# MEP & MOTOR

## Notes

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# TABLE OF CONTENTS

**---- BEST OF LUCK ----**

Feedback or suggestions regarding this issue are welcomed. Please send your valuable advice at below email address

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# 1. MOTOR BASICS

| 2-Stroke | 4-Stroke |
|---|---|
| They have long stroke. | They have short stroke. |
| 2-strokes of piston & 1complete revolution gives 1 power stroke. | 4 stroke of piston & 2 complete revolution gives 1 power stroke. |
| It is used for the power generation. | It is used for the speed generation. |
| Compression Ratio = 12:1 | CR= 16:1 |
| Poor quality of fuel can be used due to long stroke aiding for more timing for exhaust & scavenging process. | Good quality of fuel can be used due to short stroke. |
| Torque produced by 2-stroke is more at higher RPM. So, more powerful. | Torque produced in 4-stroke engine is higher at lower RPM<br>P= $T \times \omega$<br>P= $T \times \frac{2\pi N}{60}$ or T = $\frac{P \times 60}{2\pi N}$ |
| It is of cross head type i.e.; piston rod is connected with X-head bearings. | It is of trunk type i.e.; piston skirt is connected to connecting rod with gudgeon pin. |
| Crankcase is separated from cylinder space. This avoids contamination of crankcase oil due to acidic residues entering crankcase. | Crankcase is not separated from the cylinder space and hence possibility of contamination is more. |
| It has compression type piston rings. | It has compression as well as oil scrapper rings. |
| Volumetric efficiency is less, hence less efficient. | Volumetric efficiency is more, hence more efficient. |
| Lighter flywheel is used. | Heavy flywheel is used. |

| MAN B&W | SULZER |
|---|---|
| X – head lubrication – by telescopic pipe @ 4 bar | X – head lubrication by external pipe i.e., @ 12 bar |
| Alpha lubrication (in 4 – 5 revolution only once) | Pulse lubrication (In each lubrication) |
| Individual fuel injection | Common rail injection |
| Camshaft is driven by chain driven with 2 chains | Camshaft is driven by gear driver with timing gear |
| Jerk type fuel pump | Valve type fuel pump |
| In this bore cooled liner is used | Fine honed and bore cooled liner with large insulation |
| Main bearing made up of tri-metal bearing with high load carrying capacity. | White metal bearing |
| CPR type top piston ring | Chromium coating piston ring. |
| OROS type piston for better combustion area and reduction in the piston temperature. | Convex shape piston with *jet shaker cooling.* |
| Mip: indicated mean pressure | Mep: mean effective pressure |
| This can be found with the help of card diagrams. | This can be found on the shaft after all the loses (i.e., friction). |

| | |
|---|---|
| This pressure we find on crankcase or on piston or in cylinder. | |

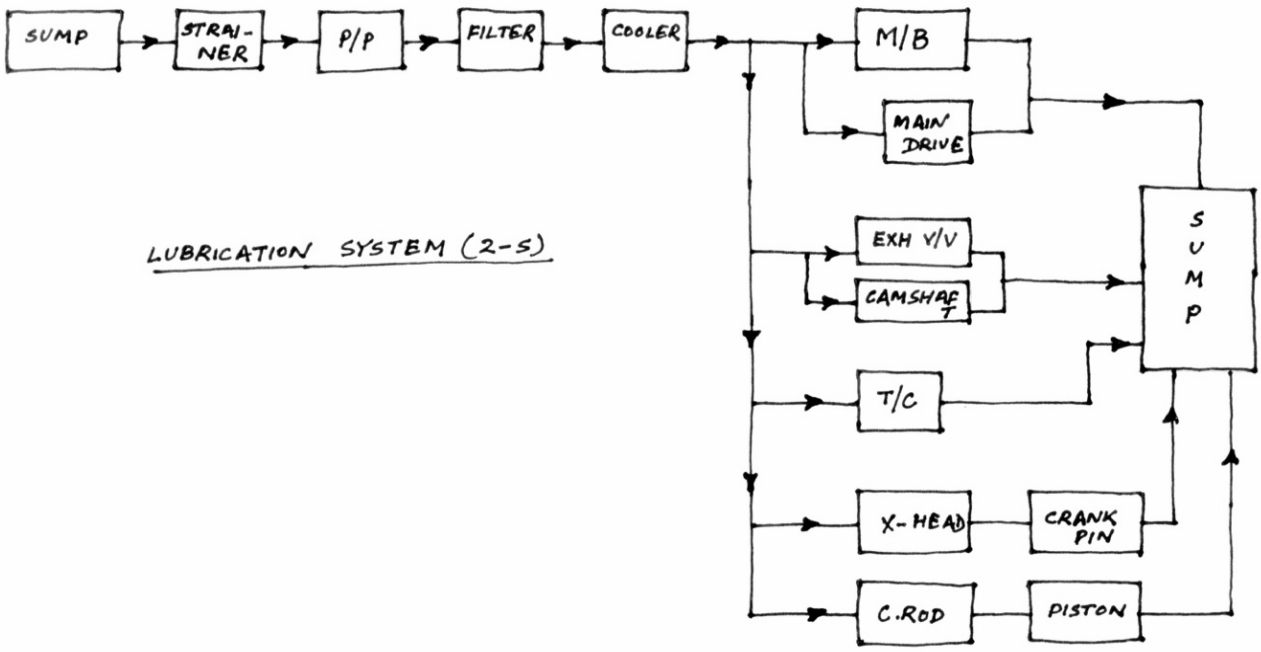
## ADVANTAGES OF SUPERLONG STROKE

1. Large diameter propeller can be used as superlong stroke provide slow rpm and hence propeller efficiency increases.
2. Low grade of fuel can be used. Superlong stroke avails more time for combustion.
3. Better scavenging take place.
4. More time available for the heat dissipation to cool down the water.
5. Power to volume ratio is reduced.
6. Reduced fouling, smoking, NOx, exhaust temperature.
7. Thermal efficiency is increased ($\eta_{thermal}$): an engine with larger S-B ratio have less surface area exposed to C.C gases as compared to short S-B ratio.

2.6 – 3.2: short stroke
3.2 – 4.0: long stroke
4.0 – 4.7 super long stroke
> 4.7: ultra large stroke

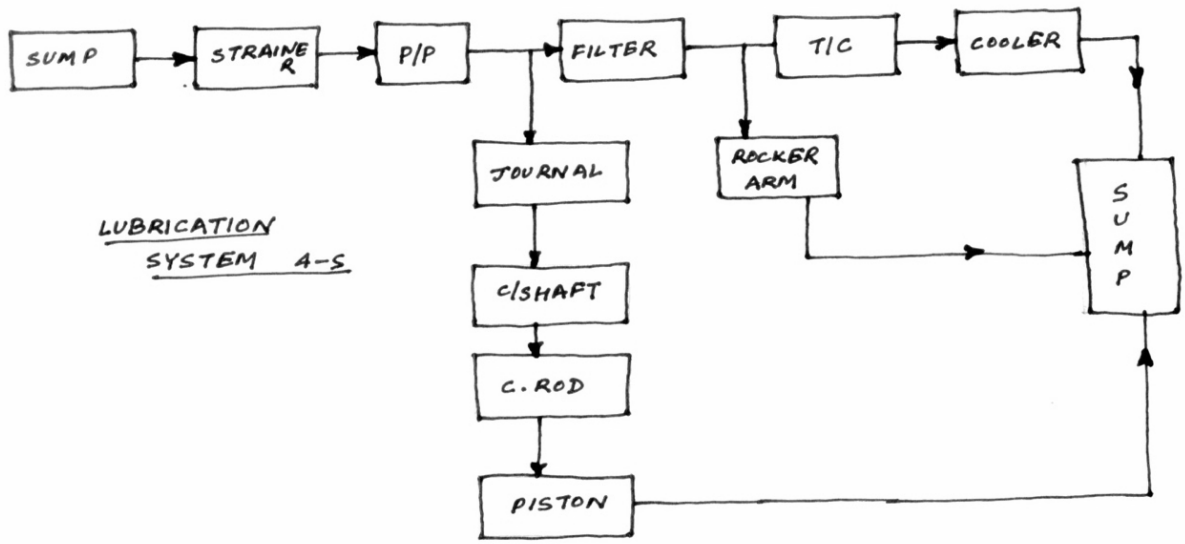
**Significance of firing order**

⇒ Firing order (F.O.) is designed such to achieve minimum vibration
⇒ F.O. is designed such to distribute the engine power evenly on the crankshaft bearing
⇒ Importance:
- Engine vibrations: positive starting
- Engine balancing: power balance in cylinder
- Equal forces: even load distribution on the bearing



LUBRICATION SYSTEM (2-S)

Sample taking points:
1. Before filter
2. Inlet to LO pump
3. Inlet to engine
4. Cooler




**Why clearance is important?**
It is the very important to maintain a good quality and quantity of the lubricating oil to all these bearings. This helps in preventing smoke of the engine.

## X-HEAD

- It is in 2 – stroke engine. This is used to connect piston rod and the connecting rod.
- Telescopic pipe is used to lubricate the X – head and crank pin.
- **Function**
  - Absorb side thrust produced during motion of the connecting rod
  - Transfer side thrust to the engine frame.

**Inspection of X – head**:

1. Check condition of the telescopic pipe
2. Check lubrication flow in the X – head
3. Check for any squeeze out *white metal bearing* and *pin*
4. Check for scratch the marks on X- head pin
5. Check surface finish on the X- head pin
6. Check all the three clearances
7. Check the oil wedges provided in the guide shoes

Guide plate >>> guide rail >>> guide shoe >>> cross head pin

Step I: turn the piston 90° before the BDC
Step II: by using feeler gauge at 3 different places, we can find clearances between:

1. Guide plate and the guide rail [port – stbd direction] {basically guide-shoe and guide plate}.
2. Guide rail and guide shoe [axial direction].
3. Shoe and pin.

**#Note**

1. Guide plates are provided to prevent coming out of the shoes
2. Guide shoe is attached to pin

**Important**: In large 2 – stroke slow engine power generated in the crankcase is transferred to the crankshaft without transmitting transverse forces to the pistons and large thrust to the crankshaft respectively.
Hence, an arrangement of *cross-head* is provided to compensate above mentioned phenomenon.

**#Note**

1. The reciprocating action of the *piston* is converted into the rotary motion. This is achieved through the 'X – shaft' by means of the X – head, where the piston rod and C.R. are attached together on both sides.
2. By using the *feeler gauge* clearance must be taken. The discrepancy between the actual and measured value is noted and if it exceeds 0.1 mm, then X – head bearing must be inspected.
3. Turn the crank throw 90° before the BDC

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# 2. MAIN BEARING CLEARANCE

Main bearing (M/B) supports the long running crankshaft throughout the engine length. This makes it imperative to check the condition of bearing at regular interval of time.

Total number of M/B = n + 1
Bearing clearance = 0.3 to 0.5 mm

There are 4 methods:

1. Bridge gauge method
2. Telescopic feeler gauge/Swedish feeler gauge
3. L.O. inlet pipe connection
4. Lead wire method

**#Note**
M/B clearance determines the amount of wear down of wear down; the bearing is subject to depth gauge. It is taken between *journal* and *web.*

**Procedure**:

1. Take immobilization certificate
2. Take all the necessary tools
3. Make work permit and proper PPE to be followed
4. Stop the Main Engine
5. Turning gear engage
6. Open indicator cock and shut off starting air supply
7. Stop L.O. pump
8. Note down draft
9. Open crankcase and ventilate the space
10. Note down the firing sequence. Start with the 1$^{st}$ unit that comes earlier in the sequence
11. Turn the crank throw towards the exhaust side (to gain access to M/B)

<u>Method I: L.O. inlet pipe connection (MAN B&W)</u>

⇒ Remove L.O. pipe connection
⇒ Insert dial gauge in screw hole which is provided in bearing. Then reading is taken of the clearance.

<u>Method II: Telescopic/Swedish feeler gauge (MAN B&W)</u>

⇒ It is the most common method used to measure the bearing clearance of the top shell.
⇒ This telescopic feeler gauge is inserted between the gap of *crank web* and *bearing cap.*
⇒ When the tip searches the shell top, the feeler gauge is inserted between *journal* and *shell* to check the clearance.

<u>Method III: Bridge with depth gauge (SULZER)</u>

⇒ With the help of hydraulic jacks, remove the bearing; keep it and remove bearing shell (top side) and now, bridge is fitted over the top of journal pin from port to Stbd, making a bridge over the crankshaft with two ends supported on *cross – girder*
⇒ Tighten it with full hydraulic jack
⇒ Vernier type depth gauge is inserted in the hole provided on bridge and scale of vernier type depth gauge is rested on crankshaft pin.
⇒ For calculating wear down of the bearing, the total depth is measured on the scale and is compared with previous reading that is mentioned in its manual.

Method IV: Lead wire method

⇒ Turn the X – shaft to TDC position
⇒ Remove the locking selection nut to lower the bottom half,
⇒ 3 length of lead wire is to be inserted or laid circumferentially at 3 different places on the bottom half position
⇒ Position the bottom half and close it. Tighten the nut to its rated torque,
⇒ Lower and open the bottom half again and remove lead wire and measure it,
⇒ It must be within limit, if it is beyond the prescribed limit, the bearing must be replaced.

## BOTTOM END BEARING CLEARANCE

Also known as crank pin bearing clearance.

Lead Wire Method:

⇒ Turn the crankshaft and set the crank at TDC position
⇒ Remove locking arrangement and mark the nut position
⇒ Slacken the nut and lower the bottom half position
⇒ Three length of lead wires are placed circumferentially at three different positions on the bottom half position
⇒ Place bottom half position and tighten it with the same torque
⇒ Again, lower the bottom half
⇒ Remove lead wires and take measurement
⇒ It must be within limits, if beyond the limit this *bearing shell* must be replaced with the new one or the clearance shall be readjusted by adding/removing shims.

Telescopic Gauge Method:

⇒ Turn the crankshaft and let the crank be at BDC position
⇒ Insert telescopic gauge between *lower half* and *crank pin*
⇒ Take the readings of the measurement

**#Note**
1. First take proper precautions.
2. 0.40 – 0.56/0.58

Feeler Gauge Method

⇒ Turn the crankshaft and set the crank to BDC
⇒ Insert the feeler gauge between lower half and reduce rpm
⇒ Take the measurement

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# 3. LINER

Material used for making liner is known as Grey Cast iron.

| Ca | Si | Mn | V | Ti |
|---|---|---|---|---|
| Carbon | Silicon | Manganese | Vanadium | Titanium |

**#Note**
To give rotary motion, scavenge ports have an oblique cut for better scavenging process. Inside liner, microscopic scratches are provided to retain the oil.

Indications of liner crack:

1. Piston goes to TDC, crankcase pressure increases and exhaust gases go to JCW system which results in black smoke at header tank (expansion tank)
2. Piston goes to BDC, crankcase pressure decreases and then water come inside crankcase. White smoke is noticed at tunnel
3. Header tank level is low
4. Pressure fluctuates inside the JCW system
5. When piston goes to TDC, there is the outcome of knocking sound as water is incompressible.

In 2 – stroke engine, liner is of split type

**#Note**
Liner (HT and HP) is thick at top and thin at bottom (low C.C. pressure and L.T.). On liner, 2 – 'O rings' are present and in between these there is a tell-tale hole.

**#Note**

1. If leakage of jacket water takes place, then water come out of tell-tale-hole from the upper sealing ring of Jacket water.
2. If leakage of exhaust gases take place, then gases come out of tell-tale-hole from the lower sealing ring.

## CHANGING OF LINER

1. Remove cylinder head, exhaust valve and all connections
2. Remove all connection of JCW and drain JCW
3. Remove quills and put cloth on it so that nothing (dirt/dust) will go inside
4. Cover stuffing box area
5. Apply rocket tool (i.e., is of I – shaped)
6. On rocket tool, an eyebolt is there, tight it and remove liner, Cu – ring is to be fitted on the top side
7. Rotate the stud so that liner will come out on its own (because stud have threads on it)
8. Now clean cylinder space, clean all holes and lubricate it properly
9. Before fitting liner back, liner calibration is to be done with the help of a special tool which consists of 10 holes provided along with threads and bolts
10. Take readings at 10 points to check for the ovality

If,

i. P – S = Fwd to Aft → liner is perfect
ii. P – S ≠ Fwd to Aft → ovality takes place (0.02 – 0.03)

Wear Down = $\frac{Present\ reading - previous\ reading}{running\ hours\ since\ last\ reading} \times 100\ hrs$

**#Note**
Maximum wear for a cylinder liner is about 0.8% of original diameter.

11. After liner calibration, note down the number which is mentioned on the liner
12. Apply rocket tool in opposite direction while putting back the liner, don't hammer it. It will slide inside by its own weight.

**#Note**
There is one marking on *liner jacket* and *liner*. Make sure while fitting back of liner they are coinciding to each other at all the time.

13. All the O – rings are to be replaced with new one. After that apply soap solution so, that it will slip into liner easily and ensure there is no – slip edges
14. When liner goes inside completely, open jacket water and completely fill the liner jacket with water and check for any leakage. And this leakage is tested before putting back the piston and cylinder head to the unit.

**#Note**
- After fitting the liner, we must take readings to see how much O – ring has been collapsed.
- While inserting the liner, there is a mirror finished surface on the liner, which is undesirable for effective lubrication to take place inside the liner. Hence, for that we create *microscopic scratches* with abrasive particles that are present on *honing tool* which is driven by electric motor. Therefore, for making rough surface – microscopic scratches are made to retain the oil inside it.

**Question 3.1: Liner is not coming out properly, what will you do?**
Answer: Rocket tool is not fitted properly that's why liner is not coming out. Action to be taken are:
1. Put descaling compound which will melt out of all the deposits and make a free outcome of the liner
2. Cool down the liner. So, that after getting contract it will easily come out from the unit(put dry ice).

## LINER WEAR DOWN

Due to wear down of the liner, *liner calibration* needs to be done regularly. This wear in liner occurs due to following reasons:
a. Abrasive
b. Corrosive
c. Frictional
d. Scuffing or adhesive

a. Abrasive Wear
   - This occurs due to the *hard particles* that are formed during combustion. This also occurs due to catalytic fines present in fuel and ash formed during combustion which all causes abrasive wear.
   - Due to abrasive wear scratches on liner are formed, which results in *'blow past'*.

b. Frictional Wear
   - The sliding friction leads to friction wear of both liners and piston ring
   - This depends on many factors like:
     i. Temperature

ii. Pressure
iii. Lubrication
iv. Speed of movement between two surfaces
v. Load on engine
vi. Combustion efficiency
vii. Improper maintenance

c. Corrosive wear
   - In fuel, high Sulphur content will form $H_2SO_4$
   - When acids are formed during combustion, these are neutralized by L.O. that are alkaline in nature.
   - $H_2SO_4$ is formed when it come in contact with low temperature surface and gets condensed (i.e., lower portion of liner).
   - This corrosive wear can generally be seen between *Quills.*
   - This wear enlarges and gives a characteristics of clover leaf shape to the wear pattern hence, termed as *clover leafing.*

Hot corrosion: due to Na and $V_2$

$V + O_2 \xrightarrow[catalyst]{Na} V_2O_5$ (Vanadium Pentoxide)

**#Note**
Corrosion due to Sulphur will be high due to presence of water in fuel and condensate in air.

d. Adhesive or Scuffing
   - Due to the insufficient lubrication, large amount of heat is produced and microscopic welding of liner surface, and piston ring take place. This lead liner to lose its property to adhere cylinder oil to the surface.

**How to prevent wear down of liner?**

1. Use low Sulphur content oil
2. Maintaining high jacket water temperature (no condensation takes place)
3. Running M/E at normal sea load, avoid running at low load
4. Increase L.O. supply so, piston and liner seizure will not take place
5. By avoiding ingress of water
6. By avoiding ingress of moisture from charged air
7. By maintaining correct grade of L.O.
8. By using proper TBN oil

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# 4. BOILER

Alarms and trips

1. Low water level alarm
2. Low – low water level alarm
3. High water level alarm
4. High – high water level alarm
5. F.O. high temp alarm
6. F.O. low temp alarm
7. F.O. low pressure alarm
8. Low steam pressure
9. High steam pressure
10. Low atomization steam pressure
11. Flame failure
12. Low combustion air pressure
13. Low feed water pressure

**Question 4.1: Low water level of boiler alarm comes? Action taken.**

Answer:

1) accept the alarm
2) stop the boiler
3) check for gauge glass and perform blow through of gauge glass (to know the actual level of gauge glass)
4) if level is low inside boiler then, never put water inside boiler otherwise tubes will get distorted due to the thermal stress
5) let the boiler get cooled by itself and after some time check the condition of furnace, just to ensure that everything is fine.

**Question 4.2: How to increase boiler efficiency?**

Answer:

1. Perform blowdown at regular intervals to remove impurities and carbon deposits
2. Maintaining proper chlorides, phosphates, alkalinity by performing tests at regular interval
3. Perform boiler water test
4. Proper treatment of water
5. Cleaning of burner at regular intervals
6. Always do pre – purge and post – purge
7. By supplying good quality fuel
8. By maintaining air – fuel ratio
9. Boiler tubes to be clean

**Question 4.3: Boiler water level not maintaining? Mention Reasons**

i. Tube leakage and white smoke can be found at funnel
ii. Efficiency of boiler feed water pump decreases
iii. Controller malfunction
iv. Steam consumption is high
v. In main line distributor ring, holes are choked
vi. Vapour lock → pump loses suction
vii. If hotwell level is decreasing and we can't able to make it up, it means, blowdown overboard valve is open or leaking

**Question 4.4: Boiler flame failure alarm comes? Mention Reasons**

Answer:

- Fuel oil pressure is low
- Burner is not maintained

- Fuel oil temperature is not maintained
- Adequate air for combustion is not there
- Water in fuel
- Flame eye faulty
- Main fuel oil pump filter chocked
- Pilot fuel oil filter choked
- Improper pilot burner electrode distance
- Swirling action improper of burner

**Imp.:** EGB tubes are leaking. Mention Indications of such.

A. White smoke at funnel
B. Hotwell level decreasing
C. Boiler pressure decreases
D. Economiser temperature decreasing
E. Manometer pressure decreases
F. Boiler feed water pump pressure decreases
G. Turbocharger surge (but in high damage)

**Cascade/Hot Well Safeties**

1. High level alarm
2. Low level alarm
3. Observation tank safety glass
4. Dump condenser controller
5. Temperature gauge
6. Filter (1st chamber)
7. Level sensor
8. Drain
9. Salinometer
10. Manual and automatic valve
11. Gauge glass

**Question 4.5: Give reasons for oil in hot well?**
Do it yourself!

## SCAVENGE SPACE INSPECTION

This is to be done after complete extinguishing of scavenge fire. We need to cool down and ventilate the space thoroughly.
Components affected by scavenge fire includes:

A. Piston rod
B. Cylinder liner
C. Stuffing box
D. Piston and rod alignment
E. Scoring or cracks in liner and tie rod

**Procedure**:

⇒ Turn engine so that piston is visible through scavenge ports. Inspect piston skirt for scuffing or *abrasion*

⇒ Inspect rings for damage and ring grooves for evidence of carbon deposits. These rings should be in good condition.

> **#Note**: *Brass Rod* is used to push the piston ring, just to check the elasticity of piston ring, if it gets struck it means it got damaged.

⇒ Turn piston down to inspect *piston crown* for excessive deposits, burning signs of poor injection, cracking.

**#Note**: If oil on crown it means → injector is dipping.

⇒ Check on liner for corrosion, scuffing or abrasion by mirror
⇒ Check all scavenge drains are clear or not
⇒ Check conditions of sludge by squeezing to check any metal particles
⇒ Check relief valve at the manifold of scavenge space at the entrance
⇒ Check conditions of locking wire below piston which hold *skirt* and *crown*

Prevention of Scavenge Fire:

a. Clean scavenge space and drain it at regular intervals
b. Keep scavenge space drain open at regular intervals
c. Excess cylinder lubrication must be avoided
d. Piston rings must be maintained properly
e. Scavenge space inspection must be carried out at regular basis
f. Piston rod stuffing box must be maintained
g. Cylinder liner wear must be within limits
h. Prolong engine or any cylinder overloading should be avoided.

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# 5. CRANKCASE INSPECTION

## 4 – S ENGINE:

1. Stop engine and wait for the engine to cool down
2. Wait for 2 hour and stop priming pump
3. Stop starting air motor
4. Put *Men at Work* tag inside ECR
5. Open crankcase door and allow it to cool down
6. Take one hammer and torch inside along with one standing by person
7. Check crankcase and if we find it dirty or block carbon deposits on liner it means blow part from one unit have taken
8. Check for any water leakage from liner, if any water leakage is there it means O – ring of liner has worn down
9. Check axial or floating movement of C.R. with the help of screw driver
10. Check the condition of gear which gives drive to camshaft
11. Check the nozzle on those gear which gives lubrication to gear
12. Check the condition of main bearing whether equal amount of L.O. is falling down to close or not
13. Check the condition of L.O. by taking some of it on hand and rub it with finger, check whether ingress of diesel or water
14. Check L.O. and if it is too sticky or too slippery than it means *bacterial* contamination have taken place, but it occurs mostly in 2 – S and not in 4 – S
15. Check for white metal particles i.e., clear indication of bearing worn out
16. Check the nuts of M/B, bottom end bearing and for that we have to hammer it to get solid sound (also for locking wires condition)
17. Generator relief door is to be pressed with hand, just to make sure everything is fine
18. Check breather of crankcase in which flame arrestor is present near to the turner, just to ensure it is not blocked otherwise, complete crankcase will be pressurized
19. Also, open crankcase and check whether roller is not stuck over the cam
20. Check condition of camshaft bearing

Thus, crankcase inspection in 4 – S takes place.

## 2 – S ENGINE

Crankcase is the space where we have crankshaft, M/B, X – head bearing, stuffing box, crankpin. This is to be done in port.

**Precaution:**

1. Tool box meeting
2. Risk assessment to be done
3. Enclosed space entry permit
4. Working permit
5. Immobilization certificate
6. Shut distributor
7. Stop L.O. pump
8. Indicator cock
9. Turning Gear (T/G) engage
10. Proper PPE to be worn

**Procedure**:

1. Open crankcase door and ventilate through blower for atleast 30 min
2. Wear special suit to avoid slippage
3. Wear gasometer and put hammer inside pocket and one extra person should always be present standby

4. Make entry after ensuring sufficient O2 level
5. Turn engine to BDC and start checking from under stuffing box area for any sign of black oil, this indicates leakage of stuffing box and also do check locking wires on stuff box
6. Check *piston rod* surface for scoring marks and roughness
7. Check piston palm bolts and locking devices (wires) for slackness and fretting
8. Check top and bottom end of CR bolts, nuts and locking devices for slackness, sign of fretting all this is done by *hammer check*
9. Check for slip of web and journal by checking the slippage mark on X – shaft
10. Check for hot spots (discoloration)
11. Check L.O. condition for any smell, discoloration or degradation, if rotten egg smell comes it means M.D. take place inside sump
12. Check for white metal particles
13. Check for paint peel off
14. Check for grating whether clogged or not
15. Check L.O. connection (i.e., telescopic pipe)
16. Check breather pipe by blowing air and check diaphragm also (E/R bilges will not come to surge metal particles will not come to sump)
17. Now crankcase door slightly open and start L.O. pump to see whether flow is good and distributed properly or not
18. Check crankcase door sealing condition and check all the tools which are with us or not
19. Check M/B cover for any signs of crack and check all bearings for silverly coloured (indicator bearing wipe out)
20. Check crankcase relief door (wire mesh should be wet, spring tension and sealing condition)
21. Check OMD sampling pipe for clear passage
22. Now, close the crankcase door

Therefore, Crankcase inspection take place.

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# 6. CRANKCASE EXPLOSION

Large amount of oil droplets is present everywhere in crankcase. Normally, the droplet having size about 200 microns are not harmful at all.
But hot spot occurs due to following reasons:

1. Crankshaft misaligned
2. L.O. circulation is improper
3. Large clearance between the bearings leading oil film to get break down
4. If piston crown is cracked then exhaust gases can leak from crankcase
5. If chain is too slack or too tight
6. Lubrication is not effective if matching gear don't have proper backlash, which generate hot – spot

Hence, hot – spot is generated in crankcase and when oil come in contact of this H.S. it starts to vapourise.
Vapours are light so it moves in upward direction in the crankcase and form white cloud just below the stuffing box (now size of oil droplets becomes 10 microns because of formation of vapours). When these settle down and get in contact with hot – spot then, *primary explosion* will occur.

**#Note**
After primary explosion, pressure inside crankcase increases suddenly. This activates crankcase relief valve which releases all the gases into E/R, leading to crankcase vacuum. At this moment, if fresh air come from E/R to crankcase, there will be *secondary explosion*.

Hence, we need to avoid the secondary explosion with the following preventions:

a. M/B and thrust bearing have high temperature alarm which give the indication of increasing temperature inside the crankcase
b. *Wear monitoring device* indicates how much wear down of M/B has taken place. If unequal wear has taken place, there is uneven distribution of oil in bearings.
c. NRV type relief valve releases all the accumulated pressure generated during *primary explosion*.

**Causes of Crankcase Explosion**

a. High temperature due to reciprocating motion of the piston
b. Due to piston ring leakage blow past causes sparks in the crankcase
c. Increase in the bearing temperature
d. Fire in the scavenge space

| Indication | Prevention |
|---|---|
| 1. Thrust bearing temperature increases | 1. Proper lubrication of the reciprocating parts |
| 2. Exhaust gas temperature increases | 2. Avoid overload of the engine |
| 3. Sudden increase in the load | 3. Use of audio and visual OMD alarm |
| 4. Abnormal noise of the engine | 4. Crankcase door should be fitted properly. Vent should be cleaned. |
| 5. Irregular running of the engine | 5. NRV pressure relief valve should be fixed on the crankcase door for instant release.<br>6. Proper monitoring of the bearing temperature |

**Crankcase Safeties**

1. Crankcase relief door
2. Crankcase relief valve
3. OMD
4. Wear monitoring device
5. Thrust bearing temperature monitoring device
6. Deflection
7. Flame trap
8. Breather pipe
9. Diaphragm (otherwise metal particles will not go to sump)

| **#Note** |
| --- |
| OMD is fitted to check the flammability range of oil in the crankcase. |

OMD senses the concentration of oil mist inside the crankcase of all units. If the concentration of oil mist increases in any unit above the mentioned limit, it activates the alarm of that particular unit.

There are three types of OMD

A. Comparator type
B. Level type
C. Light scattering type

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# 7. SCAVENGE FIRE

For a scavenge fire to occur presence of these are required

a. O2 to support combustion
b. Source of heat – at high temperature combustion will take place
c. Combustible material like oil

The oil is of combustible material which can be cylinder oil, drained from the cylinder spaces or crankcase oil carried upwards on the piston rod because of faulty the stuffing box.
In some case, cylinder oil residues may contain fuel oil. The fuel oil may get discharged from – defective fuel injectors, injectors with incorrect pressure setting.

O2 is present in scavenge air and source of heat for ignition are as follows:

- Piston ring broken
- Liner worn out
- Slow ignition
- After burning

**Causes of Scavenge Fire**

1. Faulty fuel injector
2. Piston ring broken, worn out liner, faulty, cylinder lubrication which causes blow past of combustion products
3. Excessive cylinder lubrication (which is drained down to scavenge spaces)
4. Plenty of O2 during engine operation
5. Hot – spot creation
6. Blowback of exhaust gases
    a. Fouling of the turbine blades
    b. Choking of the EGB at outlet

**Indication of Scavenge Fire**

(a) Increasing scavenge temperature causes alarm
(b) Exhaust gas temperature is high
(c) Smoke coming out of the scavenge drain
(d) Paint blisters appears on scavenge doors
(e) Spark and flame coming from funnel
(f) Exhaust gas deviation alarm
(g) Turbocharger is surging
(h) The engine power decreases leading to the reduction in rpm (fire causes the back pressure under the piston space)
(i) Black smoky exhaust due to incomplete combustion
(j) JCW outlet temperature of affluent unit increases

**Action Taken in Case of Scavenge Fire**

1. Inform bridge and reduce the rpm
2. Cut – off fuel supply of the affected unit by operating the puncture valve
3. Maintain the cooling of jacket and piston
4. Increase cylinder lubrication
5. Shut off the drain to prevent the flow of flame/spark in E/R
6. Keep track on the scavenge air temperature and exhaust temperature and let the fire to starve. Wait for it to extinguish itself.
7. After fire get extinguished, confirm the *fire stops*. After some time slowly start increasing the rpm.
8. Keep monitoring the scavenge temperature for any sign of re – ignition.

If fire get spread over the other scavenge spaces along with scavenge manifold then –

(a) Inform bridge and stop M/E
(b) Stop fuel oil system
(c) Open indicator cock, turning gear is engage and slowly turn the engine to prevent seizure of the engine
(d) Maintain the engine jacket cooling and cylinder lubrication
(e) Cover the turbocharger with canvas cover, to prevent air getting inside.
(f) Release the (CO2/Dry steam) in the scavenge spaces to extinguish the fire.
(g) Maintain the boundary cooling of scavenge spaces
(h) Wait for the complete extinguishing of the fire
(i) Before opening of the scavenge door, ventilate the space thoroughly (if CO2 was used to extinguish the fire).

Scavenge Space Protection Device:

A. Scavenge air high temperature alarm
B. Fixed fire – fighting system (CO2, Dry steam)
C. Pressure relief valve consisting of self – closing spring loaded valves are fitted.

*****

# 8. STARTING AIR EXPLOSION

Main air – line contains 30 bar of pressurized air which is not pure as it contains oil. We have sufficient O2(which is coming from leaky air starting valve) and heat or spark for fire to occur. Hence, starting air – line explosion takes place.

**#Note**
As long as engine is in running condition, explosion will not take place (as vent is open). When engine is stopped and re – started, fresh air is replaced by exhaust gas which leads to explosion.
When pipe becomes hot, the colour of tape of the pipe will change.

**Action taken**

- ⇒ Inform bridge and ask them to stop the engine, change A.S. valve
- ⇒ If not possible, cut – off fuel supply immediately of the defective unit. It will create no combustion in that defective unit.
- ⇒ meanwhile, do ready the air starting valve and on the availability of time replace it.

**Safeties**

| | |
|---|---|
| 1. Starting air – line<br>a. Bursting disc<br>b. NRV<br>c. Flame trap | 2. Safety air manifold<br>a. Vent<br>b. Drain<br>c. Thermal patch<br>d. Relief valve<br>e. Bursting disc |

**Safeties in Compressed Air System**

1. Non – return valve: It is fitted between the *air bottle* and *manifold*. It will not allow explosion to go back.
2. Bursting disc: It is fitted on the starting air – line. It consists of the perforated (Cu) disc protected by the sheet of material which will burst in case of an excess pressure.
3. Flame trap: It is fitted between NRV and Air starting valve. It will arrest any flame coming out of the leaking *cylinder air starting valve*.
4. Relief valve: fitted on the *common air manifold* which supplies air to the cylinder head. Excess pressure inside the manifold make it lift.
5. No sharp paint

**#Note**
B.D./unit and relief valve may be 1 or 2 on the whole line.

*****

# 9. EGB FIRE

Carbon in dry condition is not harmful. Its self-ignition temperature is 1000°C but when it becomes wet after getting in contact with unburnt lube oil/fuel oil, its ignition temperature drops to 200°C. Which helps in sudden catch of fire.
Reasons for the carbon deposits on the tubes are:

- Improper combustion
- Leaking exhaust valve
- Dripping fuel injector
- Maneuvering for the long time

Two types of fire occur in EGB: **Minor** and **Major**

**#Note**
If excess of carbon deposits is present on the tubes, heat transfer gets impaired. Which turns the tubes red hot, acting as a good source of ignition.
Never perform water washing; it can lead to Hydrogen fire. This Hydrogen fire soon get converted into metal fire (as O2 is in abundance); it will start to oxidise the metal.
In this case, never stop boiler water circulating pump. If level of hot – well keeps on increasing, it means tube has been burst out. Immediately stop BWC pump to prevent the hydrogen fire.

**Indication of the EGB Fire**

1. Sudden increase in the uptake temperature
2. Smell near EGB (smoky smell)
3. Smoke and spark from funnel
4. Overheat of economiser body
5. Flame visible in smoke indicator

Fuel properties that are not present in the lube oil

1. Octane number
2. Cetane number
3. Lower heating value

**Prevention Actions**

1. Regular cleaning of EGB tubes
2. Use good quality of fuel
3. Avoid low load operation of the boiler
4. Regular soot blow

**Action Taken During EGB Fire**

a) Inform bridge and request to stop M/E
b) Stop auxiliary blower, close turbocharger drains and put canvas on blower side of turbocharger
c) Close all scavenge drains and if the boiler is running then stop it
d) In some engine there is the arrangement for permanent firefighting. If this is not present, do boundary cooling.

**Question 9.1: Water from Economiser tube is leaking, how will you come to know such?**
Answer:

- Check the shoot collecting tank (leak)
- Presence of white smoke in the funnel
- Hot – well water level will go down quickly

**Question 9.2: When you go near to the shoot blower, what precaution you will take?**
Answer: First of all, inform bridge and then check the direction of wind.

*****

# 10. OMD ALARM

Action taken in case of OMD alarm

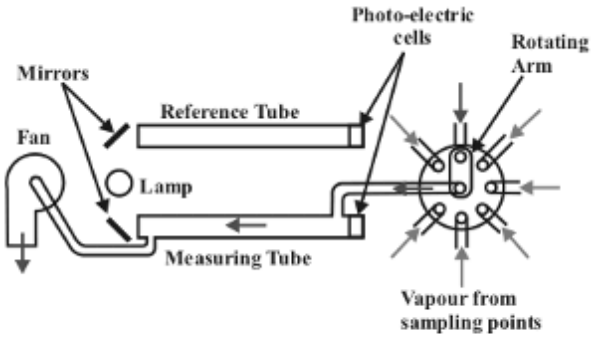
1. Inform bridge and request to dead slow speed
2. Check trueness of alarm (zero check) and sensitivity. If all are correct, put it in auto mode. If it again comes then inform C/E.
3. Request to stop the M/E from the bridge
4. Stop the engine
5. Cut – off the fuel supply and switch off the blower
6. Keep running L.O. pump and JCW pump
7. Ventilate the E/R by opening of skylight and prepare the fire – fighting equipments
8. Stop L.O. pump, shut off the starting air and engage the turning gear
9. After 20 minutes of engine stop, check by palm whether crankcase door is still hot or not. If it is still hot, wait for some more time and then open the door.
10. Just slack open the door, not to be completely open, just to ensure that the crankcase is not pressurized from inside.
11. Fully ventilate the crankcase before making an entry.
12. Now, enter into the crankcase with a torch and check the temperature of M/B, if it is more than the required, it will give white metal.
13. Check the temperature of the piston rod, stuffing box, X – head, C – rod, telescopic pipe.
14. Look out for blistered paint, squeezed out bearing metal and discoloration caused by heated surfaces
15. Locate the hot – spot and rectify it
16. Start the L.O. pump and check the oil flow from oil bearings.
17. Disengage the turning gear and start the engine.
18. Stop the engine after 15 minutes and again inspect for hot – spots in the crankcase.
19. Again, run the engine for 1 hour continuously. After stopping it, inspect the crankcase.
20. Now, run the engine on full load and inspect the crankcase and make ensure that there is no fault.

After all the inspections are done, if you are unable to find any error, check all OMD alarms are in working conditions.

**Working of OMD**

A. Comparator type: it consists of two tubes – (a) measuring tube and (b) reference tube

Both are placed parallel to each other.




**Working**:

At each end of tubes photo electric cell (photo voltaic cell) is there. It generates an electric current when light falls on it.

Reference Tube: It is filled with clean air and is used as a reference for measuring the level of the mist in the measuring tube.

Measuring Tube: Measuring tube has a connection for oil mist, which is extracted from the crankcase with the help of an electric extractor fan.

**#Note**
Samples from each cylinder is monitored by using a rotating selector switch, which connects each cylinder back to OMD.

If the concentration of oil mist increases in the measuring tube, then intensity of light reaching to P.E. (photoelectric) cell decreases. Now, both the tubes are connected electrically, reduction in generation of potential difference will induce an electrical imbalance between the two P.E. cells which leads to the ringing of the alarm.

**#Note**
When the oil mist is detected, then the rotating selector valve stops immediately. Which in particular indicates the faulty cylinder with high concentration of the oil mist.

*****

# 11. JOINTS

| Drilling | Boring | Reaming |
|---|---|---|
| It is used to originate a hole. | It is used to enlarge the diameter of an existing hole. | It is used to finish the hole surface. |
| Cutting tool – **drill** | Cutting tool – **boring bar** | Cutting tool – **reamer** |
| Drill is a double point cutting tool. | Boring bar is a single point cutting tool. | Reamer is a multipoint cutting tool. |
| Drilling is the first phase of hole fabrication. | For boring operation, a pre – drilled hole is mandatory. | It can be performed only when hole already exists. |
| Drilling can increase the length of the hole. | Boring can increases the diameter of the hole. | Neither the length nor the diameter can be increased. |
| Surface quality of the drilled hole is not so good. | Surface quality is better than drilling. | Best and highly finished surface is achieved. |
| Material removal rate (MRR) is very high. | MRR is lower than drilling but higher then reaming. | MRR is poor and that is not an issue in reaming. |

**#Note**
Brazing is similar to the soldering as both are joining two different metals. This is the process that uses

a. Combination of heat
b. Filler metal
c. Flux to join metals together

## Riveting

It is a process of fastening a metal in another metal with using riveting machine and a small cylinder shaft with head on one end. It is not strong as compared to annealing and welding. But still comes handy in different parts of the ship.

**#Note**
All these are for the hole fabrication.

## Tapping

Tap is a tool which has threads like bolt and 3 or 4 flutes cut across a thread. It is used to cut the internal threads.
Taps are made up of the carbon steel or HSS and are hardened or tempered.
Types of tap:

a) Taper tap: rougher – about 6 threads from the ends
b) Plug tap: intermediate – 3 – 4 thread from the bottom.

| Welding | Soldering | Brazing |
|---|---|---|
| Welding joints are stronger joints used to bear load. | These are weakest joints and not meant to bear load. It is used to make electrical contacts. | These joints are weaker than welding but stronger than soldering joints. |
| Welding is a process of joining two or more similar metals by melting base material or using filler material. | It is done at relatively low temperature as compared to the brazing. It is generally used to join the electronic components. Brass, Gold, Silver or Cu can be soldered. | It is a process in which filler rod is melted and filled into joint. It does not involve any melting base material. |

| | | |
|---|---|---|
| Temperature used is around 3800°C | Temperature used is upto 450°C | Upto 600°C |
| High cost and high skill required in performing the welding | Less cost and less skill required to perform the soldering | Cost is in between the aforesaid. |
| Heat treatment is required to eliminate undesirable effects of the welding. | No heat treatment is required. | No heat treatment is required. |
| No preheating of work piece is required. | Preheating of work piece is required. | Preheating of work piece is desirable. |
| Mechanical properties of the base metal changes due to heating and cooling. | No change in mechanical properties after joining. | Mechanical properties may change but is almost negligible. |

**Welding Defects**

1) Cracks: hot, cold and crater
2) Porosity: trapped gases create bubble filled weld
3) Undercut
4) Improper fusion
5) Incomplete penetration
6) Slag inclusion
7) Spatter

Welding Preparation/Precaution

1. Hot work permit
2. Enclosed space permit
3. Proper PPE, hand gloves, safety shoes, welding mask, and face shield
4. Welding material and space to be dry, neat and clean
5. Any flammable material should not be present
6. Ventilation should be proper
7. If it is enclosed space, prior 48 hours of ventilation before entering
8. Rags should be removed
9. Any combustible material should be removed.

**Question 11.1: Important things to be selected before welding and how to find the required current and diameter of the electrode?**

- Electrode size
- Electrode diameter
- Thickness of the plate to be welded
- Current
- Arc length
- Speed parameters

**#Note**

Electrode size = $\frac{t}{2} + 1$, where $t$ is the thickness of plate to be welded.

Current = electrode diameter × 20A

**Question 11.2: How to put stud in the bulkhead?**

(Hint: speak about internal thread making procedure)

Solution: 1st drill hole then make thread along with the tap.

**Drill size** = $d_1 - 2d_2$, where $d_2 = 0.64 \times$ pitch of thread [$d_1$ = hole diameter and $d_2$ = depth of thread]

# 12. HEAT TREATMENT

Composition of various metals

1. HSS (high speed steel)
    - T = 18%
    - Cr = 4%
    - V = 1%
    - C = 0.7%
    - Fe = 76.3%
2. Steel
    - Mn = 0.5 to 1.65%
    - C = 0.05 to 2.32%
    - Fe = 96%
3. Cast iron
    - Si = 0.5%
    - Mn = 1 to 3%
    - C = 2.5 to 4%
    - Fe = 96%
4. Stainless steel
    - Ni = 10%
    - Cr = 18%
    - Si = 1 to 3%
    - C = 1.2%
    - Fe = 90%
5. Mild steel
    - C = 0.05 to 0.25%
    - Fe = 98%
6. Grey cast iron
    - C = 3.52%
    - Si = 2.04%
    - Mn = 0.55%
    - P = 0.11%
    - S = 0.16%
    - Fe = 92.9%

- Brass = Cu and Zn
- Bronze = Cu and Tn
- White Metal = Cu, Tn and Sb

*Heat treatment* is a process in which a metal is heated to a certain temperature and then cooled in a particular manner to alter its internal structure for obtaining a desired degree of physical and mechanical properties such as

(a) Brittleness
(b) Toughness
(c) Hardness
(d) Softness

This is done without changing the composition of the metal.

**NITRIDING**

Heat the metal upto 500°C continuously and pass Ammonia gas (NH3) in a close container for around 40 – 100 hours. After some time, nitrogen layer forms which stops the heating.

**HARDENING**

Heart the metal upto 750 – 900°C and then do sudden quench of the metal by using oil or water. The Metal strength changes from brittleness to hardness.

Ind. Hardening
Heat the metal upto 750 – 900°C and then do quench by water

Case Hardening
Heat the metal above 900°C and put a carbon, after sometime the carbon gets deposits on the metal and then it is cooled by the air

- It produces a surface which is resistant to the wear, while maintaining toughness and strength of the core
- This applies to the low carbon steel parts, high alloy steel bearing, gears and other components.

**TEMPERING**
Heat the metal below 750°C and then do quench by the air. This is done to remove the *brittleness* of the steel.

**ANNEALING**
Heat the metal upto 750 – 900°C on the furnace and then stop it. Let it to cool by itself, keeping it inside the furnace itself.
This is done to increase the ductility properties of the metal (i.e., to draw metal into thin wire) by refining its grain structure.

**NORMALIZING**
Heat the metal upto 750 – 900°C and then do quench by the air. This is done to increase the ductility and its compact structure.

**Properties**
Sudden Quenching: Brittleness increases and fine grain structure is achieved
Slow Quenching: Ductility increases

1. Toughness: Metal goes to plastic deformation without being fractured
2. Hardness: Ability of the material to resist plastic deformation
3. Ductility: Ability to drawn the metal into a thin wire
4. Malleability: Ability to drawn metal into a thin sheets
5. Brittleness: the material having hardness and rigidity and no tensile strength. Breaking readily with a comparatively smooth fracture.

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# 13. NON-DESTRUCTIVE TEST (NDT)

It is a set of techniques used to detect any flaws. Used to evaluate the structural integrity of materials which can compromise safety or functionality of the metals.

There are 6 types of NDT:

(A) Visual inspection
(B) Liquid penetrant test
(C) Ultrasonic testing
(D) Electromagnetic testing
(E) Magnetic particle test
(F) Thermal infrared testing

**Liquid Penetrant Testing/Die Penetrant Test (surface flows)**
It consists of a cleaner, penetrant and developer. When applied it goes into the surface cracks highlighting the visible cracks/breaks present in the structure.

Procedure

(1) Pre-clean the test – piece so that rust can be removed with the help of cleanser.
(2) Apply penetrant (i.e., Red Color low viscosity oil). As penetrant have high surface wetting capability, it penetrates into the defects and cracks.
(3) After several minutes of dwell time, rinse the surface with water to remove penetrant from the surface and leave it into the cracks.
(4) After drying the test – piece, apply the developer (fine grain white powder suspended in liquid) it will form an even coating on the surface which after drying draws penetrant from the cracks out onto the surface. Now, location of the cracks can easily be found i.e., on the surface.

Welding Electrode Composition:

- Actual Metal: It can be S.S, M.S, high tensile steel; Brass, Bronze, C.I, Aluminium
- Flux Coating: Blend of cellulose; iron powder and Hydrogen

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# 14. PISTON RINGS

Sealing between the piston and liner is achieved with the help of *piston rings*. Efficiency of the engine depends upon this effective sealing. Leakage of any combustion gases will reduce leading $P_{comp}$ to increase.

**#Note**
In 2 – S marine engine
a) Compression type piston rings are used to seal the chamber.
b) *Wiper Rings* are installed below. It wipes the deposits from the liner and distribute oil on the liner surface.

**Material**:
Cast iron alloy (contains graphite in lamellar which itself acts as a lubricant assisting the sliding motion of rings and liner)

Alloying and coating is done on the piston rings. The most common form of alloying cast iron is Cr, Mn, V, Ti, Ni, Cu

**#Note**
Materials of piston rings are built harder than the cylinder liner, to provide maximum life.

*Piston Ring* seals the gas spaces by expanding outwards with the help of exhaust gases pressure which are acting behind them. Therefore, free movement of these rings inside the groove is ensured to prevent any struck.
If the piston rings get struck inside, exhaust gases will not be able to push it from back side. Thus, sealing is lost.

In 2 – S, upper rings of piston are directly in the contact with the crankcase. Hence, they need to be better protected and should be coated in such a manner to tackle the thermal stress and provide proper sealing.

In **MAN B&W**, uppermost piston ring is of controlled pressure relief type. In this several oblique shallow grooves (hard chrome plated) are provided. Allowing some gas pressure to pass through the second ring. Therefore, reducing the load on the top ring.
It has *S* type joint at the ring end.

**Second or Intermediate Rings**
The other rings have an oblique cut at the ring end. All the outer surface of piston rings are Al – coated, to help it running in.

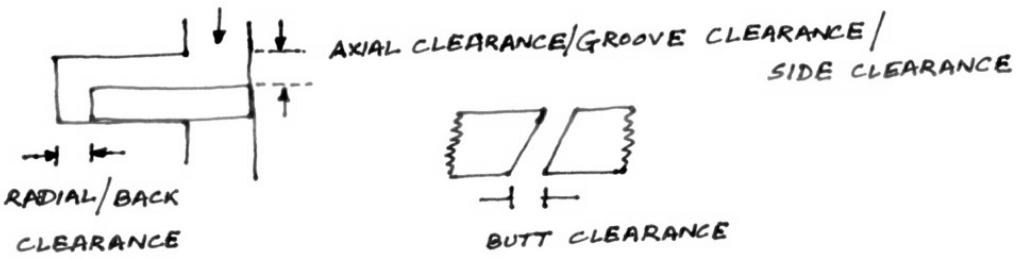
<u>In 4 – Stroke Engine</u>
1. 2 – 4 compression rings are provided to seal the gases of the combustion chambers
2. 1 – 3 oil-controlled rings are provided to avoid excess oil ingress in the combustion chamber.

The oil control rings/scrapper rings control the amount of lubricating oil passing upwards or downwards on the cylinder walls.
These oils are used to spread the oil evenly around the circumference of the liner. The oil is splashed into the cylinder walls. These rings are also called *scrapper rings* as they scrap the oil of cylinder walls and send it back to the crankcase.
These rings block the passage of oil into the space between the face of the rings and cylinder. These rings have chambered edges on the outer sides of the lands or are facing towards the crankcase to reduce the consumption of oil through improved oil scraping from bore.

Types of Clearances:

A. Axial clearance/Groove/Side clearance
B. Radial clearance/Back clearance
C. Butt clearance

## Axial Clearance




It is the clearance between 'Top of piston rings and Top groove'. Which is taken from inside, using the feeler gauge. This clearance allows the pressure to build up from behind the ring, so that piston ring get expanded and efficient sealing is achieved.

Case I: Axial clearance is less

i. No sealing is present between piston and liner
ii. Piston ring will get stuck in the groove and it is possible to blow/burn away the oil which causes *scuffing*.
iii. Chances of the scavenge fire

Case II: Axial clearance is more

i. Piston ring are worn out
ii. Groove are worn out

Ring will flutter and possibility of breakage increases.

If groove is worn out, we need to take out the piston and perform some welding on the groove. This is why we prefer *flame hardening* on the groove.
If there is increase groove wear down, more ring will come out which lead to increase in the radial clearance.

## Radial Clearance

It is the clearance between *depth of groove* and *piston ring thickness.* If there is no radial clearance then *piston ring* will absorb the side thrust resulting in high friction between the piston and liner. This results in the state of seizure.

Use: Vernier caliper is used to measure the thickness of the piston rings thickness and depth of the groove by the depth gauge. Atleast 6 different readings from different positions are jotted down.

## Butt Clearance

It is also known as gap clearance.

⇒ It is the gap between the connecting faces of the piston ring
⇒ It is taken with the help of feeler gauge
⇒ It is checked by the wooden hammer by pressing. It gets struck inside or come to its original position. If it doesn't come to its original position, then it is considered to be broken and sealing is lost.

⇒ It is taken on the unworn part of the liner (i.e., near bottom of liner) BDC, where piston never goes >>> for new piston rings
⇒ For old piston rings >>> we take B.C where the maximum wear down of liner occurs

Case I: Butt Clearance is Small
- When ring expands, butt clearance decreases. Which increases the radial pressure on the liner.
- Thus, breaking down of the oil film occur. Resulting in *piston ring seizure*.
- Clearance ranges from 0.4 – 0.5% of the liner bore

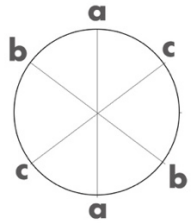
Case II: Butt Clearance is More
- Excessive gas leakage is taking place
- Low compression pressure

**Imp.**
Newly fitted *liner* and *piston rings* are machined prepared in workshop. They have surface asperities (unevenness) and there is no bedding between the liner and the piston ring. If proper step while running is not followed then blow past of combustion gases take place, leading to scavenge fire.
Therefore, we have to operate the engine at slow speed for proper bedding.

| Breaking – IN | Running – IN |
|---|---|
| Short period running of the engine with no – load so that piston rings are allowed to seat and get proper lubrication. | After breaking – in, running – in period is followed. In this gradual increase in load and speed of the engine take place. |
| Average time for 4 – S is 48 hours | In 2 – S engine cylinder lubrication is kept at the higher side in terms of oil quantity to achieve proper lubrication of the piston rings and the liner |
| It is carried out to achieve maximum wear rate so that the surface asperities break faster. Hence, HFO and low TBN oil are being used.<br>Low JCW temperature is maintained during entire process. | |

Connecting Rod Checks
1. Check serration for cracks by DPT (Dye Penetration Test)
2. This serration is to take sheer stress which withstand side thrust.
3. Bending: by putting thin wire rod we can check its bending.
4. Ovality: after removing pin, tighten nut and bolt by hydraulic jack. Check the ovality by using the *inside micrometer*
5. Use the formula to calculate ovality

$\frac{a+b}{2} - c = 0$ (No ovality)

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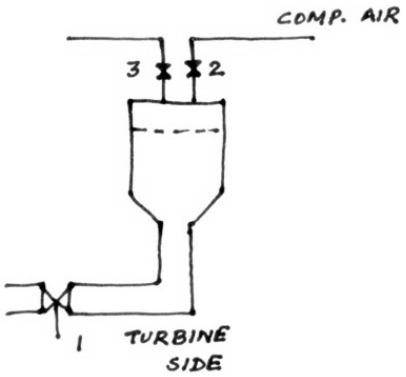
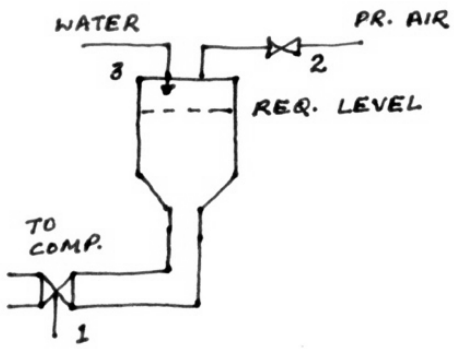
# 15. TURBOCHARGER WASHING

| Turbine side | Compressor side |
|---|---|
| Proper PPE are worn i.e., hand gloves and face shield | |
| It is done at the high load water + grit washing | It is done at the low load and T/C rpm = 4000 – 6000 |
| Procedure:<br>1) Inform bridge to increase the rpm and wait for all parameter to come at stable point<br>2) Check service air bottle and drain it<br>3) Open cock 3 and fill grit upto 3/4th level and then close it.<br>4) Open cock 1 that heads toward turbine side<br>5) Open compressed air cock and wait for a minute then close it<br>6) Check with the light of torch whether all grit is gone or not, remember to close the compressor air valve before checking. | Note: when we supply water on the compressor side at high load then, due to the thermal expansion it can cause fracture of the compressor blades or may cause *surging*.<br>Note: lukewarm water is used.<br>Procedure:<br>1) Inform bridge and request to decrease the rpm and then wait for all parameter to become normal and steady.<br>2) Put water inside the bottle on compression side and fill it upto the required level.<br>3) Now slowly open the valve until all water is filled inside, then close it.<br>4) Make the engine run for 10 minutes and then repeat this procedure for 2 – 3 times. |
| 1) Open lock 3 and fill upto 3/4$^{th}$ level and shut it<br>2) Open cock 1 that leads to turbine<br>3) Open cock 2 and wait for a minute<br>4) Shut air cock 2<br>5) Shut cock 1<br>  | 1) Open 3 and shut it<br>2) Open 1<br>3) Open 2 for a minute and shut it<br>4) Shut cock 1<br>  |
| Grit Size: 0.22 to 0.5 mm<br>Turbine blade: Nimonic alloy | Blower Blade: Aluminium alloy |

# 16. SURGING

It is the irregular pulsation due to the mass flow rate w.r.t pressure ratio.
Instead of the T/C blower supplying air to manifold there will be a reversal of flow. Which make the air from manifold to blow out in atmosphere through T/C blower along with a huge *barking noise*.

| Pressure (Scv. Manifold) > Pressure (T/C blower) |
|---|

Action Taken: reduce the rpm, to make it in the stable condition.

**Reasons of Surging**

(A) Engine room is not maintained properly, resulting in E/R blower malfunction
(B) Dirty/choked air filter
(C) Rough weather – causes sudden change in the propeller load
(D) Rapid variation of the engine load
(E) Turbine and compressor blades are damaged
(F) Cleanliness of the turbine and the compressor not adequate
(G) Uncleaned turbine nozzle ring
(H) Fouled compressor
(I) Capacity of the T/C is larger than required
(J) Scavenge fire
(K) Faulty fuel injector
(L) Blow past (downward movement of the exhaust gases from the piston ring)
(M) Highly fouled exhaust (i.e., economiser/EGB if present, it may cause back pressure in T/C and thus leading to *surging*)

Preventive Measures

- Clean the filter (intake side )
- Prevent rapid variation of the load
- Frequent cleaning of the turbine and the compressor side
- Indicator cards are to be taken to access the cylinder and power distribution of individual units
- Soot blow to be done in case of the EGB
- Proper maintenance and checks to be performed regularly.

Effects of Surging

- Bearing seize
- Rotor twist
- T/C blades damaged
- Vibrations develop in the engine
- Power reduced
- T/C efficiency is reduced
- Scavenging reduces
- Insufficient quantity of air
- Blow back of exhaust gases
- High exhaust temperature
- Smoke from the T/C drain
- Barking sound in the E/R

## CHANGE OVER PROCEDURE FROM HFO TO DO

⇒ Shut steam inlet and outlet valve of the F.O heater
⇒ Bring down the temperature between 85 – 90°C
⇒ Once the temperature is attained, slowly open the DO line valve and shut the HFO service line valve

⇒ Monitor the pressure of booster pump, when its delivery pressure starts dropping viscosity of DO is low.

⇒ Once there is pressure drop beyond the previous value of HFO. Throttle the return line valve to buffer tank i.e., shut it by 2 – 3 turns so that the pressure of booster pump remains unaffected.

**Interlocker**

1. Turning gear interlock
2. Control air interlock
3. Auxiliary blower interlock
4. Spring air low pressure interlock
5. Reversing completed interlock
6. Low L.O. pressure interlock
7. Camshaft L.O. low pressure interlock
8. Fuel pump interlock

*****

# 17. AUXILIARY ENGINE ROUTINE HOURS

Engine running on low load condition requires more frequent cleaning of exhaust spaces and the piston. Which prevents fouling. In addition to this, increase in exhaust temperature, increase in sound etc. must be investigated properly. For such we need to take care of the machinery.

Daily Checks on The Engine

1. Check fuel oil level in the service tank and the settling tank
2. Check the L.O. level in sump of the engine
3. Check the governor L.O. level
4. Check the lubrication of rocker arm, if running
5. Check
    a. L.O. pressure
    b. Exhaust temperature
    c. JCW pressure and temperature (inlet and outlet)
    d. L.O. inlet temperature, outlet temperature
6. Drain the condensate from the scavenge manifold and air cooler
7. Lubricate the fuel racks, linkages, fuel pump lock operating gear

250 Hours Routine

After 250 hours generator must be change over and stopped. Following must be done at this stage

(a) L.O filters cleaned
(b) F.O filter cleaned
(c) T/C filter cleaned/replaced

1000 Hours Routine

1. Crankcase inspection
2. Fuel injector removed and pressure test them. Adjust the pressure and put back into the place
3. Tappet clearance to be taken
4. Performance of the engine to be taken
5. Change T/C blower and turbine side oil

2000 Hours Routine

1. Crankshaft alignment must be checked and the crankshaft deflection must be taken

4000 Hours Routine

It is also known as ½ *decarbonization*

1. All the cylinder head should be removed, overhauled and carbon removed
2. Exhaust and inlet valve to be tested, lapped and inspected
3. Air starting valve overhauled
4. All gaskets, O – rings must be replaced
5. Cooling water spaces of the cylinder head must be cleaned
6. Top of the piston and cylinder liner to be cleaned
7. Renew the L.O, if required as per the analysis report

8000 Hours Routine

It is also known as *Decarbonization*

1. Remove the cylinder heads and overhaul it
2. Remove the piston, clean it and change the piston rings
3. Inspect the big end bearing
4. Overhaul the T/C and renew its ball bearings
5. Clean the exhaust piping and silencer

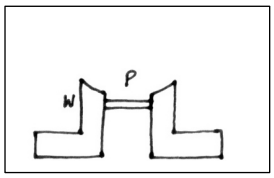
25000 Hours Routine

1. Renew the connecting rod bolts

# 18. CRANKSHAFT

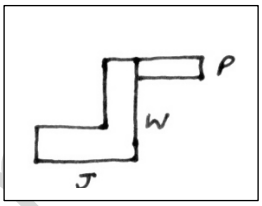
It is made up of low carbon steel. Consist of *crank journal*, *crank web* and *crank pin.*
Types of crankshaft on the basis of built-up:

(a) Semi – built (ME)
(b) Fully built (GE)
(c) Fully forged (compressor)
(d) Welded type




### Semi – Built Type Crankshaft

Crankpin and crank web are in single piece and journal is connected to web with the help of *shrinkage fit*. Which helps in increasing the stroke of the engine.




**#Note**
A light chisel *cut* on the web and half cut is on the journal in a radial line. If slip occurs between web and journal, then *cut line* (made by chisel) will get separated.

Reasons for Slip

- Leakage of the oil take place
- Propeller struck with the heavy fixed object

**#Note**
Crankshaft converts reciprocating motion of piston (driven by expansion of gases) to rotary motion.

Shrunk fit = 1 part hot + 1 part cold

### Fully Built Crankshaft (G/E)

In this all parts are fabricated separately (i.e., crank web + crank journal + crank pin). Web is heated upto 700°C to increase size of the hole, then *crank journal* and *crank pin* are inserted inside it. This is a very heavy type of crankshaft.

### Fully Forged Type Crankshaft (Compressor)

The whole crankshaft is forged from a single piece billet.

Properties:

(a) Expensive
(b) Can't repair in section
(c) Used in small high – speed engine
(d) More resistance to the fatigue failure due to continuous grain structure

### Welded Type Crankshaft

In this, *crank pin* and *crank web* are on both sides and half – length of journal on each web are forged/cast separately. Afterwards, welded together to form a complete crankshaft.

Properties:

(a) Can be repaired in a section
(b) Easy to manufacture
(c) Has resistance to the fatigue failure

## CRANKSHAFT DEFLECTION

It is the degree of the deviation between theoretical crankshaft axis and crankshaft axis arises due to loading of ship. It is taken on D/2 position, where, D is the diameter of the journal.

Reasons for Taking Crankshaft Deflection

1. To check the performance of the engine
2. To check the alignment of shaft
3. To check the bearing condition
4. To check the misalignment of M/B

Dial gauge least count = 0.01 mm (by the Dog Leg mirror method)

**When to take crankshaft deflection?**

- When the major structure gets disturbed such as fire break out, grounding, collision
- Before and after doing dry – docking
- M/B overhaul (after)
- Initial installation and after 1000 hour
- When the foundation chocks are repaired or renewed
- Bearing temperature increases

**Safeties Taken**

1. Propeller clearance
2. Smooth weather
3. Even keel
4. T/G engaged
5. Indicator cock open
6. Error free dial gauge
7. No loading and discharging

**Procedure for Taking Crankshaft Deflection**

It is taken on 5 points

- **TDC**
- **Port**
- **Stbd**
- **30° before BDC**
- **30° after BDC**

**#Note**
At BDC position it is not possible to take crankshaft deflection, as *connecting rod* will hinder in between. Hence, we take reading on 2 more sides.

Never set dial gauge to zero, first the expansion piece will be extended. Then press the dial gauge and fit it inside

$$\text{BDC} = \frac{Port(BDC) + stbd\ (BDC)}{2}$$

This dial gauge is fitted between adjacent webs and opposite to the crankpin, situated at a distance of half of the diameter from the center of shaft.
This dial gauge measures the crank web speed at different angular position of the shaft.

TDC – BDC = Vertical Deviation
Port – Stbd = Horizontal Deviation

If deflection is zero (0), then crankshaft is said to be perfect. If it is not then, there is some misalignment and reasons for such are as follows:

(a) Main bearings are damaged or wiped out
(b) Foundation bolts loose
(c) Loose or broken chokes in foundation
(d) Tie rod bolts slack or broken
(e) Fuel injector is defective
(f) Fuel pump is defective
    a. Nozzle size increases
    b. Plunger is defective

*****

# 19. STARTING OF GENERATOR

1. Check the Turbocharger (T/C) sump oil level, generator L.O level, governor oil level, alternator fwd and aft bearing L.O level, DO level in service tank.
2. Open the indicator cocks.
3. Run the *pre lube* pump to pre – lube all parts.
4. Check all valves of the L.O cooler, JW cooler, air cooler valves are in open condition.
5. Check all the lines are set.
6. By using turning bar, turn the flywheel to check for any resistance on the bottom end bearing and check any water coming out or not from the indicator cock, if water is coming out then inform it to C/E immediately.
7. While turning the engine, check all visible ports are lubricated properly or not.
8. Place the turning bar and keep it in proper position.
9. Open the starting air to start the air motor.
10. Blow through the engine (i.e., turn engine on air) in order to ensure that no water is present inside the crankcase, if present this may result in *water hammering.*
11. Close the indicator cock and pull the lever from *stop* to *start* position.
12. When the needle in rpm indicator deflects to some value (0 – 25) rpm. Press start button.
13. The engine will run on the fuel once the cylinder picks up the load speed.
14. After 5 to 10 minutes, the generator will run on *no-load* conditions.
15. Put the generator on load by closing ACB.
16. Check the alternator fwd and aft bearing L.O level by opening the oil plug mounted on alternator.

Checks on generator while running

A. <u>L.O checks</u>

- L.O level
- Governor oil level
- Alternator fwd and aft bearing L.O level
- Rocker arm L.O level
- L.O in the turbine and blower side of T/C

B. <u>Temperature Checks</u>

- Exhaust temperature of all units
- JCW temperature (inlet and outlet)
- Boost air temperature (scavenge air temperature)
- T/C inlet and outlet temperature
- Air cooler inlet and outlet temperature

## GENERATOR SAFETIES

1. Alternator bearing low oil level alarm and trip
2. Alternator bearing L.O high temperature alarm and trip
3. Sump oil low level alarm and trip
4. Low lube oil pressure alarm and trip
5. Reverse current trip
6. Overload trip
7. Overspeed trip
8. Low/high frequency trip
9. JCW low pressure alarm

## GENERATOR ALARMS AND TRIPS

1. Alternator bearing low oil level alarm and trip

2. Alternator bearing high L.O temperature alarm and trip
3. Low sump oil level alarm and trip
4. Low lube oil pressure alarm and trip
5. Reverse current trip
6. Overload trip
7. Overspeed trip
8. Low/high frequency trip
9. JCW low pressure alarm

## M/E ALARMS AND TRIPS

Alarms

1. OMD alarm and slowdown
2. Scavenge air high temperature alarm and slowdown
3. F.O high temperature alarm
4. F.O low pressure alarm
5. JCW low pressure alarm
6. Expansion tank low level alarm
7. Exhaust gas temperature high alarm
8. Thrust bearing high temperature alarm
9. Air cooler high temperature alarm
10. CW high temperature alarm

Trips

1. Thrust bearing high temperature trip
2. Low L.O pressure trip
3. T/C low L.O pressure trip
4. Control air low pressure trip
5. Camshaft and governor low pressure trip
6. Piston cooling oil high temperature trip
7. Overspeed trip

## GENERATOR SUMP LEVEL

**Increases**

First, take out one sample from sump and check whether it is *fuel mixed* or *water mixed*. If taken L.O sample is denser, it is water mixed (mixed with L.O)

Following are the reasons for rising sump level:

(a) Due to rolling and pitching
(b) Due to change in the trim by loading/discharging
(c) Service tank valve to sump may be kept open
(d) Purifier sealing water kept open
(e) Gravity disc not working properly
(f) Transfer pump not lined up properly
(g) Purification of one generator sump taking place and discharge from purifier lined up to another generator sump
(h) Fuel pump is defective so fuel oil leakage take place
(i) Water leakage via liner O – rings from Jacket water

Hence, all these checks need to be done.

## PURGING OF AIR: 4 RAM TYPE STEERING GEAR SYSTEM

Carry out system isolation. In this case of hydraulic ram type steering gear, the casing and sump should be maintained with 75% of its capacity.

Turning bar inserted inside the holes of flexible coupling i.e., between motors and pump. Then *Air Release Purge Screws* on cylinder are opened partially.

*****

# 20. FUEL INJECTOR

It atomises and injects the fuel (@high pressure) into the cylinder for combustion. The pressure at which injector operates, can be adjusted by *adjusting the load on the spring*.

Requirements of Fuel Injector

A. It should act as a NRV and does not allow combustion gases to enter back into the fuel system.
B. It should not open till it reaches its pre – set value
C. *Oil fuel ratio* should be desirable and oil should be in mist form.

**Overhauling of Fuel Injector**

Take proper precautions like face shield, gloves and then bring the fuel injector to workshop. Purge the fuel injector. Clean the fuel injector nozzle tip and remove excess carbon.

> **#Note**
> Before overhauling, pressure testing is done of fuel injector. And the injection pressure is jotted down.

Steps

1. Remove the cap – nut
2. Remove the lock – nut
3. Slacken the adjusting screw
4. Take out the nozzle retaining nut
5. Take out the nozzle
6. Take out the distance piece
7. Remove the dowel pin
8. Remove the push rod
9. Remove the spring
10. Remove the spring seat

Now, clean all the components with kerosene.

11. Take out the needle from nozzle and cover it
12. Lap the needle, spaces and contact face of the injector body with fine grinding paste (grit size = 500 mm)
13. Clean the nozzle holes with cleaning pin
14. Put the needle valve back into nozzle and this needle valve should slide inside the nozzle
15. Reassemble the components
16. Tighten the adjusting screw and test the injection pressure of injector
17. Adjust to the required pressure by adjusting the screw
18. Tighten the lock nut
19. Tighten the cap – nut

> **#Note**
> Ensure that spray pattern should be uniform and fine. Also, fuel should not drip.

**Fuel Injector Tests**

(A) Opening pressure test
(B) Drip test
(C) Spray pattern test
(D) Leak test
(E) Atomization test
(F) Penetration test
(G) Hole diameter test

**#Note**
Take the proper precautions like proper PPE, face shield, gloves etc. bring the fuel injector to workshop and purge it before cleaning excess carbon from the nozzle tip.

**Opening Pressure Test**

⇒ Fuel injector after purging should be placed in a test kit
⇒ Operate handle in quick succession
⇒ The nozzle should start discharging oil with a sharp cracking noise at a set pressure.
⇒ Note down the respective pressure and check it according to the manufacturer guidelines

**Spray Pattern Test**

Place paper inside the test kit and give a jerk, if oil comes out from more than a *number of holes* then it means holes are chocked.

**Atomization Test**

Check the coming oil (mist or not) at opening pressure.

**Hole Diameter Test**

Put GO and NO gauge to check the diameter of holes.

**Drip Test**

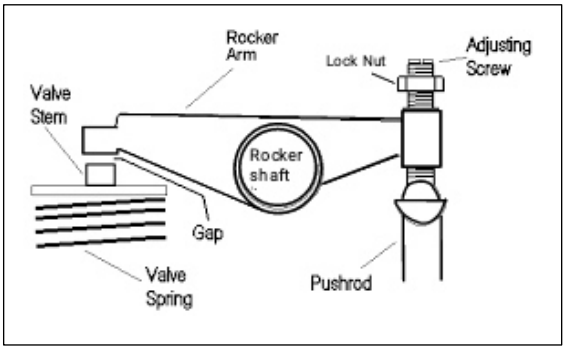
⇒ Operate hand pump, increase the pressure until it is just below the opening pressure and maintain that pressure for a few minutes and then check whether, injector is dripping or not.
⇒ It is done to check the tightness between *needle* and *seat*

**Leak Test**

⇒ It is done to check the tightness between *needle* and *guide*
⇒ Operate the hand pump and increase pressure until it is just below opening pressure. Now, observe how long it takes to decrease the pressure, if pressure starts decreasing quickly it indicates that *needle* and *guide* are not in good condition and the same should be replaced at the earliest.

## TAPPET CLEARANCE

It is taken between *tappet assembly* and *push rod*. But, in actual it is difficult to take such readings. Hence, it is taken between *rocker arm* and *valve stem*.




Conditions for Taking Tappet Clearance

1. Engine should be in cold condition
2. Engine should be isolated completely
3. F.O/L.O. should be shut
4. Remove the cylinder cover bonnet
5. Piston should be at TDC
6. 2 Piston should be at TDC and check with firing order
7. Push rod should be free (it means compression stroke) and if push rod is not free or tight, it means second one is at power stroke
8. Note down the clearance after taking reading
9. Fuel cam is on the peak [at that time inlet and exhaust valve both are close]

Adjust tappet clearance between rocker arm and valve stem by tightening or loosening the *adjusting screw*. After adjusting the *adjusting screw*, tighten the lock nut which can be done easily with the help of screw driver.

Inlet valve clearance (suction) = 0.3 mm
Exhaust valve clearance (discharge) = 0.5 mm

**#Note**
The exhaust valve clearance should be more because it always faces hot gases. Which increases the chances of expansion.

Case I: Tappet Clearance is More (MOL)
- → Exhaust valve will open late and closes early
- → Less removal of the exhaust gases. Hence, less energy is transferred to T/C resulting in scavenge air reduction. Hence, T/C efficiency decreases.
- → Power decreases.

Case II: Tappet Clearance is Less (LOE)
- → Exhaust valve will open early and closes late
- → Power decreases, $P_{comp}$ decreases and $P_{max}$ decreases
- → Burning of the exhaust valve takes places
- → T/C fouling
- → Exhaust temperature increases
- → Engine becomes imbalance
- → Induced air through inlet valve may leak out, so less air is available for the combustion

**How to find which unit is at TDC?**
For a 4 – S engine, piston will be at TDC twice in one complete cycle. One at injection (firing) as well as one at exhaust.

## FLYWHEEL METHOD
Marking(s) on flywheel are marked to indicate TDC.

Each unit have two markings on flywheel, causing each unit to go the TDC two times in one complete cycle of 4 – S, one will be at (firing TDC) and other at non – firing TDC.
The unit at TDC will have both inlet and exhaust valve closed. Hence, push rod will be free to move and can be easily turned by hand >>> this shows firing at TDC condition.

If the push rod for inlet and exhaust valves are not free i.e., valves are not close, this shows TDC but not firing TDC or not TDC (if marking on flywheel is wrong)

**#Note**
This method is useful only in working condition generator which we have just stopped to check the tappet clearance.

## CRANKCASE METHOD
Open the crankcase door and visually check which unit is at TDC.

## DIAL GAUGE METHOD
1. Remove the fuel injector and put the dial gauge inside
2. Turning gear must be engaged and the engine is turned over
3. The pointer in DG starts moving in one direction and after some time must stops
4. It again starts and move in another direction
5. The moment, the direction of *DG pointer* changes, it is to be considered the TDC of that unit.

## FUEL PUMP METHOD

→ On the body of fuel pump, there are cut marks which show *start of injection* in diesel engine. S.O.I is the injection before TDC, where both the inlet and exhaust valve are closed

→ It must be noted that this is not the exact TDC, as ignition occurs a few degrees before TDC. Hence, we rotate the engine slightly.

## CAMSHAFT METHOD

→ Open the camshaft window and look at camshaft

→ If roller of the follower is at base circle, then the particular valve is closed

→ When both the inlet and exhaust valve are closed, follower are on the base circle. Then the unit will be at firing TDC.

## VALVE SPRING METHOD

This method is used to confirm firing TDC of that unit.

⇒ To confirm that unit is at firing TDC or not, check the valve springs.

⇒ If the valve spring is not compressed (very slightly loose) the piston of that unit is at firing TDC because the valves are closed and there is less tension on valve spring.

## PUSH ROD METHOD

If the push rod is free to turn or not. If it is free, this implies that valve is closed and piston of that unit is at firing TDC.

**#Note**
If piston is at TDC, then suction and exhaust valve are shut; firing is taking place at TDC of that unit.

## SPILL TIMING METHOD

- Delivery valve of the fuel pump along with delivery valve spring is removed. In the place of HP pipe, place 'U' shaped pipe.
- Start slowly, turn the engine with T/G, slowly brought it near TDC
- At one TDC, we will observe that oil start spilling from the pipe, because oil started entering into the pump from the inlet port (which is uncovered by the plunger). That will be the injection/power stroke of the piston and that piston will be at firing TDC.

**Question 20.1: How to check fuel injection timing?**

Method I: Goose neck method

(a) Remove the delivery valve
(b) Put HP pipe in a bucket
(c) Start turning engine
(d) When plunger covers the spill port, oil starts coming out and this is the beginning of the injection and note down the angle on flywheel
(e) When oil stops coming, it is the end of the injection

Method II:

(a) Remove the delivery valve.
(b) Put a torch in vertical position and so that light is visible from spill port.
(c) Start turning the engine with turning bar. When light start to disappear, this is beginning of the injection and note down the angle on flywheel.
(d) When again light appears, this is the end of injection.

**HP Pipe Safeties**

- Double sheathed pipe
- Leak off line

**Question 20.2: How to remove broken stud?**
Hint:

- Stud extractor
- Welding
- Metal disintegration process (with the help of tommy bar – by cutting square)

**Question 20.3: How to test lube oil low pressure trip?** (in generator)
Solution: Pressure Gauge Calibrator

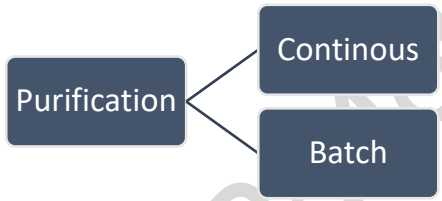
⇒ First, we drain all the L.O. from drain and then we fix pressure gauge calibrator inside the drain
⇒ Increase the pressure
⇒ Start the generator
⇒ Slowly decrease the pressure from pressure gauge calibrator. Generator will trip on L.O. low pressure trip.

Draining the L.O.

(a) Close the oil inlet to a particular relay and drain oil in the line
(b) The relay will sense low pressure and will give alarm/trip of the engine

**Question 20.4: Rocker arm L.O. pressure becomes low? Give reasons.**
Solution: Particular line gets choked from where lubrication is taking place.

## BATCH PURIFICATION

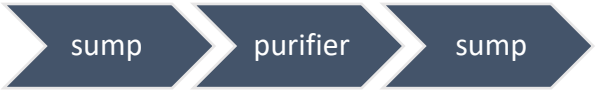



B.P.: when upto 0.5 to 1% water or impurities is present in lube oil. Then, we have to do batch purification of such.

Procedure
It has to be always done in port

(a) Immobilization certificate has to be received
(b) Empty/transfer the LO (lube oil) from sump to separate the empty tank
(c) Heat it upto 60°C for 24 hours
(d) During this, drain the separate tank frequently
(e) Run the purifier in order to get best purification; put minimum through – put 1/3$^{rd}$ or 40%
(f) Then this drained LO goes back to the sump

### Continuous Purification



Blow through of M/E

1. Engage the T/G and give a kick and turn the engine with the help of air. So, that we have to give one turn when piston start moving.
2. This is done to remove
    a. Accumulated gases in the cylinder
    b. Remove water (when water is present then pressure increases, cylinder heads and X – shaft can be damaged).
3. After giving the kick, check for water or gases (coming out).
4. While closing the indicator cocks, check by the hand for the presence of any droplets of water.

## MICROBIAL DEGRADATION

There are two types of bacteria

(a) Aerobic (needs O2 to thrive)
(b) Anaerobic (doesn't need O2 to thrive)

**#Note**
In main sump, due to the lack of O2, the anerobic bacteria thrive in the presence of water which is present at the bottom of sump and use organic hydrocarbon and its additives (present in L.O) as their food.
They decompose oil and convert it into acids. Sludge into stable sludge, corrosion cells and H2S. These bacteria are also known as *Sulphate Reducing Bacteria*.

Detection of Microbial Degradation

(a) Rotten egg smell coming out from oil
(b) Filter getting frequently choked
(c) Discoloration of oil
(d) Sludge accumulated in the crankcase
(e) Mud like deposits on the surface of oil which can be detected while taking sounding
(f) Crankcase have yellow colour patches
(g) Corrosion of purifier bowl
(h) Rust film on oil surface
(i) Loss of property of L.O

**Preventive Measures**

(a) L.O. pump should be continuously in running condition to avoid accumulation of water inside the sump.
(b) Purifier should be in continuously running condition.
(c) Heating of the crankcase should be *ON* in case of L.O. pump is stopped.
(d) L.O. testing should be carried out regularly.
(e) L.O. in the storage tanks should be treated with *Bio – Cites* to eliminate growth of microbes.

*****

# 21. IG TRIPS AND ALARMS

Trips

1. Scrubber water high level
2. Deck seal low water level
3. Emergency stop
4. Power failure
5. O2 content high (8%)
6. High inert gas temperature
7. Low pressure in line after blower
8. Low sea water supply pressure (approx. 0.7 bar to scrubber tower
9. Low sea water supply pressure (approx. 1.5 bar to deck seal)

Alarms

1. Scrubber water low level alarm
2. Deck seal high level alarm
3. High O2 content (5%)
4. Low O2 content (1%)

*****

# 22. TIE ROD

Tie rod holds *cylinder block + (A – frame) + Bed plate* under compression by itself which is undergoing tension. It is made up of a special resilient material.

**#Note**
During the fitting of cylinder, a high tensile stress develops. So, we have to provide compressive stress to avoid H.T. stress otherwise fatigue crack will develop.

Number of tie rods = 2n + 2 (if chain casing is provided)
Where, n = number of cylinders
If, no camshaft is present then, we do not add +2

Function of Tie Rod

1. It is provided for fatigue strength.
2. It helps to reduce the bending stress being transmitted to transverse/cross girder.
3. The firing pressure force of the piston is directly transmitted to the main bearing and consequently to the engine frame through tie – rod support.

**#Note**
*Tie – Rod* should be in vicinity of centerline of the crankshaft.

**Location**: Around the *Cross – Girder*

## PREVENTION OF TIE RODS FROM VIBRATION

→ Pinch the screw which is provided at the foot of the engine cylinder jacket to stop tie – rod from vibrating i.e., transverse oscillation.
→ It is fitted at anti – nodal points (max. vibration) of tie – rod and at 120° apart.
→ Each screw consists of stud which is hand tightened which are held in place by lock nut that is tightened with a torque specified by the manufacturer.

### Tie – Rod Tightening Procedure

Hydraulic Jack: In this stud is elongated and then tighten the nut within its limit.

M/E parts @ 1500 bar
Conditions: no wind and even keel

**#Note**
Always take X – shaft deflection readings after doing tie – rod tightening.

Method I:

1 2 3 4 5 6

Start from free end and tighten @ 900 bar. Then from opposite end start checking its tightness @ 900 bar. Simultaneously tighten it upto 1500 bar.

Method II:

If n = 3, then 2n + 2 = 8

1 2 3 4 5 6 7 8

(a) 4 »» 5
(b) 5 »» 3
(c) 3 »» 6

Check @ 90%, if loose then increase it upto 1500 bar.

## TIE – ROD BREAKAGE

If the tie – rod breaks then leakage of L.O. from mating surface will take place. To prevent such we have to run the engine at *slow speed.*

Reasons

(a) Scavenge fire
(b) Slacked tie – rods
(c) Overtightened/overstressed tie – rods
(d) Grounding
(e) Collision

Effects of slackened Tie – Rods

- Power decreases
- $P_{comp}$ decreases
- Fretting of bolts

**Breakage of Tie – Rods**

A. Break at neck
B. Break at the bottom
C. Break at the middle: First lift and remove top portion

*****

# 23. L.O. TESTING

TBN = Total Base Number
It is the measurement of basicity.

| **#Note** |
| --- |
| Higher the TBN, its ability to neutralize contaminants such as combustion by products and acidic materials are higher. |

M/E → 70 mg KOH/g
G/E → 20 – 40 mg KOH/g
System oil → 6 – 8-cylinder oil mg KOH/g

For L.O. testing, sample should be taken from
(a) Inlet to engine
(b) Inlet to pump
(c) Before cooler

**Question 23.1: Why we do L.O. testing?**
Solution:
1. To monitor the deterioration of oil with time
2. To check for the contamination of L.O. water, fuel oil or periodical attack
3. To determine any leak or source of contamination of fuel
4. To avoid any damage to lubricating part of machinery
5. To understand the performance of supplied L.O.

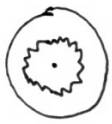
**Test**

A. Water crackle test: sample are taken in test tube and heated. Crackle noise will come and formation of the steam bubbles.
B. Viscosity test: Take flow stick into the two paths
    a. For the fresh oil
    b. For the sample oil
    Tilt this flow stick and notice what happens due to gravity.
    If viscosity increases → contamination of HO, carbon, oxidation
    If viscosity decreases → dilution of distillate fuel

C. Alkalinity test: drop of indicator solution on a blotting paper followed by a sample of oil at the center of drop. Colour changes area around the spot

| Red: ACID | Blue/Green: Alkaline | Yellow/Green: Neutral |
| --- | --- | --- |

D. Water control test:
    a. Take 5 ml sample + 15 ml of a reagent containing paraffin or toluene
    b. Before closing the lid of digital meter, a sealed sachet containing calcium hydride is kept and the container is closed tight.
    c. The meter is shaken by the hand and pressure rise due to chemical reaction in the test container is shown as water % in digital display.
E. Spot test: a drop of oil is put on the blotting paper.

| | | |
|---|---|---|
| Case I |  | Irregular shape: water present |
| Case II |  | Uniform distribution: good dispersiveness of contaminants |
| Case III |  | Contamination concentrated at center: poor dispersiveness |
| Case IV |  | Colour of spot (Black): Heavy contamination |

## JACKET WATER TESTING

1. **Nitride Test**
   5 ml water sample + 45 ml distilled water = 50 ml solution

   Now, start adding (after each adding procedure, do shake the solution)

   50 ml solution + 2 No.1 nitride tablets → white colour + add 1 nitride No.2 tablet → continue adding No.2 nitride tablet until a pink colour persist for atleast 1 minute

   Therefore,

   | Nitride (ppm) = number of nitride No.2 tablets × 180 |
   |---|

2. **Chloride Test**
   If chloride level exceeds 50 ppm, then there is a possibility of corrosion in the system

3. **pH Test**
   8.3 ~ 10.0

**Question 23.2: Problems which may occur in JCW?**

1. Scaling: it is a dense, adherent deposit of the minerals and is tightly bonded to itself and metal surfaces. As the pH increases the scaling potential also increases accordingly.

   As, the pH decreases, the potential for some forms of silica scale increases.

2. Fouling: fouling deposits are formed from the materials suspended on water (suspended solids and oil). While scale deposits are formed from minerals in the solution.
3. Microbiological activity
4. Corrosion: corrosion inhibitor containing *nitrite* protects *mild steel* and *azole* protects *copper.*

**Material of S.W. Line**
Mild steel, galvanized from both sides and are painted

**Question 23.3: You have found hole in SW line. Give suitable reasons for such.**

A. Small Hole
   - → Rubber piece and jublee clip
   - → Rubber piece and C – clamp
   - → Pipe repairing kit – it has fiber glass tape and epoxy

> **#Note**
> To repair a hole, put rubber tube and after that put the *cordabond* or DEVCON on it or put rubber joint or C.I. Putty
> Try to avoid welding, clamp.

B. Big Hole
   - → Change the pipe from flange
   - → Cut that pipe and fit new pipe and weld it
   - → Put the cement box
   - → Take a piece of larger diameter, cut it from middle and fit it and then weld it

**Question 23.4: Bilge pump is not able to take suction from aft bilge well. Give reason.**

A. If the pump take suction from one bilge well but not from other, then it means particular bilge well filter is choked.
B. Close suction valve and if vacuum exists for 1 – 2 minutes, it means pump is working properly. If vacuum suddenly vanishes, it means valves are leaking.
C. If above conditions are correct, there is possibility of choked pump suction filter.
D. Possibility of pump drawing air from main filter increases.
E. May be the pressure gauge is faulty
F. Possibility of a hole in a pipeline. For finding this hole, we have to pressurize the line with water. As all the valve on bilge line are SDNR type, so we first make main suction valve to *simple valve* by taking out its valve lid and then open priming valve of SW hence, water start going into complete bilge line.
   We can easily find out the point where hole is present, and rectify it.

*****

# 24. HFO TO DO CHANGEOVER

Let us discuss how HFO to DO change over procedure take place in purifier.

Step I: first change the *gravity disc* which is smaller than the HFO
Step II: open the heater drain valve
Step III: close the steam inlet valve
Step IV: open the heater bypass valve

**Question 24.1: How to change gland packing of hydrophore pump?**

1. Shut inlet and outlet of the pump
2. Close the pump; close the main switch of the pump
3. Open vent to depressurize
4. Open the nuts of the gland and slide them
5. Using cock – screw pull the gland packing out (top portion)
6. Lift the lantern ring and take the bottom packing out
7. Now, cut a new packing by putting the packing on the dummy shaft according to the required dimension.
8. Put the new gland packing and make sure that gland is free.
9. Now, slowly tighten the gland.
10. Make sure the gland doesn't run *hot,* tighten it until the water drops from the cases.

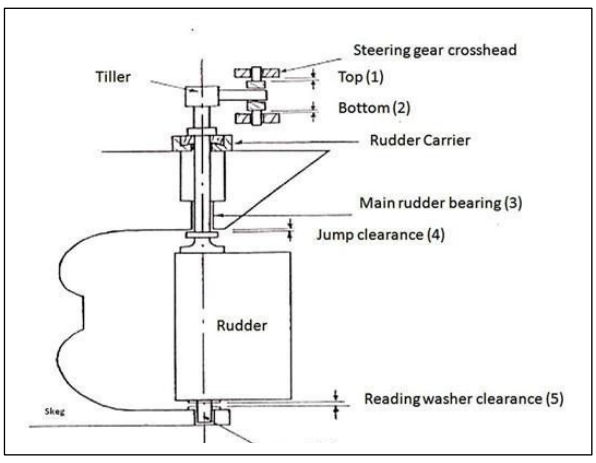
## ROUGH WEATHER PREPARATION

1. Skylight should be closed
2. Close all weather – tight doors
3. Close all E/R doors
4. L.O. tanks should be full
5. L.O. drums should be properly lashed
6. All tools should be properly arranged
7. Machinery/Motors/Pumps if opened for overhauling they should be properly secured
8. All movable objects should be secured above and below decks particularly in E/R, galley and store – room, paint locker, boson store, workshop.
9. Life boat well secured, check griper
10. Anchor to be extra lashed
11. Soundings must be checked
12. Scuppers and outlets to be kept open on deck
13. Ballast condition to be checked and conveyed with C/O and Master
14. Crew to be warned from using/going to upper deck areas, as it is dangerous in heavy weather
15. Sounding caps to be closed

## JUMPING CLEARANCE

Jumping clearance or rudder clearance is the clearance between *jumping bars* or *pads* which are welded to hull and rudder together.

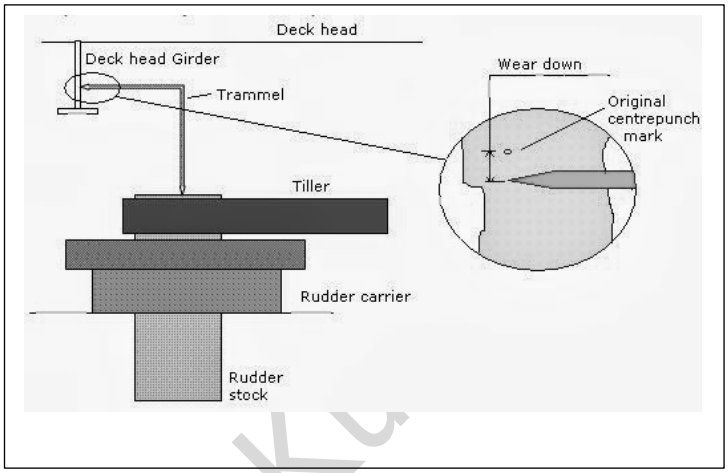
When ship is in motion, rudder jumps due to panting and pounding. The rudder may go up and hit the hull of the ship. To avoid the damage of the hull, jumping bars are fitted. Jumping clearance is provided for the safety of SG and hull of the ship. When rudder drops, jumping clearance increases i.e., Rudder Drop ∝ Jumping Clearance



Jumping clearance is around 3 mm for a new ship and maximum allowable clearance is 6 mm. It is measured by using *thickness gauge*.
It can be checked during drydock; it can also be checked by chain block arrangement in S/G room. Increase in the clearance indicates that there is excessive bearing wear.

## RUDDER DROP

Rudder drop is actually the wear down of the rudder carrier bearing. It is measured by a *trammel gauge*. Trammel gauge is an L-shaped instrument. Basically, a point marked on the hull inside the S/G room (here it is on the deck head girder) and other point marked on the rudder stock.
The distance between these points is measured and recorded at the time of construction. The difference between original and the measured is called *rudder drop* or *rudder wear down*. It is always measured in dry dock of the ship.




**#Note**
Rudder drop is the measurement of how much rudder go down due to wear down of rudder carrier bearing.

3 – 6 mm is the allowable for rudder drop. The rudder should not drop more than this allowance. If allowance becomes *zero* then weight of rudder will be directly transmitted to the rams and ram may get bent. That's why rudder drop should be less than the provided rudder drop allowance. If it is more than the rudder drop allowance then maintenance of rudder carrier bearing is required.

## PROPELLER DROP

Propeller drop (PD) is the drop in propeller shaft due to wear down of the stern tube bearings and weight of the propeller. The propeller shaft is fixed at one end and free at another end.
The free end of the propeller shaft is loaded with heavy propeller which tends to bend the shaft. Stern tube bearings are supporting the propeller shaft and avoid such bending.
For stern tube bearing lubrication, a bronze liner/chrome liner is fitted on the propeller shaft. Seals are fitted over the liner for sealing the shaft. These seals slowly create grooves on the liner and after sometime sealing is lost.
Due to loss of the sealing, SW enters in the sealing areas and lubrication is reduced and because of the poor lubrication, there is a wear down of liner and stern tube bearing.
The clearance is increased due to wear down of bearing, weight of propeller bends the shaft i.e., shaft goes down/drops and this drop is known as *propeller drop.*

**#Note**
Normally, the bearing clearance is between 0.5 – 0.6 mm. If it goes to 0.9 mm then stern tube bearings should be replaced. Maximum allowable *propeller drop* ranges from 0.2 mm – 0.3 mm.

*Poker Gauge* is used to measure the propeller drop. It is a depth measuring instrument.

**#Note**
For measuring the propeller drop special access point is given which is generally bolted with Cu gasket. This gasket is removed before measuring propeller drop.

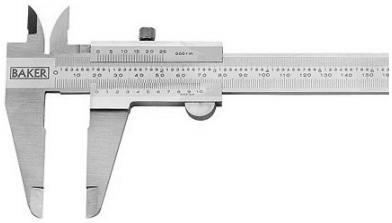
Procedure:

1. Turn the engine and bring No.1 unit to the TDC only for comparison purpose.
2. Take out plugs of aft bush and drain out the oil.
3. Put the poker gauge in access point and tighten it. Release the rod of poker gauge. As rod touches the bronze liner on propeller shaft, it will make a metallic sound. Take down reading on the scale.
4. Compare present reading with previous readings. Deviation in readings is nothing but the *propeller drop.*
5. Also, take the reading from the bottom. Here, we need to push the rod to touch the chrome liner.

*****

# 25. VERNIER CALIPER

It is a precision instrument used to measure internal and external distance in extremely accurate manner. It is considered for measuring internal depths.




**Least Count (LC)**: this is the smallest reading that can be accurately measured using the vernier caliper.

Least count of vernier caliper

$$= \frac{Mains\ scale\ least\ count}{No.\ of\ division\ on\ vernier\ scale}$$

Mains scale least count =

$$\frac{count\ the\ No.of\ small\ division\ in\ between\ 2\ marks\ points}{No.of\ divisions}$$

Exm = $\frac{1\ cm}{10\ division}$ = 0.1 cm

Number of divisions on the vernier scale = exm 10 or may be 20

Therefore L.C. of the vernier caliper = $\frac{1}{10}$ = 0.1 mm

**#Note**
Least count of the vernier caliper is equal to 0.1 mm or 0.01 cm. It means it can measure a minimum value of 0.1 mm.

**Vernier Caliper Zero Error**
When the jaws of vernier caliper are brought into contact, the *zero* of the vernier caliper must coincide with *zero* of the main scale. If not coincide, the instrument has an error called *zero error*.
These zero errors can be (-) ve or (+) ve

| Negative Zero Error | Positive Zero Error |
|---|---|
| If the zero of the vernier scale is to the left of zero of main scale then error is known as (-) ve zero error. | If the zero of vernier scale is to the right of zero of main scale then error is known as (+) ve zero error |
| Since, zero error is (-) ve then the zero correction will be (+) ve. | Since, the zero error is (+) ve then the correction will be (-) ve |

Least count of the micrometer equal to 0.01 mm

**Accuracy Check of Micrometer** (0 diameter)
Parts

1. Frame
2. Anvil – spindle
3. Index line
4. Sleeve scale
5. Thimble scale
6. Frame
7. Lock nut
8. Thimble

1. Outside Micrometer
2. Inside Micrometer
3. Depth Micrometer (measuring depth of hole)

9. Ratchet speeder

Micrometer is a tool used to measure highly accurate measurements. When the micrometer is at minimum reading then the horizontal line on the sleeve should line up with the 'O' on thimble. If 'O' doesn't line up, it is necessary to calibrate the micrometer by rotating the sleeve.
For this purpose each micrometer comes with a half – moon adjusting wrench.

| Types of Gasket | Types of Coupling | Types of welding joint |
|---|---|---|
| 1. Rubber<br>2. Non- asbestos<br>3. Cork<br>4. Pipe/flange<br>5. Transformer<br>6. Manway | 1. Star coupling<br>2. Flexible coupling<br>3. Pin & bush coupling | 1. Butt joint<br>2. Lap joint<br>3. T – joint<br>4. Corner joint<br>5. Edge joint |

## HYDROPHORE

Charging Procedure

1. Inform wheelhouse and stop all connection
2. Stop the purifier
3. Check the *pressure switch* setting, whether it is on correct point or not
4. Take the fresh water pump on manual mode
5. Open the vent to remove all air
6. Check level on the sight glass whether it is 2/3$^{rd}$ filled or not if not then charge it manually by running the pump.
7. Close the vent valve
8. Stop the forward pump
9. Charge air up to 4 bar and then close the charging valve. Slowly charge it up to 5.5 bar.
10. Take pump on auto mode
11. Open the drain valve slightly to drain water. At low pressure, check for the pump automatically starts or not.
12. If pump doesn't start then check pressure switch, perhaps vent has gone
13. Open the discharge valve of hydrophore

**TROUBLESHOOTING**

1. Frequently cut in – cutoff hydrophore
    a. Pressure switches faulty
    b. Low setting of pressure switch
    c. Air is leaking from any joint in shell
    d. Vent is leaking
    e. Pressure gauze is leaking
2. Hydrophore pump running continuously
    a. Wrong setting of the pressure switch
    b. Demand is more
    c. Insufficient air supply
    d. Cavitation in the pump
    e. Pump problem which includes
        i. loosen suction
        ii. insufficient capacity
        iii. consumption high

**GLAND PACKING REMOVAL**

**Question 25.1: How to cut the gland packing?**

Answer:

1. Butt joint (straight or 90°)

2. Skive joint (45°)

**#Note**
1. It is cut with sharp knife to avoid fraying of edges.
2. Taper joint (i.e., skive joint) gives better sealing. But it is very difficult to cut, it is skill oriented and angles on both the ends should be properly matched.

**Question 25.2: How to remove the gland packing?**
Answer: **Gland Packing Extractor**: it looks like the cork screw type; they are flexible. We have to twist it to get a grip and then packing can be pulled out.

**#Note**
Sometimes, when the packing gets old, they lose their properties and transform they into fibres. When they are not coming out of the sea water pump properly. For that, a little opening of the sea water suction valve is provided and because of the water pressure, it will push out the packing.
We have to shut it properly, to prevent flooding of bilges.

**Question 25.3: Mention the standard size of gland packing?**
Answer:

$$\text{Size} = \frac{ID\ of\ stuffing\ box - OD\ of\ shaft}{2}$$

| Shaft Size Diameter | Gland Packing Size |
|---|---|
| 16 – 28 mm | 8 mm |
| 30 – 46 mm | 10 mm |
| 50 – 75 mm | 12.5 mm |
| 75 – 120 mm | 16 mm |
| 125 – 300 mm | 19 mm |

**GLAND PACKING LENGTH MEASURING**
1. Old packing is removed, take reference and cut accordingly.
2. Put new gland packing circumferentially on a template over the shaft. Mark accordingly and cut it down.
3. Calculate the parameters or circumference after knowing diameter of the shaft.
$$P = \pi D = \pi \times 50 = 157.07\ mm$$
Therefore, this measured length should be cut from the gland packing considering a 2 mm clearance in the packing which would swell in the presence of the sea water.

**#Note**
If the gap is not kept adequate, it would seize the shaft leading to overheating and burning of the packing. This will in turn increase the load on the motor and shaft accordingly.
In most cases the shaft gets broken due to the excessive tightness.

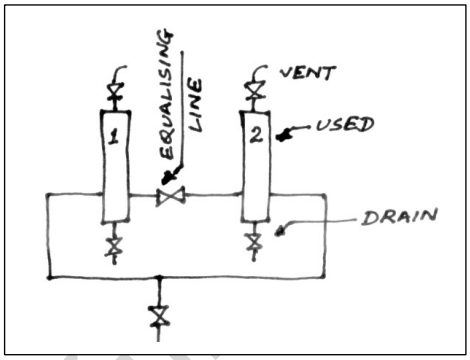
**Insertion of Gland Packing**

**#Note**
Gland packing is used to prevent the leakage between *stuffing box* and *stem*.

1. Remove old gland packing and clean the surrounded space with the help of compressed air.
2. Check the shaft for any damage (pitting or abrasion marking). If present, remove it with 300 grit emery paper. If not possible to make a smooth surface, change the sleeve.
3. Cut the gland packing and give some clearance as it will swell when coming in contact with water.
4. Fit each packing one by one with large amount of lubricant and stagger each by 90°.

5. Compress the gland to confirm/ascertain that it goes inside evenly.
6. Check the shaft whether it is free to rotate after insertion of the gland packing.
7. Slightly tighten the gland by hand till a little resistance is felt in turning of the shaft.
8. After tightening, slacken the nut and finger tighten it. The tightening must be done during *running in process*.

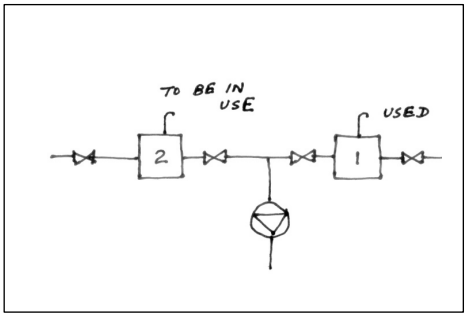
## DUPLEX FILTER CHANGE OVER PROCEDURE




1. Open the equalising line
2. Crack open the vent of duplex filter DF1
3. Once oil starts coming out from DF1 close the vent
4. Close the equalising line
5. Change over the filter to other Side
6. Check by opening the vent of DF2 and see oil is coming out or not. If oil is not coming, it means valve is holding and changeover take place successfully and if coming then it means valve is not holding
7. For cleaning the filter (2) crack open the vent (i.e., to depressurize) and let some oil come
8. Open drain of DF2 and then take – out filter and clean it with compressed air and diesel
9. Box back the duplex filter
10. Again, open the equalising Line

**#Note**
For preventing L.O. from low pressure trip, we use equalising line.

## SEA CHEST CHANGE-OVER PROCEDURE




1. Open the vent of sea chest SC2.
2. Crack open the inlet valve of SC2 and when water starts coming out, close the vent of SC2.
3. Fully open the inlet valve of SC2.
4. Gradually open the outlet valve of SC2. Meanwhile, close the inlet valve of SC1 until it gets fully open and close.
5. Meanwhile, closely monitor the pressure of M.C.S.W pump, it value should not drop.

Hence, sea-chest change over take place.

## GASKET CUTTING

**How to make a gasket when there is no space?**

1. Measure OD (outer diameter) of the desired pipe with the help of outside caliper. This gives ID (internal diameter) of flange.
2. Measure the flange OD which gives OD of flange.
3. Number of holes can be seen from outside.
4. We have to find out PCD (pitch circle diameter) and C
5. Cord length = $PCD \times sin\frac{180}{N}$ where, $N$ is number of port/holes.
6. PCD can be find out by measuring the distance between two holes, that is from outside of one hole to the upper side of another hole.

Therefore, the cord length can be found out easily. This is the distance at which we have to make holes.

# 26. THREAD MAKING PROCEDURE

**Question 26.1: How to find out the drill bit size for making internal thread if you want to drill for M5 × 0.8 thread?**

Solution: **M5 × 0.8,**

where, M is the metric thread designation
5 is nominal diameter (mm)
0.8 is pitch of thread (mm)

**#Note**
Making threads on a nut (i.e., internal thread).

A. Use a *centre punch* mark to centre a drill point
B.
   a. first drilling
   b. **Drill Size** (D) = T – 2d; where T is diameter of tap or bolt to be used (bolt size) and d is depth of thread
   c.

   Drill size (D) = T – 2 × 0.61 × pitch of thread

C. Drill a hole smaller than the measure needed for tap
D. Put some *rocal* cutting compound on end of the tap
E. Turn the tap wrench until the first cut into material has been made
F. Once grip has been made on material then turn 1 round clockwise and half round anticlockwise. This will ensure that tap will not get clogged with the off cuts of material and a better thread is created. Subsequently, add lube coil for cooling/cutting space.
G. After that use the intermediate/plug tap
H. After that use finisher/bottoming tab
I. Now check the threading with appropriate Bolt

**#Note**
External threads are made with the help of *dieing*.
If ask for M/6, then use D = T – P; D = 16 – 2 = 14 mm
Depth of the thread = 0.61 × pitch of thread

**Question 26.2: How to remove a broken stud? How to drill a M16 hole?**

Solution: Method 1

1. Check the threading of broken stud (Assume it has been clockwise tightened)
2. Drill a hole in a broken stud
3. Use an anticlockwise (A.C.W) tap to make an internal thread in broken stud; so, we can tight the tap in anticlockwise direction.
4. After that, when tap cannot be further tightened (A.C.W direction) it will try to rotate the stud in anticlockwise direction and stud will come out.

Method 2: Stud Extractor tool
Method 3: Welding – bolt weld and then remove it with spanner
Method 3: Metal disintegration

## EXTERNAL THREAD METHOD

1. Take round rod and fix it on vice.
2. File a 45 – degree chamber to the round rod, which is slightly larger than the thread depth.
3. Clamp the *round die* into die stock.
4. Use cutting spray to increase the service life and improve its surface quality.
5. Turn two turns clockwise and one turn anticlockwise to ensure that die will not get clogged

6. Clean the surface with the help of compressed air

Remember, threads are measured with the help of *thread pitch gauge*.

*****

# 27. PUMPS

## CENTRIFUGAL PUMP

Overhauling of Centrifugal Pump

1. Run standby pump and stop the pump which we are going to overhaul
2. Close the discharge valve and suction valve
3. Open the vent and check whether valves are holding or not
4. Trip the breaker and lock hit and *tag it*
5. Mark the points on coupling and casing with marker
6. After removing both motor and pump side coupling bolt and discs, remove the distance piece fitted between motor and pump coupling.
7. Remove the motor with the with the help of chain block and secure it separately. Apply insulation tape on its wires.
8. Remove the cooling connections to mechanical seal.
9. Remove the casing top cover bolts.
10. Once the casing cover top bolts are removed, the pump assembly is free to remove from place along with shaft, bearing housing, bearing, impeller, impeller shaft with sleeve, mechanical seal
11. Slacken the impeller lock nut and remove impeller from the shaft
12. Remove the shaft key
13. Remove the distance ring
14. Slacken holding screw and remove the mechanical seal rotating part
15. Slacken the bearing housing bolts fitted on casing cover
16. Remove the casing cover from the shaft
17. Remove the shaft sleeve from shaft
18. Remove the bearing covering cover
19. Remove the bearing retaining circuit IP
20. Remove the bearing housing along with bearing
21. Now, with the help of bearing puller, remove the bearing from the bearing housing.

**#Note**

1. If bearings are worn out then replace it with the new one (after discarding lace and balls of previous one). Put the new bearings in lube oil and heat it. Again, put it back in the shaft and slowly, tap it and make it fit properly in the pump shaft.
2. Check conditions of the shaft as sometime it gets bend. Hence, check it by putting it on the lathe machine that is checking its trueness.
3. Check the impeller for pitting, erosion or corrosion. If found then rectify it with *brass putty.* If impossible replace it with a new one.
4. Check the sleeve for any groove and pitting.
5. Check the wear ring clearance and replace it, if it is large
6. Check the shaft key slot
7. Check the coupling conditions

**Checks Before Starting Centrifugal Pump**

1. After all the checks, start box back the pump
2. Open the vent and inlet valve of pump. So, that all the air should get released out from casing and then close it when water starts to come out of it.
3. Check for any leakage from gland packing and casing or mechanical seal.
4. Check the alignment of pump.
5. Grease the bearing or coupling.
6. First check free hand rotation of the motor and check if it is running freely or not.
7. Give a small kick and stop it to check for any noise or vibration. Now, open discharge valve.
8. Make sure that there is a *drop-by-drop* leakage from the gland packing.

9. Now, start the pump and throttle discharge valve, check for any abnormal vibrations. Meanwhile, check the ampere of motor. When ampere drops, fully open the discharge valve.

**Checks After Starting Centrifugal Pump**

1. Check the suction and discharge pressure
2. Check temperature of the casing
3. Check for any abnormal noise and vibration

**Question 27.1: If pump shaft has worn out and no spare is present onboard. What are the actions you will take? Explain with providing reasons for such.**

Reason for pump shaft worn out

(a) Vibrations
(b) Pitting
(c) Abrasion
(d) Rubbing

A. First take-out the sleeve and replace it with new one and put 'O – ring' (new)
Temporary repair of the shaft: if shaft is of S.S, then put S.S putty

B.

a. Surface preparation to be done that includes removing of oil grease
b. Check depth of the groove
    i. if up to 25 mm shaft diameter then do 2 mm cut
    ii. if about 25 mm shaft diameter then do 3 mm cut
c. After cleaning make *dovetail* → inside girder
d. Make threads
e. Apply DEVCON metal filled epoxy (pot life – 20 minute) → that will make it hard
f. Let it dry and cure in curing time. Cut it on the lathe and do surface *finishing* using emery paper.

**Question 27.2: If coupling get worn down, what will you do if no spare parts is available onboard?**

Solution:

- If it is star coupling: put it in the opposite direction. Do not try to suddenly stop the pump.
- If it has pin and bush coupling: put a rubber inside it.

## STARTING OF EMERGENCY FIRE PUMP

There are two methods of driving the emergency pump

(a) By diesel (reserve fuel for 3 hours)
(b) By an electric motor with supply from ESB

1. Check the suction pump, whether it is fully open or not.
2. If a pump is of self – priming type (with a vacuum pump) ensure the supply tank is full which contains the priming water.
3. Close the discharge valve and open the air vent on volute casing
4. Close the vent once water start coming out.
5. Start the pump and open discharge valve gradually
6. In the self – priming type centrifugal pump, close the check valve on the attached vacuum pump line.
7. Monitor the pressure (suction and discharge) and amperage of the pump.

**#Note**

1. Most of the time, emergency fire pump will work when ship is loaded. But when the ship is in ballast condition, emergency fire pump can lose suction. We have to make sure, vacuum pump runs properly and if it runs as desired, then water will get filled in the suction line.

2. If the emergency fire pump is not taking suction, ensure vacuum pump is working as desired. The vacuum pump consists of a clutch which rotates and draws air in the pipeline. Once water start coming out, the clutch will disengage and pump keep running safely.

## RECIPROCATING PUMP

It is used in the bilge pumps, because it does not create *churning effect*. Otherwise, it is difficult to separate oil from water in oily water separator (OWS).

→ It is used for stripping duties
→ It creates high vacuum
→ It is self – priming in nature
→ Smooth flow, no churning effect
→ It can handle any liquid even air or gas

**Imp**:

A. Rate of the discharge is low but pressure is high. It is of positive displacement type pump. Relief valve is required on the discharge side.
B. Accumulator is fitted on the discharge side to avoid pulsation and ensure continuous flow.
C. As the discharge pressure rises, the air is compressed in the accumulator and as the pressure drops, the air expands. The peak pressure energy is stored in the air and returned to the system when pressure drops.

**Overhauling of Reciprocating Pump**

1. First check the availability of spare parts
2. After securing pump, *lock out* and *tag out*
3. Remove the motor after taking off all wirings

**Question 27.3: Reciprocating Pump is sucking air which creates a lot of noise. What will you do?**
Solution:

⇒ Check the bucket ring, it may be worn
⇒ Check the piston rod
⇒ Check the gland packing, whether leaking or not
⇒ Check whether pump is sucking air or not
⇒ Motor is rotating at slow speed
⇒ Pump valve is malfunction

**Question 27.4: Discharge quantity of Reciprocating pump is low. Give reasons.**
Solution:

⇒ Bucket Ring worn out
⇒ Liner worn out
⇒ Pump sucking the air
⇒ Pump valve malfunction
⇒ Motor revolution is less
⇒ Too much tightening of the gland packing

**Question 27.5: Motor get overload, what are the reasons for such?**
Solution:

(a) Pump valve malfunction
(b) Pump discharge pipe clogged

**Checks to Be Done While Overhauling Reciprocating Pump**

1. Check the valve chest for overhauling. Dismantle the valve chest and remove non returning valve.

2. Chest that is inside is to be cleaned and painted with anti – corrosive paint. Also, check valve chest for pitting, corrosion etc.
3. Valve to be lapped with the fine grinding paste with seat
4. Spring length to be check and hammer test of the spring
5. Check the shaft, accumulator, bucket, bucket – ring and liner
6. Check the gland packing
7. Note: For putting new bucket ring, place it in hot water (70 – 80°C) for some time and put it with hand gloves and press it.
8. Check the rod whether it is bent or not, corroded or not. Repair it with *Dovetail*.

## GEAR PUMP

It consists of driving gear, driven gear, casing, relief valve at the outlet. When pressure go far beyond the set pressure, the relief valve will direct the flow of liquid back to the inlet. Hence, we will get a controlled pressure at the outlet.
Because of close clearance between casing and teeth of the gears, pressure is developed and we get the pressurized fluid at the end.

**WORKING**
Fluid comes out of the inlet. When the fluid moves forward due to the vacuum created behind the teeth of two gears, it starts getting trapped inside the teeth of gears.
This trapped liquid passes through the region of fine clearance between *casing* and *teeth.* There is lack of space for the movement of liquid. This trapped liquid gets compressed and when it arrives at the outlet side, this pressurized fluid rush towards the outlet of the pump.
Relief valve checks the pressure of this outgoing fluid and acts accordingly.

Note: Tight clearance prevents the fluid from leaking backwards.

**Salient Features of Gear Pump**
1. Self – priming in nature
2. It can handle only oil, because gear requires lubrication.
3. Discharge rate is slow.
4. Direction is sensitive as the pump can't run in the opposite direction.
5. Generator or attached lube oil pump are of the gear pump type.
6. Fuel and lube oil transfer pump, boiler combustion, incinerator all use gear pump for transfer of highly viscous fluids.

**Backlash in Gear Pump**
- There is little expansion of teeth because of the heat.
- Backlash prevents overload. When pump rotates in opposite direction by mistake, there is sudden increase of load on the motor. Then, backlash will trip on overload.

**Maintenance of Gear Pump**
(a) Check the relief valve
(b) Check close running clearance between the gear and the body or teeth and the casing. If *close running clearance* is more, then *slip* will take place.
(c) Check the casing liner.
(d) Check the shaft seal, mechanical seal or gland packing.
(e) Check condition of bush bearing.
(f) Remove the cover of non – driving and put pump in upside direction.

**#Note**
- Never test the relief valve on its place. To test it, there is a separate pump provided for such.
- If the close running clearance (i.e., between teeth and casing) is more, then *slip* will take place.

**Sea Chest Mountings**

1. Vent
2. Steam connection
3. Drain
4. Compressed air connection
5. MGPS
6. Main valve

*****

# 28. VALVES

## GATE VALVE

Gate valve gives full bore flow without changing the direction. The valve lid appropriately known as *gate* is moved at right angles into flow by a screwed stem.

**#Note**
This valve is not suitable for partially open operation. Since, *wire drawing* of seat will take place.

**Overhauling Procedure**

- ⇒ Open the wheel nut and wheel
- ⇒ Open the bonnet top yoke nut
- ⇒ Open the gland nut and release gland packing pressure
- ⇒ Now open the bonnet nut and take – out the bonnet with stem from its valve body
- ⇒ Hand wheel is rotated in clockwise direction as far as possible, then hand – wheel and wheel nut can be removed.
- ⇒ Gland flange, gland Bush and gland packing can be removed with the help of gland packing extractor.
- ⇒ Take out the steam with valve lid.
- ⇒ Open the valve lid from stem as its opening depends upon the locking arrangement.
- ⇒ If there is lock nut do remove it.
- ⇒ Now, take lapping paste and apply it on the valve lid and lap it on the seat known as *grinding in.*
- ⇒ Change the gasket (body)
- ⇒ Paint it from the outside with anti – corrosive paint
- ⇒ Check the valve lid for wire drawing effect
- ⇒ Greasing and proper lubricant should be applied on the threaded parts
- ⇒ Check stem trueness with the help of *dial indicator*
- ⇒ Start boxing back
- ⇒ Clean the body with compressed air and do buffing.

**#Note**
Lapping paste → Silicon
Carborundum – 200 (fine); 500(coarse)
We add lube oil in the carborundum to make it thin. If lapping paste (rough) is not available then, we take rough emery paper of that size and remove emery and put it inside the lube oil and then use it or

(a) Gg. Buds + L.O.
(b) Wheat + L.O.



Gate Valve Uses

a. AC
b. STP holding tank
c. Sea – chest

## STORM VALVE

It is a type of gate valve. It provides positive closing.

## GLOBE VALVE

1. Valve to be isolated
2. Valve to de – pressurized by venting and bring it to workshop and keep it on vice
3. Slacken the wheel nut

4. Slacken the gland nuts
5. Slacken the bonnet nuts
6. Unscrew the gland nuts and remove them to release pressure on the packing
7. Remove the bonnet nuts and take them out
8. Now, hand wheel along with bonnet assembly is removed
9. Remove the *flex – etalic* gasket
10. Hand wheel is rotated in such a direction to close it. Then wheel nut and hand wheel are removed.
11. Rotate the stem out of the bonnet. Stem along with valve disc is taken out.
12. Gland flange, gland bush and gland packing can now be removed easily.
13. Gland packing can be removed with the help of GP extractor tool.
14. Inspect bonnet and stuffing box and clean it.

**#Note**
Check for cuts and pits on the bonnet body. Minor damages can be rectified with lapping and major damages can be rectified on the lathe machine (i.e., deeper cuts).

**Lapping Procedure**

→ Put small amount of coarse grade lapping compound on the surface plate and rotate the bonnet in *figure 8* manner and repeat this procedure several times.
→ Wipe off the lapping compound and inspect the seating surface, repeat this process many times to remove this damage.
→ Use finer grade to give smoother surface. Rotate it with light pressure.

**#Note**
Do not remove excessive metal on the lathe because Flex – Etalic gasket won't fit properly.

**Inspection**

1. Check the disk by applying thin coating of blue compound on it. Put it onto the valve and on the seat, with light downward pressure rotate it one turn and remove it.
2. Look closely at the valve seat. If proper contact is established between them, a thin blue compound on the line can be visible on valve seat with the help of a torch.
3. Now, inspect valve disc with same procedure for the proper seating. If thin line of blue comes on valve disc, valve disc is sitting properly.

**#Note**
If minor damages are present on the disc seat then use *grinding in* method. In this method, lapping compound is put on the disc, then all are put together on the valve seat. The lapping compound must be changed frequently.

4. Inspect stem bushing. In these threads of the stem rotate on the thread of bushing to open and close the valve.
5. Check the bushing threads, if they are worn then replace it.
6. Check straightness of the valve stem on the lathe with *Dial Indicator* as stem is rotated and dial indicator shows value of the worn out.
7. All the threaded surface should be cleaned thoroughly. Wire brush can be used for such.
8. Inspect the flanges of valve and pipe. Clean it with wire brush.
9. Now, paint the external surface.
10. All moving and threaded parts should be well lubricated.
11. Replace the gasket with the new one.

Hence, box back the valve.

**#Note**
Be sure to check the valve disc is in fully open condition, this prevents the disc from being driven into seat.
If the stem bushing has a grease fitting, do ensure its greasing after complete box back.

## QUICK CLOSING VALVE

Parts of a quick closing valve

- Lock nut
- Handwheel
- Spindle
- Collapsing Bridge
- Body Cover
- Threaded spindle
- Lock nut for spindle

It is a kind of pressure reducing valve. All the quick closing valve are set in open position.

**Resetting of Quick Closing Valve**

Reset collapsing bridge by turning the spindle in clockwise direction, till the release mechanism repositions itself. Slide it below the spindle nut and once this get reset a *clicking sound* will come. Hence, the lever will move in the upward direction.
Now, rotate hand wheel of the spindle in anticlockwise (ACW) direction (to keep it in open condition). Hence, resetting of quick closing valve (QCV) takes place.

**Maintenance**

1. Check proper functioning of the valve when the tank is not in working condition, whenever it seems to be necessary.
2. Wires or remote operating system should be checked for slackness and oil level respectively.
3. Quick Closing Valve (QCV) should always be checked in open position (condition). This can be done by turning the hand wheel in anticlockwise (ACW) direction until the end of the stroke. The spindle nut will be stopped by the adjusting ring. In order to ensure constant position of valve, trim gears are provided for such.

## SAFETY VALVE OVERHAUL

1. Open the lock nut and adjusting screw
2. Remove the spring
3. Remove the valve spindle
4. Separate the valve housing from valve guide
5. Remove the stop ring
6. Remove the valve flap
   Now, clean all components either with this superior kerosene or with electro cleaner.
7. Insert the valve flap and stop ring in valve guide
8. Screw the guide with valve housing
9. Insert the valve spindle and spring
10. Tighten the adjusting screw and lock nut
11. Adjust the valve to obtain correct opening pressure
12. Set the safety valve in testing device and connect the hydraulic pump to the testing device
13. Loosen the lock nut on the safety valve
14. Turn the adjusting screw till the valve closes
15. Operate the hydraulic pump and purge air in the hydraulic hose through the opening of the safety valve
16. Tighten the adjusting screw of the safety valve until the correct pressure is achieved
17. Tighten the lock nut
18. Test the valve and jot down the opening pressure

# 29. FRESH WATER GENERATOR

Boiling point of water can be reduced by reducing the surrounding atmospheric pressure. By maintaining a low pressure, water can be boiled at low temperature of about 50°C. The main source of heat for fresh water generator (FWG) is waste heat rejected by main engine carried by jacket cooling water (JCW).

**Working**

The main engine jacket water passes through the evaporator at 80°C. Feed sea water enters the evaporator through the orifice at feed inlet. Fresh water generator (FWG) consists of an *eductor* which helps in generating the required vacuum. The ejector pump helps in supplying seawater to the evaporator.

| **#Note** |
| --- |
| The vacuum is created inside a chamber where the evaporation is taking place. |

Due to the low pressure in the chamber, sea water boils and gets converted into steam. The carry over water droplets and water spray is removed by the *demister*. The separated water droplets get collected as a brine and which is extracted by the *Brine Ejector*. The steam then enters into the *condenser*, where it gets cool down from the heat exchanged by seawater. Which turns into fresh water. Distillate pump helps to pump out this fresh water from the condenser.

There are two types of fresh water generator.

- Plate type heat exchanger
- Shell and tube type heat exchanger

The condenser and evaporator are corrugated Titanium plates. These plates are corrugated with the horizontal or chevron pattern corrugation, which increases the surface area for heat exchange.

**AIR/BRINE EJECTOR**

It is used to remove air and brine from the chamber which helps in forming a vacuum.

**SALINOMETER**

- It checks the salinity of freshwater
- 3 – way valve is controlled by a solenoid. If salinity is high, water goes back to the evaporator inlet.

**Safety Equipments in Fresh Water Generation**

A. Vacuum Breaker: used for releasing vacuum when fresh water generator is shut down.
B. Relief Valve: for releasing of excess pressure
C. High Salinity Alarm: it is fitted on salinometer; when salinity of fresh water increases, it sounds the alarm.
D. Temperature Gauge: by throttling the by – pass valve, we are able to adjust shell temperature with adjusting the quantity flow.
   If, shell temperature increases – low capacity
   If shell temperature decrease – high salinity

**Methods of Fresh Water Production**

A. Reverse Osmosis
B. Low pressure evaporator/distillation
C. Physio – dialysis
D. Ultra – dialysis
E. Ultra – filtration

**#Note**
Sodium hexa-meta phosphate synthetic polymer = descaling compound/liquid.
After using *Descalax* always neutralize it with alkali water. *VAPTREAT* = 40 ml/ton or 40 ml/$m^3$ phosphate solution.
15 ppm = 15 parts per million or 15 mg/litre or 15 ml/ton.

| Osmosis | Reverse Osmosis |
|---|---|
| If pure water and salt water are separated using a semi – permeable membrane, pure water flows into salt water through a semi – permeable membrane to maintain the *Osmotic Pressure*. This is known as osmosis. | The flow direction in osmosis can be reversed by applying pressure in salt solution. Then the water from salt solution is forced to flow into the pure water through the semi permeable membrane. This process continues till the osmotic pressure of salt solution becomes equal to applied pressure. |
| Movement: Low concentration to high concentration. | The normal osmotic pressure of sea – water is 28 bar and it increases with increase in salt concentration.<br>Movement: High concentration to low concentration. |

Treatment of Water for Drinking Purpose

- Use of chlorine
- Silver ion method
- UV rays
- Ozone sterilization

All the above methods kill bacteria.

**#Note**
Water produced from fresh water generator is a kind of light acid. We need minerals like Fe, Ca, Mg, K to be added for the taste purpose. We remove this acidic nature of water by adding alkali substances(i.e., neutralizer).

**Pressure Testing**

1. Shell
   0.5 bar compressed air is given from vacuum breaker and then close it. Relief valve is set at 0.6 bar, it will lift when more pressure is given.
   Apply soap solution around the joints and packing. Observe the position of bubbles formation.
2. Condenser
   Open end cover on both sides and apply soap solution on tubes. Run ejector pump and close sea water outlet. Crack open sea water inlet to the condenser.
   The leakage in the particular tube will be detected when bubble is formed.
3. Evaporator
   Open end cover and close jacket cooling water (JCW) outlet and crack open inlet and check from where water is coming.
   or
   Close inlet and outlet of the jacket cooling water (JCW). Operate it at 1 bar pressure and apply soap solution on tubes, bubble will form if there is any leakage.
   Or
   Remove bottom cover and start jacket cooling water pump @ 3.5 bar, jacket cooling water is outside the tubes. If leakage is there, it will leak *drop by drop* from the tube. This denotes the leaking tube.

**TROUBLESHOOTING**

| High Salinity | Capacity Drop | Loss of Vacuum |
|---|---|---|
| 1. Salinometer is defective<br>2. Shell temperature decreases<br>3. Jacket cooling water temperature increase<br>4. Pressure too low<br>5. Fresh water generator running at near shore<br>6. Condenser tubes leaking | 1. Flowmeter defective<br>2. Distillate pump defective<br>3. Drain valve left open<br>4. Increase in Shell temperature<br>5. Scale formation in condenser or heating tubes<br>6. Flow rate of Jacket cooling water is low<br>7. Solenoid is leaking | 1. Vacuum breaker open<br>2. Ejector pump building less pressure<br>3. Choked Air ejector nozzle<br>4. Leaking Gasket |

**Starting Procedure of Fresh Water Generator**

1. Open inlet and outlet valve ejector pump. Open the overboard valve.
2. Start ejector pump.
3. Check the vacuum breaker that is closed and wait for the vacuum to build up at least 95% of the rated value.
4. Crack open the feed inlet valve.
5. Fully open the jacket cooling water outlet.
6. Close the bypass valve $1/4^{th}$ and simultaneously open jacket cooling water inlet valve $1/4^{th}$
7. Slowly, close the bypass valve. Fully open the jacket cooling water inlet valve.
8. Initially, vacuum drops around 69 mm of Mercury (Hg) and there is rise shell temperature.
9. Observe evaporator site glass and find the fine mist of vapour
10. These vapours encounter the baffle plate and prevent water droplets from passing down to the condenser.
11. The vapours passing inside condenser through the *demister*. Water droplets carrying salt is trapped in the *demister*.
12. This vapour condenses over the condenser tubes.
13. When water come down below the condenser. Switch ON the salinometer.
14. Open the drain valve of the distillate pump.
15. Keep the discharge shut while operating distillate pump.

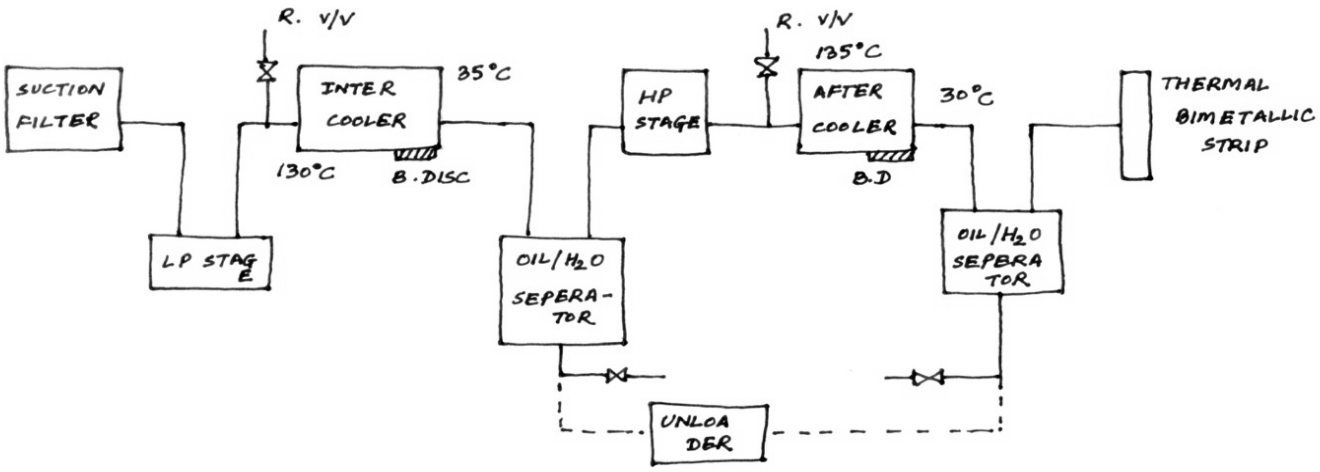
Initially, when salinity is high, keep drain valve open and once salinity get reduced to 2 ppm and sterilizes. Open the discharge valve of collection tank, close the drain valve.

**Stopping of Fresh Water Generator**

1. Close inlet and outlet of the jacket cooling water (JCW). Open bypass valve.
2. Switch off the salinometer and stop the distillate pump.
3. After 2-3 min, stop the ejector pump and close all the valves (i.e., inlet, outlet and overboard [OVBD])
4. Open the vacuum breaker.
5. Open the drain valve of evaporator.

*****

# 30. COMPRESSOR




We use the intercooler to remove excess heat from the cylinder liner. 1MPa = 10 bar

## ROTARY COMPRESSOR

In Rotary compressor

- We can compress air up to 6 bars (every stage) only. After every 6 bar there is a requirement of more intercooler.
- Maintenance is less required

Whereas, in reciprocating compressor

i. First stage operates at 6 bar
ii. 2nd stage operates at 36 bar

Hence, more maintenance is required in reciprocating compressor.

It is better to make 1st stage rotary compressor and 2nd stage reciprocating compressor respectively.

Volumetric efficiency ($\eta_v$) = $\frac{actual\ volume\ of\ air\ drawn\ in\ LP\ (suction\ stroke)}{stroke\ volume}$

We are not compressing air directly up to 30 bar, as more return stroke is ineffective.
When return stroke pressure is less than the atmospheric pressure, only fresh air will enter into the system.

**FREE AIR DELIVERY**
Amount of the air getting discharge from the first stage of air compressor.

**Safeties in Air Compressor**

1. Suction filter
2. Relief Valve
   It prevents breakdown of compressor, if operating air pressure is more than the designed or working pressure of the air compressor.
   It is fitted after the discharge of every stage.
3. Bursting Disc
   It is fitted on the water side of intercooler and aftercooler. Air flow on the tubes and water flows on outside – relieving the pressure when tubes burst.
   **Note**: To regain normal relief pressure, we need to do *annealing of bursting disc* (i.e., made up of Cu)

4. Automatic moisture drain valve
   Fitted on oil/water separator to drain moisture
5. Motor overload trip
6. Cooling water high temperature alarm and trip
7. Low Lube oil pressure alarm and trip
8. Cooling Water supply failure alarm
9. Delivery air high temperature alarm and trip on aftercooler outlet

Methods of Removing Moisture

- Pipe is made folded to remove moisture
- Cooling
- Vortex
- Directional
- Coalescence
- Coagulen

**Question 30.1: Why unloader is fitted?**
Solution:

A. It automatically drains moisture
B. It prevents overload of the compressor
C. It reduces the startup wear. Thus, reduction in motor size.
   (i.e., No lube boil is present on the bearing during staring of the compressor. After sometime lube oil will get dispersed. During starting, bearing metal will worn out and metal to metal contact will take place. To avoid such situation the unloader is fitted.)

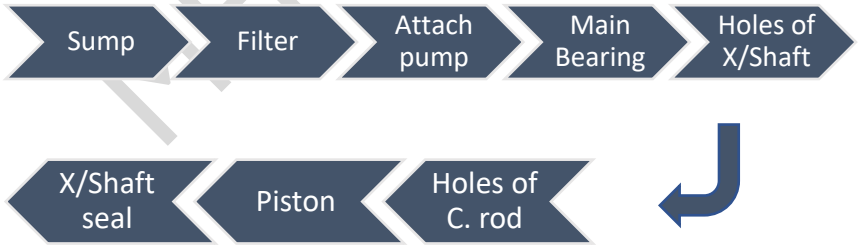
| **#Note** |
| --- |
| If unloader does not function properly, open drain of intercooler and aftercooler. |

Types of Unloader

- Drain type valve
- Suction type open valve
- Magnetic unloader

When valve opening → unloading take place
Valve closing → loading take place

## LUBRICATION IN COMPRESSOR




## BUMPING CLEARANCE

It is a clearance measured between top of piston and cylinder head of an air compressor, when piston is at TDC. It is generally 0.5 to 1% of the cylinder bore. The bumping clearance is needed because of the following reasons:

- To prevent mechanical damage to the compressor
- To provide necessary space for the valve operation
- Provide for thermal expansion

**#Note**: It must be kept as small as possible to achieve the best compressor efficiency.

**Procedure for Taking Bumping Clearance**

(a) Stop temperature and take – out fuse and *lock out* and *tag out*
(b) Drain cooling water
(c) Remove the cylinder cover and cylinder head face
(d) Place lead (Pb) wire ball on top of the piston
(e) Then place back cylinder cover on the cylinder head and tighten all head bolts with proper torque.
(f) Now turn the compressor by hand with the help of Tommy Bar and bring the piston to TDC and lead ball will get compressed.
(g) Remove the cylinder cover, lead ball will get compressed and take down the measurement of lead wire ball thickness with the help of micrometer.
(h) This measurement will give bumping clearance

**Question 30.2: How to adjust bumping clearance**?

Solution:

- Thickness of the cylinder head gasket can be changed
- Add or remove shims between the foot of the connecting rod and bottom end bearing.

| Bumping Clearance is more | Bumping clearance is less |
|---|---|
| Extra clearance would result in small volume of air being re-expanded every time causing increase in air temperature, efficiency decreases and overheating of compressor will take place.<br>Suction valve will not open, as air trapped inside is more and atmospheric pressure is low. | Volumetric efficiency increases the risk of piston hitting the cylinder head. Especially when compressor is unloaded during the start and stopping procedure. |
| Reasons for bumping clearance increase<br>• Wear down of the main bearings. This will lower the crankshaft and would thus lower the piston.<br>• Wrong Gasket fitted, when opening of the cylinder heads. | Reasons for bumping clearance decrease<br>• Wear at the crank pin bearing. The crank pin bearing wear down due to the use and this clearance can travel right up to the piston and can hit the cylinder head<br>• This type of wear can be recognised when the compressor makes impact sounds while running unloaded at the starting and stopping operation. |

**COMPOUND VALVE**

It works as both the suction and discharge valves. It opens inside during suction and during discharge it opens outside.

Advantages

1) Volumetric efficiency increases, valve get open and close in less time
2) Less bumping clearance
3) Reduced wear and tear
4) Give larger area to valve opening. Small amount of valve lift.
5) Compact build

## TROUBLESHOOTING

**Reasons for Decrease in Volumetric Efficiency**

- Air filter choked
- LP inlet air temperature is high
- Inlet water temperature is high
- Restriction in the intercooler
- Restriction in the discharge line
- Sluggish opening and closing of the suction and delivery valves
- Piston ring is defective
- Bumping clearance is more. Suction valve will not open (as less air is discharged per stroke).

| LO Pressure Low | CW Temp. High | Compressor Noisy |
|---|---|---|
| 1. Pressure gauge faulty<br>2. Lube oil level low<br>3. Leakage in pipe<br>4. Filter choked<br>5. Gear pump faulty<br>6. Increase clearance of bearing | 1. Temperature gauge faulty<br>2. No flow of cooling water<br>3. Cooling water pump faulty<br>4. Valves closed<br>5. Cooling water pipes blocked<br>6. Low level of cooling water in expansion tank | 1. Bumping clearance is less<br>2. Bearing worn<br>3. Piston ring broken<br>4. Valves defective<br>5. Valves not seated properly<br>6. Liner broken<br>7. Discharge pressure high |

**Multistage Compressor Advantages**

1) To get more pressure
2) Size of the compressor decreases
3) Lubrication is good
4) Wear down to compressing is less
5) Volumetric efficiency increases
6) Mechanical efficiency is better
7) Heat removal will be very easy. Hence, less thermal stress.

## OVERHAULING OF COMPRESSOR

1. Make sure all spare parts are available on board. Which includes joint, gaskets, major spare parts such as piston, piston – ring, bearings etc.
2. Copies of previous survey reports, running hour since last survey, recorded clearances and planned maintenance reports to be ready.
3. Isolate compressor both mechanically and electrically. Lock it and tag it out. '*Men at Work'* notice are posted.
4. Drain the lube oil in clockwise direction
5. Remove cylinder head, valves (suction and discharge), connecting rod
6. Gudgeon pin and top end bearing are removed from the piston
7. Remove the piston rings
8. Inspect all parts after cleaning
9. Safety devices are checked
10. Hydraulic testes can be used to test opening pressure of relief valves
11. Inspect *piston*, *liner*, *bearings* and replace them if necessary
12. Inspect *piston rings* and measure butt and axial – clearances
13. Check suction and discharge valves and overhaul them
14. Soak all parts of valve in kerosene or diesel oil

15. Clean all parts with soft brush, in case of the hard deposits use a copper plate of washer for scrapping action.
16. Check the valve plate and valve seat for any damage and cracks.
17. Valve plate and valve seat must be separately lapped using a fine grinding paste (CORANDUM).
18. All parts of valves must be cleaned with compressed air. Then valves must be assembled. Operationality of valve can be checked by pressing it with wooden stick to see whether it lifts fully or not.
19. Check valves for any leakage (i.e., space above valve plate is filled up with lube oil. If after sometime no drop in level/ leakage occurs, then valve is considered to be fine).
20. Check bumping clearance
21. Clean crankcase and replace its suction filter. Renew crankcase oil.
22. Conduct initial running of compressor in unloaded condition. Do check motor, ampere, noise etc. load the compressor and check for bearing overheating, test run the compressor and measure time taken to fill the air bottle (from empty to full).

| Suction valve | Discharge valve |
|---|---|
| 1. Split pin | 1. Split pin |
| 2. Castle nut | 2. Castle nut |
| 3. Washer | 3. Washer |
| 4. Valve seat | 4. Buffer plate |
| 5. Dowel pin | 5. Spring plate (3) |
| 6. Guide washer | 6. Damper plate |
| 7. Valve plate | 7. Valve plate |
| 8. Damper plate | 8. Guide washer |
| 9. Spring plate (3) | 9. Locating pin |
| 10. Buffer plate | 10. Valve seat |
| 11. Centre bolt | 11. Centre bolt |

**#Note**
Both valves look similar but direction of operation and spring stiffness are different.
Suction valve springs are of lower stiffness.

**STARTING OF COMPRESSOR**

Pre-Checks

1. Check lube oil in the crankcase sump
2. Check all valves (i.e., cooling water and filling valve), all are to be in open condition
3. Check manual drain valve to be in open condition
4. Check all alarms and trips (LO low pressure trip, CW HT trip, overload trip)
5. Check all Pressure Gauge and temperature sensor
6. Check the air intake filter to be cleaned
7. Check the generator load
8. If generator not started for a long time then it must be turned ON for few revolutions with a Tommy bar for free movement of its parts.
9. Press START button
10. Now compressor is started

During Checks

1. Check the pressure gauge for Lube oil (2.8 bar) and CW (3.0 bar)
2. Check the cooling water temperature (30 – 40°C)
3. Check for any leakage of cooling water and lube oil
4. Check for any abnormal noise and vibration
5. Check the air temperature after final stage

6. Check low pressure and high – pressure delivery air pressure
7. Check the air bottle pressure. This is time to know the compressor efficiency
8. After checking all this, put compressor in *AUTO mode.*

During starting of the motor, the starting current is too high. To avoid the overloading of the motor, compressor is started in unloaded condition. When the drawing current is reduced, unloader is closed and compressor is put on load.

**STOPPING OF COMPRESSOR**

(a) Put the compressor in *manual mode*
(b) Put the compressor in *no load* condition
(c) Press STOP
(d) Drain each stage separately
(e) Close filling the air bottle valve

**Question 30.3: Compressor is taking long time for filling. Mention reasons for such.**
Solution:

1) Suction filter choked
2) Cooling water temperature is high
3) Filling valve leaks
4) Filling line choked or hole in line
5) Compressor drain valve open
6) Air bottle drain valve opened
7) Cylinder head gasket leaking
8) Piston ring broken
9) Restriction in the intercooler
10) Relief valve leak, setting set is low
11) Main engine, G/E air valve leaks
12) Deck open

**Question 30.4: What is the free air delivery (FAD)?**
Solution: Capacity of air compressor is mentioned in unit of $m^3$/hr. The volume of air actually discharged in one hour, that would occupy if expanded(air) down to atmospheric pressure and cooled to atmospheric temperature.

**Question 30.5: Mention safeties used in reciprocating compressor.**
Solution:

1. Lubricating oil pressure low cut out
2. Busting disc
3. Non-return valve in delivery line
4. Discharge unloader
5. Relief valve on intercooler
6. Fusible plug
7. High temperature alarm

## AIR RECEIVER

There are two main air receiver and one emergency air receiver.
Capacity: must be sufficient to give at least 12 starts for reversible engine and at least 6 starts for or non – reversible engine.

**Mountings of Air Receiver**

A. Pressure gauge
B. Access doors
C. Manual or automatic drain valve

D. Filling valve
E. Main starting air valve, auxiliary starting air valve, service air valve
F. Compensation ring
G. Fusible plug → Tin + Pb + Bi (HP ~ 104.4°C), fitted at the bottom of the reservoir
H. Atmospheric relief valve → backup for fusible plug
I. Compensation ring
J. Spring loaded safety valve → setting pressure 32 bar (for 30 bar working pressure) fitted directly or with extension on air bottle

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# 31. OILY WATER SEPERATOR

**STARTING PROCEDURE**

An oily water separator can only be operated when ship is sailing or enroute. According to MARPOL, the oil content of the effluent must be less than 15 PPM and ship has an operation and ODMCS and oily water separator/ filtering equipment

1. Inform bridge to note down the timing and position of the vessel.
2. Oily water separator (OWS) overboard manual discharge valve is to be kept locked and keys are to be with the chief engineer
   Therefore, open the lock and overboard valve. Open all the valves in presence of chief engineer.
3. Open the desired bilge tank valve from which the oily water mixture is to be discharged from OWS.
4. Open air, if control valves are air operated.
5. Switch ON the power supply of the control panel and OCM unit.
6. Fill the separator and filter unit with fresh/sea water to cleanup and prime the system until the water get coming out from the vent of 2nd stage.
7. Start the OWS supply pump, this supplies oily water mixture to OWS.
8. Observe the OCM for ppm value and keep checking on sounding of bilge tank and OWS sludge tank from where OWS is taking suction.
9. A *sample collecting* valve is provided just before overboard valve and after the 3 – way valve. Keep a check on the sample for any affluent and clarity.
10. Keep a watch on the ship side at overboard discharge valve.
11. After the operation, switch OFF the power, shut and lock the overboard valve and their keys are to be handed over to chief engineer.
12. Entry to be made by chief engineer in ORB with duly signature of Operating Officer, Chief Engineer and Master.

Filters used in OWS are

| Coalescence Type | Absorption Type |
|---|---|
| → Hydraulic material i.e., glass wool | → Oleophilic material |
| → Separates water rather than oil | → Separates oil rather than water |
| → Has to be renewed after certain period | → Frequent replacement is not required |

OWS consists of three major parts:

(a) Separator
(b) Filter
(c) Control unit

There Are Two Main Compartments

- Separator Unit
  Consists of coarse separator with baffle plate which accumulates small oil particles.
- Filter Unit
  Consists of coalescence filters where impurities get trapped into separator, later removed manually.

Control Unit consists of two separate unit namely, control device and monitoring device. This consists of *test chamber*, *mixing pump*, *light source*, *controller* with inputs form *discharge rate*, *ship speed*, *oil content*.

**WORKING OF OWS**

In this separation takes place in two stages

1. First stage is done by gravity separation and second stage separation is done by coalescence filter.
2. Bilge pump delivers clean sea water or freshwater to the first stage of separator through the inlet valve. Vent valve is kept in open condition, so that all air get released and water is removed out of it. Then close the vent.
3. Now, oily water is supplied to the first stage, where gravity separation take place. Oil gets collected on the top of first stage and the remaining oil get collected or sticks on the baffle plate when water passes to the second stage. Oil droplets from plates tend to travel in upward direction towards oil collection space.
   **Note**: Oil from top of the chamber is automatically drained to the oil tank where the level reaches to the bottom of the console.
4. The oil drain valve on the top of first stage is a diaphragm controlled. Piston valve and control air is supplied to diaphragm through a solenoid operated pilot valve.
5. Capacitance probe senses the oil quantity in collection space and energizes the solenoid through the control switch.
6. Water passes downwards from the first stage to the second stage coalescence via a central pipe.
7. In the first chamber oil content is reduced to 100 PPM.
8. Filter in right chamber removes solids and oil. The coalescence filter on the left chamber removes remainder of the oil in the form of small droplets, which coalescence to form a large droplet. These all rise above to the oil collecting space.
9. At the outlet there is a 15 PPM alarm both in audio and visual.
10. The water is not thrown directly into the sea. OCM is set at 15 PPM, if oil content is less than 15 PPM, then only the overboard valves will get open and water get discharged over board. If oil content is more than 15 PPM, 3 – way solenoid valve gets activated creating alarm sound in the engine room. Meanwhile, it opens the bilge tank valve and closes the overboard valve.

The relief valve on each stage is fitted to prevent the separator from getting over – pressure and accidental discharge.

## SIPHON BREAKER/ANTI-SIPHON VALVE/VENTED LOOP

**SIPHON**

It is an inverted *U – shaped* pipe, which can cause liquid to flow in upward direction above the surface of reservoir without the help of pump.

**Use of Siphon Breaker in OWS**

When outside head is more, it won't allow oily – mixture to go out(overboard). When OWS is stopped and when outside need is less, it allows the oily water mixture to go out and pollute the environment. Hence, we don't prefer this to happen, to prevent such we use *Siphon Breaker*.

In siphon breaker air is filled into pipe and water level drops away from loop on both sides thus preventing *siphon* to occur.

Mountings of OWS

- Capacitance probe (oil level)
- Air vent
- Relief valve
- Test cock
- Drain valve
- Solenoid
- Diaphragm
- 15 ppm monitor

| Zero setting of OWS | Span setting of OWS |
|---|---|
| Pass the freshwater, it will show 0 PPM. | Pass liquid whose ppm is known. |

**#Note**
This is done to check the working condition of the sensor.

**Maintenance on OWS**

1. Cleaning of the chamber surfaces as oil sticks to them
2. Checking of the OMS
3. Checking of sensor
4. Regular changing of oil absorbing material
5. Checking of the valves which are used to regulate the flow.

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# 32. SEWAGE TREATMENT PLANT (STP)

It consists of three chambers

(a) Aeration: filled up with the sludge
(b) Settling: sludge accumulated and water goes back to the aeration compartments and water get separated.
(c) Sterilization: chlorine tablets

There are 2 types of bacteria

| Aerobic | Anaerobic |
|---|---|
| ▪ These bacteria require free $O_2$ to survive.<br>▪ They breakdown the organic matter to produce safe products such as $H_2O$, $CO_2$, inert residue and energy to synthesise new bacteria.<br>▪ These bacteria become more dangerous while doing maintenance. Always do maintenance in the presence of ventilation. | ▪ These bacteria only multiply in the absence of free $O_2$ as they utilize chemically bound $O_2$ to survive.<br>▪ They breakdown the organic matter to produce $H_2O$, $CO_2$, $CH_4$, $H_2S$, $NH_3$. This process is known as *putrefaction.* The products thus formed are noxious and toxoids. The effluent is of the poor quality and is highly corrosive. |

**COLIFORM COUNT**

Coliform is a type of micro-organism which is present in the human intestine and is recognised as an *indicator organism* of sewage pollution. Presence of these organism in the water is an indication of *pathogens* which are disease causing bacteria responsible for cholera, dysentery, typhoid etc.

Number of coliform organisms present in the sewage on ship is very large. Each person contributes around 125 billion in winter and 400 billion in summer. IMO recommends fecal coliform count of less than 250 faecal/ 100 ml of effluent after treatment.

**BIOLOGICAL OXYGEN DEMAND (BOD)**

It is a test to identify the *biological decomposable substance* and to test the strength of the sewage. It can also be defined as the amount of $O_2$ required by a microorganism in the stabilization of organic matter.

**#Note**
Purpose: When we discharge the water out, aerobic bacteria should not go alive.
BOD (raw sewage) = 300 – 600 mg/litre

IMO recommends BOD of less than 50 mg/litre after treatment through sewage treatment plant. Results are expressed as the *amount of $O_2$ taken by 1 litre sample when incubated at 20°C* for 45 days.

**TROUBLESHOOTING**

If the sewage treatment plant (STP) blower got damaged then there is one stand by blower for such emergency use.


Chamber operates in the range of 0.5 bar to 0.8 bar

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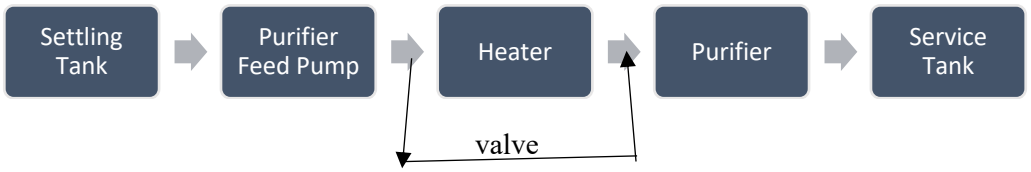
# 33. PURIFIER




The purifier is used to separate two different density fluids and particles with the help of centrifugal force. It works on the principle of Stocke's law

$$\frac{\pi}{6} \times D^3(\rho_w - \rho_o) \times r\omega^2$$

Where, $D$ is the diameter of particle to be separated
$r$ is the center to interface distance

Factors Affecting Separation Are

- Density
- Viscosity
- Feed oil inlet temperature
- RPM of rotating bowl
- Throughput of oil feed
- More time provided for better separation
- Back pressure

**#Note**
More is the density difference, better will be the separation.

| Purifier | Clarifier |
|---|---|
| It is a centrifuge used to separate water and solid impurities from the oil. Three connection at top<br>a. Clean oil<br>b. Dirty oil<br>c. Water | It is a centrifuge used to separate finer solid from the solid impurities from oil. Two connection at top<br>a. Clean oil<br>b. Dirty oil |
| Interface | No Interface |
| Sealing of the water is required | No Sealing of the water required |
| Blind disc at top of disc stack | Blind disc at bottom of disc stack |
| No water transducer | Water transducer |

**PARTS OF PURIFIER**

**Disc Stack**

Provide more surface area for the better separation. Reduces settling distance so that dirt can reach up to the periphery easily.

**Interface Line**

It is an imaginary line where clean oil and dirty oil separates. For better purification, it should be formed just inside the top disc outer circumference.

**Water Transducer**

It measures water quantity in oil (basic difference is conductivity).

**Low Pressure Switch**
0.8 bar or leakage monitor switch. Oil come from water side. So, that sludge tank fills and sounds the alarm. To prevent such *low-pressure switch* is there on clean oil outlet (low pressure switch bypass three – way valve)

**High Pressure Switches**: 1.2 bar

**Resilient Mounting**
Vibrations occurs when operating at the critical speed range. There is a rubber cushion so, that purifier vibration should not get transmitted to the other machinery.

**Paring Disc**
It is a centripetal pump which converts the kinetic energy of purified oil into the pressure energy. It is a stationary impeller mounted in a chamber at the neck of a bowl. In this, casing is rotated.

**Friction Clutch**
This ensures gentle start and operation of the machinery. It is made up of *ferrodo lining*. It is provided so that motor will not get overheated, when it gets overheated clutch slips. Gradually, the load come on to the motor. At the time of starting, high torque is required to rotate the bowl and sometime bowl is heavily loaded due to accumulation of sludge.

Safeties in purifier

1. Feed pressure low
2. High oil temperature
3. Low oil temperature
4. Heavy phase overflow
5. Back pressure low shutdown
   This measures discharge oil pressure and alarms and initiates a shutdown when below a set value.
6. Back pressure High shutdown
   This measures the discharge oil pressure and alarm and initiate a shut down when the valve is higher than a set value.
7. Emergency brake
8. Bowl not opening
   It can be done in following way: By measuring the motor current, when bowl opens, the bowl speed is dragged down due to friction effects of the discharging sludge and water. The motor current rises until the full speed is re – established. This is detected by a current sensing relay.
9. Water-in-oil
   It has a detection probe mounted in the oil discharge.
10. Low control/ seal water pressure

## GRAVITY DISC OR DAM RING

It maintains the interface between oil and water by applying back pressure on the water side. It is done with the help of inner diameter of gravity disc.

Case 1: Gravity Disc Diameter Increased
Oil pushes water outside, it will escape the bowl. The force exerted by oil will push the oil/water interface towards the periphery.
Case 2: Smaller Diameter of Gravity Disc
Water pushes oil inwards and the interface moves toward the center.

**Disc**
These discs are provide in such a way that cleaned and purified oil move towards the upward direction in a separate path through the holes that are cut into them.

**Distributor**
Feed oil is introduced through the feed inlet pipe and the distributor to the main bowl chamber.

**Purifier RPM**
15000 – 18000 rpm

**Motor RPM**
2000 – 5000 rpm

**Horizontal Shaft**
It is connected with the motor via a frictional block arrangement. Bearings in the bearing housing are provided at two ends of the shaft. Spiral gear is fitted between them.

**Vertical Shaft**
The revolution of horizontal shaft is transmitted and increased by the vertical shaft gear teeth. The bowl rotates at the top. Bowls are supported by the upper bearing housing arrangement.

**Throughput**
If the feed rate is excessively increased, the increased feed rate will increase the mass of fuel. This increased fuel will exert more force to push the water out of the bowl and this will cause the oil-water interface to move towards the periphery and cause an overflow.

> **#Note**
> High feed rate reduces the purifier efficiency. Normally, the feed rate should be 110% of the fuel consumption.

**Temperature of Fuel**
It plays an important role to maintain oil – water interface. If the temperature increases, the density of oil decreases. The force exerted by the oil reduces, this lead oil/water interface to move towards the center.

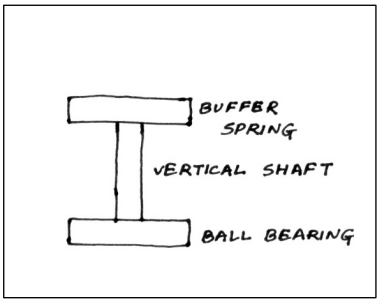
Selection of Inner Diameter of Gravity Disc

1. Monogram
    a. Specific gravity
    b. Separating temperature
    c. Gravity disc inner diameter
    d. Feed rate
2. Table method/trial method
3. Formula

$$D_2 = \sqrt{D_1^2 \frac{S_1}{S_2} + D_3^2 (1 - \frac{S_1}{S_2})}$$

## VERTICAL AND HORIZONTAL SHAFT ASSEMBLY

Purifier bowl is mounted on the vertical shaft. The bowl is driven on a keyless taper which is secured by a lock nut. The upper part of vertical shaft is supported by a bearing with 6 springs that is known as *buffer spring*. These are located in a radial direction. They absorb the vibrations in the horizontal direction. The lower part of the vertical shaft is supported by the ball bearing to absorb the *vertical thrust*.




Between the upper bearing and lower bearing, a *worm gear* is located on the vertical shaft and *worm wheel* is situated on horizontal shaft. This worm wheel is in exactly in mesh with the *worm gear*.

Horizontal shaft is supported by a ball-bearings on both the ends just to support and allow its rotation. The end of horizontal shaft is attached with the feed pump and other end have friction block which acts as a brake drum.

**FRICTION CLUTCH ARRANGEMENT**

It consists of a friction drum mounted on the horizontal shaft. Three friction pads are contained in a friction drum and these are mounted on the motors shaft. Friction pads have a curved surface with *Ferado Lining*.

When motor starts, the friction pad falls out due to the centrifugal force and it starts to touch the inner surface of friction drum. Thus, causing friction on the internal surface of the friction drum. By friction and slipping, this arrangement starts to drive the horizontal shaft. So, that a gradual account in the speed of horizontal shaft is achieved. As the motor speed reaches at maximum, the centrifugal force on pads also reaches the maximum value, creating maximum friction which gradually brings the horizontal shaft to the rated speed.

The clutch will slip if there is any obstruction on the bowl or on the drive assembly.

**Question 33.1: How to change the friction pads?**

- ⇒ Isolate the purifier motor and take – out the fuse
- ⇒ Open the terminal connection in a terminal box and mark the wire connection
- ⇒ Now open the motor foundation nut, motor casing nut and take – out motor with the help of friction pulley
- ⇒ Open the friction pulley locking and take – out friction pulley from motor shaft
- ⇒ Now remove friction pad and replace it with the new one

Remove the snap ring, then cover snap ring and friction blocks/pads respectively;
For, 50Hz = 5 friction blocks
60 Hz = 3 friction blocks
Motor shaft is coupled with horizontal shaft on which friction pad pulley is present.

## STARTING PROCEDURE OF PURIFIER

Pre checks

1. Check the gear case oil
2. Check all the fittings are in right manner
3. Release the brake
4. Check the direction of rotation
5. Ensure lines are set from the settling to service tank
6. Start purifier feed pump and put 3 – way valve in the recirculation mode, settling tank
7. Open the steam valve for heater
8. Start the purifier and check for any vibration, abnormal noise and check amperage and wait for it to come to normal rated value.
9. Check the feed oil inlet temperature and if it is not desirable, then adjust it to attain such
10. Check the RPM on the panel
11. Now, start the desludging mechanism, give displacement water as its inlet with the inlet of oil and this displaces all the purified oil to the service tank and stop it after sometime. This is done when purifier is not overhauled.
12. Stop operating water (bowl closing water)
13. Give bowl opening water for a few seconds during which water flows on the top of operating slide. The water force exceeds the spring force and it presses the operating slide in downward direction. This causes the entire bowl closing water/ operating water to discharge through nozzle. Thus, causing the sliding bowl to move in downward direction, leading to the opening of sludge ports. Thus, sludge is discharged through this sludge ports.

Hence, desludging take place.
14. Supply the bowl closing water at the bottom
15. Give the sealing water until it comes out of water outlet
16. Start giving feed to the purifier
17. Wait for the back pressure to build up and adjust it accordingly
18. Adjust the throughput, feed oil temperature
19. Check the amperage, gear case oil level and vibration and sludge ports for overflow of the dirty oil.
20. Desludge it after every 2 hours for heavy fuel oil and 4 hours for lube oil respectively.
21. Change over clean oil filling valve to the service tank

**STOPPING PROCEDURE**
1. Stop the steam inlet of heater
2. Stop the feed and de-sludge
3. Stop the purifier after filling of bowl with water
4. Apply brake and bring purifier to the rest
5. If any emergency happens, 'Emergency Stop' button is pressed.

**Question 33.2: Purifier is overflowing? What are the actions you will take?**
Solution:
1) Acknowledge the alarm
2) Changeover 3 – way valve from the purifier inlet to recirculation
3) Check the temperature of feed oil temperature, if not adequate then arrange for such
4) Check the RPM, this can be done by checking the amperage
5) Check the feed rate/ throughput
6) After correcting the RPM, de-sludge the purifier and start it again.

**TROUBLESHOOTING**
**Purifier Overflow, Reasons are**
1. Incorrect gravity disc size
2. Heavy bowl (excessive sludge)
3. Feed oil temperature not maintained
4. Excessive throughput/ feed rate
5. Density of the oil changes
6. Sealing ring worn down due to the aging or cut (bowl and hood)
7. Sealing water not given
8. Low RPM of bowl due to the friction pad worn out
9. Friction clutch finishing take place
10. Vertical height changes
11. Single phasing of motor
12. Solenoid not working properly
13. Excessive back pressure of service tank valve closed

**Purifier Not Picking Marked RPM. Reasons.**
1. Single phasing
2. Motor running overloaded
3. Friction clutch worn out
4. Vertical and horizontal shaft not aligned properly
5. Bearings worn down
6. Excessive sludge in bowl
7. Sump level too high
8. Brake is touching
9. Fiction pad worn out
10. Motor low voltage/ current

**Purifier Vibrates While Stopping**

1. Uneven distribution of the sludge
2. Critical speed
3. At the time of starting purifier, big gear drives the small gear. And during stopping, small gear drives the bigger. Due to the generation of intensive stress, worm and worm wheel arrangement may break. To prevent such, we put *brakes* on smaller gear.
4. Bearings worn out (i.e., on vertical shaft)
5. Buffer spring are gone (6 in No. present on top of vertical shaft to prevent horizontal vibrations)
6. Foundation bolts damaged

**If Vertical Shaft Height Increases Then**

Space for the operating water for closing bowl decreases. Hence, the sludge port will not close properly and overflow of oil will take place.

**If Vertical Height Decreases Then**

Space for the operating water for opening bowl decreases. Hence, the sludge port will not open and sludge discharge will not take place. The sludge accumulation and water will flow towards the oil side and thus leakage occurs.

| **#Note** |
| --- |
| If the vertical height changes, closing water or opening water holes get mismatch. Therefore, no water will go in purifier and overflow will take place. |

**Where interface form**

Outside the disk stack and inside the top of the disc.

Types of Water

- Displacement water
- Sealing water
- Bowl closing water/ operating water
- Bowl opening water/ de – sludging water

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*---------Supplementary Reading--------*

# A. BOILER WATER TEST

Reasons

A. This is done to prevent scale formation in the boiler and fresh water system (Trisodium phosphate).
B. Prevent corrosion in the boiler (NaOH is used)
C. To monitor the condition of the boiler water
D. To remove the traces of $O_2$ (Sodium sulphide or hydrazine is used)
E. To prevent entry of the foreign particles such as oil, waste, sand, copper particles in boiler
F. Prevent the sludge formation and carryover with steam

## TEST

A. Alkalinity test
    a. P – alkalinity (OH & $CO_3$)
    b. T – alkalinity (Bi – carbonates, OH and $CO_3$)
B. Chloride test: how much salt is present
C. Phosphate test: it can cause foaming and priming
D. Condensate pH test
E. Hardness test

### ALKALINITY TEST

This test is carried out to ensure the alkaline condition of the boiler water. This test ensures that boiler water prevent corrosion by neutralising acidic gases.

1. Partial alkalinity/P – alkalinity
   It gives alkalinity of the sample due to OH and CO3. It gives warning against high concentration of NaOH and subsequent damage to boiler from caustic embrittlement.
   It tells,

   $\therefore$ppm of $CaCO_3 = \frac{n}{50} drops\ of\ H_2SO_4 \times 10$
   where, *n* is molecular weight and 50% denotes dilution

2. Total alkalinity
   It gives alkalinity of the sample due to Bicarbonate + OH + CaCO3
   It tells,

   $\therefore$ppm of $CaCO_3 = \left\{\left(\frac{n}{50} drops\ of\ P + \frac{n}{50} drops\ of\ T\right) H_2SO_4\right\} \times 10$

**Procedure for Partial Alkalinity**

(a) Take the sample water 100 ml and cool it
(b) Add 10 drops of phenolphthalein in it
(c) Phenolphthalein if reacts with
    a. Acid: gives colourless
    b. Base: gives pink colour
(d) Titrate with $H_2SO_4$ and the base colour pink will vanishes and become colourless
(e) Note down how much drops of $H_2SO_4$ was added and multiply it by 10

**Procedure for Total Alkalinity**

(a) Take 100ml sample and cool it

(b) And 10 drops of phenolphthalein in it
(c) Phenolphthalein if reacts with acid gives colourless, when reacts with base gives pink colour
(d) Titrate with $H_2SO_4$ and base colour pink changes to colourless
(e) Now, add Methyl orange in it, it becomes yellow
(f) Again, titrate it with $H_2SO_4$ and this yellow colour changes to pink colour
(g) Note down the drops of $H_2SO_4$ and multiply it by 10

**CHLORIDE TEST**
This test is done to know the quantity of salt and used to minimise chloride level of the boiler water.

Procedure
(a) Take the sample
(b) Add phenolphthalein (10 drops) and $H_2SO_4$ (2 drops) and this water becomes white in colour
(c) Add 20 drops of potassium chromate and titrate it with silver nitrate
(d) This becomes *brown* in colour

Therefore, ppm of $CaCO_3$ = Drops of silver nitrate × 10

**PHOSPHATE TEST**
Large amount of phosphate in the boiler may contribute to the formation of foaming and priming. It helps to maintain phosphate reserve in the boiler to counter any possible contamination of the boiler water by corrosive and scale forming salts.

Procedure
(a) Bring sample. Don't cool it. Filter it
(b) Add 4 crystals of potassium
(c) Cool it
(d) Add Ammonium molybdate 5 ml which make the sample cloudy

**#Note**
If it becomes cloudy within 2 min → 70 ppm around phosphate
It becomes cloudy within 5 min → 20 ppm around phosphate

**HARDNESS TEST**
a. Temporary hardness
   i. Potassium Bicarbonate
   ii. Calcium Bicarbonate
b. Permanent hardness
   i. Ca chloride
   ii. Mg chloride
   iii. Mg nitrite

Procedure
(a) Take the sample water and cool it (100 ml)
(b) Make it a buffer solution by adding ammonia
(c) Add 0.2 gm of moderated II black indicator it forms *wine red colour*
(d) Titrate with EDTA (Ethylenediaminetetraacetic acid) solution then,

Wine red colour → Purple → Blue

Therefore, ppm of $CaCO_3$ = Drops of EDTA × 10

**How to Take Boiler Water Sample?**
There is a cooler provided for taking out the boiler water sample
a. First open fresh water line on the cooler

b. Open the sampling cock and first drain some of water. This is done to remove the condensate otherwise flash off will take place and correct reading is not observed. Usually, we don't prefer pipe water or rusted water that is why it is drain first.
c. After completion of previous step, collect the sample of water in the container provided by companies test kit (and temperature of water is around 25 to 30°C after cooler).

## CAUSTIC EMBRITTLEMENT IN BOILER

It is a phenomenon in which material of the boiler becomes brittle. $Na_2CO_3$ is added to remove hardness, some sodium carbonate ($Na_2CO_3$) is left behind in the boiler water. When the concentration of $Na_2CO_3$ increases, solutions undergo hydrolysis which form NaOH and afterward Sodium ferrate. Making the metal brittle.

Procedure

$Na_2CO_3$

↓ hydrolysis

NaOH

↓

Sodium ferrate; that makes metal Brittle

**#Note**
If there is oil in the boiler, to prevent such, add – Liquid coagulate/Sodium aluminate/Coagulate

Reasons: Oil will come when the heater is OFF.

**Question A.1: If you find oil in the hot well. Mention reasons for such?**

- Check the recently opened tank
- Check any pipe hole
- Check heating of the fuel tank
- Fuel oil purifier heated door

## TYPES OF CORROSION

Corrosion is a *natural oxidation* process where $O_2$ reacts with the base metal in presence of moisture and heat.

1. Pitting
2. Thinning
3. Caustic
4. Embrittlement
5. Acidic corrosion
6. CO2 corrosion
7. Stress Corrosion
8. Corrosion fatigue
9. Dezincification
10. Graphitization
11. Gaseous corrosion
12. Uniform corrosion
13. Crevic corrosion
14. Galvanic corrosion
15. Erosion corrosion

**Types of Boiler Burner**

A. Pressure jet burner
B. Rotary cup burner
C. Steam assisted or Y – type burner

We heat the fuel to reduce its viscosity.

Turn Down Ratio = $\frac{Max.\ fuel\ pressure}{Min.\ fuel\ pressure} = \frac{Max.\ oil\ throughput}{Min.\ oil\ throughput}$

**#Note**
Always keep *turndown ratio* at high. So, during starting the boiler, it keeps on running continuously with *no smoke.*

**STEAM ASSISTED OR Y – TYPE BURNER**

In this type of the burner, one separate line is provided for the steam which helps in atomisation and penetration. But starting from cold, it experiences absence of the steam. There is one compressed air connection to achieve such proper atomisation and penetration.

## BUNKERING PREPARATION

1. All the responsible officers should be familiar with all aspects of bunkering and the ship's bunkering system
2. He/she should personally supervise the operation (one person)
3. He must be in close contact with the shore/barge especially w.r.t stopping of bunkers in case of emergencies
4. All valves should be checked and those not to be used, must be securely closed
5. Oil Absorbent materials should be easily available
6. Fire – fighting equipment must be kept ready
7. Scupper should be sealed
8. Communication system should be checked
9. All hoses connections are to be frequently checked
10. Before bunkering, sounding of all tanks and barge must be jotted down
11. Flowmeter counters to be noted
12. Chief Engineer to be overall in-charge of the operation
13. Quantity of Bunker taken, grade of fuel oil to be calculated first
14. Then, company is informed about this bunker procedure.
15. Proper lightning should be arranged. Cranes are checked for its working
16. Overflow tank must be emptied. And the tank vent drip trays drains are to be closed
17. Bunkering checklist to be filled and properly signed by chief engineer, officer in charge
18. Bunkering should start at a minimum rate so that any problem may be detected at the earliest. The tanks should not be filled more than 90% of its capacity.
19. For final topping up of the tanks, pumping rate should be reduced.
20. Special care is to be taken while doing the hose disconnection after completion of the bunkering.

Before any transfer of the product is undertaken, the officer must confirm the following with the person in – charge of barge/terminal bunkering. Each one will sign the form to acknowledge such

- Pumping Data
- Quantity, type of fuel
- Initial transfer rate
- Maximum transfer rate
- Maximum transfer pressure
- Anticipated stoppage time
- Method of communication between Shore/barge/terminal and vessel
- Hose condition
- Crane condition
- Are scupper plugs being in place
- Action taken in the event of an oil spill
- All unused manifold connection is blanked off
- Method of sampling

**#Note**
After completion of bunkering, BDN is to be delivered and entries are to be made in ORB.

*****

# B. BOILER

ESD is the external superheated D – type boiler. In ESD we control the degree of superheat.

ESD 1: we control the degree of superheat with the help of *control of air flow* and a *flap*
ESD 2: we control the DOS with the help of *flap* in the *boiler uptake*
ESD 3: we control the DOS with the help of valve which allow, how much of steam should go to the boiler water to heat it and how much to bypass.

**Safeties in Gauge Glass**

1. Cock
   Vertically open and horizontally close it otherwise, it will automatically close. If it opens horizontally due to vibrations it will provide the wrong readings.
2. Hollow Steel ball on water size
   If the gauge glass breaks, water of a 6-bar pressure starts coming out of it. That will harm it, as it is acting on the top of water.
3. Orifice on steam side

Types of Gauge glass (GG)

- Tubular type
- Plate type
- Reflex type

**#Note**
GG are made up of the gun metal or forged steel. Plate type gauge glass is usually preferred because we can see the level from a far distance.

**LP Boiler**: 0 – 7 bar
**HP boiler:** 7 – 18 bar
**HP boiler:** 18 – 64 bar

| Water Tube Boiler | Smoke Tube Boiler |
|---|---|
| 1. Water passes through the tubes | 1. Gases passes through the tubes |
| 2. Bigger in size and compact | 2. Less Compact |
| 3. Rate of the steam generation is high | 3. Rate of the steam generation is less |
| 4. Rate of the water evaporation is high | 4. Rate of the water evaporation is low |
| 5. Steam holding capacity is low | 5. Steam holding capacity is high |
| 6. High pressure boiler | 6. Low pressure boiler |
| 7. Used where steam demand is more | 7. Used where steam demand is less |
| 8. Required good control over the water treatment and quality of the water | 8. Required less control over the quality of water |
| 9. Costly | 9. Cheaper |
| 10. More components are required | 10. Less components are required |

**BOILER ALARMS AND TRIPS BOILER SAFETY**

1. High high-water level
2. High water level
3. Low-low water level
4. Low water level
5. Low feed water pressure
6. High fuel oil temperature
7. Low fuel oil temperature
8. Low fuel oil pressure
9. Low steam Pressure
10. High steam pressure
11. Low atomizing steam pressure
12. Low combustion air pressure
13. Flame failure

**BOILER MOUNTINGS**

1) Air vent
2) Main steam stop valve
3) Gauge glass
4) Safety valve
5) Main feed Check and control valve
6) Pressure gauge Connection
7) Scum blowdown valve
8) Boiler blow down valve
9) Low level alarm
10) Water level controller
11) Sampling connection
12) Salinometer
13) Furnace drain valve
14) Manhole door
15) Automatic Feed water regulator
16) Soot blower

Internal Mountings

A. Distributor and Ring
B. Demister: prevents carryover from the boiler
C. Funnel: through which scuum BD takes place.

**CARRY OVER**

It is also known as priming. It is any solid, liquid or vapour contaminates that leaves boiler along-with the steam.

Effects

- Erosion
- Corrosion
- Scale formation
- Water hammering

Reasons

a. Rolling and pitching
b. Oil in water
c. Demister not working properly
d. Boiler water level too high
e. Improper chemical dosage
f. Irregular blow down
g. Operating pressure is low

**Foaming in Boiler**

Formation of the bubbles in the upper part of the boiler (i.e., on the steam drum) is known as *foaming*. Causes for such:

- Due to excess of chemical addition
- Presence of oil
- Excess dissolved and suspended solids

Action Taken

- Scuum blow down
- Reduce boiler fire rate
- Reduce addition of the chemicals

**SWELLING OF BOILER**

If boiler steam demands go high then pressure of steam at the top decreases. Water start expanding due to which its level increases. But in actual, level is not increasing but the sensor senses that level and stop feeding any water inside the boiler, this irregularities is known as *swelling of the boiler*.

**SHRINKAGE OF BOILER**

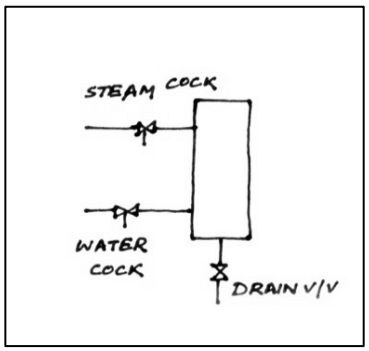
If the boiler steam demand goes down, steam pressure on the top increases. It forces liquid to move downwards, which results in level of the water go down. But in actual it doesn't go down, then sensor

senses that level and start feeding the water inside the boiler (this water is undesirable). This is known as *shrinkage of the boiler*.
To avoid swelling and shrinkage we use three element control method in which pump will only start when/after sensing

- Water level
- Steam flow rate
- Water flow rate

## GAUGE GLASS BLOW THROUGH

We want to check the working condition of the gauge glass whether it is functioning properly or not




Procedure

1. Check the drain valve condition by closing steam cock and water cock. If water or steam is not visible, it means drain cock is functioning properly.
2. It also tells us that the steam cock and water cock are working properly.
3. Open and shut the water cock. If water comes out from the drain valve quickly this shows that water cock path is clear.
4. Now, open and shut the *steam cock.* Steam with pressure comes out from the drain and this shows that the *steam path* is clear.
5. Close the drain cock
6. Open the water cock, water should gradually rise to the top of the gauge glass
7. Open the steam cock and observe following conditions:

Case 1:
When the water cock is opened. Water is not coming up to the gauge glass. This indicates that *water is well below the water cock*. Hence, it is unsafe to put the feed water in the boiler.

Case 2:
When the water cock is open, water starts coming up to the top of the gauge glass. When the steam cock is open then, water suddenly vanishes. This shows water level is between *water cock* and *steam cock*. It is safe to put the feed water into the boiler.

Case 3:
When the water cock is open, water start coming to the top of the gauge glass and get vanishes. Then steam cock is opened. When water in the gauge glass does not drop down, it indicates water level is above the *steam cock*. So, there is a danger of priming or carry over, if any addition of the feed is put into the boiler.

**Action Taken During Low Water Level Alarm**

1. Accept the alarm
2. Shut the boiler
3. Go for checking the gauge glass and perform the blow through of gauge glass: to know the condition of actual water level
4. If the level inside is low, never put water inside the boiler otherwise tubes will get distorted due to the thermal stress.
5. Hence, let the boiler cool down and after sometime check the conditions of the furnace to make sure everything is working properly.

**Question B.1: How to check the low water and high-water alarms in boiler?**
Solution: Many boiler operations require the low water alarm and shutoff to be tested on a shift or daily basis.

Both the high and low-level gauge glass stop valves are closed isolating the boiler water level gauge glass from the boiler drum. A normally closed spring-loaded tested button or switch is pressed to bypass the boiler shutdown logic, while the water level gauge glass blowdown valve is opened to drain the gauge glass.
The low water alarm sound is the proof that alarm is working properly.
Now, blowdown valve is closed and both the high and low stop valves are kept opened. The gauge glass fills with the water clearing the low – level alarm and the test button is released. Testing is completed with the logging of time and results.

## BOILER BLOWDOWN

Reasons

(a) Excess water comes then, chances of carry over occurs. Hence, to prevent this blowdown take place
(b) To remove the precipitates from chemical addition to boiler water
(c) To remove the solid particles, dirt, foam or oil molecules from boiler water
(d) To reduce the density of water by reducing the water level
(e) For the maintenance of tubes or boiler

There are two types of blowdown

a. Scum
b. Bottom blowdown

**#Note**
Carbon deposits and impurities

a. Scum
b. Bottom deposits

**Bottom Blowdown Is of Three Types**

I. Complete Blow Down
For the maintenance or survey purpose.

II. Partial Blowdown
When the boiler water is to be changed partially for adjusting chlorides, phosphates, exceeds alkalinity. In this case, water is blown down up to the bottom level of the gauge glass and again replace it with fresh water.

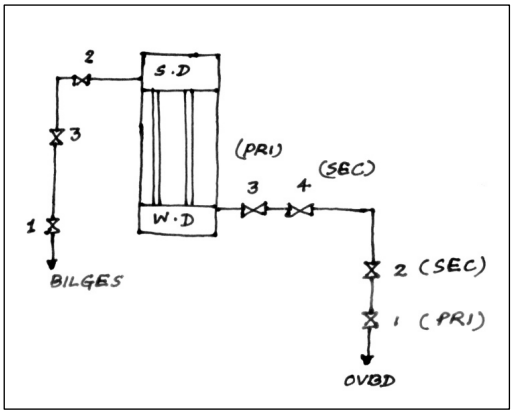
III. Flash Blowdown
Boiler impurities get settled at the bottom and to remove these

a. Open ship side valve first and this is done to ensure that the pipeline from the boiler to ship side is not pressurized
b. Open the boiler side valve (2)
c. Open the Intermediate valve (3) adjacent to the boiler valve and close it. This open and closing is repeated for several time which agitates the bottom impurities along with the water to escape *overboard*.

**SCUM BLOWDOWN**

This is done to remove the oil and it will always go to the bilges, because we don't want it to overboard.

For scuum blow down throttle valve 3. Keep a watch on pressure (open this valve for only 1 – 2 min) also close it.




**Question B.2: Boiler water is not maintaining the desired level. Give reasons for such.**

Solution:

1. Boiler water tubes leaking. White smoke is observed at the funnel.
2. Steam consumption is too high
3. Controller malfunction
4. Boiler pump efficiency decreases
5. In the main line, *distributor ring* holes are choked

6. If the hotwell level decreases and we can't able to maintain the boiler water level then it means blowdown overboard valve was open or leaking.
7. Vapour lock: in this pump loses its suction

**Question B.3: How to increase the boiler efficiency? Mention briefly.**
Solution**:**

1. Always do pre – purge and post – purge
2. Maintain chlorides, phosphates, alkalinity by performing boiler water test
3. By performing the boiler water test
4. Always perform the blowdown at regular interval and remove all impurities and carbon deposits
5. By maintaining a proper air – fuel ratio
6. By supplying a good quality fuel
7. By doing a proper maintenance of burner
8. By performing the tubes cleaning at regular intervals
9. By maintaining the proper fuel oil pressure, steam pressure, combustion air pressure
10. Maintaining the flame eye

**Question B.4: There is a sound of boiler flame failure alarm. Give reasons.**
Solution:

1) Flame eye sensor faulty
2) Burner not maintained properly
3) Swirling action improper of burner
4) Improper pilot burner electrode distance
5) Fuel oil pressure not adequate
6) Fuel oil temperature not proper
7) Steam air pressure not proper
8) Water in fuel
9) Combustion air pressure is low
10) Fuel oil pump filter choked

**Question B.5: Why boiler manhole door is elliptical in shape?**
Solution:

(a) Hidden pockets; not shown in the pressure gauge
(b) Sealing is proper due to the internal pressure
(c) Due to the Hoop's stress (it is circumferential force per unit area)

For elliptical surface $\left\{\sigma_H = \frac{pd}{4t}\right\}$

## COLD STARTING OF BOILER

1. Make sure nothing is present inside the boiler and all fittings are proper
2. All the connections of fuel oil, air and steam are in order
3. Make sure safety valve is in order
4. Shut main steam stop valve and open vent
5. Make sure boiler plant is in operational order
6. Take water upto $1/4^{th}$ level of gauge glass
7. Start blower and do pre-purge to make combustion chamber gas free
8. Start circulating pump and booster pump
9. Now light up the boiler
10. According, to manufacturer, initial running hours are decided as follow

| | |
|---|---|
| 5 min ON<br>15 min OFF | This is done for 2 hours |

| | |
|---|---|
| 10 min ON<br>15 min OFF | For next 2 hours |
| 10 min ON<br>10 min OFF | For next period of time till small steam starts coming out from the vent valve |

11. Leave the vent open until boiler pressure reaches 2 bar
12. Now close the vent
13. Ensure that sufficient quantity of water is available in the boiler (i.e., $3/4^{th}$ of gauge glass).
14. Boiler should operate on load within 12 hours after this cold starting. This avoids thermal stress.

## HYDRAULIC TESTING OF BOILER

If any major work is carried out on the boiler then, before putting boiler in operation, we have to make sure everything is working properly.

Procedure

After overhauling the boiler, we have to test the pressure of the boiler at 1.5 times of the design pressure

1. Make sure nothing is inside the boiler (i.e., welding equipment, electrode, rags etc.)
2. Fill the boiler completely and keep the vent open until water comes out of the vent
3. Measure the circumference of boiler before raising pressure
4. Raise the pressure to 1.5 times the design pressure
5. Hit at welding point with hammer and check any crack is present at welding point, if there is such, then water will come out of it and pressure drop can be easily observed on the gauge.
6. Maintain the pressure for about half an hour and keep a watch.
7. Again, measure circumference of the boiler.
8. After depressurization, measure circumference of the boiler.

**#Note**
If there is increase in the circumference, it means *elasticity* becomes *plasticity*. If circumference is same as of the earlier, boiler is said to be in perfect condition for its use.

### ACCUMULATION OF PRESSURE

⇒ Accumulation of pressure test means, safety valve keeps on lifting up with slight increase in the boiler pressure.

⇒ This test fails when the pressure exceeds more than 10% of working pressure in 7 minutes if the boiler is of water tube type boiler and 15 minutes if it is of smoke tube type boiler respectively.

⇒ It means we have to check the setting of safety valve, which consists of the blowdown ring and internals of safety valve like drain, exhaust steam piston.

**Procedure**

1. Take sufficient water in the boiler
2. Close the steam outlet valve
3. Bypass the high pressure (HP) cutout
4. Start firing of the boiler with full load
5. Check at what pressure safety valve lifts up. Check for the time and pressure to ensure this full-fills the working conditions.
6. If condition is not satisfied. This test fails.

## BOILER BACKFIRE

Occurs when the fuel accumulated inside the boiler furnace due to repetitive failure of starting catches fire. So, sometimes this leftover oil spontaneously catches fire and result in huge pressure increase in the boiler furnace. This huge increase in pressure facilitates gases to come out from the burner side.

**Precautions**

- Maintain the burner in good condition
- Always do pre-purge and post – purge at the time of starting and stopping of the boiler

Post Purge

We need to remove exhaust gases from the boiler furnace which can later cause corrosion and decrease the tensile strength of the boiler.

**EGB Tubes Leaking Indication**

1) Hotwell level decreases
2) White smoke at the funnel
3) Economiser temperature decreases
4) Manometer pressure decreases
5) Boiler pressure decreases
6) Turbocharger surge (occurs only in high damage)
7) Boiler feed water pump pressure decreases

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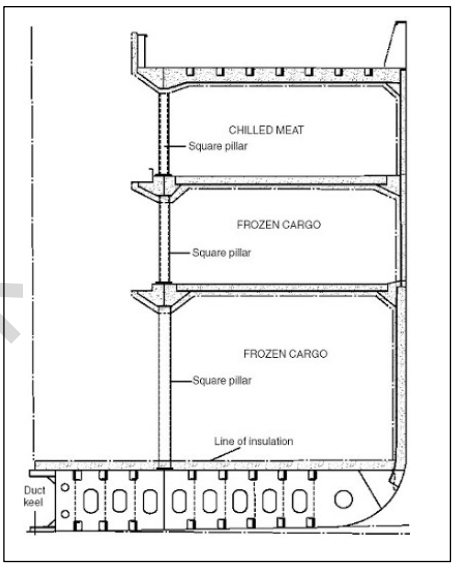
# C. REFRIGERATION AND AIR CONDITIONING

Followings are the safeties fitted in the refrigeration plant of ship.

1. LP cut out
2. HP trip
3. Oil differential pressure cut out
4. Relief valve on condenser
5. Cooling water low pressure cut out
6. Master solenoid valve
7. Belt driven
8. Oil heater
9. Sight glass on condenser
10. Pressure gauges
11. B disc on compressor

**LP Cut Out**




- → It cuts the compressor in the event of pressure drop in the suction line
- → It gets activated when all room temperature reaches its set value
- → System will not go under vacuum else air will come inside compressor
- → Starving of the evaporator
- → Expansion valve gets choked

**HP Cut Out**

- → When discharge side pressure increases above the set limit value, this gets activated
- → If condenser gets choked then high – pressure cutout will get activated
- → If this fails then relief valve on the condenser helps
- → This is not an auto – reset, this has to be done manually. We have to manually attend the fault, which is causing rise in the pressure. Otherwise, this can lead to overloading of the compressor parts and can damage the same.

**Relief Valve**

It is fitted on the condenser to avoid damages to the condenser, if there is a high pressure in discharge line.

**#Note**
If there is a fire near the refrigerant vicinity, liquid inside condenser gets expanded and explosion will take place. So, it is set at 20 – 22 bar.

**Oil Differential Cut Out**

Actual oil pressure – suction pressure = DP

This is a safety for the compressor. In the event of low supply or no supply of the lube oil in the bearing differential cut out pressure will get activated which safeguards the bearing and crankshaft both. Compressor will operate only when differential pressure (DP) is 1 bar, otherwise it will get tripped.

**Belt Driver**

All refrigerant compressor is belt driven. In any case liquid get in contact with the compressor, belt slips. This prevents the compressor from getting damage.

**Pressure Gauge**

**Sight Glass**

**Oil Heater**

**Master Solenoid Valve**
To prevent liquid getting into the compressor when plant is in the stand still condition.

**Cooling Water Low Pressure Cutout**

**PARTS OF REFRIGERATOR COMPRESSOR**

1. Compressor
   It circulates the refrigerant. Also helps to raise the pressure above the condensing pressure that is known as the *discharge pressure*.
2. Oil Separator
   If oil goes to the system, heat transfer gets affected. That's why we remove the oil by using the coalescence method. *Oil separator drain* drains to the crankcase.
3. Condenser
   In this, refrigerant is condensed to the high-pressure liquid. It removes *heat of compression* and heat from the space i.e., to be cooled. Heat of compression (HOC) is the heat added to the vapour by the work done on it during compression.
4. Thermostatic Expansion Valve
   It is a kind of orifice that regulates the flow according to the need. It converts high pressure (HP) to low pressure (LP) (i.e., saturation temperature will drop). To maintain constant degree of superheat at the outlet of evaporator we have to maintain a degree of superheat.

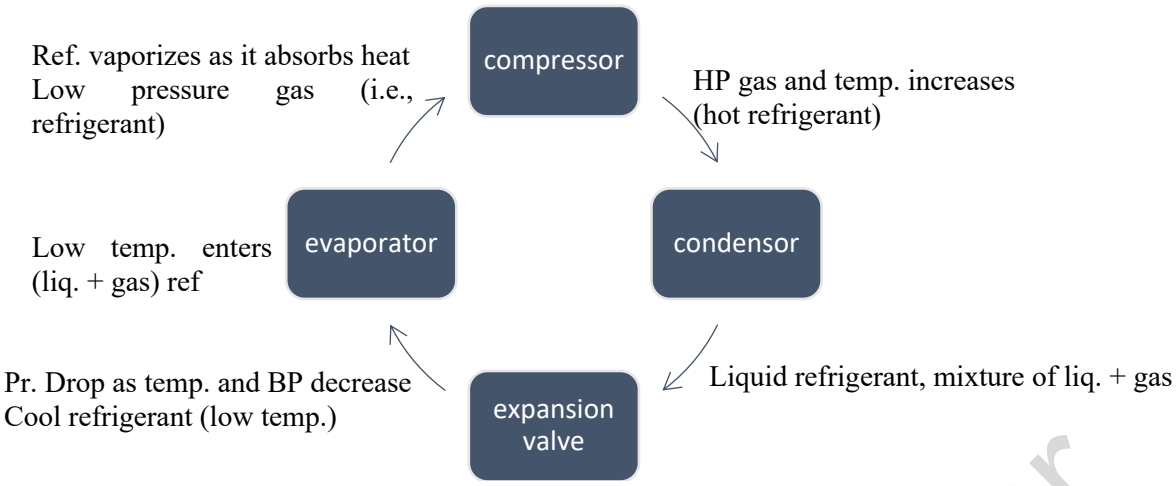
| | | | | |
|---|---|---|---|---|
| **Degree of Superheat** | = | Actual temperature of refrigerator leaving evaporator | - | Saturated temperature at that pressure |

5. Evaporator
   It collects heat from the surrounding. The refrigerant will again attain saturated vapour form.

| | | | | |
|---|---|---|---|---|
| Absolute pressure | = | gauge pressure | + | atmospheric pressure |

6. Back Pressure Valve
   It is always fitted where the refrigerant flow is less needed (i.e., in veg room). It is a kind of the spring loaded non return valve. Since, outlet is distributed in all three rooms which are connected to the same return line (i.e., common); the refrigerant tends to move inside the evaporator coil (veg room) i.e., towards low pressure side. To avoid such circumstances, back pressure valve is fitted.

**#Note**
Back pressure valve is suitable for slow cooling.




7. Crankcase Heater
   Before starting the compressor, heater is kept ON and refrigerant will start to heat up. So, that oil and refrigerant will not get mixed together. Refrigerant will go to bearing along with oil, the moment we start the compressor.
8. Equalising Line
   To prevent the evaporator from starving, a direct connection is provided between the *underside of bellow.* Suction piping of the compressor is preferred between the bulb and compressor.

**Methods of Finding Leak Detection**

A. Soap solution
B. Ultrasonic leak detector
C. Fluorescent leak detector
D. Halide torch
E. Electronic leak detector
   a. Heated diode
   b. Corona suppression

**HALIDE TORCH**

Upon the detection there is a change of blue flame into the green flame. It is a sensitive detector that supports locating of leaks as small as 20 PPM of CFC and HCFC refrigerants. It includes the leak detector and probe hose, displaying single colour LED with a 6 level of leak alarm.

Leaks is located when chlorine based refrigerant gases are drawn in through the probe hose. Upon exposure to the heated copper reactor plate, it starts giving alarm and LED colour changes from Blue to Green. CFC and HCFC are easily detected; whereas HFC can't be detected easily.

**ELECTRONIC LEAK DETECTOR**

HFCs, CFCs, HCFCs and HCFC based refrigerant blends can be detected easily by using electronic leak detector method. This detector has a filter that prevents contaminates and water from entering into it. It is also able to work in an environment which is contaminated by the refrigerants using the recalibration feature.

## TROUBLESHOOTING

**AIR IN THE SYSTEM**

Reasons:

a. Flange leaking
b. During charging

c. Low pressure (LP) cutout defective in this case compressor will keep on running even if the suction pressure is low and sucking the refrigerant gas in the compressor system.

Indication

a. Pressure gauge fluctuates
b. Small Bubbles in the sight glass
c. Compressor running hours increases
d. Condenser and compressor outlet temperature is high
e. HP cut out activated

**Removal Procedure**

1. First do pump down
2. Close the king valve that is positioned after condenser
3. Compressor will trip on low pressure cut out and all refrigerant come under receiver
4. Bypass low pressure cut out and start compressor manually. So, that all line refrigerant come in the condenser.
5. Stop the compressor. Hence, *pump down* gets completed.
6. Keep cooling water (CW) running and after sometime, $CW_{IN} = CW_{out}$
   This means that refrigerant temperature = $CW_{IN} = CW_{out}$
   On chart see,

| Sat. Temperature | Vs | Sat. Pressure |
|---|---|---|
| 30°C | | 7 bar |
| 45°C | | 9 bar |

**#Note**
After this observe the chart and check values whether saturation temperature and saturation pressure are same according to the pressure on the HP (pressure gauge).

Case 1

If the pressure on the gauge is same as given on the chart. It corresponds to the refrigerant temperature or $CW_{IN}$ *or* $CW_{out}$ temperature. This signifies that air from the system has been removed completely.

Case 2

If pressure on the gauge is more than as on the chart. It corresponds to the refrigerant temperature or $CW_{IN}$ *or* $CW_{out}$ . This signifies that there is some air inside the condenser. Therefore, we bring the pressure on the gauge which corresponds to respective pressure value in the chart by slightly opening the vent. Hence, air is passed out from the system.

**DEFROSTING**

It is a method of removal of the frost, built up on the evaporator coils. It should be done before the snow thickness exceeds 1/4$^{th}$ inches.

| **Reasons** | **Effects** |
|---|---|
| a. During refrigeration cycle, moisture in air freezes and sticks on the evaporator coils as a Frost.<br>b. Faulty defrost timer<br>c. Defective defrost heater<br>d. Defective defrost thermostat | a. Liquid back to the compressor<br>b. It affects air flow and the circulation<br>c. It affects the heat transfer properties |

**Methods of Defrosting**

A. Electrical defrosting
   Electrical heating coils are present inside the tubes (evaporator) but two conditions are there for such. If manually operated,
   a. Stop liquid shut off valve, so that no refrigerant flows
   b. Stop the fan
   c. Open the drain line
   d. Try to clean whole room and run the refrigerant again
B. Hot gas defrosting
   Passing hot refrigerant to the evaporator coils. So, that ice get started to melt. Instead of the condensing refrigerant in the condenser, we send it into the evaporator (i.e., reverse flow) as a separate arrangement is provided.
C. Passing warm water on evaporator
D. Stopping the system

**Question C.1: What is a short cycling?**

Frequently cut in and cut out of the compressor is known as the *short cycling*. These are the following reasons of such

a. LP cut out faulty
b. Low setting in LP controller
c. Shortage of the refrigerant (low receiver level and big bubbles in sight glass)
d. TEV choked partially
e. Frosting of the evaporator coils
f. Master solenoid valve leaking during off cycle
g. Ambient air temperature low
h. Moisture in the system (frost on TEV and it won't allow refrigerant to flow)
i. High/low voltage on the three-phase supply
j. Too much cooling water to the condenser or condenser pressure rise causes short cycling (SC)

**#Note**

While charging the refrigerant, there is a formation of ice on the charging line. When the bottle is emptied ice start melting.

Always do brazing in the presence of N2. Never do it in presence of O2, it leads to the formation of copper oxide and will twist the pipe.

**UNDERCHARGE OF REFRIGERANT**

| **Indication** | **Remedies** |
|---|---|
| a. Frost soft ice on suction side<br>b. Big bubbles on the sight glass<br>c. Compressor runs and stops (short cycle) frequently<br>d. Compressor delivery temperature is high<br>e. Low discharge pressure | Charge the refrigerant until bubbles disappear in the sight glass and it will correct pressure gauge reading. We have to find out the leakage point by using<br>⇒ Soap solution<br>⇒ Ultrasonic leak detector<br>⇒ Fluorescent leak detector<br>⇒ Halide torch<br>⇒ Electronic leak detector |

**OVERCHARGE OF REFRIGERANT**

**Indication**

1. Solid ice on the suction side
2. Full liquid level in the sight glass
3. High discharge pressure

4. Compressor runs cold
5. Excess frost on the compressor suction line after the evaporator

**Remedies**: Excess refrigerant is released from the relief valve on the condenser and is collected in the receiver or by fitting the recovery bottle.

## CHARGING OF REFRIGERANT

1. Shut the King valve (receiver outlet valve). Compressor will trip on LP cut out and all refrigerant come in the receiver.
2. Now bypass the LP cut out and manually start compressor. So that, whole line refrigerant gets collected into receiver.
3. Stop the compressor and *pump down* gets completed.
4. Weight of the refrigerant is measured before and after charging to ensure the adequate quantity of refrigerant is charged into the system.
5. Put drier in use by opening the inlet and outlet valve and shut the bypass valve.
6. Connect the refrigerant gas cylinder to the charging line on the liquid side of the system and the cylinder should be always in the vertical position.
7. Connect the recovery cycle to recovery line.
8. First open the filling valve and recovery line valve and then crack open the liquid cylinder valve to purge out any entrapped air. Close the recovery line valve and open main valve that leads to the drier and tighten the connection.
9. The liquid refrigerant will start flowing to the system.
10. Start compressor and continue to charge the system and observe the level in the sight glass.
11. Close liquid cycle valve and main charging valve.
12. Close the drier inlet and outlet valve and open the bypass valve.
13. Now, start the system by opening the King valve or the *condenser outlet valve* and observe its efficiency for 20 minutes.
14. Check the liquid level in the receiver (SG)
15. In addition, whenever charging of the system is required repeat this entire process.
16. Hence, charging of refrigerant take place

We charge the liquid refrigerant before filter drier. Never charge the liquid refrigerant to the outlet of evaporator otherwise the liquid refrigerant will tend to move towards the compressor, resulting in the damage of the compressor.
We used to prefer a liquid refrigerant charging. It is easy to maintain the liquid refrigerant at any temperature. Chances of leakage are more in gas charging, as gas being lighter.

## CHARGING OF OIL IN CRANKCASE

Why oil level goes down? When oil goes into the system, we can find that separator is not working properly.

Methods of the charging

- Hand pump method
- Vacuum method

**A. Hand Pump Method**
In this method, there is no need of stopping the compressor and no need to create vacuum.
Raise the pressure more than suction pressure that leads oil to flow. Before doing above mentioned step, first purge connection line and once LO start coming, connect it to crankcase and charge it.

**B. Vacuum Method**
First do *pump down*. So, that the crankcase will be under vacuum.

Shut the king valve or receiver outlet valve. Compressor will trip on LP cut out, bypass LP cut out and start compressor manually. So, that vacuum is created inside the compressor. It can be checked from the pressure gauge.
Now, open the oil connection valve. Because of the vacuum, oil will move into the crankcase.
To ensure that there is no air inside the system we do purge of the connection before charging.

**Question C.2: Temperature of meat room is not reaching to desired value. Mention the reasons for such.**

1. Door remains open
2. Door insulation worn down
3. Evaporator of the meat room frosted
4. Thermostatic expansion valve choked
5. Solenoid is not working for the meat room
6. Particular room fan is not working

**Question C.3: Temperature of all room is not dropping. Why?**

1. Compressor is not running properly
2. Less refrigerant in the system
3. Presence of moisture in the system and drier is not working properly due to which the expansion valve of all rooms is blocked.

| HP Cutout Reasons | LP Cutout Reasons |
|---|---|
| 1. Overcharging of the refrigerant<br>2. Condenser fouling (No proper HT)<br>3. HP cut out faulty<br>4. Air in the system (air is non – condensable so efficiency of the condenser decreases)<br>5. Discharge pressure increases | 1. LP cut out faulty<br>2. Suction pressure decreases in line<br>3. Starving of the evaporator<br>4. Expansion valve get choked<br>#Note: This get activated in order to prevent the system to undergo vacuum otherwise the air will come inside the system. |

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