESS SYSTEM IS

STARTUP PROCEDURE

- REMOVE BLINDS FROM/TO COMMON HEADER LINES ,INCLUDING VENT AND DRAIN HEADERS,AND OPEN ALL PROCESS SYSTEM VENT VALVES TO SAFE LOCATION.PRESSURISE BLOCKED IN PROCESS SYSTEM BY OPENING PRESS EQUILIZATION VALVES ACROSS THE INLET MAIN VALVE. ALLOW SUFFICIENT VENT TIME BEFORE CLOSING THE VENT VALVES STARTING WITH THE NEAREST INLET MAIN VALVE.WHEN THE BLOCKEDIN SYSTEM PRESS EQUILIZES IN LET MAIN HEADER PRESS OPEN INLET MAIN VALVE AND CLOSE EQUILISING VALVE.
- OPEN THE PRESS EQUILISING VALVE ACROSS THE OUTLET MAIN HEADER. WHEN THE PRESS EQUILISES OPEN THE OUTLET MAIN VALVE AND CLOSE THE EQUILISING VALVES.
- DIS-ENGAGE THE BARRING GEAR AND LOCK IN OFF POSITION .
- REMOVE ALL TOOLS AND ENSURE WALKWAYS ARE CLEAR

STARTUP PROCEDURE

- **STARTING**
- CHECH COMP AND DRIVER, PROCESS VALVES , COOLERS AND AUX EQUIPMENT ARE READY FOR STARTUP
- CHECK VARIOUS OIL LEVELS.
- SWITCH ON AUX OIL PUMP OF FRAME LUBRICATING SYSTEM.
- PRELUBRICATE THE CYLINDERS AND STUFFING BOXES BY SWICHING ON THE ELECTRIC LUBRICATOR OR CRANK THE LUBRICATOR BY HAND FOR TWO MINUTES.
- START CW CIRCULATION AND CHECK FLOW AND PRESS .
- SET CAPACITY CONTROL ON NO LOAD(0%)
- DRAIN GAS SUCTION LINES ,PULSATION DAMPERS, COOLERS AND SEPARATORS.

STARTUP PROCEDURE

- START MAIN DRIVER
- CHECK LUBRICATING OIL PRESS AND TEMP,DELIVERY OF FORCED FEED LUBRICATOR AND CIRCULATION OF CW . IN ORDER TO PREVENT GAS CONDENSATION KEEP CW TEMP AT CYLINDER INLET ATLEAST 6^0C HIGHER THAN THE GAS TEMP.
- LOAD THE COMP AS REQUIRED STEPWISE.
- CHECK COMP SUCTION AND DISCH PRESS.
- MONITOR SUCTION AND DISCH PRESS, TEMP, LUBE OIL PRESS TEMP, CW PRESS AND TEMP, BEARING TEMP, MOTOR CURRENT /VOLTAGE

TROUBLE SHOOTING OF RECIPROCATING OMPRESSORS WITH REMEDIAL SOLUTION

TROUBLE	PROBABLE CAUSES	REMEDIAL SOLUTION
Compressor does not start	1. Power supply failure 2. Switch or starting panel 3. Low oil pressure shut down switch 4. Control panel	1. Correct voltage or power supply 2. Check circuitry and interlocks ,relays etc 3. Install momentry bypass switch on direct gear driven oil pumps 4. Check connections and settings of all devices
Motor does not get synchronised	1. Low voltage 2. Excessive starting torque 3. Incorrect power factor 4. Excitation voltage failure	1. Correct voltage suppy 2. Unload compressor during starting 3. Adjust exciter field rheostate 4. Check field ezcitation system
Low oil pressure	1. Oil pump failure 2. Oil foaming from counter weightts striking oil surfaces 3. Cold oil 4. Dirty oil filters 5. Inferior frame oil leaks 6. Excessive leakage at bearing shim 7. Improper lub oil pr setting 8. Low lub oil gesr relief valve setting 9.Defective pr gauges 10.Plugged filter/strainers 11.Defective relief valves	1. Check oil pump power supply 2. Reduce oil level 3. Use frame oil heater and steam trac ing adequacy in oil pipings 4. Set shim tabs and bearing clearances 5. Reswt 6. Reset relief valves 7. Replace pressure gauges 8. Clean strianers 9. Repair or replace valves

TROUBLE	PROBABLE CAUSES	REMEDIAL SOLUTION
Relief valve popping	1. Faulty relief val;ve 2. Leaking suction valves or rings 3. on next higher stage Obstruction ,blind or valve closed position in discharge line	1. Test and reset 2. Repair replace defective parts 3. Relieve obstruction
Frame knocks	1. Loose crosshead pin,pin 2. caps,crosshead shoes Loose /worn main crank pin or cross head brgs 3. Low lub oil pr 4. Cold oil 5. Incorrect oil 6. Knock is actually from cylinder end	1. Tighten loose parts /replace 2. Check clearances of brg and tighten it properly 3. Increase oil pr,repair leaks 4. Warm oil before loading reduce oil supply to oil coolers 5. Use proper lub oil 6. Tighten piston nut etc
Crankshaft noil seal leaks	1. Faulty setting of oil baffleslinger 2. Clogged drain holes	1. Set baffles and clear obstructions

TROUBLE	PROBABLE CAUSES	REMEDIAL SOLUTION
Piston rod oil scrapper leaks	1. Worn scrapper rings 2. Scrapper rings incorrectly zssesmbled 3. Worn or scored piston rod 4. Inproper fit of rings to rod /side clearances	1. Replace rings 2. Assemle 3. Replace rod 4. Replace rings
Motor does not get synchronised	1. Low voltage 2. Excessive starting torque 3. Incorrect power factor 4. Excitation voltage failure	1. Correct voltage suppy 2. Unload compressor during starting 3. Adjust exciter field rheostate 4. Check field ezcitation system
Noise in cylinder	1. Loose piston 2. Piston hitting outer head 3. Loose crsshead lock nut 4. Broken or leaking valves 5. Worn or broken piston rings, expander 6. Valve improperly seated /damaged gasket seat surfaces 7. Free air unloader chattering	1. Disassemble a& tighten piston 2. Adjust piston rod for proper end clearances 3. Tighten nut 4. Repair replace parts 5. Replace rings 6. Replace gasket and re-assemble properly

TROUBLE	PROBABLE CAUSES	REMEDIAL SOLUTION
Excessive package leakage	1. Worn packing rings 2. Improper lub oil/insufficient lub rates 3. Dirt in packings 4. Excessive rate of pr increase 5. Packing rings assebmled incorrectly 6. Improper ring sides or end gap clearances 7. Plugged packing vent system 8. Scored piston rod 9. Excessive piston rod runout	1. Replace packing rings 2. Use correct lub oil and maintain correct rate of flow 3. Vlean piping and gas supply 4. Reduce pr and increase at more gradual rates or as instructed by OEMs 5. Reassemble as reqd 6. Maintain correct clearances 7. Remove blockages and provide low point vent /LPD 8. Replace rod 9. Correct run out/reshim srosshead
Packing overheating	1. Lubrication failure 2. Improper lub oil and /poor flow 3. Insufficient cooling	1. Replace lubricator check valves/lubricator unit 2. Use proper lub oil and maintain flow as reqd 3. Clean coolant passages increase supply of water /reduce coolant inlet temp
	1. Excessive lub oil 2. Improper lub oil(too light) high carbon residue 3. Oil carry over from inlet system or previous stage 4. Broken or leaky valves causing high temp..high pr ratio across cylinder s	1. Adjust lub oil 2. Use lub oil as revcommended by std /OEM 3. Instal oil separaters/drain system 4. Repair repla ce parts 5. Claen exchangers,valves and correct use of high pr

TROUBLE	PROBABLE CAUSES	REMEDIAL SOLUTION
Leaky valves	1. Faulty seat gasket 2. Improper screw tightening 3. Worn valve seats /channel or plates 4. Improper valve assembly- channels sticking in guides 5. Piping system leaking	1. Check for their correctness as mentioned in above slides
Insufficient capacty	1. System demand exceeds caqpacity 2. Dirty air filter 3. Unloader stuck up 4. Woorn or broken piston rings 5. Head gasket leaks 6. Speed too low ,defective capacity control 7. System pr setting too high	1. Check for corrctiness as suggested above
Insufficient pressure	1. Unloader bypaqssing 2. Loose valves 3. Pr gauge improperly calibrated 4. Air demands exceeds capacity 5. Broken vaalaves /pipoing system leaky 6. Worn or broken piston rings	1. Check for their correctness as mentioned in above slides

TROUBLE	PROBABLE CAUSES	REMEDIAL SOLUTION
Compressure overheats	1. Discharge pr setting too high 2. Inadequate supply of cooling water 3. Improper cylinder or crank 4. case lubrication Broken or loose valves	1. Check for their correctness as mentioned in above slides
Intercooler pr below normal	1. Defective unloader in low pr cylinder 2. Loose discharge valve in low pr cylinder 3. Defective capacity control /stuck up unloacder	1. Check for their correctness as mentioned in above slides
Intercooler pr above normal	1. Worn or missing valve strips in high pr cylinder 2. Loose valves,leaky gasket in high pr cylinder 3. Worn piston rings in high pr cylinder 4. Defective capacity control or stuck up unloader	1. Check for their correctness as mentioned in above slides

TROUBLE	PROBABLE CAUSES	REMEDIAL SOLUTION
Receiver pressure too high	1. Inadequate cylinder control pressure , 2. Leaky high pr pipings 3. Unloader not working 4. efficiently Improperly adjusted capacity control	1. Check for their correctness as mentioned in above slides
temperature too high	2. Unloader stuck up or defective 3. Improper cylinder or crankcase lubrication 4. Inadequate cooling water supply	mentioned in above slides
Cooling water temp too high	1. Sludged cylinder jacket sneed dechoking 2. Fouled heat exchanger tubes 3. Poor discharge of cooling water pumps	1. Check for their correctness as mentioned in above slides

TROUBLE	PROBABLE CAUSES	REMEDIAL SOLUTION
Compressor knocks	1. Loose valves or unloaders 2. Broken unloader control spring 3. Loose flywheel or sheaves 4. Excessive main or crank case beasring clearances 5. Loose piston rod nuts 6. Loose motor rotor on the shaft in case of driven by motor	1. Check for their correctness as mentioned in above slides
Compressor vibrates	1. Imprper grouting 2. Incorrect operating speed 3. Excessive discharge pressure 4. Imprperly supported piping 5. Defective capacity control 6. Stuck up unloader 7. Loose flywheel or sheaves loose motor rotor on the shaft	1. Check for their correctness as mentioned in above slides

Common problems & trouble shooting in compressors

- 1) Noise in cylinder
- 2) Excessive packing leakage
- 3) Packing over heating.
- 4) Excessive carbon on valves.
- 5) Leaking valves.
- 6) Relief valve popping.
- 7) High discharge temperature
- 8) Piston rod oil scrapper leaks.

Noise in cylinder

- **Probable cause**
- **1)Loose piston**
- **2)Piston hitting outer head.**
- **3)Loose cross head lock nut**
- **4)Broken valves**
- **5)Worn /broken piston rings**
- **6)Improperly Seated valves/damaged seat gasket**

- **Remedies**
- **1)Piston nut tightening.**
- **2)Adjust piston rod for proper clearance.**
- **3)Tighten nut**
- **4) Replace parts**
- **5)Replace rings**
- **6)Replace gasket &reassemble properly**

Excessive packing leakage

- 1)Worn packing
- 2)Improper lube oil / lube rate.
- 3)Dirt in packing.
- 4)Packing ring incorrect assembly.
- Improper ring side or end gap clearance.

- Replace packing.
- Use correct lube oil / increase lube rate.
- Clean piping / supply.
- Reassemble as per instruction.
- Establish correct clearance.

Continued…….

• Plugged packing vent.	• Remove blockage and provide low point drains.
• Scored piston rod.	• Replace rod.
• Excessive piston rod run out.	• Correct run out or Reshim cross head.

Packing over heating

- Lubrication failure.
- Improper lube oil / improper lube rate.
- Insufficient cooling (In water cooled)

- Check lubrication system.
- Use correct lube oil / lube rate.
- Clean coolant passages and increase coolant pressure.

Excessive carbon on valves

- Excessive lube oil.
- Improper lube oil (Too light ,high carbon residue.)
- Oil carryover from inlet.
- Broken valves causing high temperature.
- Excessive temperature due to high P2 / P1

- Adjust lube supply.
- Use lube oil as per recommendation.
- Install oil separator / drains.
- Repair or replace parts.
- Clean exchanger and correct cause of high P2/ P1

Leaking valves

- Faulty seat gasket
- Inadequate set screw tightening.
- Worn valve seat or plates.
- Improper valve assembly

- Replace gasket.
- Tighten set screws as per instruction.
- Replace seat and lap plates.
- Reassemble properly.

Relief valve popping

- Faulty relief valve.
- Leaky suction valves of next stage.
- Obstruction in discharge line.

- Test and reset.
- Repair / replace defective parts.
- Remove obstruction in discharge line