Dear Engineers,

Mexa Training Centre started its humble beginning as a Maritime Training Institute with just one candidate. Today, we are proud to have trained 100 candidates in such a short time. Mexa aspires to be the pioneer in Maritime Training from India training the world. We at Mexa strongly believe in creating world class Engineers to become a dominant Maritime fraternity. We at Mexa Training Centre have been inspiring engineers to excel in their field. We are also involved in training with hands-on experience for those who have the desire to learn.

We are proud to release a verified set of answers for the benefit of all who are appearing for their Class IV exams. While we endeavor to compile answers for examination purpose, we would like to emphasize that understanding the subject matter and presenting it to surveyor in either the written format or oral delivery totally depends on the candidate and that alone will help you climb steadily and firmly on your career growth.

We want to ensure that the candidates are exposed to the correct answers. Please note that we will be releasing the online version soon so that the updates are available live on your mobile.

Having said the above, we would like to inform you that this edition will be charged minimum for printing costs and courier charges alone. It would be kind of you to not replicate the book.

- ***Author***
Mexa Training Centre

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Main Propulsion Machinery

◆ **Notes:**

Describe the nature and the possible effects on machinery operation of deposits, which may adhere to the internal surfaces of exhaust gas turbo-blowers and explain how these deposits are removed (16)

Aug 23

Deposits on the internal surfaces of exhaust gas turbo-blowers, especially when operated on Heavy Fuel Oil (HFO), can have various adverse effects on machinery operation. These deposits, originating from the engine's exhaust gases, can consist of carbon, soot, and other exhaust deposits. The nature and possible effects of these deposits, as well as the methods for their removal, are described below:

Nature of Deposits:

• Deposits mainly comprise carbon, soot, and other combustion by-products.
Fuel quality, engine operating point, and combustion quality influence the extent of fouling.
• Deposits adhere to internal surfaces, particularly on the turbine side of the turbocharger.

Possible Effects on Machinery Operation:

• Fouling decreases the turbocharger's efficiency, leading to higher exhaust gas temperatures and increased fuel consumption.
• Deposits can affect engine performance, causing a decrease in power output.
• If not cleaned, fouling on the turbine side can lead to back pressure and surging, potentially resulting in the breakage of turbine blades.
• On the blower side, insufficient cleaning can reduce the supply of air to the engine, leading to incomplete combustion and the emission of black smoke.

Methods for Deposit Removal:

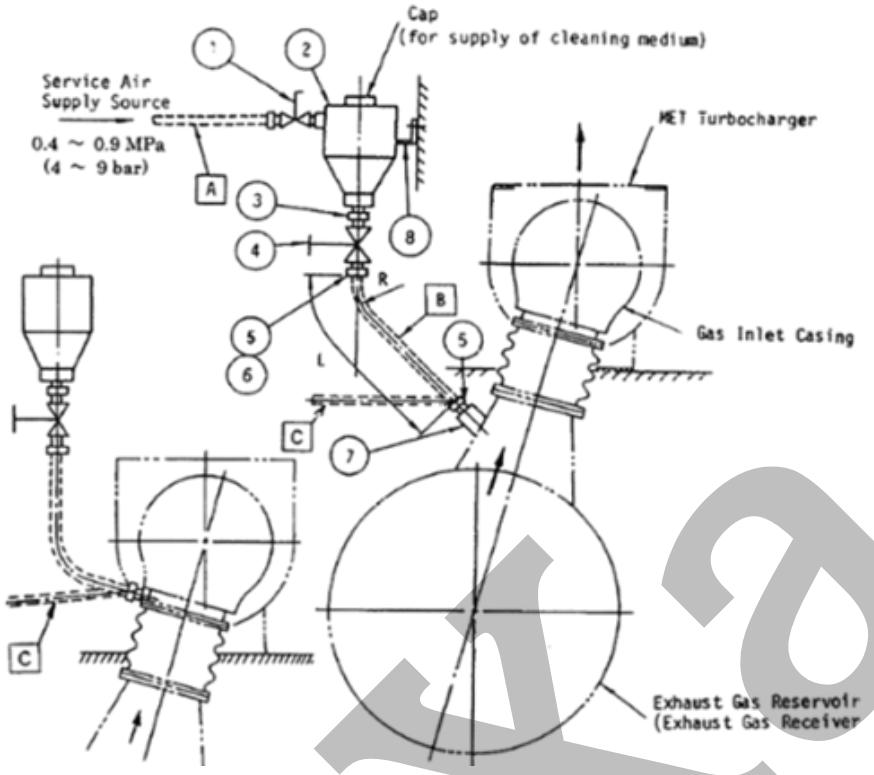
Turbine Side Cleaning:

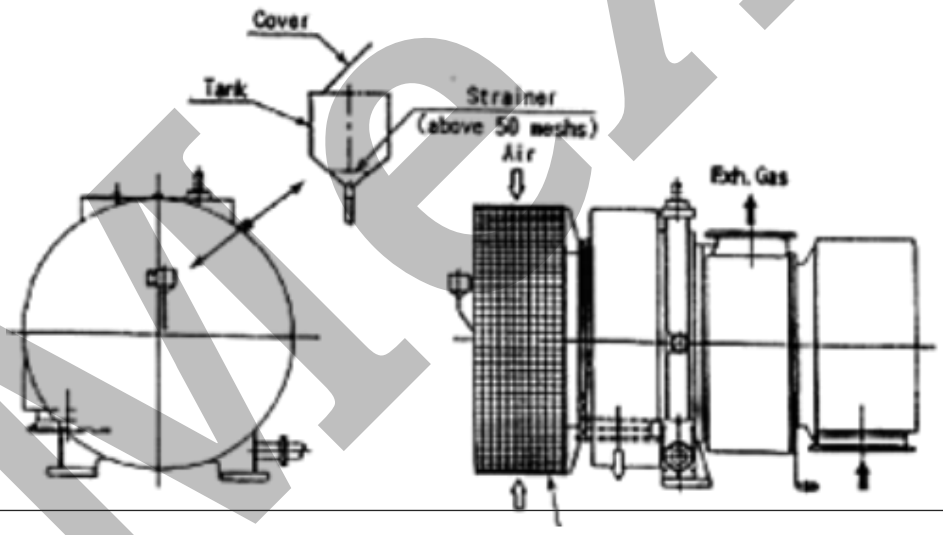
Water Washing: Engine speed is reduced until exhaust inlet temperature falls. Hot fresh water is injected through a regulating valve connected to the turbine side to avoid thermal shock. The ABB Turbocharging system allows turbine cleaning at reduced load.
The drain is kept open during water washing. After closing the water feed, the drain is observed until no water comes out. The engine runs for an additional 20 minutes at lower RPM to dry the turbine. Abnormal vibrations are checked before increasing RPM.

Dry Washing: Carbon granules are injected into the turbine through a compressed air system. Engine speed is not reduced during dry washing to avoid thermal stress.

Blower Side Cleaning:

Fresh Water Cleaning: Engine runs at full load RPM to achieve effective cleaning. Compressed air carries water under pressure, and the kinetic energy of water cleans the blower.
A container is connected to an inlet line from the blower discharge side, and the outlet line goes for washing the blower side.





With reference to Main Engine Turbo chargers:
(a) What are the indications of water leakage in a turbo charger casing and consequences of this leakage, if unnoticed? (8)
(b) Precaution to be taken during water washing at sea of blower side and dry washing of turbine side (8)

Nov 22

(a) Indications of water leakage in a turbocharger casing:
Main Engine Cooling Water Header Tank Low Level alarm is triggered. Excessive water discharge when the turbocharger drain is opened indicates a significant water leak.

Consequences of Water Leakage in a Turbocharger, if unnoticed
• Water leakage can lead to the corrosion of the turbocharger blades, reducing their efficiency and affecting the performance of the turbocharger.

• Corrosion and damage to the turbocharger components can result in a gradual loss of speed and efficiency in the turbocharger.
• A damaged turbocharger may not deliver the required volume of compressed air to the engine, leading to a decrease in the supply of combustion air.
• Reduced air supply and inefficient turbocharger operation can result in a loss of engine efficiency, leading to reduced power output and increased fuel consumption.

(b) Precaution to be taken during water washing at sea of blower side and dry washing of turbine side

Precautions During Water Washing of Blower Side (Compressor Side):

1. **Check Manufacturer's Guidelines**: Always follow the manufacturer's recommendations for water washing intervals and procedures. Over washing can lead to unnecessary wear on the compressor blades.
2. **Ensure Proper Water Temperature**: The water used for washing should be at the correct temperature (not too hot or cold) to avoid thermal shock to the compressor components.
3. **Avoid Using Excessive Pressure**: When performing water washing, ensure that the water pressure is not too high, as it can damage the delicate compressor blades and seals.
4. **Use Clean, Fresh Water**: Use clean, uncontaminated water to prevent introducing foreign particles that could damage the turbocharger.
5. **Dry Thoroughly After Washing**: After water washing, ensure the blower side is dried properly to prevent corrosion of internal components, especially the compressor blades and bearings.
6. **Monitor the Turbocharger After Washing**: After the water washing process, monitor the turbocharger's performance to ensure no damage has been done and that it's functioning correctly.

Precautions During Dry Washing of Turbine Side (Exhaust Side):

1. **Ensure No Debris Entering the System**: Dry washing should be performed with care to avoid introducing any debris or foreign objects into the turbine side. These particles can cause significant damage to the turbine blades or other components.
2. **Follow the Correct Procedure**: Dry washing is typically done using cleaning agents or air. Ensure the method follows the manufacturer's specific instructions to prevent damage or overheating of the turbine.
3. **Avoid Overheating**: While performing dry washing, ensure that excessive heat isn't generated during the cleaning process, as the turbine materials are sensitive to temperature changes.
4. **Check for Oil Contamination**: Ensure that no oil or other contaminants are present in the turbine side, as these can cause fouling of the turbine blades and reduce efficiency.
5. **Monitor for Abnormal Noises or Vibration**: After the dry washing process, check the turbine for any unusual noises or vibrations that might indicate improper cleaning or a potential issue.
6. **Confirm Proper Operation Post-Wash:** After dry washing, ensure the turbocharger operates properly, with no signs of blockage or reduced performance, as this can indicate incomplete cleaning or underlying issues.

(a) Describe 2-stroke Main Engine cylinder liner diameter measuring procedure. (8)
(b) What is the modern system for Liner Diameter Measurement? (4)
(c) What are the advantages of modern system over old system? (4)

Sep 23 **May 23-2**

(a) Cylinder liners are gauged internally at fixed intervals, typically during cylinder overhauls scheduled every 6000-8000 hours. Continuous and detailed records are maintained for each cylinder, ensuring a comprehensive history of wear and measurements.

• Before measurement, the cylinder liner is thoroughly cleaned and inspected. The surface condition can provide insights into the adequacy of lubrication.

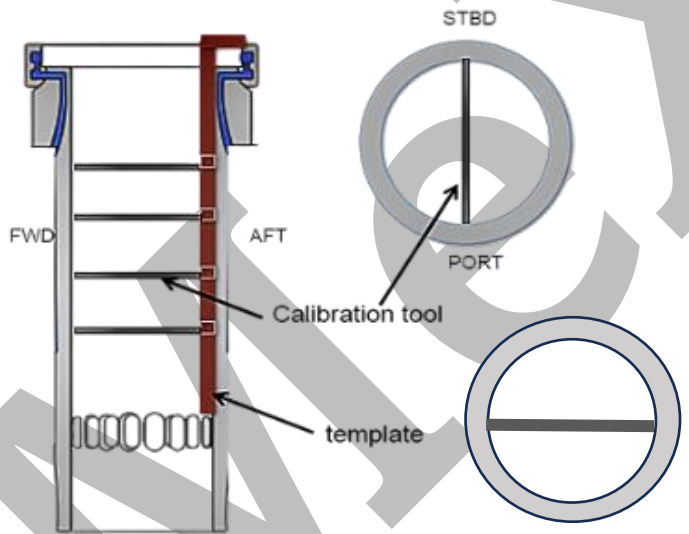
• The liner is measured using a micrometer and extension bar. This measuring instrument is calibrated against a master gauge to ensure accuracy.

•Ideally, measurements are taken with the liner at a cold temperature. If not possible, the measuring gauge must be at the same temperature as the liner to eliminate expansion effects.

•Measurements are taken both fore-aft and port-stbd directions to ensure comprehensive assessment.

•A template or trample gauge may be employed to ensure readings are taken at corresponding points, enhancing accuracy.

•Gauging figures, noting total wear from the original and mean rate of wear since the last recording, are crucial. Normal wear rates are monitored, with maximum wear typically limited to 0.6 - 0.8% of the original diameter.



(b) Chris Marine has introduced the Liner Diameter Measurement Instrument (LDM), offering a modern approach to investigate the condition of cylinder liners in 2-stroke engines. Notable features include:

•The LDM allows measurement without the need to remove the cylinder head or exhaust valve housing, eliminating the traditional disassembly requirements.

• The LDM is inserted through the scavenge ports, replacing the traditional internal micrometer.

•The system can be preset with engine data for a variety of 2-stroke engines, streamlining the measurement process.

•Measured data is transmitted wirelessly to a handheld terminal and can be further transferred to a PC via Bluetooth, USB, or SD card.

(c) Advantages of Modern System Over Old System:

•The modern LDM system eliminates the need for extensive disassembly, allowing inspections of all liners on a 2-stroke main engine in a single day. This significantly increases efficiency.

•The LDM provides highly accurate reports on cylinder liner wear, remaining life, ovality, and any clover leafing without the need for time-consuming disassembly.
•Operators can proactively plan for liner replacement, take corrective actions, or confidently operate with knowledge about liner conditions. This proactive approach helps avoid unexpected off-hire periods due to unforeseen failures.
•The LDM system includes features such as a CE-label for EU and Turkey compliance, with further tests planned for other international standards (USA, Japan, China, Korea). The measured data can be easily transferred and analyzed using standard PC applications, enhancing global connectivity and ease of data management.
• The modern system facilitates a proactive condition monitoring program, allowing operators to plan periodic LDM checks for their entire fleet. This approach contributes to effective maintenance planning and cost-effective liner replacement strategies.

Describe the routine maintenance necessary on the following components in order to obtain optimum performance from a main engine turbocharger
(a) Lubricating oil for ball bearings. (4)
(b) Air intake silencer/filter. (4)
(c) Turbine blades. (4)
(d) Diffuser ring. (4)

Sep 22

(a) The routine maintenance necessary for lubricating oil for ball bearings of a main engine turbocharger are:
• Clean the filters in the lube oil line.
• Check for any abnormal noise and vibration in lube oil pumps.
• Keep an eye on the oil level in header tank.
• Try out the low-level alarm in the weekly routine.

(b) Air intake silencer/filter
Marine turbochargers come with mesh filters to avoid any particles, moist oily air mixture etc. from going inside and fouling/ damaging the compressor turbine. It is recommended to put an extra felt filter over the turbocharger compressor to absorb oily air mixture as such filters can be changed frequently. The fitted mesh filter must be chemically cleaned bi-monthly or as per the running hours described by the manual.

(c) Routine maintenance carried out on turbine blades is cleaning during service.
Dry cleaning:
The cleaning is affected by injecting a specified volume of crushed nut shells or similar. The highest efficiency is obtained at full load (cleaning should not be carried out below half load).
Water cleaning: The cleaning is effective by injecting atomized water through the gas inlet, at a reduced engine load.

(d) Diffuser Ring: Routine maintenance for the diffuser ring of a turbocharger includes the following:
• **Inspection:** Inspect the diffuser ring for wear, damage, or distortion. Look for cracks, erosion, or signs of leakage. If any abnormalities are detected, consult the manufacturer's guidelines for appropriate actions, which may involve repair or replacement.

• **Cleaning:** Clean the diffuser ring to remove any accumulated dirt, oil, or deposits. Ensure that the passages are clear and free from obstruction to maintain efficient air flow through the turbocharger.

An air cooler of a large two stroke marine diesel engine is showing poor performance. Suggest some measures you would initiate to rectify the problem and improve the performance.

Oct 22

To rectify the poor performance of the air cooler on a large two-stroke marine diesel engine and improve its efficiency, several measures can be initiated:

Regular Drainage and Maintenance:

• Regularly drain the air cooler to remove accumulated water.
• Clean both the air side and water side of the tubes to remove fouling deposits.
• Inspect and replace sacrificial anodes as needed to prevent corrosion.

Air Side Cleaning:

• Monitor the air side for fouling and deposits using differential air pressure measurements.
• Clean the air side regularly while the engine is in service.
• Use specialized air cooler cleaner in dosing pots for effective cleaning of air-side components.

Circulating System for Cleaning (Large Engines):

• For large engines, consider using a circulating system designed for cleaning air coolers. This involves a circulating pump attached to the Chemical Cleaning tank.
• This system can efficiently clean and maintain the air cooler's performance over time.

Chemical Cleaning for Small Coolers:

• For smaller air coolers, remove them from the engine and soak them in a specialized solvent.
• Alternatively, use ultrasonic cleaning to remove deposits and fouling.
• After chemical cleaning, thoroughly rinse the air cooler with freshwater to remove residual chemicals and deposits.

Water Side Cleaning:

• Clean the water side of the tubes using specialized tube brushes.
• Brushing helps remove soft deposits and slime.
• For scale deposits or hard marine growth, use high-pressure water jets or descaling agents.

Anode Replacement and Corrosion Prevention:

• Regularly inspect and replace anodes to prevent corrosion of the air cooler's components.
• Consider using corrosion inhibitors in the cooling water system to protect the cooler from corrosion.

Monitoring and Maintenance Schedule:

• Establish a regular maintenance schedule for cleaning and inspection of the air cooler.
• Monitor the air cooler's performance and efficiency over time to ensure continuous improvement.

Describe the following turbocharger cleaning operations.
(a) Turbine side water washing. (6)
(b) Turbine side Dry Cleaning. (5)
(c) Blower side water washing (5)

Jul 23 | Dec 24 | Jul 24 | Feb 24

The Cleaning of the Turbine side and blower side is necessary at regular intervals to remove carbon, soot, and other exhaust deposits. There are two methods to clean the turbine and compressor side of a turbocharger while running.

(a) Turbine side cleaning can be carried out with both water and Dry washing methods:
Procedure for Water Washing on the Turbine Side:

- Inform the bridge
- Reduced engine speed until the temperature of the exhaust inlet to turbocharger falls below 400 °C (approx., follow User Manual Instructions)
- Open the turbocharger drain valve.
- Open the water-washing injection nozzle.
- Supply water with about 1.5 bar pressure to the turbine side.
- Water washing must be done until the clean water comes out from the drain.
- Close the water supply and remove the nozzle.
- The exhaust side drain can be closed after all water is drained out and dried.
- Run the M/E for 10 minutes on the same load.
- Inform the bridge and increase the M/E rpm gradually to sea speed.
- For usual practice, cleaning is done every 500 running hours, depending on the cleanliness of the turbocharger.

Disadvantage of Water Washing

- Engine speed must be reduced.
- Thermal stress and corrosion usually occur because of water usage.
- More time is required to complete the operation.
- Very fine hard deposits and residues cannot be removed easily with water washing.

(b) Procedure for Dry Washing on Turbine side:

- Dry washing is carried out by walnut shell, with a grain size of 12 to 34 mesh.
- Compressed air of (5-7 bar) is used to help the grains strike the deposits on Turbine Blades and Nozzles, giving effective cleaning of hard particles.
- The air supply pipe is fitted to a solid grain container, and grains are injected into the exhaust system by air pressure at the same point (as in water washing) just after the exhaust grids.
- The turbine casing drain is kept open during cleaning time (about 2 minutes only)
- Dry washing should be carried out every day while M/E is running

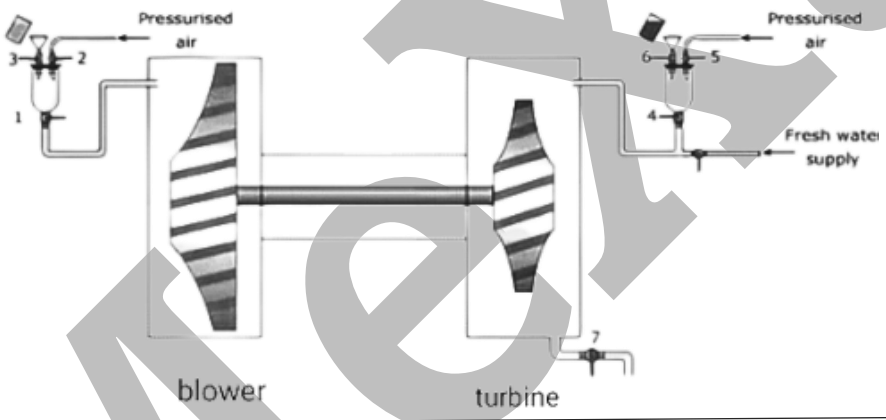
Advantages

- Not required to reduce engine rpm, thus not affecting the vessel performance.
- No use of water, so there is no corrosion and thermal stress.
- Cleaning time is short and easy to carry out.
- Effectively remove combustion residues and hard particles.

(c) Compressor side Water washing: Water washing of the compressor/blower side is carried out to remove dirt and carbon deposits, which affect the performance and efficiency of the compressor.

Procedure for Water Washing on the Blower Side:

- Compressor/blower side washing is to be done when the M/E is on full load to achieve the best possible cleaning.
- A container is fitted with an inlet line coming from the blower discharge side, and the outlet line from the container or cylinder goes for washing the blower side.
- Fill up warm, fresh water in the container and close the cover.
- When the valve in the inlet of the cylinder or container is opened, compressed air carries water with pressure, and the kinetic energy of water cleans the blower.
- Close the valve, once cleaning is done, open the cover to ensure it is empty.
- Ensure the correct amount of water is used for cleaning to prevent thermal stress and corrosion to the blower. Additionally, precautions should be taken to prevent water ingress into the engine intake system, which could lead to engine damage or malfunction.



(a) Describe the reasons for checking crank web deflections. (8)
(b) Describe the procedure for taking and recording crank web deflections of main engine. (8)

Jul 23

(a) Crank web deflections are checked primarily to assess the alignment of the crankshaft. The crankshaft's weight rests on the main bearings, and any uneven wear in these bearings will cause the crankshaft to bend, either upwards or downwards. This uneven wear leads to variations in the deflection measured between the webs. By checking these deflections against the manufacturer's specified limits, we can determine if the crankshaft alignment is within acceptable tolerances. Accurate measurements require minimising external influences; therefore, measurements should be taken when the vessel is at an even keel to avoid the impact of ship trim on the readings. Deflections are also measured after maintenance work (e.g., main or bottom end bearing replacement), following accidents (e.g., grounding) where misalignment is suspected, and at regular intervals to monitor crankshaft condition over time. Readings are *not* taken during loading, discharging, or ballasting operations or while the ship is in dry dock.

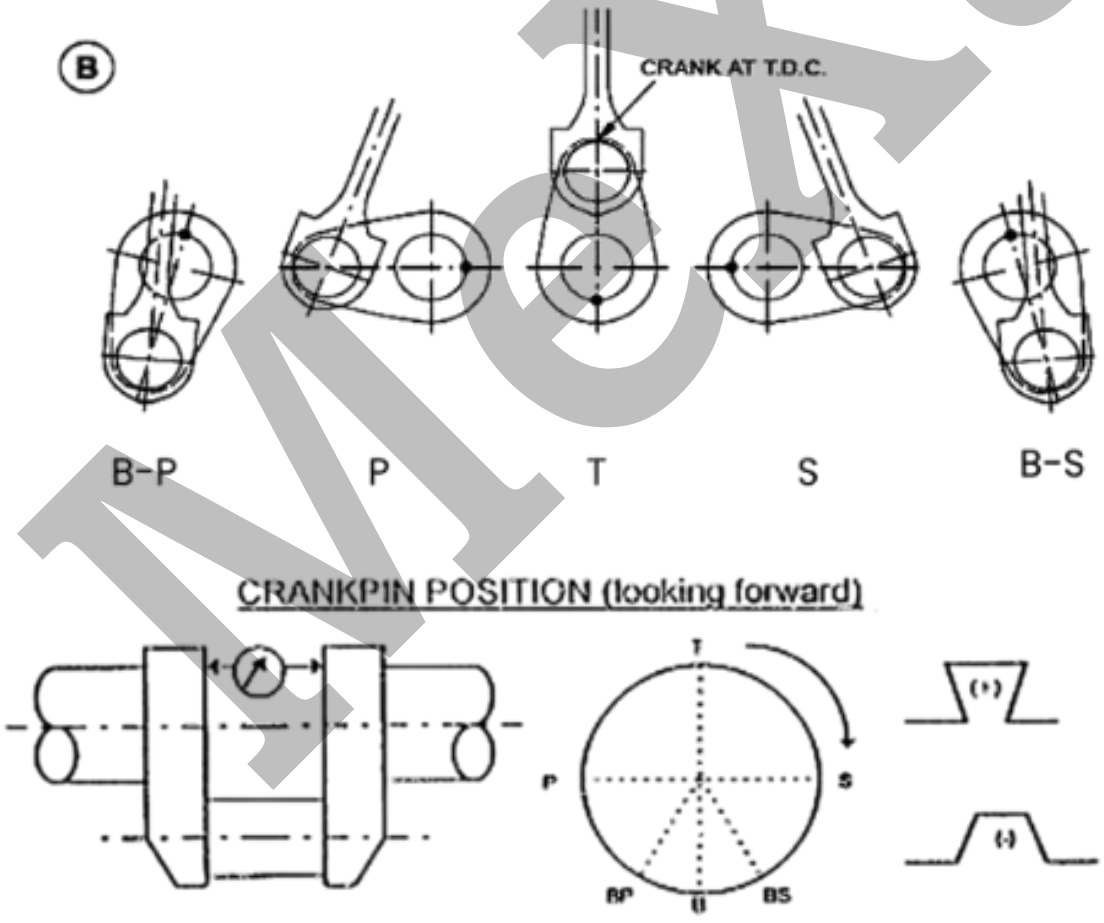
(b) Preparations for taking crank web deflections:

- Stop the engine and let it cool down for at least 30 minutes before the check.

- Stop the Lube oil pump and cooling water pump.
- Make sure indicator cocks on the auxiliary engine cylinder are opened.
- Make sure you have all the required devices ready for the reading.
- Make sure to get permission from the chief engineer and isolate the engine by switching off the breakers in the local panel and engine control room and opening up the crankcase door.
- The weather must be calm so that to gain the correct reading.
- Make sure that the crankshaft is seated down in each bearing.
- The person taking the deflection must have the control to turn the turning gear.

Procedure to measure crankshaft deflection:

- Start measuring deflections from the unit farthest to the flywheel.
- Place the crank pin at the point of 30° (position 'B') past the bottom dead centre.
- Install the deflection gauge in the pop point provided for this purpose.
- Set the reading on the gauge to 0 (zero reading) at position 'B' in the figure.
- Slowly conduct the turning of the engine in the normal direction of rotation and measure the reading on the scale when the crankshaft is at the angle of 'B-P', 'P', 'T', 'S' and 'B-S', respectively, of which data shall be recorded.

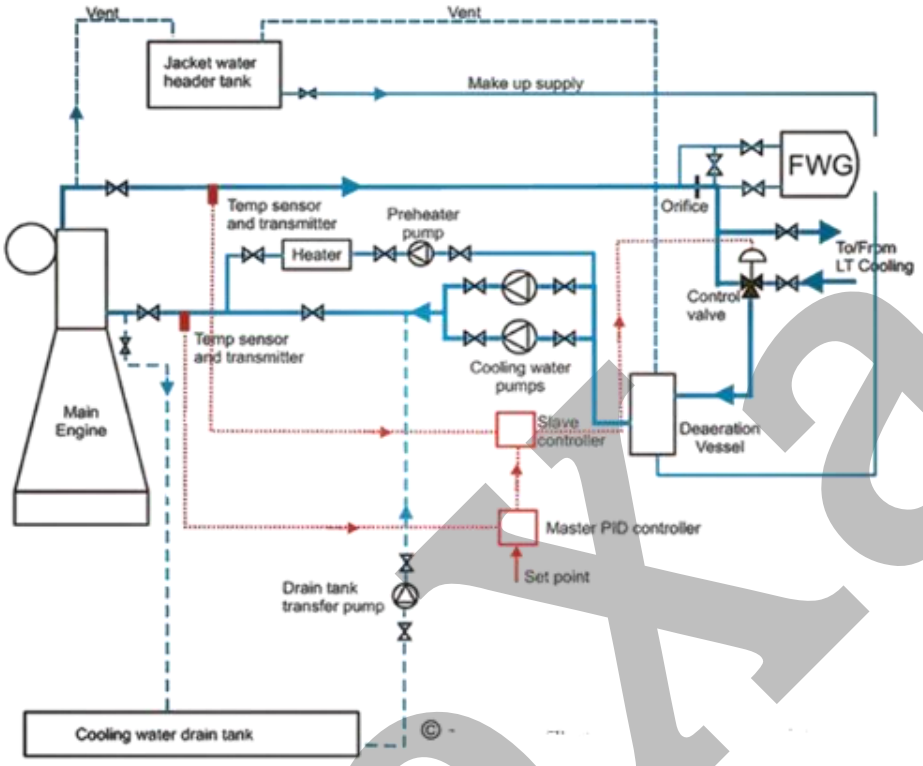


Calculating deflection (d): Calculate the deflection values based on the measured values and in accordance with the following formula and record the calculated values.

Vertical (V) deflection: dV = T – (BP+BS/ 2)
Horizontal (H) deflection: dH = P - S
positive/ negative deflection: open downward (+), closing downward (-) A, B, C, D, and E represent the measured values respective at each corresponding position shown in the figure above.

Draw cooling water system of main engine and naming each component and describe flow of cooling water through the system. (16)

Jan 24 | Jun 24 | Nov 24



Header Tank/ Expansion Tank:

Expansion tank having mainly three functions storage of fresh water, maintaining constant head and allowing for the expansion/contraction of the water as its temperature changes. It is also known as a Makeup water tank**.**

Air Separator/ De-Aerator:

It is an important component in the system, de-aerator removes the air accumulated in the system. Air accumulates in the system because of the heating of water or improper purging after maintenance. If it is not removed air lock in the system is likely to happen

J.W Cooler

Cooling can be done by dedicated coolers which cools the hot jacket water from the main engine. The cooling medium is fresh water or sea water, in new ships central cooling systems are used, where fresh water is a cooling medium.

Circulating Pump:

There are two jacket water circulating pumps used onboard with a discharge pressure of 3-4 bars. The Circulating Pump takes suction from the deaeration tank to the main engine.

Pre-Heater:

When the main engine is not running, or the ship is passing through colder areas it is necessary to keep the jacket water temperature at 80-85 degree Celsius. To accomplish this, a preheater is provided, which will not allow the jacket water temperature below 80-85 degrees Celsius.

Fresh Water Generator:

Fresh water generators act as a cooling component in the jacket water system. It uses the waste heat to produce distilled water.

Valve controller

This will control the three-way valve according to the jacket water engine outlet temperature. If the temperature at the outlet is less than the desired value valve controller bypasses the cooler with the help of 3-way valve.

(a) Describe indications of crank case explosion in main engine. (4)
(b) Describe actions to be taken, if there is crank case explosion in main engine. (8)
(c) Describe means of prevention of crank case explosion (4)
(d) Indications of Crankcase Explosion in Main Engine (4)

Jun 23 | Jan 25-1 | Jul 24 | Feb 24

(a) Indications of crank case explosion in main engine.

• Irregular running and excessive heating of the crankcase door(s), indicating potential issues.
• Unusual or abnormal engine noise within the crankcase can serve as an early warning sign of a developing problem.
• Elevated temperatures in the bearing lubricating oil and possibly the exhaust temperature may signal impending issues leading to a crankcase explosion.
• The presence of a distinct white oil mist odor is a clear indication of a potential crankcase problem.

(b) Actions to be Taken in the Event of a Crankcase Explosion

• Gradually reduce speed to a safe level, request permission from the bridge to stop the engine, and promptly execute the engine stop order.
• Open skylights and/or "stores hatch" for ventilation, leave the engine room, lock casing doors, and stay clear of potential danger zones.
• Do Not Stand Near Crankcase Doors or Relief Valves. Avoid proximity to potential danger zones such as crankcase doors or relief valves.
• Take necessary steps to prepare fire-fighting equipment for immediate use.
• Wait at least 30 minutes after stopping the engine before attempting to open the crankcase.
• When opening the crankcase, be mindful of possible spurts of flame and take precautions to stay clear
• Strictly prohibit the use of naked lights and smoking in the engine room during this emergency. Identify the "hot spot," inspect sliding surfaces for overheating, and take measures to prevent hot spots. This includes engaging in turning gear, checking oil flow, and ensuring proper lubrication.

(c) Means of Prevention of Crankcase Explosion:

• Conduct regular inspections and maintenance of the engine components, paying close attention to bearings, thrust bearings, piston rods, crankpin bearings, crosshead bearings and guides.
• Maintain a consistent and adequate supply of circulating oil to all bearings and critical areas within the crankcase.
• Address any identified issues leading to hot spots promptly, making permanent repairs to sliding surfaces and ensuring they are in good condition.
• Monitor the engine's performance, analyze any bearing metal found in the oil tray, and use the information for continuous improvement and preventive measures.

(a) Particles of metal have been found in the oil filter of a diesel engine crankcase. Describe how the nature and source of these particles may be determined. (5)
(b) (i) State the possible reasons for crankcase lubricating oil filters becoming choked over periods with the necessity for frequent cleaning (3)
(ii) Describe how this problem may be reduced (3)
(c) State the effect that restricted oil flow can have on different parts of an engine. (5)

Sep 22

(a) Determining the Nature and Source of Metal Particles in the Oil Filter of a Diesel Engine Crankcase

To determine the nature and source of the metal particles found in the oil filter of a diesel engine crankcase:

1. **Visual Inspection:** The particles can first be examined visually to determine their size, shape, and colour. These characteristics might indicate whether the particles are from bearings, pistons, or other engine components.
2. **Magnetic Testing:** A magnet can be used to determine if the particles are ferrous (magnetic), which would indicate they come from iron-based components, such as engine blocks or crankshafts. Non-magnetic particles might be from aluminum, copper, or other non-ferrous materials.
3. **Microscopic Examination:** Using a microscope, the structure and type of the metal can be analyzed to identify its composition and source. This might help pinpoint if it is from a particular engine part like piston rings or cylinder liners.
4. **Chemical Analysis:** Techniques such as spectrometric analysis (e.g., X-ray fluorescence, or atomic absorption spectroscopy) can be used to determine the exact composition of the particles. This could help identify the source by revealing the material elements present.
5. **Oil Analysis:** A detailed oil analysis can be performed to look for wear metals (like copper, iron, or aluminum). By comparing the concentration of these metals to typical engine wear patterns, the specific source of wear can be deduced.

(b) (i) Possible Reasons for Crankcase Lubricating Oil Filters Becoming Choked Over Time

1. **Excessive Engine Wear:** Over time, the engine parts may wear, releasing metal particles into the oil. These particles can accumulate in the filter, leading to clogging.
2. **Contaminant Ingress:** External contaminants like dirt, dust, or debris entering the engine can accumulate in the oil filter, contributing to the clogging.
3. **Oil Breakdown:** Over time, oil degrades due to high temperatures, oxidation, and contamination. This breakdown can cause the oil to become thicker, which in turn results in a faster accumulation of contaminants and clogging of the filter.

(ii) How to Reduce the Problem of Clogged Oil Filters

1. **Regular Oil and Filter Changes:** By adhering to a regular maintenance schedule of changing the oil and oil filter, the accumulation of contaminants can be minimized, reducing the likelihood of the filter becoming clogged.
2. **Improved Filtration System:** Using a higher quality oil filter with better filtration capacity and a higher dirt-holding capacity can help reduce clogging over time.
3. **Use of Synthetic Oils:** Synthetic oils have better oxidative stability and cleaner burn properties, which reduces the number of contaminants and particles in the oil, helping prevent clogging of the oil filter.

(c) Effect of Restricted Oil Flow on Different Parts of an Engine

Restricted oil flow can have several detrimental effects on various parts of an engine:

1. **Bearing Damage:** Insufficient oil flow to engine bearings (e.g., crankshaft or camshaft bearings) can cause them to overheat and wear out, potentially leading to complete failure.
2. **Piston Seizure:** The pistons require oil for lubrication. If oil flow is restricted, the pistons can overheat, causing them to seize inside the cylinders due to excessive friction.
3. **Overheating:** Oil plays a critical role in engine cooling. Restricted oil flow can prevent heat from being dissipated from engine components, leading to overheating, which can damage the engine.
4. **Reduced Lubrication of Valves and Lifters:** Insufficient oil can result in inadequate lubrication of valves and lifters, causing wear and tear, noise, and possibly failure of the valvetrain.
5. **Increased Friction and Wear:** Without proper lubrication, friction increases between moving parts (such as the crankshaft, camshaft, and valve lifters), leading to faster wear, reduced engine efficiency, and potential failure of engine components.

During the watch main engine crank case mist detector alarm has sounded

(a) List the steps to be taken to meet this emergency situation. (8)

(b) Subsequent inspection and action required to put the engine on normal operation (8)

Sep 22 | **Feb 25** | **Sep 24** | **May 24**

(a) Steps to be taken to meet this emergency (Crank case Mist Detector Alarm)

- On activation of the main engine oil mist high alarm, Engine will slow down automatically - this is because reducing the load on the engine will reduce the loading on the bearings (usual location of hotspot)
- The standby generator should start automatically and parallel with the running generator. If it does not start automatically, start it manually - this is because additional power will be required as auxiliary blowers and boilers will be started.
- Inform bridge, C/E and 2/E about the situation, if the vessel is not in navigational danger, stop the engine. This will help in cooling the hotspot.
- Evacuate all personnel from engine room. If there is a secondary explosion, this will cause injury to personnel.
- Do not go near crankcase relief valves. This is to prevent injury in case there is an explosion.
- Wait at least 20 minutes before opening the crankcase doors. Allowing oxygen by opening the doors may cause an explosion.

(b) Subsequent inspection and action required to put the engine on normal operation

- Isolate the engine (shut off start air, stop LO pumps, engage turning gear) this is to prevent accidental start
- Open crankcase doors and find the cause of overheating.
- Inform captain of damage and estimate time for repair. Inform DPA and superintendent so that they will know about the situation. May be will need to re-schedule of vessel.
- Repair/ rectify cause of overheating. This could be due to a bearing, chain rubbing, piston rod fouling on stuffing box, cracked piston etc. may involve in taking unit out of operation. Engine should not be restarted until cause is established and corrected.

- Before restarting check the oil flow through the bearings, chains/jet sprayers, piston cooling return. Turn engine and monitor load on turning gear motor (to check engine is not binding on tight spot)
- When restarting, keep close eye on any repairs. Use IR temperature gun to monitor location of overheating. Stop engine after 30 seconds, 2 minutes and 10 minutes running at low load and check for overheating. To prevent reoccurrence.
- Increase load over 2 hours, keeping a close eye on bearings temperature and oil mist detector. If running with unit out of operation, then must remain in Engine room control with conventional watch keeping. Look out for excessive vibration, T/C surging. Damage may be caused otherwise.
- If engine is fully operational, when Chief Engineer is satisfied with the running of the engine, hand back to bridge control.

During your watch you observe that Main Engine L.O. sump level is rising due to contamination of lubricating oil. Describe the procedure to:
(a) Identify the contaminant. (6)
(b) Locate the cause of contamination (6)
(c) Action to make the oil suitable for its continued usage. (4)

Dec 23 | **Oct 24** | **Apr 24-2** | **Apr 24-2** | **Aug 23** | **Aug 22**

(a) To identify the contaminant:
Conduct Water Content Test:
• Collect a representative sample of the contaminated lubricating oil.
• Perform a water content test using a suitable testing method to quantify the amount of water present.
• Compare the results with the maximum allowable amount of water for the specific engine type (e.g., < 0.2% for crosshead type engine).

Conduct Fuel Dilution Test:
• Check for fuel dilution in the lubricating oil by analyzing the sample.
• Conduct a fuel dilution test to identify if poor atomization of fuel injectors or other issues are causing fuel contamination.
Inspect for Solid Contaminants:
• Examine the lubricating oil for the presence of solid contaminants.
• Perform a particle analysis or visual inspection to identify and quantify any solid particles.

Microbial Degradation Test:
• Check for indications of microbial degradation, such as a rotten egg smell or increased acidity.
• Perform microbial degradation tests to confirm the presence of microbial contaminants.
Spectroscopic Analysis:
• Conduct spectroscopic analysis to study the overall contaminant levels and identify the types of contaminants present.

(b) Locate the cause of contamination:
Investigate Water Sources:
• Check for water leaks from leaking Cylinder liner O-rings, coolers, heaters, purifiers, and steam heating coils.

• Investigate possible causes such as condensation within the crankcase or leakage from cooling water systems.

Examine Fuel and Acid Sources:
• Investigate sources of fuels and acids, such as products of combustion, leaking seals of fuel cams, or poor atomization of fuel injectors.
• Determine if diesel contamination is reducing the viscosity of the lubricating oil in diesel engines.

Inspect for Solid Contaminants:
• Identify sources of solid contaminants from combustion or external sources during maintenance.
• Check for wax content, as it affects the pour point of lubricating oils.

Check Piston Cooling System and L.O. Purifier:
• Inspect the piston cooling system for water leaks.
• Check the L.O. purifier, ensure the gravity disc is correct, and verify the water outlet sight glass.

Monitor Sump Oil Level:
• Investigate the rate of decrease or increase in sump lubricating oil level.
• Check for possible leakages, such as a bed plate crack, and take appropriate action.

(c) Action to make the oil suitable for its continued usage:
Remedies for Contamination:
• Depending on the identified contaminants, implement proper purification methods, such as filtering, gravity separation, or centrifuging.
• Add special additives to reduce acids, sludge, and finer oil-insoluble matter.

Batch Purification Procedure:
• If heavy contamination is confirmed, follow the batch purification procedure.
• Obtain an immobilization permit and pump the entire oil charge into a settling tank, allowing it to settle for at least 24 hours.
• Drain water and sludge periodically, clean the sump tank interior, and pass the oil through the purifier before returning it to the sump tank.

Handling Sea Water Contamination:
• If the lubricating oil is contaminated with sea water, identify and stop the source of leakage.
• Transfer contaminated oil to a settling tank, settle for at least 24 hours, drain water and sludge periodically, and pass the oil through the purifier.
• Clean and examine the sump tank's interior, test the purified oil in the laboratory, and only reuse it if lab results indicate its fitness for further use.

(a) Describe what is Slipping of Crank web and its effect on main engine. (4)
(b) What actions are required if crank web slipping has occurred? (4)
(c) Describe reasons for Slipping of web on the journal. (4)
(d) Describe precautions against prevention of slipping crank web and journal. (4)

Nov 23 | Sep 24-2 | Apr 24

(a) Slipping of Crank web and Its Effect on the Main Engine:

Slipping of the crank web refers to the situation where the relative position between the crank web and the journal changes, deviating from their original alignment. This slippage can occur in a crankshaft that is assembled using the shrink-fitting method, where reference marks are made to indicate the correct positioning of the crank web and journal. If these marks show a misalignment during crankcase inspections, it indicates slippage. The effects of such slippage on the main engine can be significant. The timing for the exhaust valve and fuel injection may become altered for the affected units, leading to improper engine operation. This change in timing can also affect the air start timing, potentially causing issues such as turbocharger surging due to the altered airflow into the cylinders. Additionally, the crankshaft may experience abnormal vibrations, further compromising engine performance and safety.

(b) Actions Required if Crank web Slipping Has Occurred

If crank web slippage is detected, the appropriate action depends on the degree of slippage. For minor slippage (up to about 5°), it may be possible to adjust the fuel pump and exhaust timing by hydraulically expanding and rotating the cams on the camshaft. This adjustment can help compensate for the altered timing, although careful monitoring is needed to ensure that the slippage does not worsen. If the slippage is more significant, there are two primary options: replacing the crankshaft or attempting to jack it back into its original position. The jacking process involves chilling the journal pin with liquid nitrogen or dry ice, warming the web with a broad flame, and then carefully jacking the web back into place. However, this procedure is risky, as applying too much pressure can cause the webs to jump back suddenly, leading to further slippage or damage to the crankshaft. If this occurs, the shrink fit may be destroyed, necessitating crankshaft replacement.

(c) Probable Reasons for Slipping of Web on the Journal

Many factors can cause the web to slip on the journal. One common cause is the application of starting air to cylinders that contain water or fuel, which can create a hydraulic lock and result in excessive force on the crankshaft. Attempting to start the engine while the propeller is constrained, such as when it is stuck in ice or a log, can also lead to slippage. Additionally, if the engine encounters a rapid, unscheduled halt, such as striking a submerged object, the sudden stop can cause the crank web to slip on the journal. These scenarios all involve significant forces being applied to the crankshaft, leading to the misalignment of the crank web and journal.

(d) Precautions Against Prevention of Slipping Crank web and Journal

Regular checks of the crankshaft alignment are essential to detect any developing defects early on. Monitoring the wear on bearings is also important, as substantial differences in bearing wear can indicate underlying issues that need to be addressed. Proper treatment and maintenance of lube oil are crucial to avoid bearing damage, which can lead to slippage. Additionally, the foundation bolts of the engine should be checked and tightened regularly to ensure they remain secure. Finally, operators should avoid running the engine within its critical speed range, where vibrations can cause excessive stress on the crankshaft and potentially lead to slippage. By adhering to these precautions, the likelihood of crank web slippage can be significantly reduced, thereby enhancing engine reliability and safety.

State with reasons which one of the following would most help to correct a pronounced discoloration of the M/E lubricating oil: (16)

(a) "Make up" from reserve tanks

(b) Increase purifier throughput

(c) Increase frequency of filter pack

(d) Overhaul piston rod stuffing boxes
(e) Check tank top integrity of sump tank

Oct 23 | Dec 22

(a) "Make up" from reserve tanks Freshening up from reserve tanks will certainly reduce the discoloration, but this will only suppress the immediate problem, not cure it. **The root cause of discoloration must be traced and eliminated**.

(b) Increase purifier throughput for more efficient purification, the oil throughput in the purifier must be reduced. Increasing the throughput will have the opposite effect and **should not be done**.

(c) Increase frequency of filter pack cleaning
When a filter is dirty, there will be a larger pressure drop across the filter and there may be oil starvation at the bearing leading to serious consequences. Therefore, the filters must be cleaned regularly and as often as necessary depending upon the amount dirt in the filter. However, mere cleaning of the filter will not solve the problem of discolouration of the oil.

(d) Overhaul piston rod stuffing boxes Leaky piston rod stuffing box will allow sludge and unburnt carbonaceous matter from the piston under space to enter the crankcase and discolour the oil by contamination. This may indeed be the root cause, and if so, overhaul of the, piston rod stuffing boxes should prevent further discolouration.

(e) Check tank top integrity of sump tank on large ships, the lubricating oil circulating tank is formed as a "triple bottom" by providing coffer dams not only on all sides, but also at the bottom of the circulating tank. As long as the coffer dams adjoining the circulating tank are dry, these will unlikely be the source of contamination.

However, if the tank top just above the circulating tank has any crack or leak then dirty oil and water collected on the tank top can enter the circulating tank and contaminate or discolour the oil. A rise in sounding of the circulating tank should provide a clue to the problem. It will nevertheless be prudent to check the integrity of the tank top.

With reference to stuffing Box of a two-stroke main engine explain following:
(a) Why stuffing box is required in two stroke diesel engines. (8)
(b) Explain the maintenance carried out on stuffing box during piston overhaul (8)

Dec 23 | Oct 24 | Apr 24-2 | Nov 22

(a) Stuffing box in a two stroke engine is required for:
• One of the primary functions of the stuffing box is to create a reliable seal between the scavenge space and the crankcase. This prevents any undesired exchange of substances and air between these two crucial engine areas.

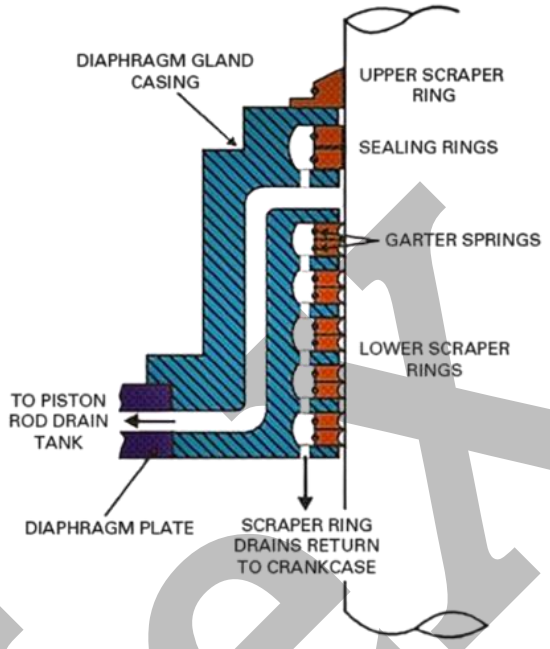
Preventing Scavenge Air and Residues Entry:
• The upper section of the stuffing box acts as a barrier to prevent scavenge air and any residues present in the scavenge pace from entering the crankcase. This ensures the crankcase remains uncontaminated.

Preventing Oil Carry-Over:

• The lower section of the stuffing box serves to prevent oil carry-over through the piston rod from the crankcase to the scavenge space. It helps maintain proper lubrication in the engine while keeping the scavenge space clean.

Neutral Section for Leakage Drain:

•The middle or neutral section of the stuffing box is designed to provide a drainage pathway for any potential leakage from either the upper or lower sections, preventing the accumulation of fluids within the stuffing box.



(b) Maintenance carried out on Stuffing box during overhaul:

•Vertical clearance between the ring and the housing groove is carefully inspected. Excessive clearance can lead to hammering of the rings within the housing during engine operation.

•Ring end clearance, also known as butt clearance, is checked. Inadequate clearance can result in ineffective sealing.

• The tension of the springs in the stuffing box is assessed. This is done by measuring the spring length at different loads, as specified in the manual, and comparing it to the free length of the spring as given in the manual.

•Some types of scraper rings can have their scraping function restored by replacing the lamellae that slide into the scraper ring segments. If Lamellas are worn, replace them.

•When fitting new ring segments, any sharp edges should be removed by gently rubbing the segments against a piece of emery cloth taped to the piston rod.

•During reassembly, it is important to ensure that the ring sets have their gaps offset correctly for effective sealing and scraping functions.

Describe reasons and solutions for following troubles occurring during starting of main engine;

(a) Engine fails to start. (4)

(b) Engine does not reverse. (4)

(c) Engine starts on starting air but shuts down. (4)

(d) Engine runs unevenly. (4)

Jun 23

(a) Engine Fails to Start:
• Low air bottle pressure or closed airline valves.
• Malfunctioning air bottle isolating valve, automatic valve, or distributor.
• Faulty control air valves or insufficient control air pressure.
• Jammed start air automatic valve.
• Engaged turning gear or faulty limit switch.
• Incomplete reversing action.
• Fuel or 'start' control valve not in its end position.
• Damaged bursting diaphragm on the start airline.
• Fuel lever not in remote mode.
• Insufficient spring air pressure to close the exhaust valve, causing compression loss.
• Inoperative or non-automatic auxiliary blower.
• Start air distributor issues like activation failure, sticking piston, wrong adjustment, or sticking control valve.
• Defective or sticky cylinder air starts valves.

(b) Engine Does Not Reverse:
• Sticking start air valve for the specific unit.
• Jammed reverse control valve.
• Jammed reversing servomotor of the fuel or start air distributor.
• Propeller force requiring more air and fuel for starting against the propeller's rotation.
• Propeller tending to turn the engine in the original direction, blocking fuel.
• Issues with the solenoid valve coil, control air signal, or air route affecting the desired direction of rotation.

(c) Engine Starts on Air but Shuts Down:
• Improperly vented puncture valves in B&W engines.
• Jammed fuel regulating linkage or hindered by the stop cylinder.
• Fuel lever not in remote mode.
• Defective governor or lack of boost air to the governor.
• Sticking rotary valve of the rotation direction safeguard.
• Shutdown of fuel pumps.
• Blocked fuel filter or low fuel pump index.
• Low pre-set control air signal to the governor.

(d) Engine Runs Unevenly:
• Presence of water in the fuel.
• High fuel volatility.
• Fuel gas lock.
• Injection variation.
• Worn-out governor linkages.
• Poor fuel quality.
• Unbalanced units.
• Overly sensitive governor setting.
• Air in the governor.

Auxiliary Diesel Engines

◆ **Notes:**

(a) Outline the advantages and disadvantages of a planned maintenance scheme for an auxiliary diesel engine. (6)
(b) State the advantages of condition monitoring as a method of deciding when auxiliary engine component overhaul is necessary. (5)
(c) Suggest the means that are normally available (i.e. without the need for elaborate or expensive equipment) to check the condition of a diesel engine as a guide to ascertain the maintenance that is actually needed.

Aug 22

(a) Advantages and Disadvantages of a Planned Maintenance Scheme for an Auxiliary Diesel Engine:

Advantages:

• Planned maintenance helps minimize unexpected failures, leading to higher operating efficiency as the engine is kept in good working condition.
• Maintenance tasks are scheduled in advance, allowing for proper allocation of labor and materials at times that are, favorable to the ship's operation, reducing operational disruptions.
• Maintenance is carried out at times convenient for the ship's staff, ensuring that the workforce is efficiently utilized.
• Replacement spares can be acquired and stored in advance, reducing the time required to source and replace parts during maintenance.
• Planned maintenance helps keep the equipment in a safe condition, reducing the risk of accidents and damages.
• Specialized manufacturer services can be obtained at convenient times, aligning with the ship's operational schedule.
• Short-life components can be replaced at predetermined intervals, preventing unexpected failures.

Disadvantages:

• Planned maintenance may result in higher maintenance costs due to the regularity of maintenance tasks, even if they are not immediately required.
• In some cases, unnecessary and invasive maintenance may be carried out, leading to additional expenses and potential risks.
• Planned maintenance is primarily suitable for addressing age-related deterioration and may not address sudden or unexpected failures.
Maintenance activities themselves can sometimes induce failures, especially if not executed correctly or if components are replaced prematurely

(b) Advantages of Condition Monitoring for Auxiliary Engine Component Overhaul:

• Condition monitoring ensures that maintenance is performed only when necessary, saving manpower and minimizing downtime.
• By monitoring the running condition of equipment, condition monitoring maximizes equipment availability, minimizing production loss and operational disruptions.
• Knowing the running condition of equipment enables safe and efficient operation, reducing the risk of damages and accidents.
• Condition monitoring allows for the detection of faults before they become serious, preventing major damage and avoiding costly repairs or replacements.
• It enables the analysis of the causes of failures, allowing for effective rectification and addressing underlying issues.

• Condition monitoring data helps in planning maintenance activities, organizing labor, and arranging for spare parts in advance, streamlining the maintenance process.

(c) Means to Check the Condition of a Diesel Engine without Elaborate or Expensive Equipment:

Regularly inspecting the engine for visible signs of wear, leaks, corrosion, or loose components can provide valuable information about its condition.

• Sampling and analyzing engine oil can reveal the presence of contaminants, wear particles, and chemical changes that signal potential issues.

• Using simple temperature gauges to check for abnormal temperature fluctuations in the engine can indicate overheating or cooling system problems.

• Listening for unusual sounds and monitoring vibrations during operation can help identify abnormal engine behavior.

• Monitoring performance metrics such as fuel consumption exhaust emissions, and power output can provide insights into engine health.

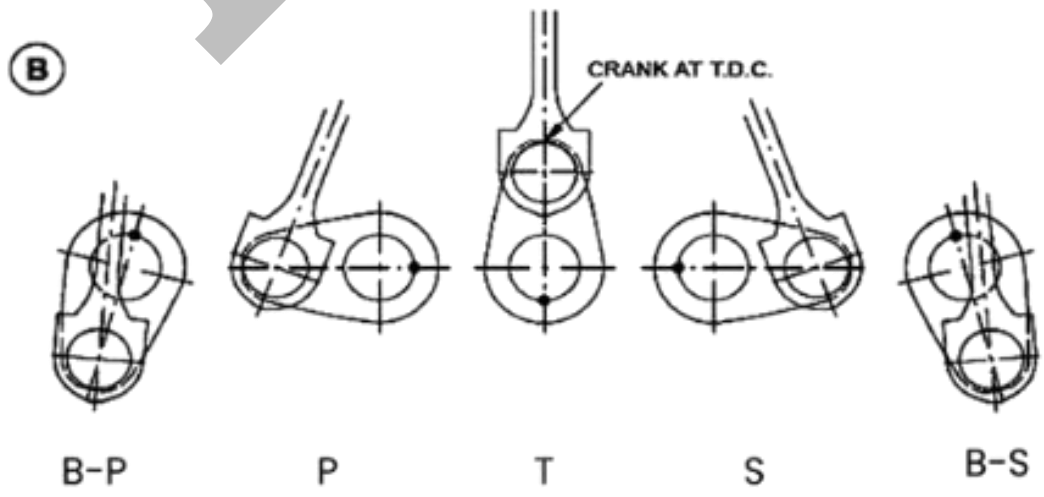
• Keeping detailed records of maintenance and repairs can help track the engine's history and identify recurring issues.

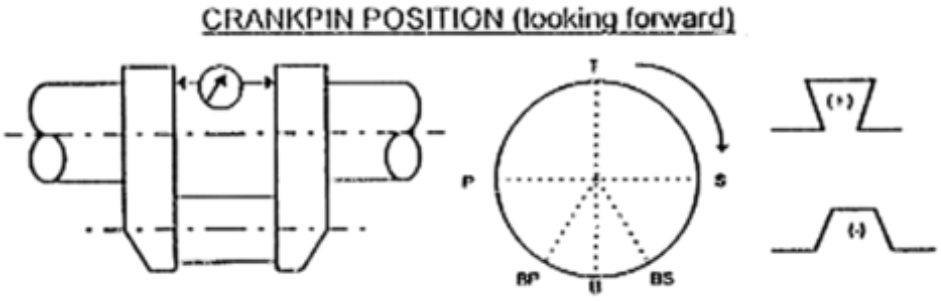
(a) Describe how Auxiliary engine crankshaft deflections are measured. (6)
(b) State how the measurements can be checked for accuracy. (5)
(c) Specify with reasons other checks that should be made on the crankshaft.

Jan 24 | Nov 24 | Jun 24 | Oct 24 | Sep 23 | Oct 22 | Dec 22 | Sep 22

(a) The deflection of the crankshaft shall be represented by the value when the engine is cold, and since the values measured when the engine is warm sometimes differ significantly depending on the measured conditions, be minded not to use the value measured when the engine is warm as standard.

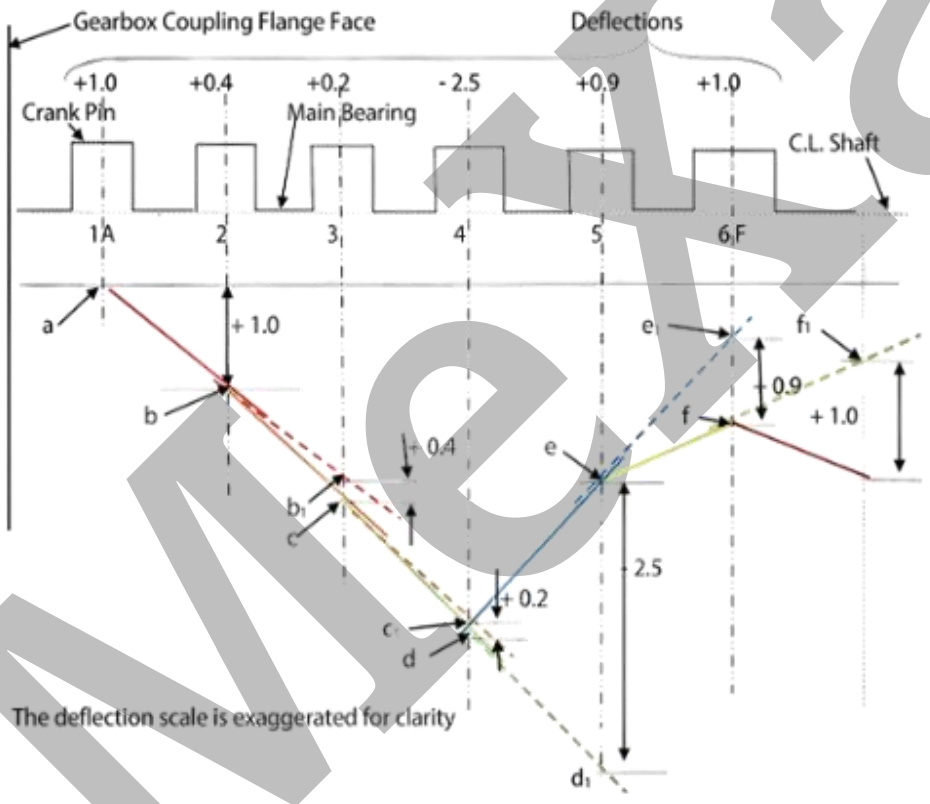
• Stop the engine and engage the turning gear.
• Start measuring deflections from the unit farthest to flywheel
• Place the crank pin at the point of 30°(position 'B') past the bottom dead center.
• Install the deflection gauge in the pop point provided for this purpose.
• Set the reading on the gauge to 0 (zero reading) at the position 'B' in the figure.
• Slowly conduct turning of the engine in the normal direction of rotation and measure the reading on the scale when the crankshaft is at the angle of 'B-P', 'P', 'T', 'S' and 'B-S' respectively, of which data shall be recorded.





Calculating deflection (d): Calculate the deflection values as based not the measured values and in accordance with the following formula and record the calculated values.
Vertical (V) deflection: dV = T – (BP+BS)/2 Horizontal (H) deflection: dH = P - S deflection: open downward (+), closing downward (-).

(b)



A curve is drawn with the values of the vertical misalignment obtained at each crank. Starting from one end. The deflection at each crank is progressively added and the points are plotted. If the deflections are uniform. The curve drawn through the points is smooth. The curve is allowed to deviate at each crank position by an angle proportional to the deflection measured at that crank. The curve displays an unequal deviation. The curve is used to isolate the faulty bearing.

(c)

- The working surface of journals and pins to be examined for signs of corrosion or pitting caused by water or acid contamination of the lubricating oil
- Shrink-fit reference marks should be checked
- Crank web deflection to be taken
- The tightness of coupling bolts should be checked
- Locking of coupling bolts to be examined

• The tightness of oil pipes and bearing locking devices should be checked
• Oil holes must be cleaned
• Balance weights securing arrangement to be checked and inspection for cracks to be carried out
• Plug in oil holes and check oil tightness Check crankpin bearing and main bearing clearances.

With reference to exhaust valves of an auxiliary diesel engine
(a) Describe how valves are reconditioned (8)
(b) Explain how valve timing is checked and corrected. (8)

Apr 23

(a) The process of Reconditioning Exhaust valve spindle & seat:
• Sandblasting
• Testing and inspection of markings to determine is - Stellite type or Nimonic
• Machining of the seat surface
• Machining of fire side face (up to 6mm)
• Preheating
• Gradual build-up of fire side face using original material (up to 6mm)
• Gradual rebuilding with Nimonic 80A (for Nimonic Type) or stainless steel with Stellite #6 in way of seat area (for Stellite Type)
• Gradual cool down and stress relief after all welding procedures
• Dye check for crack detection on completion of work
• Grinding of the seat to makers tolerance

(b) valve timing is checked and corrected
• The valve train is geared or has a chain drive with sprockets on the camshaft and crankshaft.
• Any slight variation from the correct timing setting will result in loss of power and overheating.
• Any large variation and the engine will not start.
• To accurately check the valve timing, it will be necessary to remove the timing cover to gain access to the timing gears.
• The gears or sprockets are fitted to the crankshaft and camshaft by keys so they can only be fitted in one position.
• However, they can be incorrectly lined up to each other. It can be varied by modifying the camshaft, or it can be varied during engine operation by variable valve timing.
•It is also affected by the adjustment of the valve mechanism, and particularly by the tappet clearance.

The exhaust temperatures of an auxiliary diesel engine are found to be excessive and uneven at normal load, with dark exhaust at the funnel.
Describe EACH of the following:
(a) An investigation into the situation (5)
(b) The procedure to remedy the immediate problems (6)
(c) Any further action that might be necessary (5)

Dec 23 | **Dec 24-1** | **Oct 24** | **Apr 24-2** | **Mar 24** | **Oct 23** | **Dec 22** | **Sep 23**

(a) Investigation of the Situation:
Exhaust Smoke Color:

• The dark exhaust at the funnel indicates incomplete combustion and excessive carbon particles in the exhaust. Investigation is needed to identify the root cause.

Air-related Problems:
• Check the turbocharger air filter for choking and cleaning or replace it if necessary.
• Inspect the turbocharger turbine blades for fouling or damage, affecting air supply.
• Examine the turbocharger inlet grid in the exhaust manifold for choking.
• Check compressor blades for dirt or damage affecting air compression.
• Inspect scavenge ports for blockages.
• Verify the condition of scavenge valves.

Fuel-related Problems:
• Check fuel temperature, as low temperature can lead to poor atomization.
• Inspect fuel injectors for dripping or malfunction.
• Verify the timing of fuel pumps.
• Examine fuel injector holes for wear.
• Check spring pressure of fuel injectors.
• Ensure the correct fuel grade and quality are used.
• Verify valve lift of fuel injection valves.
• Check for unbalanced engine operation.
• Investigate if any units are not firing.

Turbocharger and Blower Speeds:
• Measure and compare the actual speeds of the turbocharger and engine room blowers with their rated speeds.

(b) Procedure to Remedy Immediate Problems:
• **Stuck Fuel Rack:** If a fuel rack is stuck, manually pull it back and lubricate it. If it doesn't free up, replace the fuel pump with an overhauled one.
• **Low Turbocharger Speed:** Attempt turbine washing or dry grit cleaning. If speed doesn't improve after multiple washes, open and clean the turbine.
• **Temperature Drop Across Turbocharger:** Perform turbine washing. If the issue persists, open the turbine and clean it.
•**Dirty Turbocharger Compressor:** Perform water washing of the blower. If it's ineffective, open and clean the compressor.
• **Dirty Air Filter:** Replace the air filter and adjust the mesh density if needed.
• **Incorrect Fuel Pump Timing:** Re-adjust the fuel pump timing to the manufacturer's specifications.
• **Faulty Fuel Injection Valves:** Stop the engine, pressure test all fuel valves, and rectify any faults found.
• **Low Fuel Temperature:** Heat up the fuel to the recommended temperature as per the manufacturer's guidance.
•**Scavenge Fire:** Slow down and stop the engine. After cooling, clean the under-piston space and investigate the cause of the fire.

(c) Further Action:
• Address any issues found during the immediate remedy procedure, such as repairing or replacing faulty components.

• Regularly monitor exhaust conditions and perform routine maintenance to prevent recurrence of issues.
• Analyze data and trends from the engine's performance monitoring system to detect potential problems early.
• Perform regular maintenance of the turbocharger, fuel injection system, air filters, and other relevant components to ensure optimal performance.
• If the problem persists despite corrective actions, consider a comprehensive inspection or even an overhaul of the engine's major components to ensure long-term reliability and efficiency.

(a) Describe the importance of taking crank web deflections of Auxiliary engine. (4)
(b) Describe preparations for taking crank web deflection of Auxiliary Engine. (4)
(c) Describe procedure for taking crank web-deflection of Auxiliary engines and their evaluation (8)

Jun 23

(a) Crank web deflection: When the piston is on top dead centre at that time load on the crank pin is from the piston rod, con rod and piston crown in the downward direction. This will cause the web to move APART from its axial position. When the piston is on the bottom dead centre at that time load on the crank pin is from the piston rod, con-rod, and piston crown in a downward direction this will cause the web to move INWARD direction from its axial position. When to take deflection:

- Deflection to be taken when any maintenance work is been carried out such as the main bearing, or bottom end bearing.
- In case of any accident such as grounding or in doubt of any misalignment of engine has taken place
- It also required taking a reading at specific intervals of time to monitor the condition of the crankshaft alignment
- No deflection should be taken while loading, discharging and ballasting operation and also not when the ship is in dry dock

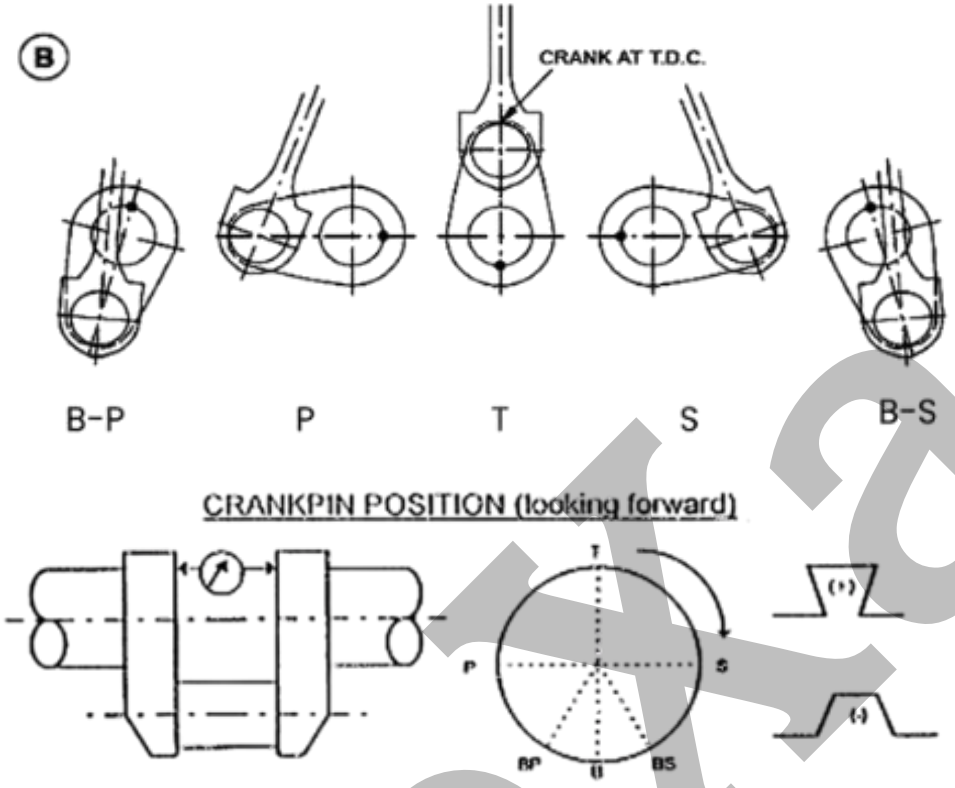
(b) Preparations for taking crank web deflections:

- Stop the engine and let it cool down at least for 30 minutes before the check
- Stop the Lube oil pump and cooling water pump.
- Make sure indicator cocks on the auxiliary engine cylinder are opened
- Make sure you have all the required devices been kept ready for the reading
- Make sure to get permission from the chief engineer and isolate the engine by switching off the breakers in the local panel and engine control room and opening up the crankcase door
- Weather must be calm so that to gain correct reading
- Make sure that the crankshaft is seated down in each bearing
- The person taking the deflection must have the control to turn the turning gear

(c) Procedure to measure crankshaft deflection:

- Start measuring deflections from the unit farthest to the flywheel
- Place the crank pin at the point of 30° (position ‘B’) past the bottom dead centre.
- Install the deflection gauge in the pop point provided for this purpose.
- Set the reading on the gauge to 0 (zero reading) at position ‘B’ in the figure.

- Slowly conduct the turning of the engine in the normal direction of rotation and measure the reading on the scale when the crankshaft is at the angle of 'B', 'C', 'D', 'E' and 'A' respectively, of which data shall be recorded.



Calculating deflection (d): Calculate the deflection values as based not the measured values and in accordance with the following formula and record the calculated values.

Vertical (V) deflection: dV = D - BP+BS/ 2
Horizontal (H) deflection: dH = P - S

positive/ negative deflection: open downward (+), closing downward (-) A, B, C, D and E represent the measured values respective at each corresponding position shown in the figure above.

(a) What mountings are installed on a 4-stroke auxiliary engine cylinder head (6)
(b) Describe the procedure for lifting auxiliary engine cylinder head. (10)

Feb 23

(a) The mountings on a 4S aux engine cylinder head are:

- Exhaust valve
- Inlet valve
- Rocker arm
- Fuel injectors
- Air starting valve.
- Indicator cock
- Cooling water connections
- Safety valve.
- Fuel connections

(b) Describe the procedure for lifting the auxiliary engine cylinder head.

• Before overhauling, take off the top and bottom cover from the cylinder head.
• The cylinder head assembly is connected to the exhaust manifold, scavenge manifold, cooling water system, starting air system, and fuel oil high pressure pipe.
• To take out the cylinder head for overhaul remove the scavenge and exhaust manifolds.
• Remove all the pipes connected to the cylinder head.
• Remove the Rocker arm holder.
• Take out the valve Yokes, push rods, and the protective tubes.
• Remove the indicator valve and fuel injector.
• Hydraulically tightened nuts hold the cylinder head.
• Place the jack mounts on the nuts.
• Tighten the jacks on the studs fully and open half turn.
• Connect high pressure hose.
• Operate the hydraulic pump and purge the air through the air vent plug.
• Operate the hydraulic pump and increase it to the prescribed pressure.
• Slacken the nuts using the Tommy bar through the opening in the mount.
• Take off the hydraulic Jack mounts and unscrew the cylinder cover nuts.
• Lift the cylinder head clear from the top face of the liner, using the appropriate lifting tool.

Fuel injector needle valves are found to be seizing frequently. Explain:
(a) The effects on the engine operation (8)
(b) The probable causes and remedial actions to be taken (8)

Sep 22

(a) The effects on the engine operation

1. Reduced power: A seized needle valve can prevent the injector from fully opening or stuck in a certain position causing less fuel or no fuel into that cylinder causing reduce overall power output. Partly open and stuck needle valve may cause the injectors to dribble causing exhaust smoke- high NOx and eventually low power output.
2. Poor Fuel Economy: Wrongly timed injection, inadequate fuel or excessive fuel may lead to incomplete combustion and wastage of fuel. This leads to reduced fuel economy.
3. NOx emissions may increase due to improper timing and wrongly metered fuel quantity.
4. Increased Exhaust Smoke: More fuel compared to air may create a state of improper or incomplete combustion, leading to black smoke at Funnel.
5. Starting problem of Engine
6. Irregular- Improper combustion.

(b) The possible cause could be either:

- Overheating of the fuel injector due to inadequate cooling
- Abrasives in the fuel from inadequate fuel preparation.

The following actions to be taken to minimize the seizing of fuel injector needle valve:

1. Take a sample of the fuel entering the engine and send it for analysis to investigate possible contamination from metal elements
2. Remove all of the other injectors at the earliest opportunity to examine for defects and to test the injectors.
3. Examine the injector tips looking for overheating. If this is present, then check the operation of the injector cooling system (if fitted) and the cylinder head cooling system.

Inspect the same system for internal fouling of the heat transfer surfaces. Ensure that the high temp alarms are functioning.

4. Ensure that the flow rates for the fuel oil purifiers are as low as possible whilst still maintaining the service tank level. If a gravity disc is used, check that the largest sized disc is fitted without causing water seal failure. Both of these actions will reduce the level of contamination in the purifier clean phase outlet. oil purifiers are as low as possible whilst still maintaining the service tank level. If a gravity disc is used, check that the largest sized disc is fitted without causing water seal failure. Both of these actions will reduce the level of contamination in the purifier clean phase outlet.
5. If two settling tanks are available, ensure that the filling of one settling tank differ from that with the active FO separator suction. This will maximize fuel settling time and provide cleaner fuel at the purifier suction.
6. Check the condition of the cold and hot fuel oil filters for physical damage, that would allow dirt to pass through the filtering unit.
7. Check the correct operation of the fuel injector test unit, with regard to the correct calibration/protective oil.

Auxiliary Machinery Purifiers

- **Notes:**

(a) Describe the safe isolation procedure of centrifuges on board ships before starting maintenance work. (6)
(b) Describe maintenance schedule of centrifuge for satisfactory operation. (10)

Sep 24-2 | Apr 24

(a) The safe isolation procedure for centrifuges on board ships before starting maintenance work involves the following steps:

- Inform the relevant personnel, including the Chief Engineer, Second Engineer, and other crew members, about the maintenance work to be carried out on the centrifuge.
- Ensure that the power supply to the centrifuge is isolated by switching off the main power supply and locking the electrical panel
- Secure the area around the centrifuge by placing warning signs and barriers to prevent unauthorized access
- Drain the system of any fluids or gases that may be present in the centrifuge.
- Ventilate the area to remove any fumes or gases that may be present
- Use lockout/tagout procedures to ensure that the centrifuge cannot be operated while maintenance work is being carried out.
- Check for any residual energy in the centrifuge, such as stored hydraulic or pneumatic pressure, and release it if necessary.
- Wear appropriate PPE, such as gloves, goggles, and a face shield, to protect against any hazards.
- Follow the manufacturer's instructions for safe isolation and maintenance of the centrifuge.
- Perform a risk assessment to identify any potential hazards and take appropriate measures to mitigate them.

(b) Maintenance schedule for centrifuge for satisfactory operation:
Every 500 running hours:
Separator bowl:

- Dismantle, cleaning and inspection of bowl parts, disc and disc stack
- Bowl assembly and discharge mechanism should be inspected after dismantling and cleaning
- Checking of: Sliding bowl, Discharge mechanism, Guide surface, Bowl spindle cone and bowl body, Lock ring, Height position of paring disc, Corrosion and erosion of bowl assembly parts, Corroded and eroded bowl parts may be replaced with original parts

Gear case:

- Check the gear oil condition, collect a sample and send for Ferro-graphic analysis. Replenish the gear case oil with a fresh charge. Check the worm-wheel shaft

Friction pads:

- Check the thickness and roughness of the friction lining in the friction pads. Dress up the pads or replace them as required.

Every 1000 running hours:
Separator bowl:

- Dismantling, cleaning, and inspection of the inlet and outlet of the frame hood
- Inspect the inlet and outlet pipe with frame hood, check the sealing faces

Paring Disc:

- Dismantling, cleaning and assembling of paring disc
- Inspect the paring discs, height of paring discs and sealing rings
- Exchange of sealing rings and gasket and carry out replacement of O-rings
- Height of paring disc adjusted as per maker specification

Worm wheel arrangement:

- Gear case inspection
- Check the worm wheel shaft, worm wheel, and worm gear for abrasion marks, rubbing and axial play of the worm wheel shaft. If abrasion and erosion are unacceptable, replace the parts
- If the axial play is unacceptable, adjust as required.

Frame feet:

- Checking the foundation for bolt tightness.

Every 2000 running hours:
Worm wheel arrangement:

- Check the axial play of the shaft
- Replacement of friction pads
- Wear of groove in worm and wheel
- Replacement of bearings. Inspection of top bearing springs and ball bearings. Replace the springs and ball bearings, if necessary.

Every 4000 running hours:
Worm wheel arrangement:

- Dismantling, cleaning and inspection of the worm wheel shaft
- Renew ball bearing, sealing washer, seal ring
- Inspect the shaft in the way of the bearing seating area
- Check the height position of the bowl spindle

Every 8000 running hours:
Frame feet:

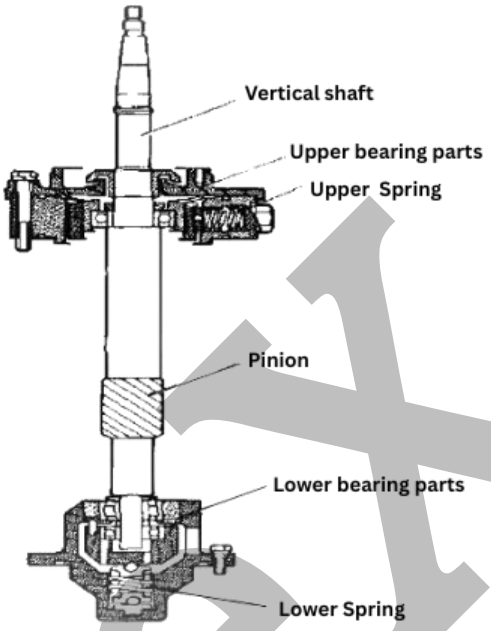
- Inspection of rubber cushions, exchange of rubber cushions
- Renew horizontal shaft parts with ball bearings
- Renew vertical shaft parts will ball bearings

(a) Explain briefly the procedure for maintaining vertical shaft of a centrifuge (purifier); name the parts with simple sketch. (12)
(b) Briefly explain what is the purpose of gravity disc in a purifier? (4)

Jul 22

(a) The vertical shaft parts are dismantled once in 8000 hours. Usually, bearings, bearing housing and bearing springs are checked and renewed as appropriate. Sealing rings and O-rings are renewed as per maker's recommendations. Bowl spindle is inspected in the way of ball bearings. Replace the vertical shaft if the bearing seating area has thinned down. Bowl spindle: Prior to dismantling the bowl spindle, the inlet and outlet, frame hood, bowl and paring disc device for operating water must be removed. Clean all dismantled parts thoroughly. Check for damage and for corrosion on spindle top. Presence of black deposits on the spindle parts indicates that the

oil base has deteriorated seriously or that some of the oil additives have precipitated. Vertical shaft parts: The vertical shaft parts drive bowl which is heavy and rotates at high speed by means of friction force of conical part on top of vertical shaft. Accordingly, a satisfactory maintenance is very important as it would directly affect the balance of bowl, contact of bowl with frame, vibration and damages of various parts. The life of vertical shaft parts, different from that of each part of bowl, is not governed by the properties of oil to be treated, but they are composed of many parts requiring replacement after it is put into operation for certain fixed hours. If required to adjust vertical height, a shim may be put under bowl or removed as the case may be.



1. Since corrosion may happen on the part above the upper bearing fitting part, it shall be inspected well and shall be replaced according to the degree of corrosion.
2. In case there are partial flaws on fitting part with bowl, they shall be repaired and smoothed with a set of files and sand paper. If the flaws are formed in a continuous ring shape, it shall be replaced.
3. In case threaded part has partial struck flaws, it must be repaired and smoothed with a set of files and sandpaper.
4. As for abrasion of fitting part with bearings, if the inner race of bearing is slippery, it must be replaced.
5. If the teeth of pinion are rough and have slight abrasion, they shall be repaired with a set of files, sandpaper and oilstone. In case of abnormal abrasion, it shall be replaced together with spiral gear.
6. Centre deviation of vertical shaft shall be measured at tapered part. fitting part with lower bearing and middle part of the shaft. It shall be limited to less than 5/100 mm and if it is over 5/100 mm, the shaft must be replaced

(b) Gravity Disk in Purifier alters the location of the oil-water interface and is responsible for creating an interface between the oil and water. And further, the Interface can be shifted inwards or outwards with the correct selection of the gravity disk in your purifier. And with the proper selection of the gravity disk, the efficiency of the separation can also be improved. The gravity disc with proper inner diameter i.e. with the diameter that corresponds to the difference in densities of the oil-water mixture to be treated should, therefore, be inserted in the bowl, this disc can be chosen from the set of discs provided with the separator. The inner diameter of the

disc to be chosen can be determined by: Calculation Experiment. The general rule is: Small diameter gravity disc when treating light.

Give reasons why each of the following conditions can result in oil being carried over with the water discharge from lubricating oil centrifuges:
(a) High throughput of mixture (6)
(b) Abnormally high temperature of mixture (6)
(c) Appreciable accumulation of solids in bowl (4)

Aug 23

(a) High throughput of mixture:
When the throughput of the mixture is high, the centrifuge may not have enough time to separate the oil from the water effectively. This results in a lower oil-to-water interface because of higher throughput and separation will not be efficient. This can result in oil being carried over with the water discharge.

(b) Abnormally high temperature of mixture:
High temperatures can reduce the viscosity of the oil, making it more difficult for the centrifuge to separate the oil from the water. Lower viscosity results in lower density which does not comply with the principle of centrifuge to separate lower density of fluid from higher density of fluids. This can result in oil being carried over with the water discharge.

(c) Appreciable accumulation of solids in the bowl:
Centrifuge bowl should be cleaned in regular intervals based on the quality of oil and viscosity. If not, bowl will be filled with sludge and deposits. If there is a significant accumulation of solids in the bowl, the centrifuge may not be able to effectively separate the oil from the water. This can result in oil being carried over with the water discharge.

With respect to centrifuge
(a) Explain how the vertical height is measured, and why vertical height of the shaft is so critical? (6)
(b) Describe the troubles that occur on centrifuges during operation and their rectification procedure. (10)

Dec 23 **Oct 24** **Apr 24-2**

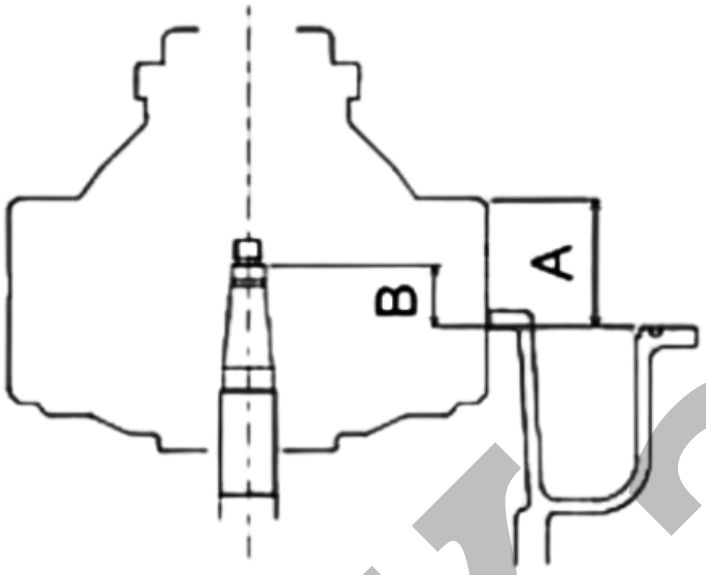
(a) With respect to centrifuge:

- Vertical height basically signifies whether the bearings are placed in the right position or not.
- It affects bowl movement as well.
- If the height is not proper, then it will not be able to assemble your purifier.

Procedure to measure vertical shaft height:

- Vertical shaft height A or bowl height is measured by placing a straight, non-flexible solid bar on the bowl. The vertical height between them is measured using a scale.
- Vertical shaft height B is measured by placing a straight, non-flexible solid bar on top of a vertical shaft. Measure this vertical height using a scale, this is known as total height; then, we measure the height of the threaded portion of the vertical shaft using an vernier. This value is subtracted from total height, and we have vertical shaft height B.

- Both vertical shaft heights, A and B, are then compared with manual specification to confirm it is within limits.



(b) Troubles that occur on centrifuges during operating and their rectification procedures:

1. Bowl opens unintentionally during operation:

- No water in the operating water tank.
- Fill water in the tank.
- Bowl opening solenoid leaks during operation.
- Repair or replace the solenoid valve.

2. Bowl fails to open for discharge:

- Nozzles in the bowl are clogged.
- Clean the nozzles.
- Bowl-opening water has low pressure.
- Fill more water in the tank or increase the height of the tank.
- Too much sludge accommodation causing the sliding bowl to fail to operate.
- Open and clean the bowl manually.

3. Unsatisfactory separation results

- The throughput is too high.
- Reduce the throughput
- The bowl speed is too low.
- Check Clutch shoes and bearings.
- The Bowl disk stack is clogged.
- Clean the disc stack manually.

4. Separator vibrates

- The vertical height of the spindle is wrong. Adjust height according to the maker's recommendations.
- Uneven sludge deposits in sludge space.
- Clean manually.
- Vibration-dampening rubber washers are worn out.
- Replace the rubber washer.

Auxiliary Machinery Air Compressors

- **Notes:**

To achieve the optimum performance from a main air compressor, describe the routine maintenance necessary on the following components (16)
(a) Unloader
(b) Air intake filter
(c) Suction/Discharge valves
(d) Intercoolers

Dec 23 | Apr 24-2

(a) Unload:

- Sometimes external agents (dust, Teflon, etc.) contaminate the inside of the solenoid valves and cause the device to malfunction. To confirm this, inspect the internal condition, perform a suitable cleaning (if required).
- During the internal inspection of a solenoid valve, any piece (membrane, seals, or O-rings) found damaged must be replaced.
- Confirm that the voltage and frequency are correct. Check the condition of the coil and measure its resistance, in case it tends to zero, this coil is burnt and needs a replacement.
- Ensure the valve is installed in the correct orientation with the airflow, by looking at the arrow indication on the valve housing.

(b) Air intake filter:

- The air filter must be checked at frequent intervals and approximately every 250 hours or whenever the air discharge temperature becomes high. The air filter element must be replaced with a new one and sufficient spares must be available onboard.
- It must be noted that the air compressors are installed at a place where there is sufficient air supply to ensure the suction is never devoid of air.
- One must make sure that the old cartridge is not blown with air and reused, as this may damage the air filter.
- Dirty air filters affect the volumetric efficiency of the compressor and so does the temperature of the inlet air to the compressor

(c) Suction / Discharge valve:

- When removing and installing a valve, extreme care must be taken that no valve parts are damaged. This applies to the sealing surface of the valve.
- Different types of compressors have different types of valves and removal methods for different stages
- The valves must be removed and should be checked for leakage with diesel oil or water
- The valves must never be held on vice but should rather be held on the tool given for the same.
- All the parts must be properly cleaned after opening the valve and they must be checked for carbonization as well. Over-carbonization reveals that the oil topped-up is more than required. This would lead to the sticking of the valves and eventually they would break.
- Sticking of the valves will also reduce the volumetric efficiency of the compressor as the quantity of air discharged would be comparatively lesser.
- The valve plate should be checked by pushing the valve plate from the side of the valve seat by a screwdriver. The valve plate will move at a distance that is equivalent to a valve lift.
- The springs and valve plates should be changed if required. The plate could be lapped as well if no spares are available.

(d) Intercoolers:

- Intercoolers are generally arranged after every stage of the main air compressor to reduce the work done in compressing the air by successfully cooling it down between stages. The intercooler is generally in the form of copper tubes bent in a U form. The air passes through the tubes and water circulates around them. These intercoolers could be a single tube type or straight tube type.
- These types of intercoolers are provided with purge-spots to collect and drain water/oil which might find its way to the air coolers.
- The intercoolers are generally opened up as per the maintenance frequency and are supposed to be cleaned by a solvent and the integrity of tubes to be checked as well.
- They're provided with a bursting disc in order to relieve the pressure in case a tube bursts.
- The single tube type coolers are difficult to clean and the rate of wear is more than the straight tube types.
- The straight tube types, on the other hand, could be plugged if they leak.

Component	Maintenance Tasks
Unloader	Inspect wear, clean, lubricate, test functionality, replace faulty components
Air Intake Filter	Clean regularly, inspect for damage, replace periodically, ensure proper fit
Suction/Discharge Valves	Clean valve seats, check for leaks, inspect spring tension, replace worn parts
Intercoolers	Clean tubes/fins, inspect corrosion, check coolant flow, test temperature drop

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(a) Describe uses of compressed air onboard the ship. (6)
(b) Describe maintenance schedule of various systems on main air compressor. (6)
(c) Describe Isolation procedure of main air compressor before starting any work. (4)

Apr 23

(a) Compressed air is used for the following purposes on a ship.

• For starting of main engine and auxiliary engine
• For automation and control air for main and auxiliary engine.
• For different application on the deck side and in engine room such as chipping, drilling, buffing, pressurized water jet cleaning etc. by use of pneumatic tools and machinery.
• For overhauling machinery by use of pneumatic tools and hydraulic jack.
• For pressure testing of different machinery parts, pipeline etc.
• Compressed air is also used for ships whistle and fog horn.
• It is used in life boat for heaving up, if air motor is attached as a heaving provision.
• For supplying water to accommodation and various parts of the ship through hydrophore by keeping the hydrophore pressurized with air.
• For conducting aerobic breakdowns of the on board sewage in sewage plant.
• For pressurized spray painting.

• Used in soot blowing of boiler and economizer.
• Used in portable pneumatic pumps like Wilden pumps for oil, water and bilge transfer.
• For general cleaning and services.

(b) Maintenance Schedule for Main Air Compressor Systems:

- Check oil level Daily.
- Clean and inspect valves: Every 150 hours
- Clean suction filter: Monthly

Every three months

- Check the water jacket safety disc.
- Change crankcase oil

Every six months

- Check safety valves
- Check auto operation, gauges, thermometers, etc.

Annual maintenance

- Overhaul valves, change rubber rings, etc.
- Change oil filter
- Check holding down bolts.
- Check coupling alignment
- Clean coolers: Every two years
- Complete overhaul: Every four years

(c) Isolation procedure for main air compressor before starting any work

- Stop the compressor
- Put off the circuit breaker in ECR and at the local electrical panel
- An electrical isolation permit should be obtained
- Shut off the cooling water as appropriate
- Shut off the high-pressure discharge line
- Remove the compressor from auto-start and from priority
- Display 'Men at work' warning notice

With reference to multi-stage, single crank air compressors explain why:
(a) (i) 'Bumping' clearances are checked (3)
(ii) Bottom end adjustment does not affect 'bumping' clearance. (3)
(iii) The clearance is not adjusted on one stage alone. (3)
(b) Describe how bumping clearances are corrected. (7)

Oct 22

(a)

(i) 'Bumping' clearances are checked.

Bumping clearance is checked to ensure that there is enough clearance between the top of the piston and the cylinder cover.

If bumping clearance decreases, it may cause contact between the piston top surface of the cylinder cover and may cause subsequent damage to parts.

If bumping clearance increases, there will be a loss of volumetric efficiency.

(ii) Bottom end adjustment does not affect 'bumping' clearance

Bottom end bearing adjustment, such as adding or removing shims to adjust bearing clearance, does not affect bumping clearance because the piston primarily rests on the
top half of the bottom end bearing when it is at TDC. The addition of shims for bearing adjustment does not significantly alter the position of the piston, and as a result, it does not impact the bumping clearance.

(iii) The clearance is not adjusted on one stage alone
In multi-stage, single crank air compressors, each stage contributes to the overall compression process. If the clearance is adjusted on one stage alone, it can disrupt the balance of compression across stages, potentially leading to inefficiencies or uneven compression. Therefore, adjustments to the clearance are typically made across all stages to maintain optimal performance and balance throughout the compressor system.

(b) Bumping clearances are corrected
Adjustments are made by altering the cover joint thickness or adding/removing shims between foot of conrod and bottom bearing. Sometimes, it is adjusted by adding shims over the liner, below the head (but this alters the clearance of one stage only) Ideal clearance = 0.5-1.0% of the cylinder bore
During the lead ball test, the clearances of the main and crankpin bearing have not been taken into account. So use a crowbar to jack up the conrod once it reaches the TDC position.

Aspect	Explanation
Why Bumping Clearance Checked	Prevent piston-cylinder head collision; maintain efficiency
Bottom End Adjustment Effect	Does not directly affect TDC clearance; vertical alignment only
Multi-Stage Adjustment	Ensures balanced compression ratios across stages.
Correction Methods	Adjust gaskets, shims, replace bearings, use wire/feeler/dial gauge methods.
Other Crankshaft Checks	Alignment, bearing condition, surface cracks, lubrication system, vibration analysis.

Describe what examination you will carry out on the following parts of Air Compressor:
(a) Suction and delivery valves and seats (4)
(b) Relief valves and bursting discs (4)
(c) Coolers and cooling passages (4)
(d) Piston and piston rings (4)

Oct 23 **Dec 22**

(a) Suction and Delivery Valves and Seats:
• **Leakage Check:** Remove the valves and check for leakage by applying diesel oil or kerosene to the valve seats. Any leakage indicates a faulty valve seat or valve.
• **Cleaning:** Thoroughly clean all parts after disassembling the valves. Check for carbonization which may lead to valve sticking.

• **Valve Plate Check**: Push the valve plate from the side of the valve seat using a screwdriver. The valve plate movement should correspond to the valve lift.
• **Spring and Plate Inspection:** Inspect springs and valve plates for wear, distortion, or damage. Replace it if necessary.
• **Lapping (if needed):** If no spare parts are available, valve plates can be lapped for better seating.
• **Locating Pin:** Ensure the locating pin is not worn out, bent, or loose in the vent seat.
• **Replacement:** Renew valve plates and spring plates to prevent fracture due to fatigue.
• **Valve Seat Damage:** If the valve seat's seating face is damaged, it should be replaced.
• **Assembly:** Properly fit spring plates on the locating pin. Tighten castle nuts with correct torque and secure with split pins.

(b) Relief Valves and Bursting Discs:
• **Bursting Disc:** Slacken the spindle and inspect the disc. clean dirt accumulation and replace the O-ring after cleaning the seating area. Reset to lift at 10% in excess of max working pressure.
• **Relief Valve:** Test the relief valve's functionality by bringing the system up to operating pressure, pulling the ring to depressurize, turning off the system, and restarting to ensure it returns to operating pressure.

(c) Coolers and Cooling Passages:
• **Intercoolers:** Open intercoolers per maintenance schedule and clean using solvent. Check tube integrity. Bursting discs are provided for pressure relief in case of tube bursts.
• **Single Tube Coolers:** Clean and inspect them. Single tube coolers are harder to clean and wear faster than straight tube types.
• **Straight Tube Coolers:** Check for leaks. Plugged tubes can be an issue in these types.

(d) Piston and Piston Rings:
• **Ring Assembly:** Assemble rings in respective grooves. Measure side clearance with a feeler gauge. • Replace rings if side clearance exceeds specified limits.
• **Ring Gap Alignment:** Ensure gaps of adjacent rings are in opposite directions. This prevents oil and compressed air leaks and enhances compressor efficiency.
• **Cleaning:** Clean piston and ring grooves thoroughly after removing carbon deposits.
• **Gudgeon Pin:** Examine the gudgeon pin for damages.
• **Butt Clearance Measurement:** Insert the ring into the cylinder, level with the top surface. Measure butt clearance with a feeler gauge. Replace rings if but clearance exceeds specified limits.

Component	Examination Tasks
Suction/Delivery Valves	Visual inspection, leakage testing, surface condition checks, replacement
Relief Valves/Bursting Discs	Pressure testing, visual inspection, cleaning, replacement
Coolers/Cooling Passages	Cleaning tubes/fins, corrosion inspection, flow testing, leakage checks
Piston/Piston Rings	Wear inspection, clearance measurement, lubrication checks, replacement

Auxiliary Machinery Refrigeration & Air Conditioning

- **Notes:**

(a) Sketch, describe and explain the operation of the domestic refrigeration system of a ship using one of the HFC as refrigerant. What kind of maintenance is essential for the system. (8)

(b) Describe the causes for the following in the domestic refrigeration system: (8)

(i) Frequent cut-in and cut-off of the compressor

(ii) Lub oil low pressure cut out of the compressor

(iii) High pressure cut out of the compressor

(iv) Frosting on the compressor suction side

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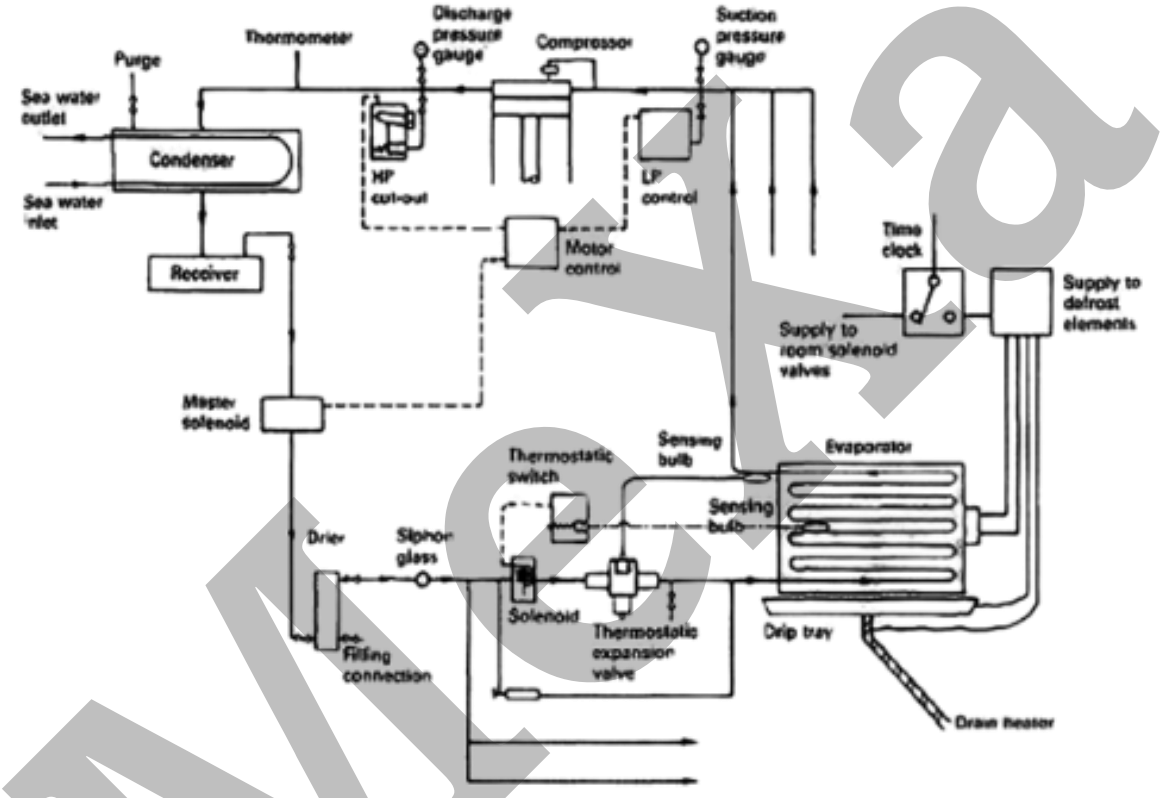
(a)



Operation of the Domestic Refrigeration System of a Ship using R22 Gas:

• **Compressor:** The compressor acts as a circulation pump for the R22 refrigerant. It compresses the low-pressure, low-temperature vapor from the evaporator to a high-pressure, high-temperature vapor.

• **Low- and High-Pressure Cut-outs:** The compressor is equipped with safety cut-outs, including Low Pressure (LP) and High Pressure (HP) cut-outs. The LP cut-out automatically stops the compressor if the suction pressure drops too low, while the HP cut-out requires manual reset and trips the compressor if the discharge pressure rises excessively.

• **Condenser:** The hot, high-pressure refrigerant vapor from the compressor is passed through a condenser to release heat and cool it down, transforming it into a high-pressure liquid.

• **Receiver:** The liquid refrigerant is then directed to a receiver. This receiver can be used to collect and store the refrigerant when major repair work is needed.

• **Master Solenoid:** Positioned after the receiver, the master solenoid is controlled by the system's control unit. In case of a sudden compressor stoppage, the master solenoid closes to prevent the flooding of the evaporator with liquid refrigerant.

• **Room or Hold Solenoid and Thermostatic Valve:** These components regulate the flow of refrigerant into the various rooms or holds to maintain the desired temperatures. The expansion valve is controlled by a diaphragm that responds to pressure variations, operated by a bulb sensor filled with an expandable fluid located at the evaporator outlet.
• **Thermostatic Expansion Valve:** This valve supplies the correct amount of refrigerant to the evaporators, where it absorbs heat from the rooms and boils off into vapors, resulting in a drop in temperature.

Maintenance required:
Every Three Months:
• Check for refrigerant leakages.
• Grease bearings if required.
• Inspect and test safety cut-outs.
•Check and adjust belt tension.

Every Six Months:
• Inspect all couplings for wear or damage.
• Check the oil filter and oil level in the compressor.
• Clean strainers.
• Check and replace dryers if necessary.

Every Twelve Months:
• Renew lube oil and filters.
• Examine all valves for proper operation.
• Calibrate thermometers and gauges.
• Weigh spare gas bottles to ensure an adequate supply.
• Examine fans for wear and tear.
• Recharge dryers as needed.

Every Twenty-Four Months:
• Overhaul reciprocating compressors (screw type compressors can run for longer periods).
• Inspect and possibly replace pistons, bearings, and shaft.
• Check and clean coolers.
• Conduct pressure testing on heat exchangers.

(b) (i) Frequent Cut-in and Cut-out of the Compressor:
• Gas trapped in the coil due to over-frosting.
• Low refrigerant charge.
• Presence of air in the system causing high discharge pressure and tripping on HP cut-out.

(ii) Low Oil Pressure Cut-out of the Compressor:
• Defective or maladjusted oil pressure regulator.
• Insufficient oil in the compressor crankcase.
• Blocked oil suction and/or delivery strainers.
• Loose or worn bearings.
• Blockage of oil pathways in the crankshaft.
• Low gas suction pressure.

(iii) High Pressure Cut-out of the Compressor:
• Air in the system.

- Blocked or dirty condenser tubes.
- Corrosion of the partition wall in the condenser.
- High cooling water temperature or insufficient water flow.
- Excess refrigerant in the condenser, reducing the heat exchange area.
- Delivery stop valve not open wide enough.
- High gas suction pressure during the start-up period.

(iv) Frosting in the Compressor Suction Side:

- Abnormal operation of the thermostatic expansion valve (TEV).
- System overcharged with refrigerant.
- Moisture in the system due to a dirty dryer.
- Defective suction valve.

With reference to main refrigeration plant give reason for each of the following operational irregularities and state how these are dealt with
(a) Rapid loss of lubricating oil from the crankcase of a " vee " block compressor (4)
(b) Steady "fall off" in refrigeration effect over a comparatively short period of time (4)
(c) Excessive "icing up " at compressor suction (4)
(d) Short cycling (4)

Aug 23

(a) Reason for rapid loss of lubricating oil from the crankcase of a "Vee" block compressor are:

- **Worn Piston Rings:** Worn piston rings can cause oil to leak past them and into the compression chamber, resulting in a rapid loss of lubricating oil. The remedy is to replace the worn piston rings.
- **Faulty oil separator:** if the oil separator is not separating oil, then the oil could be carried over in the refrigeration system. Overhaul or replace the separator.
- **Crankcase Pressure:** high crankcase pressure can cause lubricating oil to be forced out of the crankcase and into the refrigeration system. The remedy is to reduce the pressure**.**
- **Crankcase Overfill:** Overfilling the crankcase causes excessive oil foaming and results in a rapid loss of lubricating oil. The remedy for this is to drain and refill the crankcase with the correct amount of oil.

(b) Steady "fail off" in refrigeration effect over a comparatively short period of time could be due to:

- **Refrigerant Leakage:** Even small leaks in the system can cause a gradual reduction in the amount of refrigerant in the system, resulting in reduced cooling capacity over time. Check and arrest the leak.
- **Faulty Expansion Valve:** A faulty expansion valve can cause a reduction in the amount of refrigerant flowing through the evaporator coil, resulting in reduced cooling capacity. Repair or replace the expansion valve.
- **Reduced Compressor Efficiency:** due to wear and tear on the compressor components, the compressor becomes less efficient over time and it can cause a gradual reduction in the refrigeration effect. Overhaul the compressor.
- **Inadequate Refrigerant Charge:** too low a refrigerant charge in the system can affect the system's cooling capacity and cause a steady "fall off" in refrigeration effect over time. Charge the system with refrigerant.

(c) Excessive "icing up" at compressor suction

- **Faulty Expansion Valve:** a faulty expansion valve can cause a higher refrigerant flow rate, resulting in lower temperatures in the system and excessive "icing up" at the compressor suction. The remedy for this is to repair or replace the faulty expansion valve.
- **Dirty Evaporator:** a dirty evaporator can cause restricted airflow and lower temperatures in the system, leading to excessive "icing up" at the compressor suction. The remedy for this is to clean or replace the dirty or clogged components.
- **Defective Defrost System:** If the defrost system is not functioning properly, it can cause ice buildup on the evaporator, leading to excessive "icing up" at the compressor suction. The remedy for this is to repair or replace the defective defrost system.
- **Oil in evaporator:** oil acts as an insulator inside the evaporator tubes causing reduced heat transfer, which causes "icing up" of the compressor suction. The remedy is to clean the evaporator.

(d) Short cycling of compressor could be due to:

- **Clogged suction filter:** The compressor is provided with a filter in the suction line. If that is clogged, it will lead to frequent LP cut out. Clean the filter
- **Differential Setting Span is Small:** The low pressure (LP) cut-out setting span is too small, which will lead to frequent cut-in and cut-out of the compressor. Change the setting and increase the span between starting and stopping compressor pressures.
- **Incorrect refrigerant charge:** If the refrigerant charge in the system is incorrect, the compressor may short cycle. Charge the system with the correct refrigerant.
- **Electrical problems**: Electrical problems, such as faulty wiring or faulty contactors, can cause the compressor to short cycle. Repair or replace the faulty equipment.

(a) How Leaks are detected and rectified on refrigerating plant? (4)
(b) Describe how Suction & Discharge valve are tested for tightness? (4)
(c) Describe how refrigerant charging is carried out? (8)

May 23 | Dec 24-1 | Mar 24

(a) Leaks can be detected using the following methods:
Electronic Leak Detector:
•Ventilate the compartment thoroughly before usage.
•Switch on the device and adjust sensitivity.
•Slowly move the probe through suspected areas, and the device will provide visual and audible alarms upon detecting a leak.

Halide Leak Detector:
•Consists of a burner, needle valve, suction tube, and chimney with a copper reaction plate.
•Move the detector tube slowly through suspected areas; a change in flame color indicates a leak (greenish tinge for small leaks, vivid blue flame for large leaks).

Soap Solution:
•An old and cost-effective method.
•Apply soapy foam to suspected areas; bubbles will form at the site of a leak.

Pressure Test:
•Conducted in shipyards or after major repair works.
•Fill dry nitrogen into the system.

•Close compressor suction/discharge valves and other valves not suitable for high pressure.
•Use soap solution to detect leaks.
•Pressurize the system to the test pressure (around 20 bar for HP side, 15 bar for LP side).
•Monitor system pressure stability over a specified duration.

(b) Suction & Discharge valve tightness check:
Discharge Valves
•Close the liquid valve in the receiver outlet and collect the refrigerant.
• The compressor will stop on LP trip.
• Shut the suction and discharge valves quickly.
•Observe the suction and discharge pressure gauges. If the discharge pressure falls roughly by 1 bar and above in five minutes and simultaneously if suction pressure rises, then the discharge valve is leaking.

Suction Valve
•Run the compressor under manual control.
•Close the suction valve slowly to prevent foaming of lubricating oil in the crankcase.
•With the suction valves shut, the compressor should develop a vacuum of 0.4 bar or more.
• This indicates the suction valves are 'holding' and functioning correctly.

(c) Refrigerant Charging Procedure
•Close the receiver outlet valve.
•Allow the refrigerant to collect in the receiver until the LP pressure gauge reads 0.2 bar.
• Verify the gas level in the sight glass.
•Shut off the suction and discharge valves of the compressor.
•If the refrigerant level is sufficient, stop charging and investigate other reasons for low cooling effect.
•If the level is insufficient, proceed with refrigerant charging.
•Record the weight of the refrigerant bottle.
•Invert the bottle if charging is necessary.
•Connect the gas outlet line to the charging hose.
•Ensure a non-return valve is connected to the gas collection bottle.
•Open the three-way valve to connect the gas collection and charging bottles.
•Open the gas outlet line to purge air from the hose.
•Charge around 5 kilograms of refrigerant into the system.
•Pump down the system and check the refrigerant level.
•If not satisfactory, repeat the charging procedure.

(a) What are the reasons of frosting in the refrigeration chambers and its effect. (6)
(b) What are the methods used for defrosting refrigerated chambers? (6)
(c) What is the arrangement of Reefer Chamber drains? (4)

Jun 23

(a) the reasons of frosting in the refrigeration chambers and its effect.
•Inadequate insulation in the refrigeration chamber can lead to heat transfer between the inside and outside, causing condensation and subsequent frosting.

•Unsealed doors, gaps, or damaged insulation can allow warm, moist air to infiltrate the refrigeration chamber. When this air comes in contact with the cold surfaces inside, it can lead to frost formation.
•Frequent changes in the temperature settings or abrupt compressor cut-offs can result in temperature fluctuations inside the chamber, leading to condensation and frosting.
•Damaged or ineffective door seals allow external warm air to enter, leading to moisture accumulation and frosting.
•Overloading the refrigeration chamber beyond its capacity can obstruct proper air circulation, creating pockets of stagnant air where frost can form.
•Inefficient air circulation within the chamber can result in uneven temperature distribution, promoting localized areas of frost

Frosting can cause:
• Reduced cooling efficiency, as the accumulated frost acts as insulation, hindering heat exchange.
• Increased energy consumption as the compressor works harder to maintain the desired temperature.
• Risk of damage to stored goods due to uneven cooling and potential thawing during defrost cycles.
• Longer defrosting cycles may be required, impacting the overall operational efficiency of the refrigeration system.

(b) Methods for Defrosting Refrigerated Chambers:
Electric Defrosting:
•Electric heaters are installed within the refrigeration chamber or on the evaporator coils.
•When frost accumulates, the heaters are activated to melt the frost.

Hot Gas Defrosting:
•During the defrost cycle, hot refrigerant gas is redirected from the compressor to the evaporator coils.
• The heat from the gas melts the frost, and the resulting water is drained out.

Air Defrosting:
•Warm air is circulated through the refrigeration chamber using fans.
•The warm air melts the frost on the evaporator coils, and the water is drained away.

Water Defrosting:
•Water is sprayed or circulated over the evaporator coils, melting the frost.
• The water is then drained from the chamber.

Reverse Cycle Defrosting:
•The refrigeration cycle is temporarily reversed, turning the evaporator into a condenser.
•The warm refrigerant releases heat to melt the frost.

Off-Cycle or Natural Defrosting:
•The refrigeration system is temporarily turned off, allowing the accumulated frost to naturally melt.
•This method may require longer downtime and is less energy efficient.

(c) A particular problem in insulated spaces is drainage, as ordinary scuppers would nullify the effects of the insulation. To overcome this problem brine traps are provided in drains from the tween deck chambers and insulated holds.
•The brine in the trap forms an effective seal against the ingress of warm air, and it will not freeze, preventing the drain from removing water from the compartment.

(a) Describe how air in the refrigeration plant is purged out (6)
(b) Describe how lube oil is added in the refer compressor (5)
(c) Describe how the lube oil filter of a reefer compressor is cleaned (5)

May 23

(a) To remove air from the system:
• Change the compressor to manual position
• Close the liquid stop valve after the condenser
• Pump down the entire charge into the condenser until the suction pressure just above zero.
• Stop the compressor and close the condenser inlet valve
• Then allow the condenser contents to cool.
• Air is expelled through the purging valve until the refrigerant gas appears at the valve.

(b) To fill lube oil to reefer compressor, proceed as follows:
Change the compressor to manual running.
Pump down the entire charge to the condenser.
Connect the L.O. hand pump to L.O filling valve after air is purged out.
When the compressor suction pressure just above zero, open the oil filling valve and inject the L.O. into the crank case.
Then stop the compressor and close the compressor discharge valve. Then cool down the refrigerant.

(c) Cleaning of lube oil filter in a reefer compressor:
• Close the liquid valve at the receiver outlet and collect the refrigerant.
• The compressor will cut off on LP trip.
• Close the suction and discharge valves of the compressor.
• Open plug provided between compressor and suction valve, vent trapped gas in to retrieval gas bottle.
• Place a receptacle underneath the drain plug, Open the crankcase drain plug slowly and collect the crankcase oil.
•A suction strainer is attached to the drain plug. Clean the oil strainer.

Briefly explain the following;
(a) How would you know a Refrigeration System is Undercharged? (4)
(b) What should you do to ensure that there is no Water Leakage into the Engine Cylinder before preparing Main Engine for Sea? (6)
(c) What would cause the Level of the Lub Oil Sump of Main Engine or Drain Tank to Rise? (4)
(d) How can Exhaust Valve Leakage of Auxiliary Engine be confirmed? (2)

Oct 22

(a) Undercharged Refrigeration System:
Symptoms:

• Low discharge pressure.
• Large bubbles in the liquid sight glass.
• Elevated compressor delivery temperature.
• Increased running time between cut-out cycles.

Remedies:
• Charge the refrigerant until bubbles disappear in the liquid sight glass.
• Correct pressure gauge readings by adjusting the refrigerant charge.
• Detect and locate leaks using methods like a halide torch, soap solution, or electronic leak detector.

(b) Preventing Water Leakage into Engine Cylinder before Preparing Main Engine for Sea:
• **Indicator Cocks Check:** Turn the engine with indicator cocks open. Monitor the indicator cocks for any signs of water discharge, indicating potential leakage.
• **Blow Through:** Just before starting, perform a blow-through procedure. This involves turning the engine manually while air is supplied to each cylinder. Check for any indications of water leakage during this process.

(c) Causes of Rising Lube Oil Sump Level in Main Engine or Drain Tank:
• **Contamination with Fuel:** Leakage from the fuel pump's umbrella seal or other fuel-related components can lead to fuel mixing with the lube oil.
• **Contamination with Fresh Water:** Cracking of water-cooled piston, sealing water leak from the lube oil purifier, or other cooling water leaks can introduce fresh water into the sump.
•**Contamination with Seawater:** Leaks in the lube oil cooler combined with a non-operational lube oil pump can allow seawater to mix with the oil.

(d) Confirming Exhaust Valve Leakage of Auxiliary Engine:
• **Indicator Card Analysis:** Take an indicator card from the engine with the fuel system both "on" and "off" for the unit.
• **Signs of Leakage:** If the exhaust valve is leaking, there will be indications on the indicator card. Compression pressure and maximum pressure values will be lower than expected.
• **Progressive Symptoms:** Valve leakage leads to rising exhaust temperatures, power loss, and potential damage to the valve and seat

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(a) List out at least five problems faced in running Air Conditioning system with indications, causes and remedial action. (12)
(b) What is the purpose of Solenoid valve in the A/C system? (4)

Jul 22

(a) Excessive pressure:
• **Over charge of gas:** reduce the charge by bleeding off excess gas into recovery bottle until correct pressure is obtained.
• **Reduced cooling in condenser:** ensure that there is sufficient cooling water available at condenser. If the condenser is dirty, clean the condenser.
Low pressure at evaporator suction:
• **Suction valve might be shut:** open suction valve
• **Not enough refrigerant:** check the level of refrigerant and charge the system

Compressor cycling:

• **Clogged suction filter:** Compressor is provided with a filter in the suction line. If that is clogged, it will lead to frequent LP cut out. Clean the filter
• **Differential Setting Span is Small:** The low pressure (LP) cut out is provided with starting and stopping pressure setting. If the setting span is too small, it will lead to frequent cut-in and cut-out of the compressor. Change the setting and increase the span between starting and stopping compressor pressures.

Compressor running for long periods, but not lowering the temperature in the cold rooms:

• **Refrigerant charge is low in the circuit**: Check for leakage of refrigerant and charge with required refrigerant
• **Cold room door not shut:** shut the doors

Compressor operating noisily:

• **The oil pressure is low:** Ensure that the oil level is maintained and no foaming of oil is developed. Replenish or refill the lube oil if required
• **Loose foundation:** Ensure that the compressor foundation is secured and all foundation bolts are checked for tightness

(b) Master solenoid valve is fitted in the common or main line after the condenser discharge. It closes when the compressor stops or trips to avoid overflow of refrigerant into evaporator.
• Solenoid valve is a liquid stop valve.
• The valve is either fully open or close.
• To control the temperature within set limit
•It is an electromagnetic cut-in cut-out device when the room temperature reaches the desired point, the pressure switch which is connected to the thermo bulb in the room shuts the solenoid valve which stops the refrigerant flow into the evaporator.

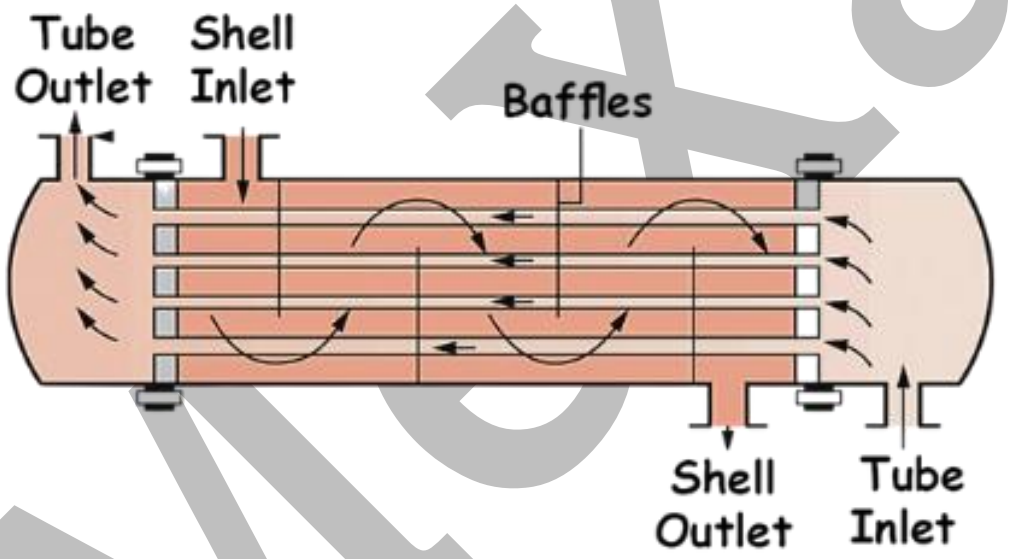
Auxiliary Machinery Heat Exchangers

- **Notes:**

(a) Describe shell and tube type heat exchanger and its function with the aid of a diagrammatic sketch, naming each part. (8)
(b) Describe the physical cleaning procedure of cleaning tubes. (4)
(c) Describe the Chemical cleaning of the shell side of the heat exchanger. (4)

Nov 23 | Sep 24-2 | Apr 24

(a) A typical shell and tube heat exchanger consists of a set of tubes forming a nest. The tube nest is called a tube stack and is embedded within a shell. Cupro-nickel alloy is commonly used in heat exchangers and possesses a high corrosion resistance. In a heat exchanger, one fluid flows through these tubes while the second fluid flows inside the shell over the tube. The cooling or heating medium flows through the tubes in one or more passes depending on the requirement. In a single pass, the coolant enters through one side and leaves from the other side, whereas in a double pass, one set of tubes carries the coolant in one direction while the other set of tubes passes the coolant in the reverse direction. Directing the flow causes the heating or cooling medium to stay longer in the tube stack. This is known as dwell time.



(b) Mechanical cleaning methods are often used to remove debris from the tubes. Common methods include:

- **Brushing:** Using brushes inserted into the tubes to scrub and remove deposits.
- **Pigging**: Pushing a specially designed cleaning pig through the tubes to dislodge and remove deposits.
- **Hydro jetting:** Using high-pressure water jets to clean the tubes.

(c) Chemical cleaning is carried out by circulating a chemical solution through the heat exchanger by a pump. The pump draws chemicals through a tank and pumps it to the inlet of the exchanger, and the outlet returns to the tank from where it is recirculated. The process is continued until there is no discolouration of the chemical. After this, the chemical in the tank is replaced with fresh water, which is then flushed through the heat exchanger till clean water returns. The manufacturer's instructions must be strictly followed to avoid any damage to the heat exchanger.

With reference to plate type heat exchangers:
(a) State the advantages and disadvantages compared with tube type heat exchangers (6)

(b) State the likely causes of plate leakage (5)
(c) State how it can be ascertained that the plate stack is correctly tightened and the likely result of excessive tightening (5)

Sep 22

(a) Advantages of plate heat exchangers:
• High heat transfer.
• They are smaller and lighter.
• No extra space is needed for overhaul.
• Plates can be added in pairs to increase capacity.
• Cleaning and maintenance are relatively simple. Prolonged interval for cleaning
• Turbulent flow reduces fouling.
• There is no limit to flow velocity.
• Each plate and the design of the gasket prevent the mixing of two liquids.
• The plates are available in different versions of trough geometry.

Disadvantages of plate heat exchangers:
• Any leaks in the plates due to cracks are difficult to locate.
• Joints can deteriorate and may fail due to brittleness.
• Plates, made of titanium are expensive.
• Over-tightening can cause permanent damage to the plates. Gasketed plate heat exchangers cannot be used for high-pressure applications
• Have pressure and temperature limitation of 20 bars and 200 Deg

(b) The common causes of a leak in your heat exchanger are:
improper tightening, incorrect plate installation, pressure surges from your pump, wrong gasket material selection and long periods of use in high pressure/ temperature applications.

(c) Before the start-up of production, whenever plates or gaskets have been removed, inserted or exchanged, it is strongly recommended to perform a hydrostatic leakage test to confirm the internal and external sealing function of the plate heat exchanger. In this test, one media side at a time must be tested with the other side open to the ambient pressure. In a multi-pass set up, all sections of the same side must be tested simultaneously. The recommended test time is 10 minutes for each media side. Overtightening can cause damage to the plates, as can an incorrect tightening procedure.

(a) Describe how leak in leaky tube in Heat exchanger is detected? How to rectify leaky tube? (8)
(b) Describe how division plate on the inlet and outlet end is detected? (4)
(c) Describe reasons for poor performance of heat exchanger and actions to rectify the same. (4)

May 23

(a) Leakage Detection in Shell and Tube Type Cooler
The working pressures in case of jacket water system or lubricating oil system are usually of higher pressure than sea water system. If the leakage takes place in the jacket cooling water side or lubricating oil side, the flow from any point of leakage is in to the sea water side of the cooler. If the leakage is heavy then, usual indication is loss of jacket cooling water or lubricating oil.

Procedure:

Ensure the end covers are removed from the sea water box side and secure the tube stack by dog clamp arrangement-tube stack should not be disturbed when shell is under pressure.

1. Clean the sea water side of the cooler.
2. Start the fresh water cooling pump or lubricating oil pump.
3. Let the fluid circulate through the cooler spaces on the outside of the tubes
4. Leakage within the tubes or at the junction of the tube plate will show up as liquid trickling.
5. Identify the tube which is leaking. It is a time consuming procedure so be patient.

Fluorescent Halo Test

1. Small leaks are extremely difficult to detect, especially if the time available is very less. Owing to paucity of time it, will be difficult to get sea water cooling spaces dried out. The damp tube plates deter the small amounts of leakage. If the leakage is very small and time availability is less then follow the below procedure:
2. A small amount of fluorescent sodium crystals is dissolved in water within the space surrounding the tubes
3. The tube plates are then viewed under a source of ultra violet light, Even very small leakage is sharply visible as a fluorescent halo.

Soap Bubble Test

If the time availability is high and if the heat exchanger can be isolated, then carry out then following procedure:

1. Ensure the end covers are removed from the sea water box side.
2. Isolate the entire cooler and pressurize the shell side with air. use soap solution and apply the same at the tube ends.
3. Use soap Bubble formation will indicate the leaking tube.

Plugging the Tube

1. Bubble formation will indicate the leaking tube.
2. Once the leaky tube is detected, measure the inside diameter of the tube and find suitable plugs for plugging.
3. For plugging the leaky tube or tubes plugs made of brass [same material as the tubes] or plastic are being used on either end of the leaky tube. Plug
4. should be driven securely so as to isolate it completely. Carry out a leak test again to confirm that the leakage is arrested.

(b) The division plate can slowly erode and fail over a period of time. This results in short-cycling of sea water. Because of short-cycling. Sea water does not flow through the tubes but instead flows from inlet side to outlet side. Failure of joint material in the way of division plate can result in short-cycling. Regular inspection of end covers or water boxes are carried out. If the division plate is corroded and eroded beyond repairs replace the same with a spare.

(c) Fouling and clogging of heat exchangers usually on the sea water side cause huge problems and down time. The economic penalty for fouling are reduced thermal efficiency, increased pressure drop, additional maintenance and loss of production due to down time.

Back-flushing is an easy and efficient method to prevent clogging and fouling of heat exchangers. The cleaning effect is achieved by changing the flow of direction in the heat exchanger so that the dirt accumulated in the inlet region and the heat exchanging channels is flushed out the same way as it entered.

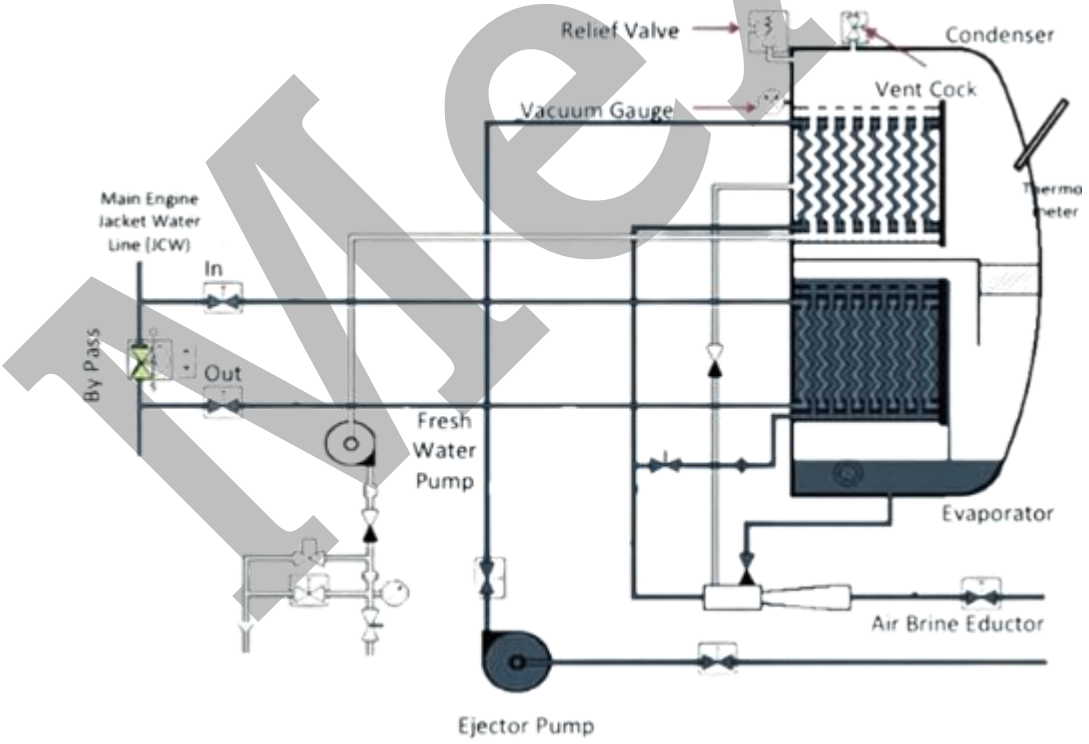
Auxiliary Machinery Fresh Water Generator

- **Notes:**

(a) Describe with the aid of a sketch an evaporator for the production of fresh water. (6)
(b) (i) Explain how scale is formed. (5)
(ii) State measures to reduce or remove scale.
(c) Show how the water is made potable. (5)

Aug 22

(a) The evaporator in a freshwater generator operates on the fundamental principle that reducing the pressure surrounding water lowers its boiling point. It is a central component in the process of producing fresh water from seawater. The process begins with the creation of a vacuum in the evaporator chamber using a combined air/brine ejector, which drives seawater through the system. As the seawater enters the evaporator chamber, its temperature is approximately 50 degrees Celsius. The low-pressure environment within the evaporator allows the seawater to evaporate at temperatures ranging from 40 to 60 degrees Celsius, facilitated by a heating coil that utilizes waste heat from the main engine jacket cooling water. The evaporated water, or vapor, is then separated from water droplets using a deflector and a built-in demister. The resulting vapor contacts the condenser, where it is condensed back into liquid form with the help of incoming cold seawater. The distilled water is extracted by the integral freshwater pump and controlled by a salinometer and solenoid valve. This process ensures the production of potable water while efficiently utilizing heat and maintaining a vacuum for optimal performance. Additionally, measures are taken to control salinity and prevent scale formation, enhancing the overall efficiency and reliability of the freshwater generation system.



(b) (i) Scale formation occurs due to salts that are not completely insoluble in the water. Hence the salts reach the surface in a soluble form and precipitate. The presence of calcium and magnesium salts is the main cause of scaling in evaporators. Scale salts generally consist of carbonates, bicarbonates, and sulfates that form slowly in a concentrated pattern, reducing the heat transfer. If overlooked, scales can be extremely difficult to remove even by using chemical treatment.

(ii) Measures to Reduce/Remove Scale:

• Run the freshwater generator at its rated capacity, never exceeding it. Overloading can lead to scale formation.
• Maintain the temperature of the freshwater generator at an appropriate level to prevent the formation of hard scales.
• Use safe chemicals to minimize scale formation. Most chemicals contain poly sulphate compounds with anti-foaming characteristics.
• Two commonly used chemicals are Vaptreat and Ameroyal, which are chosen for their safety and effectiveness.
• Conduct regular maintenance and cleaning to remove existing scales and prevent their build-up.

(c) Water can be made potable by treating water using one of the following methods.

- Chlorination or chlorine bed filtration
- Ag ion sterilization
- UV lamp sterilization

(a) A biological sewage system develops a fault, which necessitates opening the unit for repair. Explain the following
(i) The risk associated with opening the unit (5)
(ii) The precautions taken to reduce the risk (5)
(b) Explain the significance of biological oxygen demand (B.O.D.) (6)

Aug 23 | Sep 24 | May 24 | Feb 24

(a) The Risk Associated with Opening the Unit:
- One significant risk associated with opening a biological sewage system unit for repair is exposure to harmful gases. Sewage systems can produce toxic and potentially lethal gases, such as hydrogen sulphide (H2S) and methane (CH4). These gases can accumulate in confined spaces, posing a serious health hazard to workers.- Another risk involves direct contact with hazardous materials present in sewage, including pathogens (bacteria, viruses), heavy metals, and chemicals. This exposure can lead to infections, chemical burns, or other health issues.
• The unit itself may have structural weaknesses or damaged components, posing risks to workers. Accidents such as falls or equipment malfunctions can occur if the unit is opened without proper precautions.
• Improperly managed opening of the unit can result in accidental spills or leaks of sewage, leading to environmental contamination and harm to aquatic ecosystems.

Precautions Taken to Reduce the Risk:
• Wear appropriate PPE, including gloves, goggles, respiratory protection, and protective clothing to minimize exposure to harmful substances and gases.
• Adequate ventilation systems should be in place to remove hazardous gases and maintain a safe atmosphere inside the unit.
• If the repair requires entry into the plant, strict confined space entry procedures should be followed. This includes testing the air for toxic gases, using confined space permits, and having a standby rescue team.
• Toolbox meeting and training to be carried out in handling sewage systems, understanding the risks involved, and following safety protocols. Ongoing safety training is essential.
• Conduct a thorough risk assessment before opening the unit, identifying potential risks, and implementing control measures accordingly.

• Have a well-defined emergency response plan in place, including procedures for spills, gas leaks, and medical emergencies.
• Implement measures to prevent accidental spills or contamination of the environment, such as containment systems and spill response equipment.

(b) B.O.D. is used to quantify the pollution level of water bodies. High B.O.D. values indicate a high level of organic pollution, often resulting from the discharge of untreated sewage or other organic contaminants.
Elevated B.O.D. levels in water bodies lead to reduced dissolved oxygen levels, harming aquatic ecosystems by suffocating fish and other organisms. This can result in fish kills and the degradation of water quality. B.O.D. is a key parameter in evaluating the effectiveness of sewage treatment processes. Lowering B.O.D. levels in treated effluent is a primary goal of sewage treatment plants to protect receiving water bodies.

Auxiliary Boiler

- **Notes:**

(a) Describe maintenance required on auxiliary boiler burner. (8)
(b) Describe safety features provided on fuel burning system of auxiliary boiler (8)

Jul 23 | Jan 25-1 | Feb 24 | May 23

(a) Maintenance Required on Auxiliary Boiler Burner:

- Check the condition of nozzle for clogging
- Check there is no leakage or dripping from the burner
- Check all the connections are tightened and wiring is in good condition
- Check the solenoid valve controlling the fuel in the main burner is working fine
- Ensure there is no leakage from the solenoid valve connection
- Check and clean the cup for hard deposits in rotary cup burner
- Check the burner nozzle size is as per the load demand of the steam.
- Ensure the trip limit switch on the burner door is working fine as the boiler will not fire until the door is properly shut
- Check the oil passage in the burner is cleaned with diesel oil and is free from HFO deposits
- Ensure the fan inlet is kept clean off all deposits and obstructions
- Make sure the burner register is kept clean
- Check the air passage to register for deposits and dust
- Ensure flame stabilizer is inspected and kept clean from carbon deposits
- Flame stabilizer should be checked for heat corrosion

(b)

- **Low Fuel Oil Pressure Alarm:** The fuel system includes a fuel oil pump, with a standby pump to ensure continuous operation. A low fuel oil pressure alarm is incorporated to detect insufficient pressure for atomization, preventing dripping and potential blow-back of the burner.
- **Low/High Fuel Oil Temperature Alarm:**

Modern marine boilers accommodate different fuel grades, and oil temperature control is crucial for viscosity, atomization, and combustion efficiency. The system is equipped with alarms for deviations from set temperatures, indicating potential issues.

- **Flame Failure Alarm:** A photocell or flame eye is utilized in the burner unit to detect the presence of a flame inside the furnace. The flame failure alarm is triggered if the burner is abruptly stopped or if the main burner fails to produce flame during startup.
- **Smoke Density Alarm**: Environmental regulations necessitate monitoring post-combustion products. The boiler exhaust is equipped with a smoke density sensor to detect smoke density, especially during boiler startup and low loads.
- **Force Draught Fan Stop Alarm:** Efficient combustion requires a proper mixture of air and fuel, facilitated by a forced draught fan (FDF). A stoppage in the FDF operation triggers an alarm, signaling a potential disruption in the air-fuel mixture.

Describe actions to be taken with reasons for the following malfunction on auxiliary boiler
(a) Pilot burner does not fire (4)
(b) Efficiency of boiler is low (4)
(c) Low water level in boiler (4)
(d) Flame failure. (4)

Feb 23

(a) Pilot burner does not fire:

- A Pilot burner nozzle is very small and can be blocked by carbon deposits and sludge resulting in flame failure.
- Some pilot burner consists of small filter which can be clogged after continuous operation resulting in flame failure because of carbon accumulation.
- Initial spark for generating a flame is produced by electrode which may be clogged due to carbon deposits on them or fault in the circuit of electrodes etc.

(b) Actions to be taken when boiler efficiency is Low:

• Ensure that the feed water temperature is maintained at approximately 80-85°C. Lower water temperatures lead to increased time for heating, higher fuel consumption, and decreased overall efficiency.

• Regularly monitor the hot well for correct temperature and level. A sudden fall in hot well level results in increased addition of cold water, reducing the feed water temperature.

• Control the percentage of air/steam supplied to the burner for efficient combustion. Maintaining the correct air/ steam ratio reduces flue gas losses and improves overall boiler efficiency.

• Check for leaks, deformations, or bulging in the boiler shell. Ensure the insulation and refractory are in good condition to maintain temperature and prevent heat loss.

• Schedule regular blowdowns to control chloride levels. Uncontrolled continuous blowdown wastes boiler heat and efficiency. Regular, short-duration blowdowns help maintain chloride levels and reduce thermal stresses.

• Avoid operating boilers below 50% load, as this increases air requirements, leading to higher sensible heat loss.

• Regularly clean boiler and economizer tubes to prevent soot deposits, which reduce heat transfer efficiency.

(c) Low Water Level in Boiler:

• If there's a low water level alarm, refrain from immediate blow through unless the boiler is completely shut off. Performing blow through without stopping the boiler completely may result in tube damage due to the low water level.

• Stop the boiler completely before performing a blow through to check the water level. Be cautious to prevent tube damage. Stopping the boiler and allowing sufficient cooling time ensures safe inspection and prevents potential damage during blow through.

• After stopping the boiler, allow it to cool completely before checking the furnace's condition. Ensure everything is in good condition before filling water.

(d) Flame Failure:

• Flame eye should be inspected and cleaned weekly. Remove any dirt or carbon buildup to ensure proper sensing of an active flame. Carbon buildup on the flame scanner may prevent it from detecting an active flame, leading to flame failure.

• Regularly clean and inspect the fuel oil strainer to prevent contaminants from clogging the system. A clogged strainer restricts fuel flow, resulting in an inefficient or nonexistent main flame. Ensure an adequate supply of fuel oil. Monitor daily logs of fuel usage to detect any sudden drops that may indicate low oil levels. Insufficient fuel oil can cause a sudden inability to start the main flame.

• Confirm that the fuel supply valve is open. If closed, reopening it will restore the fuel supply. A closed fuel supply valve can prevent fuel flow to the burner, causing flame failure.

• Check and reset control linkages for proper fuel/air mixture. Damaged or improperly set linkages can cause flame failure. Improperly set or broken linkages can lead to issues with fuel/air mixture and result in flame failure.

(a) State the purpose of boiler water treatment; (4)
(b) Chemicals added for maintaining desired quality and (6)
(c) Tests that are carried out to ensure the desired quality. (6)

Jul 22

(a) Purpose of Boiler Water Treatment:

•Boiler water treatment aims to prevent the formation of scale within the boiler and feed system. Scale, composed of mineral deposits, can impair heat transfer efficiency and lead to increased energy consumption.

• Treatment helps in preventing sludge formation, reducing the likelihood of carryover with the steam. Sludge can contribute to boiler inefficiency and damage downstream equipment.

•Treatment measures aim to maintain the boiler water in an alkaline condition. This helps to mitigate the corrosive effects of acidic water and promotes the longevity of boiler components.

•Boiler water treatment works to keep the boiler water free from dissolved gases, particularly oxygen. This is crucial to prevent corrosion within the boiler system.

•The treatment also serves to prevent the entry of foreign matter, such as oil, waste, mill scale, ferrous oxides, and sand, into the boiler. These impurities can lead to equipment damage and operational issues.

•Regular boiler water tests are conducted, and chemicals are added accordingly to maintain the desired water quality. These tests help in assessing parameters like pH, alkalinity, TDS, and others.

(b) Chemicals Added for Maintaining Desired Quality:

•**Oxygen Scavengers:** Examples include sodium sulphate, hydrazine, and catalyzed sodium bisulfite. They remove dissolved oxygen to prevent oxygen-related corrosion.

•**Scale Inhibitors/Dispersants**: Chemicals like phosphates, polyphosphates, polymers, and chelating agents prevent scale formation and disperse existing scale formation and disperse existing deposits.

pH Adjusting Agents: Sodium hydroxide or sulfuric acid is used to adjust and control the pH level of the boiler water within the desired range.

•**Corrosion Inhibitors:** These include filming amines, neutralizing amines, and sodium nitrite. They form a protective layer on metal surfaces to prevent corrosion.

(c) Tests Carried Out to Ensure Desired Quality:

•**Total Dissolved Solids (TDS):** Measures the total concentration of dissolved minerals and salts in the boiler water. High TDS levels can lead to scale formation.

•**pH Level:** Monitors and maintains the proper acidity or alkalinity of the boiler water. Optimal pH levels help prevent corrosion and scale formation.

•**Conductivity:** Provides an indication of the concentration of dissolved ions in the water, serving as an indicator of TDS levels and water treatment effectiveness.

•**Dissolved Oxygen:** Monitors dissolved oxygen levels to ensure they are within acceptable limits, preventing oxygen-related corrosion.

• **Alkalinity:** Determines the concentration of alkaline substances in the water, influencing pH stability and preventing acidic corrosion

• **CHLORIDE test** - This is to test for chlorides in the water. To monitor and control the concentration of chloride salts within boiler water, indicating the ingress of salt water from coolers. If high chlorides are found, it could indicate there is seawater ingress somewhere in the system.

• **Hardness Test:** The hardness test determines the level of hardness due to calcium and magnesium ions in the water. Monitoring hardness is essential to prevent scale formation, which can reduce heat transfer efficiency and damage the boiler.

• **PHOSPHATE reserve** - To check chemicals added to remove hardness salts. If hardness salts are found in the system an insulating layer will be formed on the tubes, again this hints at a saltwater leak.

Purpose of Treatment	Treating Chemicals	Type of boilers
To prevent scales	Sodium Phosphates	All up to 84 Bar WP
To give alkalinity	Sodium Hydroxide Sodium Carbonate	All up to 84 Bar WP All up to 60 Bar WP
To condition sludge	Poly electrolytes Or Starch Or Tannin Or Sodium Aluminates	All up to 84 Bar WP All up to 84 Bar WP All up to 84 Bar WP All up to 37.5 Bar WP
To remove traces of oxygen	Sodium Sulphate Or Hydrazine	All up to 42 Bar WP From 31.5 Bar to 84 Bar
To reduce of risk of caustic embrittlement	Sodium Sulphate Or Sodium Nitrate	All up to 31.5 Bar WP A All up to 31.5 Bar WP
To reduce risk of carry over of foam	Anti Foams	All up to 84 Bar WP
To neutralise CO2	Neutralising Amines	----------
To protect steam/ condensate line	Filming Amines	----------

With reference to auxiliary boilers

(a) Briefly describe the maintenance procedures for oil burning equipment. (5)

(b) Explain the need for, and the use of, soot blowers. (5)

(c) Describe how a boiler should be taken out of service. (6)

Oct 22

(a) Maintenance procedures for oil burning equipment.

Fuel Oil Supply System:

- Check for fuel pipe leaks.
- Inspect flanges, joints, and connections for any leaks.
- Verify that manual valves are operating correctly.
- Ensure there are no leaks from valve components, such as the valve gland.
- Examine the condition of the lagging on heavy oil pipes.
- Check the tracing steam lines for proper functioning.
- Inspect all steam traps in the tracing Clean and inspect heavy oil filters.

• Ensure that pneumatic/solenoid valves before the pilot and main burner are functioning correctly.
• Confirm that the fuel supply pump is on standby and operating within normal parameters.
• Verify that all line filters are clean.

Main Burner:
• Check the nozzle for clogging.
• Inspect for leaks or dripping from the burner.
• Tighten all connections and ensure wiring is in good condition.
• Verify the solenoid valve controlling the fuel in the main burner is operational.
• Ensure there are no leaks from the solenoid valve connection.
• Clean the cup to remove hard deposits in a rotary cup burner.
• Check that the burner nozzle size matches the steam load demand.
• Confirm the trip limit switch on the burner door is functioning correctly, as the boiler will not fire until the door is properly shut.
• Clean the oil passage in the burner with diesel oil to remove heavy fuel oil deposits.
• Keep the fan inlet free from deposits and obstructions.
• Check the air passage to the register for deposits and dust.
• Inspect the flame stabilizer for carbon deposits and heat corrosion.

Ignition Burner:
•Check and clean the burner nozzle.
• Test the atomization of fuel, replacing the nozzle if atomization remains poor after cleaning.
• Clean the electrodes with an electro-cleaner solution.
• Inspect the electrodes for damage.
• Examine the condition of ceramic insulation on the electrodes for any damage.
• Avoid changing the angle of the electrodes with respect to the nozzle during maintenance to prevent ignition problem instability and carbon deposits.

Forced Draft Fan:
• Periodically remove and overhaul the electric motor according to the planned maintenance schedule.
• Clean the impeller to remove dust and deposits that can cause imbalance or vibration.
• If deposits are hard, use a scraper tool.
• Drain any water from the spiral casing.
• Check for fuel accumulation in the casing and identify the cause.
• Ensure the impeller is properly cleaned and balanced during installation.
• During startup, monitor for any signs of vibration, and investigate the cause if vibration occurs.

(b) Soot blowers are used in auxiliary boilers to clean the gas surfaces of the boiler tubes during operation. They are steam or air-operated devices that rapidly remove loose sooty deposits from the tube surfaces without requiring a boiler shutdown. The need for and use of soot blowers are as follows:
• Soot blowers help reduce the possibility of soot fires, which can occur when excessive soot accumulates on the tube surfaces. Soot fires can lead to hotspots in the furnace tubes, causing structural weakness. Preventing soot fires is crucial to maintaining the integrity and safety of the boiler.
• Soot is a heat insulator, and excessive soot buildup inside equipment can hinder heat transfer and increase energy consumption. By periodically using soot blowers to clean the boiler tube

surfaces, the heat transfer efficiency is improved, reducing energy requirements to reach and maintain optimal operating temperatures.
• Soot blowers help prevent the buildup of soot and ash on the tube surfaces

(c) Procedure to take boiler out of service:
• Change over from Heavy Fuel Oil (HFO) to Diesel Oil (DO) for all systems, including the main engine (ME), auxiliary engine (AE), and boiler, as steam is required for HFO usage.
• Turn the switch to the stop position, after post-purging. Manually purge the furnace if necessary.
• Close the main steam stop valve to prevent steam flow.
• Stop the feed water pumps and fuel oil circulating pumps. If there is a fuel oil heater, also stop it.
• Ensure that the vessel is not in a loaded condition to avoid seawater backflow during blowdown.
• After completing the changeover, stop the Exhaust Gas Boiler (EGB) circulating pump and close the suction side valve from the boiler and the discharge side valve to the boiler.
• Open the vent for the EGB to release any trapped pressure.
• Stop the boiler and the boiler feed water pump.
• Close the valve for the feed water controller.
• Isolate the Differential Pressure (DP) transmitter by opening the equalizing line and closing the inlet and outlet lines.
• Initiate blowdown of the boiler until the trapped pressure.
• Stop the boiler and the boiler feed water pump.
• Close the valve for the feed water controller.
• Isolate the Differential Pressure (DP) transmitter by opening the equalizing line and closing the inlet and outlet lines.
• Initiate blowdown of the boiler until the low-low water level alarm is activated.
• Allow the boiler pressure to drop to 2 bars.
• Ensure that the boiler body temperature gradually decreases.
• When the drum pressure reaches 2 bars, open the vent.
• Wait until the pressure drops to 0-0.2 bar.
•If required, drain the remaining water and use pressurized air through the air vent to ensure complete water drainage.

(a) Describe maintenance to be carried out on safety valve of Auxiliary Boiler to keep them in good order. (10)
(b) Describe procedure for setting safety valve. (6)

Apr 24 **Sep 24-2** **Nov 23**

(a) Maintenance carried out on boiler safety valve:

- Cleaning of safety valve.
- Complete dismantling of safety valve.
- Cleaning, polishing & buffing of parts.
- Thorough inspection of all parts.
- Seat & disc lapping.
- Spindle run out (bend) checking.
- Spring checking for any abnormalities like cracks, bends, reduced tension, etc.
- Lapping of both disc seats

(b) Procedure for setting of Boiler safety valve

1. Easing gear of the safety valve to be checked free before setting the valve.
2. Two safety valves, each safety valve is set independently.
3. Boiler pressure gauge accuracy is verified before the test, or the surveyor attending may use a standard gauge alongside the working gauge when safety valves are being adjusted.
4. One valve is gagged, and the other valve is tested for lifting pressure.
5. The valve to be tested is initially set to the correct position, then steam pressure is increased to the desired blow-off pressure, and arrangements are made to keep this pressure constant while the valve is adjusted to lift.
6. Pressure is now lowered and raised again to confirm the lifting pressure of the valve
7. The second valve is set similarly after gagging the 1st valve.
8. Fit locks on both valves after completion of the test.
9. Safety valves must be set at a pressure not exceeding 3% above the approved working pressure of the boiler. The correct WP of the boiler is found on the maker's nameplate affixed on the boiler front.

(a) What is pressure accumulation, test for boiler and what is its purpose (6)
(b) Describe the procedure to carry out pressure accumulation test (10)

Feb 23 **Mar 24**

(a) The capacity of the safety valve is checked by an accumulation test. This test is carried out to see whether the mountings chosen for the boiler are able to withstand excess pressure. As per the Classification society requirement during a test of 15 minutes for fire tube boilers, or of 7 minutes for water-tube boilers, with the stop valves closed and under full firing conditions, the accumulation of pressure is not to exceed 10 percent of the design pressure. During this test, no more feed water is to be supplied than is necessary to maintain a safe working water level.
The purpose of the accumulation pressure test is:
• To detect whether the safety valve and other boiler mountings are suitable for this boiler or not.
• To limit the rise in boiler pressure under full fire conditions.

(b) Procedure for boiler accumulation pressure test:
• Shut off feed water
• Closed main steam stop valve.
• Increase cut off pressure of boiler.
• Bypass high pressure cut off of the boiler.
• Arrange the boiler fire rate to a maximum.
• Safety valve will lift during the test.
• Boiler firing is continued as long as water permits in the boiler (i.e until low water level alarm activates)
• Accumulation pressure should not exceed 10% of working pressure in the specified time.
Specified time is 15 mins for a smoke tube boiler and 7 mins for water tube boiler.

With reference to the treatment of water for auxiliary boilers:
(a) State the major risks from: (6)
(i) Hard water
(ii) Soft water
(b) Describe FIVE types of boiler water tests that are carried out on board stating the reason for EACH (5)

(c) State why regular blow down and make up of the contents of a boiler is essential (5)

Oct 23

(a) (i) Hard Water:

•**Scale Formation:** Hard water contains dissolved calcium and magnesium salts. When heated, these salts precipitate and form hard scale on the inner surfaces of the boiler tubes and heat exchangers. This reduces heat transfer efficiency and increases fuel consumption.

•**Corrosion:** The carbonate hardness in hard water can lead to the formation of an alkaline environment. This can cause caustic embrittlement and corrosion of the boiler internals, leading to leaks and reduced lifespan of the equipment.

•**Foaming and Carryover:** Hard water can cause foaming due to the presence of dissolved impurities. Foaming can lead to carryover of water droplets into the steam, potentially causing damage to downstream equipment and reduced steam quality.

(ii) Soft Water:

•**Corrosion:** Soft water, which lacks mineral content, can be corrosive to metals. It can cause rapid corrosion of boiler internals, leading to leaks and equipment failure.

•**pH Instability**: Soft water has low alkalinity and buffering capacity. This can result in pH fluctuations, which can contribute to corrosion and reduced boiler water stability.

•**Increased Solubility of Oxygen:** Soft water's lower mineral content increases its oxygen-carrying capacity. This can result in increased dissolved oxygen levels in the feedwater, contributing to oxygen-related corrosion.

(b) Five Types of Boiler Water Tests and Their Reasons:

PH test (Alkalinity) -To ensure boiler water stays alkaline and does not become corrosive. The water needs to be slightly alkaline to prevent corrosion which would be caused if it was acidic.

CHLORIDE test - This is to test for chlorides in the water. To monitor and control the concentration of chloride salts within boiler water, indicating the ingress of salt water from coolers. If high chlorides are found, it could indicate there is seawater ingress somewhere in the system.

Oxygen (Hydrazine) - Oxygen needs to be kept to a minimum. To Monitor levels of chemicals added to remove oxygen from the water to prevent corrosion.

Hardness Test: The hardness test determines the level of hardness due to calcium and magnesium ions in the water. Monitoring hardness is essential to prevent scale formation, which can reduce heat transfer efficiency and damage the boiler.

PHOSPHATE reserve - To check chemicals added to remove hardness salts. If hardness salts are found in the system an insulating layer will be formed on the tubes, again this hints at a saltwater leak.

(c) Regular blowdown and makeup of boiler contents are essential for:

•**Removal of Impurities**: Blowdown removes dissolved and suspended solids that accumulate in the boiler water. This prevents scale formation, reduces foaming, and minimizes corrosion risks.

•**Control of TDS Levels**: Blowdown helps in controlling TDS levels by removing excess dissolved solids. High TDS levels can lead to scale, corrosion, and reduced heat transfer efficiency.

• **Maintaining Water Quality:** Continuous blowdown maintains the quality of boiler water by preventing excessive accumulation of impurities, which can cause operational issues and reduce boiler lifespan.

•**Prevention of Concentration**: Blowdown prevents excessive concentration of impurities in the boiler water, which can lead to foaming, carryover, and poor steam quality.
•**Makeup Water Addition:** Regular makeup water addition compensates for the loss of water due to blowdown and steam production. This helps maintain proper water level, pressure, and heat transfer efficiency in the boiler.

Where a waste heat boiler is subject to persistent leakage at the tube/tube plate connection, state with reasons:
(a) The possible causes of such leakage(6)
(b) The effects of this leakage (5)
(c) Methods of effecting a permanent repair. (5)

Jan 23 **Nov 22**

(a) The possible causes of such leakage
External wastage due to waterside corrosion and pitting caused by using bad quality feed water or improper boiler water treatment.
• Wastage of the ligaments due to soot blowing with wet steam.
• Due to local overheating or design fault, unequal thermal expansion between tube and tube plate.
• Due to overheating, deformation or panting tube plate.

(b) The effects of this leakage
• Excessive feed water consumption from cascade tank.
• Continuously running boiler feed pump.
• If large amount of leakage, boiler water level low, steam pressure drop & continuous firing of boiler.
• Unstable firing in case of oil-fired boiler.
• Water leak through check valves when engine is stopped.
• Boiler smoke is white and flashes off as soon as it comes out of funnel.

(c) Procedure for permanent repair
• After cool down, inspection of leakage and opening up for renewal of tubes,
• Cut both ends of leaking tube about 50 mm from tube plate and chisel out.
• Remove remaining pieces by
(i) chiselling and (ii) knocking out by heating and cooling to achieve shrinkage.
• Clean polish tube holes for dye check for any cracks, minor damage at the tube hole.
• Diametrical clearance between tube and hole about 1.5 mm.
• The ends of new tube cleaned thoroughly and carefully expanded by rolling into the hole and tube plate.
• New tube protruded from tube plate by 6 mm at least.
• Bell mouthing should be 1 mm for every 25 mm of tube outside diameter plus 1.5mm

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Steering Gear & Rudder

- **Notes:**

With reference to Steering Gear & Hydraulic Power Rotary pumps
(a) Explain how the reserve of fluid in the system is checked and how make-up is achieved. (5)
(b) Describe how a steering system is tested prior to leaving port with reference to SOLAS. (5)
(c) Explain how tests are made for leaks, and air and other gases are bled from the system. (6)

Oct 22

(a) the reserve of fluid in the system is checked and how make-up is achieved
The reserve of fluid in a hydraulic system, such as a steering gear or a hydraulic power rotary pump, can be checked through the monitoring of fluid levels in the system's storage tank. This storage tank is equipped with a gauge glass that indicates the fluid level. Regularly checking this gauge glass allows operators to ensure that an adequate reserve of fluid is maintained in the system. It's common practice to keep the storage tank about 90% full to accommodate any emergency requirements.

b) According to SOLAS regulations, the ship's steering system is tested within 12 hours before departure by the ship's crew. The test procedure includes the following:
• **Operation Testing:**
• Main steering gear.
• Auxiliary steering gear.
• Remote steering gear control systems.
• Steering positions on the navigation bridge.
• Emergency power supply.
• Rudder angle indicators in relation to the actual rudder position.
• Remote steering gear control system power failure alarms.
• Steering gear power unit failure alarms.
• Automatic isolating arrangements and other automatic equipment.

Checks and Inspections:
• Ensure full movement of the rudder according to the required capabilities of the steering gear.
• Conduct a visual inspection of the steering gear and its connecting linkages.
• Verify the operation of the means of communication between the navigation bridge and the steering gear compartment.

(c) Air in the Steering gear system will lead to hunting of the steering gear. Hence removal of air is necessary for proper functioning of steering gear and safe navigation. Following procedure is carried out for removing air from the system:
- Set the steering gear for local operation (i.e. emergency mode - operation by mechanical handle)
- Open the stop valves and close the bypass valves
- Start motor and carry out air venting from vent valve on the discharge side of hydraulic cylinder while operating the steering gear port and starboard alternatively by means of mechanical handle
- This is done until air bubbles are completely removed. Rudder angle stopper attached to the mechanical handle is to be adjusted beforehand so that steering can be done within rudder angle of 35 degrees.

- Once the air is vented, close air vent cock completely and replenish oil.

With reference to a rotary vane steering gear
(a) State, what symptoms would indicate leakage across vane seals (8)
(b) State what steering gear tests you would carry out before a voyage begins (8)

Aug 22

(a) Symptoms That Indicate Leakage Across Vane Seals in a Rotary Vane Steering Gear

1. **Loss of Steering Power**: A decrease in the steering ability or resistance in the rudder movement may indicate that hydraulic fluid is leaking across the vane seals. This would result in a reduction of the power transmission to the steering gear mechanism.
2. **Unusual Fluid Loss**: A visible decrease in hydraulic fluid levels or finding hydraulic fluid in the bilge could indicate leakage across the vane seals, as the seals are meant to keep the hydraulic fluid contained within the system.
3. **Erratic Rudder Movement**: If the rudder behaves unpredictably or responds inconsistently, it could be a sign that hydraulic pressure is being lost due to leakage, affecting the vane seals' sealing efficiency.
4. **Abnormal Pressure Readings**: If the system pressure drops or fluctuates unexpectedly, it may be due to hydraulic fluid leaking across the vane seals, resulting in a lack of proper pressure within the steering system.
5. **Overheating of the Steering System**: Hydraulic fluid leakage can cause a loss of lubrication and cooling properties in the steering gear, potentially leading to overheating. Overheating of the system components may be a direct result of leaking seals.
6. **Visible Fluid Leaks Around Vane Seals**: A direct symptom of leakage across the vane seals is the visible presence of hydraulic fluid around the seals, particularly during or after operation of the steering gear.
7. **Increased Noise from the Steering Gear**: If the steering gear starts producing unusual noise (e.g., whining or grinding sounds), it could indicate that air or water is entering the system due to seal leakage, leading to cavitation or improper functioning of the hydraulic system.
8. **Difficulty in Centering the Rudder**: Difficulty in centering or returning the rudder to the midship position can also be a sign of vane seal leakage, as loss of hydraulic fluid or pressure may cause inconsistent response during operation.

(b) Steering gear tests that would be carried out before a voyage begins

•Main steering gear and system
• Auxiliary steering gear and system
• The remote control systems of steering gear
• The steering position indicator on the navigation bridge
• The emergency power supply to one of the steering units
• The rudder angle indicators show the actual position of the rudder
• Power failure alarms for the remote steering gear control system
• Power unit failure alarms for the steering gear unit
• Automatic isolating arrangements and other automatic equipment
• Test movement of SG from bridge 35°P to 30°S and then time to ensure within 28 seconds

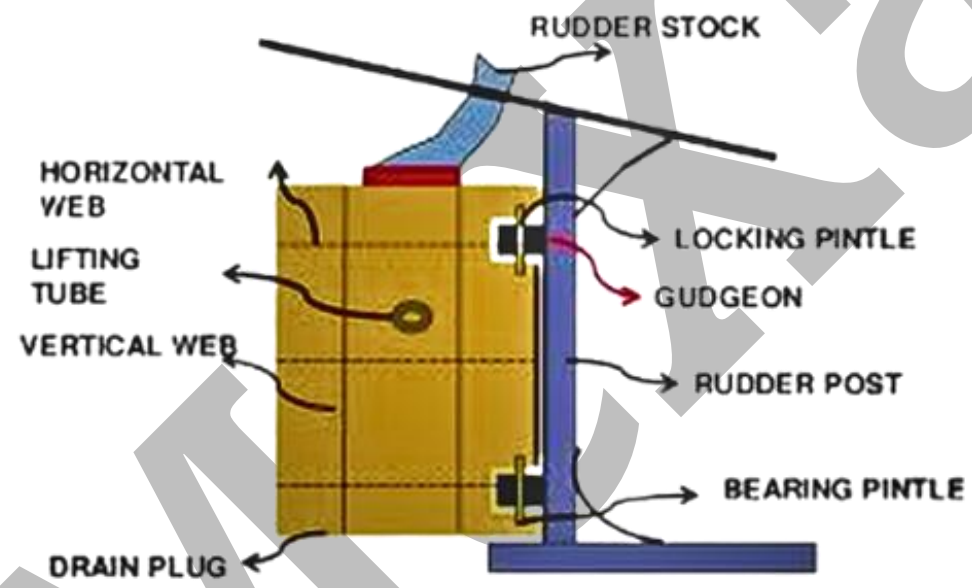
The following listed procedure must be included along with the check and tests described above:

1. The full movement of the rudder as per the required capabilities of the steering gear system present onboard
2. A visual inspection of all the linkages and connections in the steering gear
3. The means of communication between the steering gear room and the navigational bridge must always be operational.

(a) Describe, with the aid of a sketch, how the weight of the rudder is carried (8)
(b) Explain how replacement of the bearing is catered for (4)
(c) Explain how the rudder stock is located (4)

Aug 22

(a) Rudder may be hinged on the pintles and gudgeons, or they may turn about an axle which passes down through the rudder. The weight of the rudder may be taken by bearing pintles or by bearing at the rudder head (rudder carrier), or by a combination of both.



(b) how replacement of the bearing is catered

- Lock steering gear in mid position
- Remove the earth wire
- Measure clearances (rudder drop and jumping clearances)
- Fix the eye bolt to the rudder stock and take the load with the help of the chain block at the strong point provided
- Remove the bolts of the gland housing and remove the gland packing.
- Remove the locking ring
- Remove grease plug
- Remove the moving cone which is in 2 pieces (bolted with each other). Put eye bolt diametrically opposite
- Remove the bottom half which is also in 2 pieces and attached to ship structure via chocks

(c) the rudder stock is located

The rudder stock is located by the journal beneath, also grease lubricated. Support for the bearing is provided by framing beneath the steering gear deck.

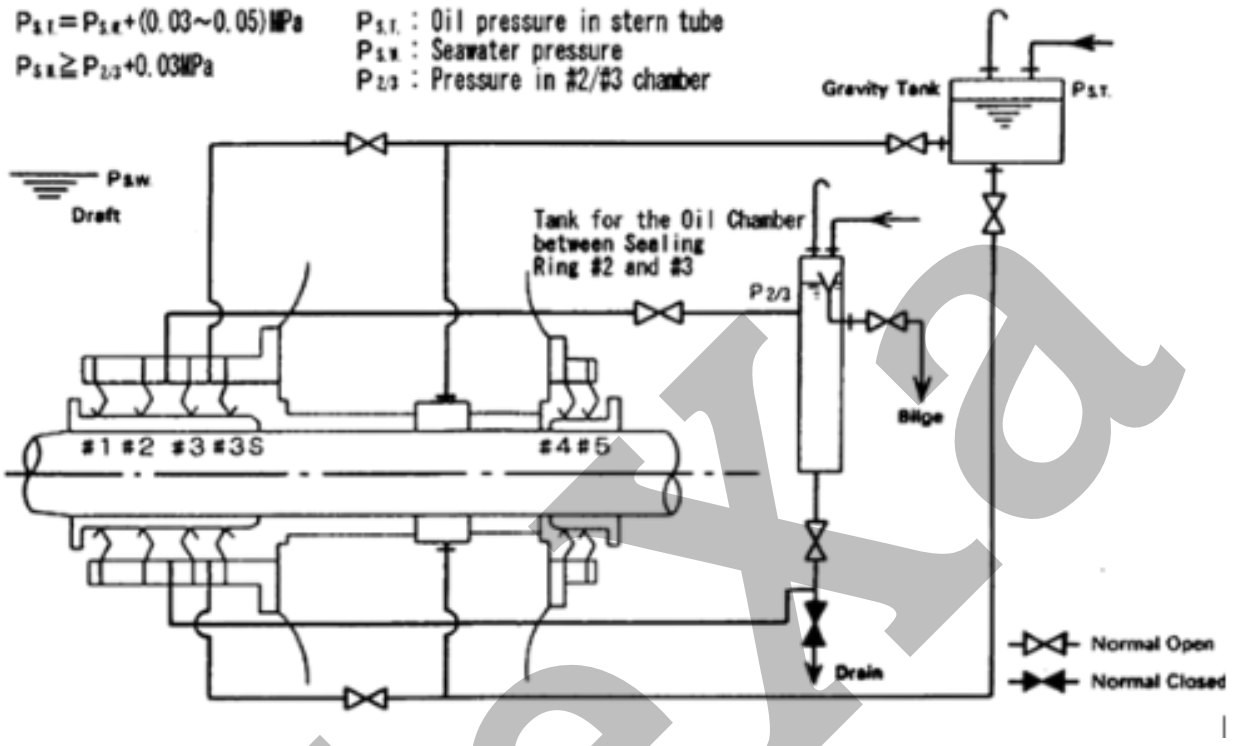
Shafting & Stern Tube

- **Notes:**

(a) With a simple sketch show the stern tube arrangement and describe the same. (10)
(b) Show the Aft seal arrangement with a neat sketch (6)

Jul 22

(a) With a simple sketch show the stern tube arrangement and describe the same.

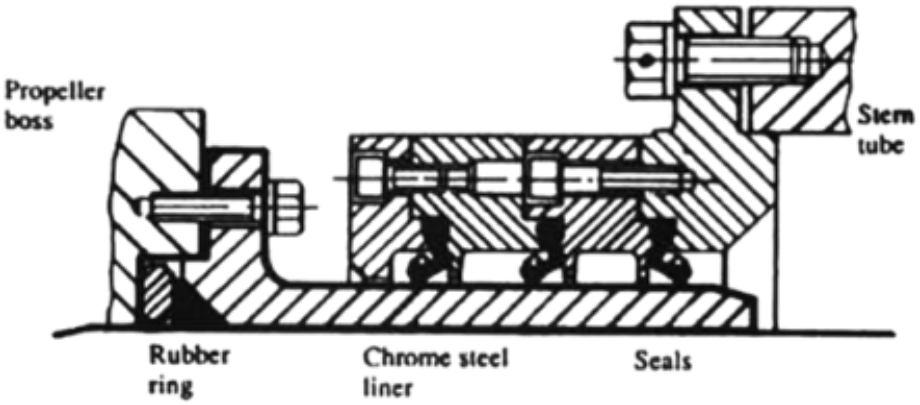


A stern tube is a critical part of a ship's propulsion system, housing the shaft that connects the ship's engine to the propeller. It's located at the aft (rear) of the ship and is designed to ensure smooth and efficient rotation of the shaft and prevent seawater from entering the hull.

Here's a description of a simple sketch for the stern tube arrangement:

- **Stern Tube:** The tube is a cylindrical housing running through the hull from the stern to the propulsion system.
- **Propeller Shaft:** The shaft runs through the stern tube, transmitting power from the engine to the propeller.
- **Stern Bearing:** Bearings located within the stern tube support the propeller shaft and allow it to rotate freely with minimal friction.
- **Seals:** Rubber or mechanical seals are located at both ends of the stern tube to prevent seawater from leaking into the vessel while allowing the shaft to rotate.
- **Lubrication System:** The stern tube is typically lubricated by oil or water to reduce friction and prevent wear on the shaft and bearings.
- **Waterproof Bulkhead:** A waterproof bulkhead is provided near the stern to further protect the vessel from water ingress.

(b)Show the Aft seal arrangement with a neat sketch:



Aft Seal Arrangement

The aft seal arrangement is a critical component in a ship's propulsion system, as it prevents seawater from entering the stern tube and the ship's hull. The aft seal is located at the end of the stern tube, closest to the propeller, and it seals the space where the propeller shaft exits the stern tube.

Here's a simple explanation and a description of the aft seal arrangement:

Key Components of Aft Seal:

1. **Stern Tube:** The cylindrical tube housing the propeller shaft, extending from the hull to the propeller.
2. **Aft Seal (Stern Tube Seal):** Located at the aft end of the stern tube, the aft seal prevents seawater from entering the stern tube.
3. **Sealing Mechanism:** The sealing system usually consists of rubber seals or mechanical seals, which are designed to maintain a water-tight barrier while allowing the propeller shaft to rotate.

Lubrication: Lubrication oil or water is typically used to ensure proper operation of the seal and to minimize friction between the moving shaft and the seal.

(a) Describe function of oil seals. (6)
(b) Describe materials with their qualities used for making shaft seals. (6)
(c) Describe cares to be taken in storing shaft seals. (4)

Jul 23

(a) Describe function of oil seals

The primary role of oil seals is to prevent the leakage of fluids, such as lubricating oil or hydraulic fluid, from the clearance between the rotating shaft and the housing. This is essential for maintaining proper lubrication and preventing fluid loss.

Oil seals act as a barrier to external contaminants, such as dirt and debris, preventing them from entering the machinery through the clearance. This helps in maintaining a clean and efficient internal environment.

Oil seals contribute to minimizing friction between the shaft and the bore, ensuring smooth rotation without excessive wear. Proper installation is essential for effective sealing.

The seal lip should be correctly oriented toward the medium being contained to optimize its function.

Some oil seals are equipped with a spring to maintain constant contact between the seal lip and the rotating shaft. This feature ensures a more effective seal, especially during variations in shaft

movement. The sealing orientation and direction are critical factors to consider for oil seals, as they impact the efficiency of fluid containment and contaminant prevention.

(b) materials with their qualities used for making shaft seals

The material used for making shaft seals is nitrile rubber. It has elastic properties for gripping the rubbing surface in order to have an efficient and effective sealing. If the temperature of the seal material exceeds 110°C the rubber may lose its elasticity property. There are different positions where the oil seal is placed. The outer seals dissipate the heat to outboard sea water and the inward seals dissipate heat to the oil by the method of convection.

The lip seals create a grooving over the chrome liner due to friction, which can be overcome by using a ceramic filler for the groove by using a distance piece with some allowance to compensate for the shaft and stern tube expansion.

(c) Describe cares to be taken in storing shaft seals.

Proper storage practices must be observed to prevent deformation and deterioration of seals. Most synthetic rubbers are not damaged by storage under ideal conditions. However, most synthetic rubbers will deteriorate when exposed to heat, light, oil, grease, fuels, solvents, thinners, moisture, strong drafts, or ozone (form of oxygen formed from an electrical discharge). Damage by exposure is magnified when rubber is under tension, compression, or stress. The following care to be taken:

• Improper stacking of parts and storage containers can lead to deformation.
• Force applied to corners and edges, as well as squeezing between boxes, should be avoided to prevent creasing.
• Storage under heavy parts should be avoided to prevent compression and flattening of seals.
• Staples used for identification should not cause punctures.
• Hanging seals from nails or pegs can lead to deformation and contamination.
• Seals should be kept in their original envelopes for preservation, protection, identification, and to track the cure date.
• Avoid piercing sealed envelopes or using wire hanging devices. Contamination from fluids leaking from adjacent parts should be prevented.
• Adhesive tapes applied to seal surfaces should be avoided. If the seal package is torn, secure it with pressure-sensitive moisture-proof tape without contacting the seal surfaces.
• Seals should be arranged to use older seals first, preventing the retention of overage parts due to improper storage.

Describe the Stern Tube Lubrication System by drawing a schematic diagram and explaining function of each component. (16)

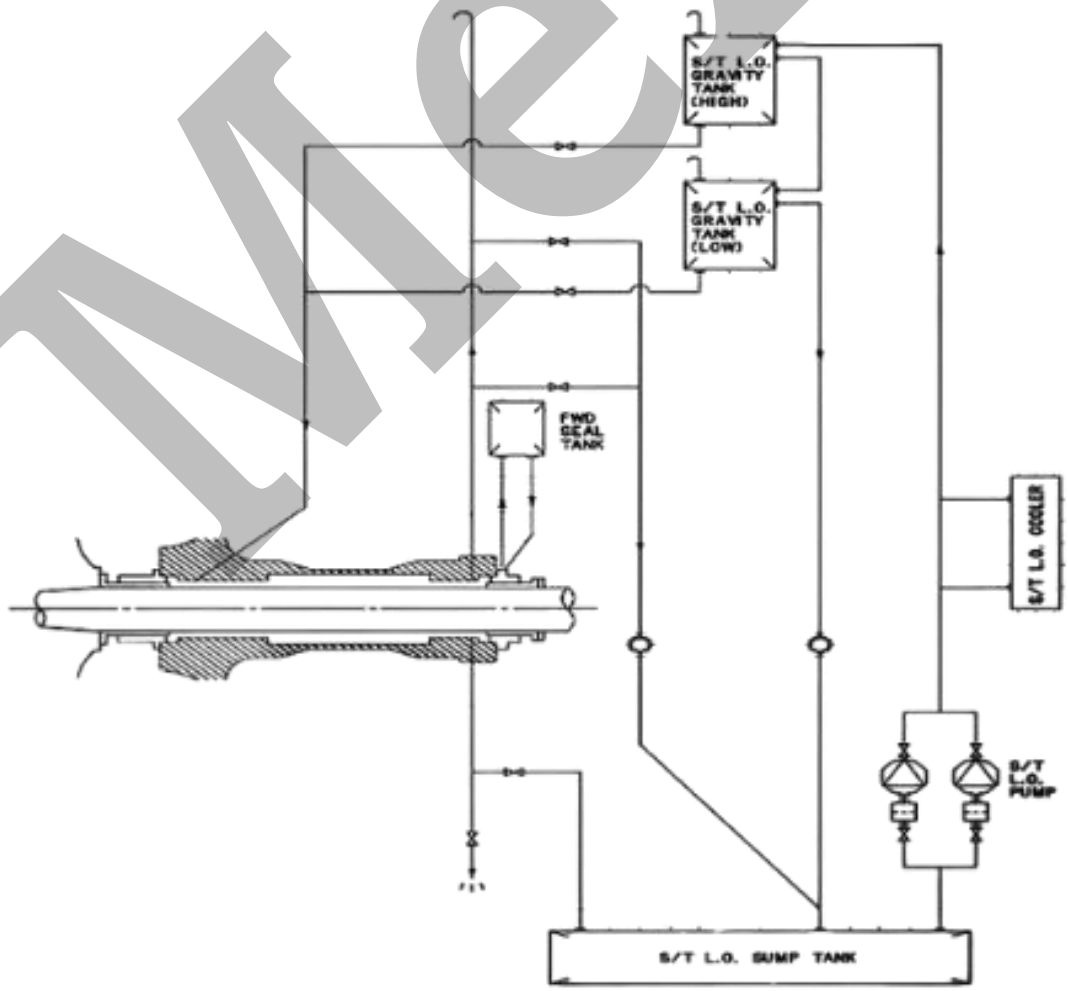
Jan 24 | Dec 24

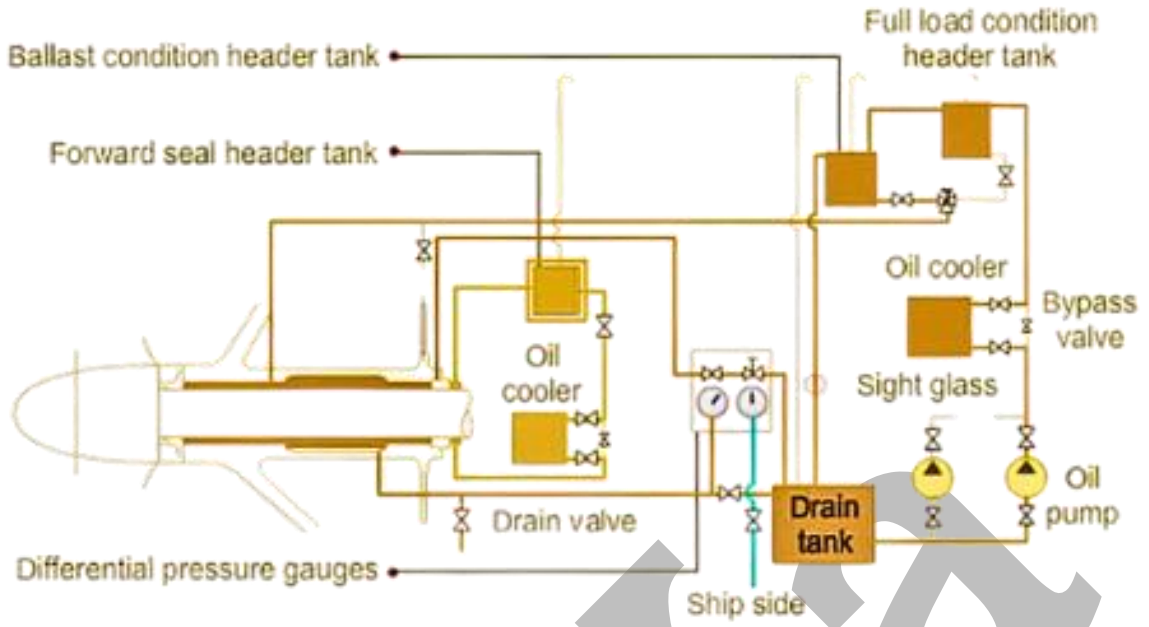
Stern Tube Lubrication System:

- **Drain Tank:** The stern tube lubrication system consists of a drain tank that acts as a reservoir for the storage of oil. The drain tank is a double-bottom tank located in the aft of the engine room.
- **Oil Pumps:** The system consists of two sets of oil pumps. The purpose of having two pumps is that if one pump fails, the other pump can take over and continue the operation. The pump draws suction from the drain tank and sends it to the oil cooler.

- **Oil Cooler:** The cooler cools the lubricating oil and maintains the temperature of the oil to its optimum range for effective lubrication and sealing operation. The cooling medium used is water.
- **Header Tank**: The oil reaches the header tank at the full load condition, and from there, it overflows to the ballast condition header tank. Both the tanks have an outlet valve located at the tank bottom. The pressure head is exerted by the oil level in the header tank, and the water draught is monitored in the pressure gauge. A drain valve is fitted to check water intrusion. A small pressure differential of air (increase in pressure) ensures water exclusion.
- **Stern Tube Bearing:** The lubricating oil passes through the Stern tube bearing. The oil pressure is sufficient to generate hydrodynamic fluid film lubrication. Since a static head generates oil pressure, it is sometimes called static lubrication.
- **Forward Seal:** The diagram also shows a lubrication system for the forward seal. The oil circulation within forward seals is achieved by natural convection. Oil in the forward seal tank is cooled by a cooler. In some cases, the tank is provided with radiation fins on the tank surface. The air in contact with the fins cools the tanks, which in turn cools the oil.

The Sealing rings are spring-loaded and seal the shaft against water ingress. The forward sealing rings prevent oil leakage to the sea by Spring load and oil pressure of the system. The lip seal keeps oil within the Stern tube and accepts slight misalignment. Chrome Steel liners are located at the aft and forward ends of the propeller shaft. They act as rubbing surface lip seals. The liner at the outboard end protects the Steel shaft from seawater and corrosion. The lubrication system is connected between the two fwd seals.





(a) Describe with suitable schematic diagrams Inspections and checks to be conducted on Tail Shaft, highlighting areas to be attended (10)
(b) Describe the procedure for repair in way of shaft CONICAL AREA. (6)

Sep 23 | **Jul 24** | **Feb 24** | **May 23-2**

(a) The propeller and stern tube assembly is an independent survey from the docking survey. The survey would typically include the complete withdrawal of the propeller and tail shaft.

It could consist of an examination of the following, as applicable:

- Visual inspection of the propellor
- Fasteners and leak tightness of the hub and blades would be carried out on the controllable pitch propellers
- Dismantling of the CPP may not be carried out unless considered necessary by the surveyor
- Wear down measurement and recording of the aft bearing
- Aft stern tube seal leakage testing and recording
- Propeller nut and threaded end of the tail shaft
- Propeller cone, key and keyway
- The use of an efficient crack detection method on the aft end of the cylindrical part of the tail shaft and part or all of the tail shaft taper
- Where the propellor fitting is by solid flange coupling, crack detection is to be carried out on the flange fillet area of the tail shaft
- Tail shaft in the way of stern tube bearings
- Stern tube bearing(s) clearance measurements.

On re-assembly, the following is noted:

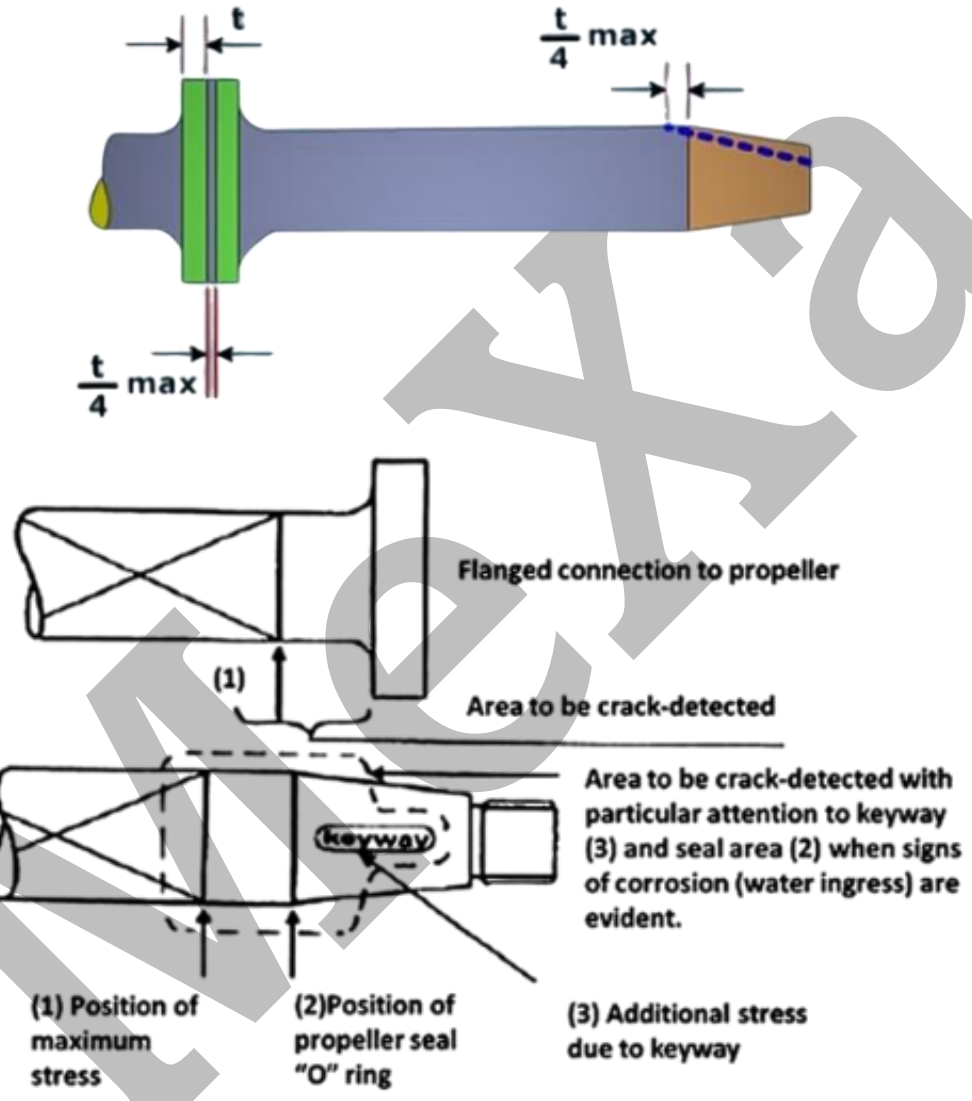
- Propellor push-up distance and hydraulic force
- Wear down measurement and recording
- Aft stern tube seal leakage performance
- Refitting of any rope guards/cutters

(b) Corrosion on the conical part of the propeller shaft may be repaired by machining the taper. This will result in the propeller moving forward which must be contracted by fitting a spacer between the shaft couplings. The maximum thickness allowed for this spacer is 25% of the

intermediate shaft flange thickness. It is therefore the intermediate shaft flange thickness that determines the maximum amount that can be machined off the cone.

e.g. Intermediate shaft coupling flange thickness 100-120 mm, then maximum spacer which may be employed = 25 mm, if propeller shaft taper = 1 in 12 the radial amount which may be machined = 25/12 = approx. 2mm

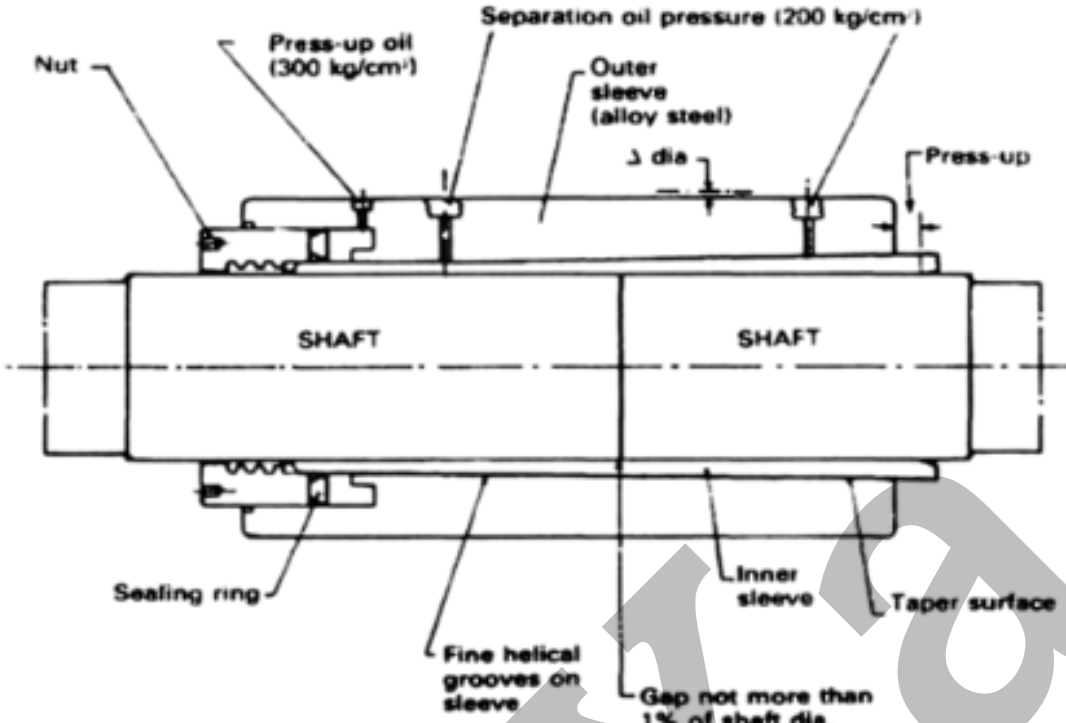
The surface contact of the propeller bore to the shaft cone should be checked using Prussian blue. There should be a minimum of 70 % contact equally distributed.



(a) Sketch a transmission shaft coupling which enables the propeller shaft to be withdrawn outboard. (8)
(b) (i) Describe the coupling and the method of fitting and dismantling. (4)
(ii) State how the grip of the coupling can be checked when fitted. (2)
(iii) State what safety precaution should be taken when dismantling the coupling. (2)

Aug 22

(a) Sketch a transmission shaft coupling which enables the propeller shaft to be withdrawn outboard



(b) (i) An alternative to the conventional flange couplings for the tail shaft, the muff coupling allows the shaft to be withdrawn outboard. The SKF coupling, shown in the above figure, consists of two steel sleeves. The thin inner sleeve has a bore slightly larger than the shaft diameter and its outer surface is tapered to match the taper on the bore of the outer sleeve. The nut and sealing ring close the annular space at the end of the sleeves. When the coupling is in position, the outer sleeve is hydraulically driven on the tapered inner sleeve. At the same time, oil is injected between the contact surfaces to separate them and thus overcome the friction between them. Oil for the operation is supplied by hand pumps, two for the forced lubrication and another hand or power pump for the riving oil pressure. When the outer sleeve has driven onto a predetermined position, the forced lubrication pressure is released and drained. Oil pressure is maintained in the hydraulic space until the oil between the sleeves drain and normal friction is restored. After disconnection hoses, plugs are fitted and rust prevention is applied to protect exposed seating. A sealing strip is brought to a set pressure in the hydraulic space. Then with the shafts supported, oil is forced into the sleeves. The outer sleeve slides off the inner at a rate controlled by the release of the hydraulic oil pressure. When it is required to remove the propeller, the process is equally simple and even quicker with the injection of oil between the surfaces obviating the need for any form of heating or mechanical withdrawn equipment. Precautions are necessary to prevent the propeller from jumping at release.

(ii) The grip of the coupling is checked by measuring the diameter of the outer sleeve before and after tightening. The diameter increase should agree with the figure stamped on the sleeve.

(iii) To disconnect the coupling, oil pressure is brought to a set pressure in the hydraulic space. Then with the shafts supported, oil is forced between the sleeves. The outer sleeve slid off the inner at a rate controlled by the release of the hydraulic oil pressure. Care must be taken to release the hydraulic pressure very slowly to avoid and prevent the propeller from jumping at the release of the hydraulic pressure. When it is required to remove the propeller, the process is equally simple and even quicker with the injection of oil between the surfaces obviating the need for any form of heating or mechanical withdrawal equipment. Precautions are necessary to prevent the propeller from jumping at release.

Drydocking

- **Notes:**

(a) Describe safety issues which need to be addressed at all times during vessel is in Dry Dock(8)
(b) Describe common Dry Dock Jobs with their inspection points during dry docking of the vessel.(8)

Jul 23

(a) Safety Issues During Dry Docking:

- Enter the dock only after water has been completely pumped out and safety is confirmed.
- Exercise caution, ensuring a safe environment for personnel.
- Watch for objects falling from above when close to the side shell or dock wall.
- Implement measures to prevent injuries from falling tools or equipment.
- When docked, the ship is supported by logs (sock/side shores) on the dock wall, preventing toppling.
- Take note of ship support structures while walking underneath for personal safety.
- Exercise caution during shell cleaning with high-pressure water jets.
- Direct impact of high-pressure water on the body can be dangerous; safety measures are crucial.
- Exercise vigilance when anchors and chains are being lowered.
- Ensure proper communication and coordination to avoid accidents during handling.
- Warning notices.
- Fire line under pressure/ fire fighting appliances kept ready.
- CO2 room locked.
- Means of communications established.
- Usage of galley and WCs restricted as required.
- Hot work permissions/precautions.
- Earthing of vessel.

(b) Common Dry-dock jobs and their inspections:

- Bottom Inspection And Corrective Action As Recommended By Classification Society Surveyor
- Bottom Preparation And Painting As Per the Company‘s Painting Specifications
- Anchor Cables Ranging And Calibration
- Cleaning And Painting Of Chain Locker
- Building Up The Hawse Pipe Cast Steel Collars At Both Ends
- Echo-Sounder Transducers Cleaning And Checking Of Water Tight Terminal Boxes
- Speed Log / Sal Log Or Doppler Speed Log
- Sacrificial Zinc Anodes Or Impressed Current System
- Sea Chests Cleaning And Painting
- Sea Suction And Discharge Valves Overhaul And Survey
- Sanitary Storm Valves Overhaul And Their Survey
- Damaged Portions Of Bilge Keels To Be Renewed
- Rudder Pintle Clearances, Jumping Clearance, Any Repairs And Hydraulic Testing.

(a) Under which all circumstances drydocking of a vessel is required. (8)
(b) What all repair and maintenance work are expected to be carried out in Dry Dock? (8)

Feb 24 | Jul 24 | Jul 24 | Sep 23 | May 23-2

(a) Drydocking of a vessel is typically required under the following circumstances:

• Regular inspections and surveys as per regulatory requirements (e.g., statutory surveys by classification societies).
• Repairs and maintenance that cannot be conducted while the vessel is afloat, such as extensive hull cleaning, painting, or repairs below the waterline.
• Overhaul or replacement of major components like propellers, shafts, rudders, or sea valves.
• Structural repairs due to damage, corrosion, or fatigue.
• Installation or inspection of equipment that requires the vessel to be out of the water (e.g., thrusters, stabilizers).
• Conversion or modification works that necessitate the vessel to be out of service and in a controlled environment.
• Upgrades to comply with new regulations or improve operational efficiency.
• Assessment and repair of damage caused by grounding, collision, or other accidents.

(b) Repair and maintenance works are expected to be carried out in Dry Dock are:

• Hull cleaning, blasting, and painting.
• Inspection and repair of the propulsion system, including propellers, shafts, bearings, and rudders.
• Overhaul and inspection of sea valves and other through-hull fittings.
• Structural inspections and repairs to the hull, including welding, plating, and stiffener renewal.
• Inspection and maintenance of the bilge and ballast systems.
• Examination and repair of the ship's bottom and keel blocks.
• Inspection and maintenance of the ship's machinery, such as engines, boilers, and auxiliary equipment.
• Replacement or repair of electrical and piping systems.
• Inspection and testing of safety equipment, including lifeboats, davits, and fire suppression systems.
• Installation or upgrade of equipment to comply with new regulations or improve operational efficiency.

Describe the procedure for flooding of DRY DOCK after completion of drydocking. Describe all the precautions to be taken on the ship prior flooding of the drydock. (16)

Feb 23

Immediately prior to flooding up, the Master, Chief Officer, Chief Engineer and Superintendent together with the Dock Master, Paint Manufacturer's inspector and Ship Repair manager will carry out a final Dry-dock inspection to ensure that all Dock work has been completed, and the vessel is in a fit condition to float.

All bottom and rudder plugs are secure in position (note: Chief Officer is responsible for the safekeeping of removed Bottom & Rudder plugs during the Dry-dock period);
• All scupper plugs have been removed.
• Paintwork has been adequately cured.
• Propeller/Thruster blade / Stem Tube(s) seals are free from leakage.
• Sea chest / Thruster Tube grids are correctly secured.
• All contractor's equipment, staging and loose objects have been removed from the dock bottom.

- All tapes / tallow applied on anodes for paint protection have been cleared.
- Echo sounder impressed Current System and Sal-log (Speed Log) have been secured.
- Rudder test has been performed satisfactorily, and propeller is free to turn.
- No other leakages are evident.
- General inspection of hull and its skin-fittings (i.e. say overboard valves) to ensure readiness for flooding.

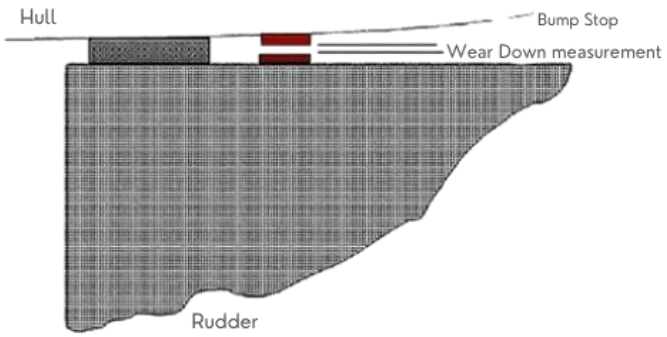
The Chief Engineer is to confirm to the Superintendent that all ship side sea valves and associated pipe work have been closed up. The Chief officer is to confirm this with the Dock Master and report to the Superintendent that all non-essential connections have been removed, and that the vessel is correctly moored in order to hold its position, once afloat.
The Shipboard Management Team is to confer with the Superintendent, Dock Master and Ship Repair Manager to confirm that adequate personnel are standing by to check ships spaces for increasing any water. The "final order" to commence flooding will be given by the Master.
During flooding up, the flooding is to be suspended at a draft which is about one foot less than the draft at which the vessel just-floats-off-the-keel-blocks (known to the Dry dock authorities), i.e., leaves the blocks, and all sea valves are to be fully opened and closed to the satisfaction of the Chief Engineer and Superintendent. The Second Engineer is responsible for the coordination of the transfer of electrical power from shore to ship supply when flooding level is sufficient and generator sea water cooling system have been proved to be watertight. During flooding an effective communication system is to be maintained to ensure that in the event of any evidence of lack of stability or untoward ingress of water being detected, the flooding operation may be halted without delay. On completion of flooding, the shipboard Management Team, Superintendent and Ship Repair Manager will confirm. The order to move out of the dock will be given by the Master.

Describe following procedures for rudder maintenance in a dry dock.
(a) What is Jumping Clearance and why is it considered a value of importance? (8)
(b) What is Rudder Drop and describe the procedure for measuring the rudder drop? (8)

Jan 24 **Nov 24** **Jun 24**

a) Pads are welded to the hull and rudder. A clearance is given (sometimes referred to as the jumping clearance). As the carrier wears this clearance will increase.

The jumping clearance is required to prevent damage to the steering gear, regardless of the rudder type. Therefore the maximum jumping clearance should always be less than the clearance between the tiller and steering gear. An increasing jumping clearance can indicate that the bearing wear is excessive. Higher jumping clearance causes striking of the tiller with the ram and causes damage to it. There is not much significance of it in the rotary vane steering gear system.

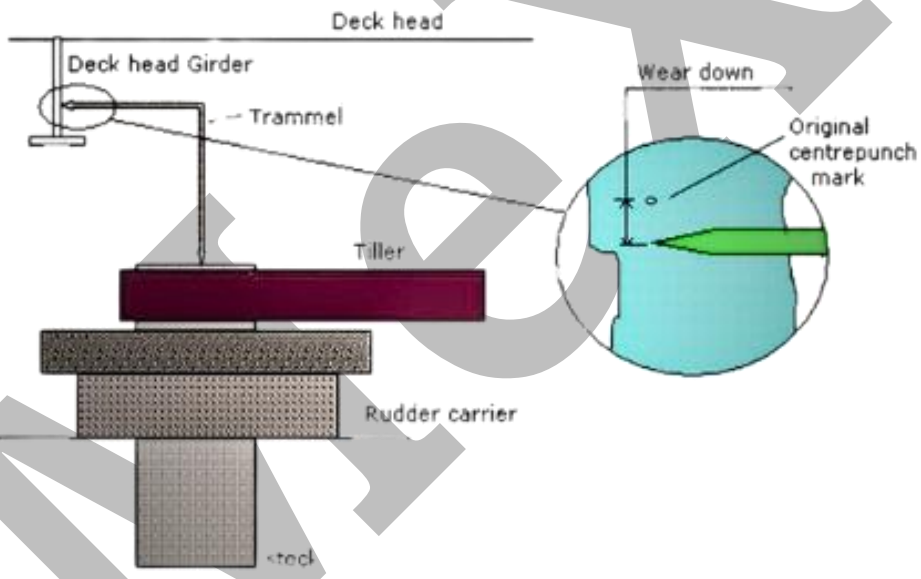


Jumping stopper and jumping clearance

If the rudder is lifted when underway due to the wave impact or contact with floating objects, and/or bottom contact, the steering gear may be damaged. To prevent such damage, a jumping stopper is provided. The jumping stopper, as shown in the figures below may be fitted over the gudgeon or assembled in the rudder carrier. The designed clearance is 2.0 mm maximum.

There are no instances of damage or corrosion to the jumping stopper itself. However, if the clearance measured is found to be large, it can be concluded that the rudder has moved down. Because a hanging rudder does not have a shoe piece, one does not know whether the rudder has moved down or not. Therefore, it is recommended to enter the transom space (refer Fig 6 below) for approaching the rudder trunk and measure the clearance between the base of rudder carrier and the jumping stopper. If access is not available, the clearance is measured from outside the ship on top of the rudder at the upper pintle where the jumping stopper piece is fitted.

(b) "Rudder drop" - is the wear down of the rudder carrier bearing. It is measured by a 'trammel gauge'. The trammel gauge is an L-shaped instrument. A point is marked on the rudder stock and another point is marked on the hull inside the steering gear room (Here it is on the Deckhead girder). The distance between these points is measured and recorded at the time of construction. The difference between the original and the measured is called rudder drop or rudder wear down



(a) Why is drydocking of the vessel required and what are the major activities planned during the drydocking of the vessel? (8)

(b) Describe what preparations are required by the vessel before entering Dry Dock? (8)

Nov 22

(a) The primary reason for drydocking is to maintain the ship's hull. This involves cleaning, scrubbing, and preparing the hull by de-scaling any rusted areas. The hull is then painted to restore its smooth surface, which not only enhances the ship's aesthetics but also improves its hydrodynamic performance. A smooth hull reduces drag, thereby improving speed and fuel consumption, bringing it back to its original efficiency.

Drydocking provides the opportunity to examine all critical components located underwater, such as propellers, rudders, and tail shafts, for defects or wear and tears. Any necessary corrective actions, repairs, or replacements can be carried out during this period.

Some of the major activities include inspecting and taking corrective action on the ship's bottom, painting anchor cables, cleaning and painting the chain locker, conducting checks on echo-sounders and speed logs, inspecting and testing MGPS (Marine Growth Prevention Systems) and ICCP (Impressed Current Cathodic Protection) systems, cleaning and painting sea chests and filters, overhauling storm valves, checking rudder pintle and jumping clearances, pressure testing and internal painting of the rudder if required, reading poker gauge readings for propeller drop, conducting stern seal leak checks, and performing propeller polishing or repairs if needed. Additionally, a tail shaft survey may be conducted, and bottom plugs may be removed and refitted as required.

(b) Preparation and Essential information that would be sent to dry-dock management before dry-docking.

• Name of vessel and IMO number and vessel specification.
• Date required to dock vessel and number of days to complete docking.
• The drydock repair contract would detail who would be legally responsible for all aspects covering safety in the dock. This would include gas-freeing certificates, hot work, staging and lifting.
• Docking Plan.
• Dry-dock repair specification includes all survey items to be completed.
• List of Specialized contractors to be employed by the vessel directly.
• Contact numbers for the vessel and the technical manager in charge of the repair.
• Number of personnel remaining on board.
• Shore power required and location of the connection.
• Fresh water requirement and connection location.
• Cooling water requirement if staying on ships power.
• Sludge connection location.
• Access points to ship for gangways (2 points required).
• Method of waste collection and disposal of shipboard-generated waste.
• Sewage disposal method to be adopted in the dock.

(a) Describe the preparations required before Dry Docking a vessel (5)
(b) Describe what preparation is to be made prior entering a dry dock (6)
(c) Describe actions to be taken when vessel has set on the blocks in Dry Dock. (5)

Jun 23

(a) Preparations Before Dry Docking a Vessel:

•The shipboard defect list is prepared well in advance by the ship's crew and approved by the ship superintendent, in charge of that vessel.
• The approved defect list comes back on the ship and is retained by the Deck and the Engine Departments for follow-up.
•Before docking, if there is to be any extra-ordinary item that must get included in the defect list, must be negotiated with the yard and once the vessel is in the docks, there should be no or minimal change to be accepted on the defect list.
•The Master and Chief Engineer shall ensure that all required supplies, service engineers, Class, Flag and insurance surveyors, paint supplies, sub-contractors and agents for the dry-docking are requisitioned via the Planned Maintenance system and confirmed from the office and shall keep them fully updated on the vessels schedule.

• The Master shall detail any cleaning, gas freeing, slop disposal or other preparatory works to the office well in advance of the repair or dry-docking dates and discuss the arrangements and schedules in detail with the office, ensuring the best use of resources and time. - Before arrival at the docks all the above preparations must be thoroughly gone through by the ship superintendent, if possible, with a checklist toward ensuring an uninterrupted work schedule.
• There is another aspect of docking, which is operational and normally handled by the ship manager with assistance from the vessel. This involves providing necessary information to the dock master or the yard directly, as applicable.

(b) Preparation Prior to Entering a Dry Dock:
• Ensure requisition of supplies, service engineers, class, flag, insurance surveyors, paint supplies, sub-contractors, and agents through the technical department.
• Keep all parties involved fully informed of the vessel's schedule.
• Detail cleaning, gas freeing, slop disposal, or other preparatory operations to the office well in advance of repair or dry-docking dates.
• Discuss arrangements and schedules in detail with the office for optimal resource and time utilization.
• Master reports progress of cleaning works and ETA readiness for the repair port regularly to the superintendent and owners.
• Attend repair items on the defect list that can be safely repaired within the ship's capability while in service.
• Allocate duties as per the repair list and monitor shipyard work.
• Check necessary spare parts and keep ready items for repair.
• Assess previous dry dock reports, particularly measurements.
Prepare tanks and cofferdams, secure heavy weights, and check firefighting equipment.
Ensure tanks and bilges are cleaned, and if the ship is a tanker, cargo tanks are cleaned and gas freed.
• Test emergency generator and lighting, secure all heavy weights, and prepare shore connections for cooling water.

(c) Actions When Vessel is Set on Blocks in Dry Dock:
• Maneuver the vessel into the dry dock chamber safely.
• Anchor or use mooring lines to secure the vessel to the dock floor, preventing movement during dry docking.
• Ensure all water ballast is emptied for the vessel to sit properly on the blocks.
• Thoroughly inspect dock blocks for damage or wear.
• Place blocks at appropriate locations along the hull to distribute weight evenly.
• Fill ballast tanks as needed for stability.
• Ensure bilge pumps are operational to handle water accumulation during dry docking.
• Disconnect and secure external systems vulnerable during dry docking, such as sea chests, sea valves, and underwater equipment.
• Secure the vessel's propulsion system.
• Remove anchors, anchor chains, and any external equipment interfering with the dry-docking process.
• Inspect the hull for damage or fouling before the vessel is fully set on the blocks.
• As the vessel settles onto the blocks, slowly and evenly lower keel blocks (if used) to support the keel properly.
• Ensure the vessel's weight is evenly distributed across all blocks.

• Ensure access to the vessel is safe for personnel.
• Implement safety measures such as scaffolding or barriers for personnel working around the vessel.
• Continuously monitor the vessel's stability and alignment on the blocks.
• Adjust block positions if necessary to maintain stability.
• Once securely positioned on the blocks, initiate maintenance and repair tasks, including hull inspections, painting, welding, and equipment maintenance.

Work is being carried out in drydock on a large sea water inlet chest and the valves. Describe the inspection you would carry out;
(a) As the work starts; (8)
(b) During and after the work. (8)

Apr 23 | Feb 25 | Sep 24 | May 24

(a) As the work starts:
Sea Chests Cleaning and Painting:
• Begin by dismantling the suction grids of the sea chests in the machinery space area.
• Clean the suction grids thoroughly, removing any debris or marine growth.
• Inspect the internal surface of the sea chests and scrape them clean of all growth.
• Gauge the casing plate thicknesses to ensure they meet safety standards; renew plates as necessary.
• Renew zinc anodes within the sea chests.
• Paint the cleaned sea chests according to the ship's hull painting specifications.
Sea Suction and Discharge Valves Overhaul and Survey:
• Overhaul all sea suction and discharge valves, ensuring proper functioning.
• Check air and/or steam connections to suction boxes for any defects; address and repair as needed.
• If applicable, overhaul main intermediate valves and mud filters attached to them.

Sanitary Storm Valves Overhaul and Survey:
• Dismantle flaps of sanitary storm valves.
• Renew leather washers and replace defective hinge pins during the overhaul.
• Inspect soil pipes for excessive corrosion, cracks, and conduct necessary renewals.

(b) During and After the Work: Sea Chests Cleaning and Painting:
• Periodically inspect the progress of sea chests cleaning to ensure thoroughness.
• Monitor the gauging of casing plate thicknesses and oversee any renewals deemed necessary.
• Supervise the renewal of zinc anodes within the sea chests.
• Confirm that the painting of sea chest adheres to ship’s hull painting specification.

Sea Suction and Discharge Valves Overhaul and Survey:
• Monitor the progress of valve overhauls, ensuring all components are properly inspected and serviced.
• Verify the integrity of air and/or steam connections to suction boxes during the process.
• Ensure proper documentation of the overhaul process for future reference.
• Oversee the inspection and potential overhaul of main intermediate valves and mud filters.

Sanitary Storm Valves Overhaul and Survey:
• Inspect the progress of storm valve flap dismantling and renewal of leather washers.

• Monitor the inspection of soil pipes for corrosion and cracks, ensuring necessary renewals are carried out.
• Confirm that all components are reassembled properly and functionally tested.

Workshop Knowledge

- **Notes:**

Describe the procedure for:
(a) Rivetting two plates. (6)
(b) Removing a rivet from the plates. (4)
(c) Tools required. (4)

Apr 23

(a) Procedure for riveting two plates:

• **Align and position the plates:** Ensure that the two riveted plates are properly aligned and positioned, with the holes for the rivets properly aligned as well.
• **Insert the rivet:** Insert the rivet through the aligned holes in the plates, with the head of the rivet on one side and the tail on the other.
• **Support the rivet:** Place a supporting tool, such as a bucking bar, against the tail of the rivet to prevent it from deforming while the rivet is being formed.
• **Form the rivet**: Using a riveting tool, such as a rivet gun, apply pressure to the head of the rivet, causing it to deform and create a bulge on the tail side. This deformed portion secures the plates together.
• **Repeat the process:** Repeat the process for the remaining rivets, ensuring consistent pressure and deformation for each rivet.
• **Inspect the rivets:** After riveting, visually inspect the rivets to ensure they are properly formed and securely holding the plates together.
• **Trim excess rivet material**: If necessary, trim the excess tail of the rivet using appropriate cutting tools to achieve a clean and finished appearance.
• **Check for tightness:** Verify that the plates are tightly secured and that there is no excessive movement or play between them.
• **Conduct a functional test**: Depending on the application, perform a functional test to ensure the riveted joint can withstand the required loads or stresses.
• **Document and record:** Keep records of the riveting process, including the number of rivets used, specifications, and any other relevant information for future reference.

(b) Procedure for removing a rivet from plates:

• **Identify the rivet:** Determine the location and type of rivet to be removed.
• **Drill a pilot hole:** Use an appropriate-sized drill bit to create a pilot hole in the center of the rivet head. This hole allows access for further removal steps.
• **Drill out the rivet:** Select a larger drill bit that matches the diameter of the rivet shank and drill through the center of the rivet head until the head is completely removed.
• **Separate the plates:** Once the rivet head is removed, the plates can be separated, allowing access to the remaining rivet tail.
• **Remove the rivet tail:** Use pliers or a suitable tool to grip and pull the remaining rivet tail from the plates. Apply steady and controlled force to extract the rivet completely.
• **Inspect the plates:** After rivet removal, inspect the plates for any damage or deformation caused during the process. Repair or replace any damaged plates if necessary.

(c) Tools required:

• **Rivets:** Various sizes and types of rivets suitable for the specific application.
• **Riveting tool:** A rivet gun or rivet setter used to deform the rivet and secure the plates together.
• **Supporting tool:** A bucking bar or similar tool used to support the tail of the rivet during the riveting process.

• **Drilling tools:** Drill bits of appropriate sizes for drilling pilot holes and removing rivet heads.
• **Cutting tools**: Tools like pliers or cutters for trimming excess rivet material or removing rivet tails.
• **Inspection tools:** Visual inspection tools to check the quality and integrity of the riveted joint, such as magnifying glass or measuring tools for dimensional verification.

Write short notes on
(a) gear/ bearing pullers (4)
(b) Taps and dies (4)
(c) Surface plate (4)
(d) Vice and their usage on board (4)

Jul 22

(a) Gear/ Bearing Puller:
• Bearing pullers are tools used to remove bearings from shafts, housings, and other mechanical components.
• They come in different sizes and shapes to accommodate different bearing sizes and types.
• Bearing pullers work by applying force to the bearing, usually through the use of jaws that grip onto the bearing.
• Some bearing pullers use hydraulic power to apply force, while others use manual force or mechanical power.
• Proper use of bearing pullers is important to prevent damage to the bearing or the surrounding components.
• Bearing pullers are essential tools for maintenance and repair on ships

(b) Taps and Dies:
• Taps and dies are cutting tools used to create internal and external threads on a variety of materials such as metal, plastic, and wood.
• A tap is used to create internal threads, while a die is used to create external threads.
• Taps and dies come in different sizes and shapes to accommodate different thread sizes and pitch.
• When using a tap, it is important to use a lubricant to reduce friction and prevent the tap from breaking.
• Similarly, when using a die, it is important to use a clamp or vise to secure the workpiece and prevent it from rotating.
• Taps and dies are essential tools for creating threaded connections for various applications on ship

(c) Surface plate:
• A surface plate is a large, flat, and level platform used for measuring the flatness and straightness of surfaces.
• They are made from high-quality materials such as granite, cast iron, or steel, which are resistant to warping or deformation.
• Surface plates are typically used in manufacturing, engineering, and inspection settings, where precise measurements are required.
• They are available in different sizes and grades, with higher-grade plates having a greater degree of accuracy.
• Surface plates are essential tools for achieving accurate and precise measurements

(d) Vise

• A vice is a mechanical tool that is used to hold objects firmly in place while work is being done on them.
• On board a ship, vices are commonly used in engineering and maintenance tasks, such as metalworking, welding, and pipefitting.
• Vices are usually made of high-quality materials such as cast iron, which can withstand the rigors of heavy use.
• They come in different sizes and designs, such as bench vices, pipe vices, and hand vices.
• Proper use of a vice requires the use of appropriate personal protective equipment, such as gloves and eye protection.
• Vices are essential tools for safe and efficient work on board ships and other industrial settings.

Write short notes on the following with materials/tools used for same
(a) Riveting (4)
(b) How to remove a rivet (4)
(c) Soldering (4)
(d) De-soldering (4)

Oct 22

(a) Riveting is a method of joining two or more metal parts together using a rivet, a cylindrical metal fastener. The process involves drilling holes through the materials to be joined and inserting a rivet into the holes. The rivet is then deformed or "set" to permanently secure the parts. Common materials and tools used in riveting include:
• **Rivets:** Typically made of steel, aluminum, or copper.
• **Rivet gun or rivet setter:** A tool used to set the rivet by applying pressure to the tail end while holding the head of the rivet.
• **Rivet bucking bar or anvil:** A solid metal block used to support the tail end of the rivet during the setting process.
• **Drill:** Used to create holes in the materials to be joined.
• **Rivet gauge:** A tool used to measure the diameter and length of rivets.

(b) To remove a rivet, the following tools and materials can be used:
• **Drill:** A drill with a drill bit slightly larger than the rivet diameter is used to drill out the center of the rivet.
• **Punch or center punch:** Used to create a small indentation in the center of the rivet head to guide the drill bit.
• **Pliers or wrench:** Used to hold and rotate the rivet while drilling.

(c) Soldering is a process of joining two or more metal components using a filler metal called solder. The solder is heated and melted to create a bond between the metal parts. Common materials and tools used in soldering include:
• **Solder:** Typically a combination of tin and lead or other suitable metals, in wire or paste form.
• **Soldering iron or soldering station**: A tool used to heat the solder and transfer heat to the joint.
•**Flux:** A chemical compound applied to the metal surfaces to remove oxidation and promote solder flow.
• **Soldering stand**: Used to hold the soldering iron when not in use.
• Soldering sponge or brass wire cleaner: Used to clean the soldering iron tip.

(d) De-soldering is the process of removing solder from a joint or component. The following tools and materials are commonly used for de-soldering:

- **Soldering iron or soldering station:** The same tool used for soldering, but with a de-soldering tip or vacuum attachment.
- **De-soldering pump:** Also known as a solder sucker, it is a hand-held tool used to create suction and remove molten solder from the joint.
- **De-soldering braid or wick:** A thin copper braid that absorbs molten solder when pressed against the joint and heated.
- **Flux remover:** A cleaning agent used to remove flux residue after de-soldering.

(a) Describe required properties of cutting tools. (8)
(b) Describe materials used for making cutting tools. (8)

Apr 23

(a) The required properties of cutting tools are:

Cutting tools must maintain their hardness at elevated temperatures to resist wear and deformation during high-speed machining.

- Tools should have good toughness to withstand shock loads and prevent fractures or chipping during cutting operations.
- Cutting tools should resist wear caused by the abrasive action of workpiece materials and chips during machining.
- Tools should possess sufficient mechanical strength, especially shear strength, to withstand the forces and stresses encountered during cutting.
- Cutting tools should be easy to sharpen and work with to maintain their cutting edges and precision.
- Cost-effectiveness is essential for manufacturing processes, so the materials used for cutting tools should be economical.
- Minimizing friction between the tool and the workpiece reduces heat generation and extends tool life.

(b) Materials Used for Making Cutting Tools:

Carbon Steels: These contain 0.8 to 1.15% carbon and are primarily used for hand tools and chisels. They offer low heat and wear resistance.

High Carbon Steels: These are similar to carbon steels but have higher carbon content, providing slightly better properties. They are used in applications like hand tools.

High-Speed Steels (HSS): High-speed steels contain carbon (up to 0.8%) along with alloying elements such as tungsten, molybdenum, cobalt, chromium, and vanadium. HSS tools are suitable for drills, turning tools, taps, etc., and offer excellent wear resistance and hot hardness.

Medium Alloy Steels: These steels include alloying elements like tungsten, molybdenum, chromium, and vanadium, along with carbon (up to 1.5%). They are used for tools like taps, reamers, dies, and punches, offering improved performance. Carbides: Carbide-cutting tools consist of carbon mixed with other elements. They are made by mixing tungsten powder (typically 94%) with pure carbon (6%) under high heat. Carbides are ideal for machining very hard steels and brittle materials like cast iron and bronze.

Stellites: Stellites are non-ferrous cast alloys that contain elements like cobalt, chromium, and tungsten. They retain hardness at high temperatures and provide cutting speeds twice as high as HSS tools. They are often used for cutting rubber and plastics.

Diamonds: Diamond-cutting tools are made from the hardest cutting material available. They offer cutting speeds 50 times faster than HSS and can resist
temperatures up to 1250°C. They are used for very hard materials like abrasive wheels, glass, ceramics, and more.

Ceramics: Ceramic cutting tools are made from materials like aluminum oxides and are produced by sintering. They have high compressive strength, high hot hardness, and can withstand temperatures up to 1200°C. Ceramic tools offer a cutting speed 40 times faster than HSS and are used for machining cast irons, plastics, and other materials, often without the need for coolant. They require strong support during machining.

Describe safety guidelines to be followed for the usage of the following tools:
(a) General safety precautions for electric tools (6)
(b) Safety precautions with powered abrasive tools like grinding, cutting, wire buffing tools (6)
(c) Safety precautions using pneumatic powered tools (4)

Mar 23

(a) General safety precautions for electric tools:
- Always read and follow the manufacturer's instructions before using any electric tool.
- Make sure that the tool is properly grounded.
- Use the correct type of extension cord for the tool.
- Do not overload the circuit.
- Wear safety glasses and hearing protection when using electric tools.
- Keep the work area clean and free of clutter.
- Disconnect the tool from the power source when not in use and before servicing.
- Do not use the tool if it is damaged or not working properly.

(b) Safety precautions with powered abrasive tools like grinding, cutting, wire buffing tools:
- Always wear safety glasses and hearing protection when using powered abrasive tools.
- Make sure that the tool is properly grounded.
- Use the correct type of abrasive wheel for the tool.
- Do not overload the circuit.
- Keep the work area clean and free of clutter.
- Disconnect the tool from the power source when not in use and before servicing.
- Do not use the tool if it is damaged or not working properly.
- Use a dust mask when grinding or cutting metal.
- Wear gloves when handling abrasive wheels.
- Be aware of the sparks generated by grinding or cutting.
- Do not grind or cut near flammable materials.

(c) Safety precautions using pneumatic powered tools:
- **Eye and Ear Protection:** Wear safety glasses or goggles and hearing protection when using pneumatic tools to protect against flying debris and excessive noise.
- **Air Supply:** Ensure that the air supply to the tool is clean, regulated, and properly connected. Use a filter and lubricator to maintain the air quality and extend the tool's lifespan.
- **Hose Inspection**: Regularly inspect the pneumatic hose for any signs of wear, damage, or leaks. Replace damaged hoses immediately to prevent accidents.

• **Tool Maintenance:** Keep pneumatic tools clean and well-lubricated according to the manufacturer's recommendations. Follow proper maintenance procedures and ensure that the tool is in good working condition before use.
• **Secure Workpiece**: Similar to other tools, secure the workpiece properly to prevent movement or displacement during pneumatic tool operation.
• **Proper Use of Attachments**: Use the correct attachments, such as appropriate bits or tips, for the pneumatic tool you are using. Ensure they are securely attached and properly aligned.

Deck Machinery

- **Notes:**

With reference to hydraulic deck machinery:
(a) State the sources for contamination of the system (6)
(b) Describe possible effects due to contamination (6)
(c) Explain how the oil can be monitored by ships staff (4)

Aug 23 **Aug 23**

(a) Sources for Contamination of the Hydraulic System:
• **Water Ingress**: Water, if not excluded, can enter the hydraulic system and promote rusting of steel components. Sources include sea water entering through shaft seals of deck machinery and system coolers.
• **Condensation:** Open reservoir tanks exposed to the atmosphere can lead to condensation on cold surfaces, introducing water into the hydraulic system.
• **Rust Contamination:** Rust particles can detach and circulate in the hydraulic circuit, causing jamming of valves with fine operating clearances and accelerating oil deterioration.
• **Metal Wear**: Inevitable metal wear occurs, and fine filters are installed to remove wear particles, corrosion particles, and any grit or dirt that enters the system.
• **Abrasive Particles:** Fine metal wear particles, acting as abrasives, can cause additional wear on system components.
General Particulate Contamination:
Particles of various sizes can enter the system, potentially blocking small passages or jamming valves.

(b) Possible Effects of Contamination:
- Contaminants increase friction and wear, leading to a decrease in the overall efficiency and performance of hydraulic machinery.
- Particulate contaminants damage seals, valves, pumps, and other components, causing premature wear and increasing the risk of system failures.
- Contamination-related damage necessitates more frequent maintenance and component replacements, leading to higher operational costs.
- Contamination interferes with the proper functioning of hydraulic valves and actuators, potentially resulting in accidents or a loss of control over machinery.
- Contamination compromises the reliability of hydraulic systems, especially critical in emergency situations or during heavy-duty operations.

(c) Monitoring Hydraulic Oil by Ship Staff:
- Periodically take oil samples from the hydraulic system and send them to a laboratory for analysis to identify contaminants like particulates, water, and impurities.
- Regularly inspect hydraulic components, hoses, and connections for signs of leaks, corrosion, or damage. Visual inspection helps identify external sources of contamination.
- Ensure hydraulic filters are in good condition and replaced as recommended. Filters trap contaminants and prevent them from circulating through the system.
- Familiarize ship staff with cleanliness standards (such as ISO 4406) for hydraulic oil. Monitoring oil cleanliness according to these standards assesses contamination levels.
- Maintain accurate records of maintenance and oil analysis results to track the hydraulic system's condition over time and plan necessary maintenance or component replacements.

(a) Describe safety limits provided on deck cranes (6)
(b) Describe regular maintenance required on deck cranes. (5)
(c) Discuss in the Indian context, the inspection, testing and certification regime being followed for the lifting appliances on ships. (5)

Dec 23 **Oct 24** **Apr 24-2**

(a) Crane limits

Luffing:
In the movement of jib up and down, the limit switch works when limit switch prevents jib from exceeding a certain angle of inclination. This stops the motor and luffing drum.

Hoisting:
The up and down movement of the hook from the jib by means of running wire limit switch stops motor and drum before the hook block touches the base plate.

Slewing:
The rotation movement of the whole crane through 360 deg with all the machinery; the aftmost crane near to the accommodation can be rotated only 180 deg and it is provided switch.

Slack wire limit:
If the operators by mistake pay out excess wire rope during lowering, the wire gets slack. Then the slack wire limit switches activate and stop the hoisting operation by stopping the hoisting motor and drum.
This is to avoid winding of the wire irregularly in the drum while heaving and causing damage to the drum, supporting brackets, and other parts related to the hoisting. The operator's cab is designed to provide a clear view of all cargo working areas so that the crane operator can function alone.

Manual Safety Stops and Cut Outs:
Bells, flashing lights, and manual safety stop buttons are integral safety features. They should be regularly checked. Manual safety stop buttons are provided and situated at the base of each leg of the crane and also on the top platform and in the driver's cab.

(b) The maintenance required for cargo gears generally includes regular greasing and oiling and inspection of wire ropes, sheaves and other moving parts. Cleaning of gantries to prevent loose scale from falling.

The hydraulic piping units are to be checked and tested periodically for leaks. Since hydraulics are used for the rigging and unrigging of the gantry and are not required during cargo work, hydraulic repairs are done immediately only when they can be done without interrupting cargo handling or when they are causing immediate problems.

Normally they are completed during the first removal interruption to cargo to avoid any delay which could be blamed on the ship. The rams must be removed occasionally for renewal of ring and packings, which can be done at the time of the vessel's dry docking. Since each crane uses ten motors, there is a need for a great deal of high quality electrical maintenance. The driver motor in each of the four legs incorporates a set of disc brakes that also need regular inspection and maintenance.

Wires: The wires for the cranes those fitted and any spares should each have a certificate and these should be kept with the cargo gear record book. Although not a requirement, the ship should maintain a record of the wires for each crane, listing the certificate for each wire and when the wires were fitted.

Wires should be regularly inspected for any damage. Wires may be damaged during cargo operations, in particular, due to chafing against the hatch coaming. Deck crew on watch during cargo operations should notify any damage as soon as it is identified and prepare a stevedore damage report. Damaged crane wires should be assessed for replacement in accordance with the crane manufacturer's guidance or in accordance with ISO4309 Cranes Wire ropes Code of practice for examination and discard. Wires should be lubricated with the correct wire rope lubricant.

Hydraulic Oil: The majority of cranes onboard ship are of the electro-hydraulic type. It is important that the hydraulic oil is maintained in good condition. In addition to regularly checking oil levels, filter should be regularly inspected.

These often have indicators to show when they need cleaning and may have a magnet fitted, which should be inspected for any significant build-up of ferrous debris. One of the bigger causes of failures of hydraulic systems is dirty oil. Although hydraulic oil may look clean, particles in the oil that cannot be seen by eye can cause control valves to jam and will also cause wear of components. Water in the oil can cause corrosion and if the oil emulsifies this can lead to sluggish operation.

Routine oil analysis should be carried out to ensure that the oil is in satisfactory condition and ideally, this should include a particle count. It is important that the oil cooler is regularly inspected and cleaned, particularly if the cranes are being operated at high ambient air temperatures. This may need cleaning more frequently if the ship is regularly loading and discharging dusty cargo. A dirty oil cooler may result in the crane cutting out when the high-temperature limit is reached, which could lead to a performance claim if the cranes are repeatedly stopping. Hydraulic oil leaks should be attended to as soon as they have been identified. In addition to being a safety hazard, the stevedores may refuse to use the cranes.

Brakes and safety devices: The brakes on the cranes should be regularly inspected and their condition recorded. Band brakes often have indicators to show the correct brake tension but linings should be checked to ensure they are of adequate thickness and are not contaminated with oil. Disk brakes are usually checked by measuring the clearance, and this should be recorded in the maintenance records.

One of the most important parts of the cranes is the safety devices. Limit switches should be regularly checked to ensure that they are operating correctly. Ensure that covers on limit switches are properly fitted and waterproof. If limit switches and controls are not functioning correctly, this can result in damage to the crane and/or risk of injury to personnel. Deck cranes can be subject to demanding operating conditions, but the reliability of the cranes and the avoidance of costly and time-consuming breakdowns rely on the cranes being properly maintained.

(c) Lifting appliances are examined in accordance with legal frameworks, depending on the type of equipment and its purpose. Ships deck cranes, engine room cranes, and lifting equipment are examined in accordance with:

1. The Merchant Shipping Regulations
2. Flag state requirements
3. International Labour Organization (ILO) Convention 152, where it applies

For ships registered in India, the lifting gears are inspected by competent persons authorised by the Dock Safety board. Classification societies such as Lloyd's Register offer two survey and examination services for lifting appliances (excluding LSA davits):

- Certification
- Classification

Classification is used in two situations:

Mandatory where the lifting appliance is the essential feature of a classed ship. This applies for example to a heavy lift crane on a heavy lift barge, or lifting arrangements for diving operations on diving support ships.

Optional when the owner requests classification, even though the lifting appliance may not be an essential feature of a classed ship.

Documentation: Before commencing a thorough examination of a lifting appliance (excluding LSA davits), it will be necessary for the attending surveyor to see the Register of Lifting Appliances and Cargo Handling Gear (the Register book). The surveyor will need to

- Check the existing certificates for the appliances, the ropes, and the loose gear.
- Look at the survey history of the appliance.
- Check for any issues which are outstanding from the last examination
- Check if there are any recurring problems which will require particular attention in the examination
- Review rocking test/grease sampling data, where applicable.

Secondly, it will be necessary to see any maintenance and service records and check:

- What has been serviced
- Which components have been replaced
- What lubrication has been carried out.

Finally, to confirm everything is in its correct location, it will be necessary to look at general arrangement plans Reeving diagrams Block lists.

Ship Safety

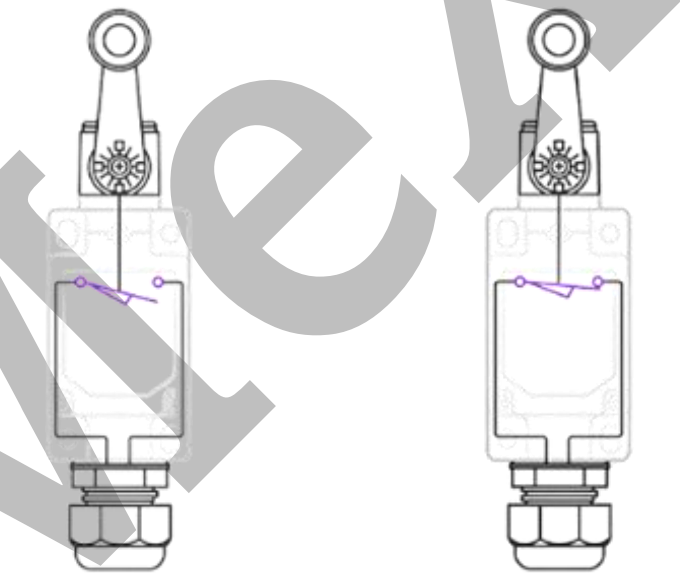
- **Notes:**

With reference to lifeboats and davits describe (a & b) with the aid of sketches:
(a) The purpose and types of "limits switches" (6)
(b) The centrifugal brake and state the method of testing (5)
(c) Enumerate routine maintenance of the lifeboat engine and the lifeboat winch. (5)

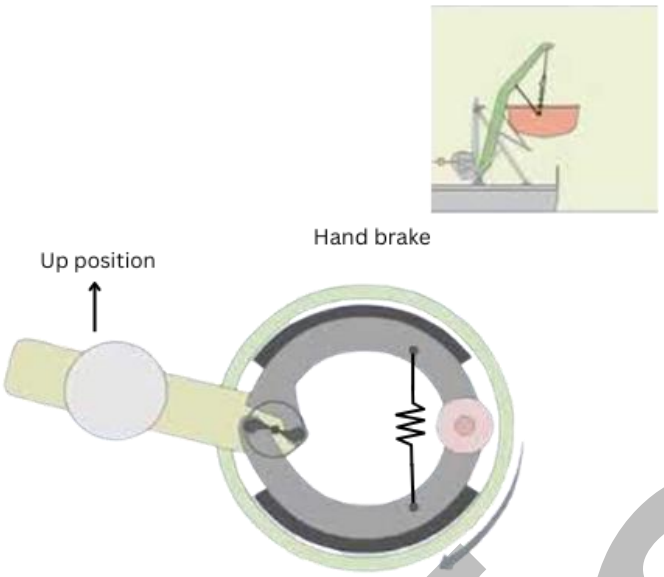
Jan 24 | Nov 24 | Jun 24 | Nov 22

(a) The limit switch serves to cut power to the davit winch motor before the davit arms reach the hard stops. The limit switch must be wired into either the control circuit or the power circuit and stop the arms a minimum of 12 inches before hard contact will occur. If the davit winch motor were to pull the arms all the way to the hard stops, catastrophic damage could occur to either the motor, the gear box, or the wire ropes.

Types of limit switches:
Open Limit Switch: This type of limit switch is designed to open the electrical circuit when the davit arms approach the specified limit or hard stop. When the switch opens, it interrupts the power supply to the davit winch motor, preventing further movement of the arms.
Close Limit Switch: Close limit switches operate in the opposite manner. They close the electrical circuit when the davit arms approach the designated limit. This closure of the circuit can trigger control actions, such as stopping the motor or signaling the operator that the limit has been reached.



(b) The centrifugal brake system consists of brake shoes that are of a calculated weight. These shoes act on the liner surface of a stationary drum. The brake shoes are normally held in place by restraining springs.
To test the centrifugal brake, you should manually lift the handle of the brake mechanism. Lifting the weighted lever releases the hand brake. When the weighted lever is lifted, the brake lining loses contact with the brake drum, allowing the drum to start rotating.
Observe the descent of the lifeboat during this test. Ensure that the lowering speed of the lifeboat does not exceed 36 meters per minute. If the descent speed remains within this limit, it indicates that the centrifugal brake is functioning properly.



(c) Routine maintenance of the lifeboat engine and the lifeboat winch:

- The engine should be tried out weekly.
- Check the quantity of fuel.
- Propulsion has to be checked on both the fwd. and astern sides.
- Mechanical linkage and electrical equipment of launching gear are checked including lubrication.
- Cleaning of the limit switch of Davit.
- According to SOLAS weekly the lifeboat will be lowered up to the embarkation ladder and all davit mechanisms will be inspected and checked.
- Winch-type hand-operated brake will go static and dynamic test.
- Lifeboat should be launched once in 3 months and go for a round in order to ensure the proper functioning of lifeboat.

Describe the procedure for the regular maintenance routines to be carried out on the various types of portable fire extinguisher on ships. (16)

Apr 23

• **Leakage Check:** Portable fire extinguishers are pressure vessels. Regularly check them for any signs of leakage, corrosion, or physical damage. Replace any extinguisher that shows signs of leakage.

• **Operating Mechanism Check:** Every three months, where possible, test the operating mechanism of the extinguisher. Ensure that the locking pin, handle, and discharge lever operate smoothly.

• **Vent Holes Clearance:** Verify that the vent holes in the extinguisher's nozzle or horn are clear. Blockages in these holes can affect the discharge pattern.

• **Cap Threads Greasing:** Apply a light coat of grease to the threads of the screw-on caps. This helps prevent them from becoming corroded and difficult to remove in an emergency.

• **Plunger Inspection:** Check the plunger for free movement. Replace any missing or damaged plungers promptly.

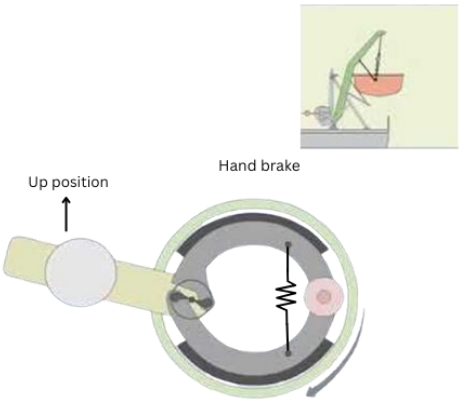
• **Types and Locations:** The number, types, and locations of portable fire extinguishers are determined by SOLAS requirements, flag state, and class regulations. Ensure compliance with these regulations.

• **Readiness:** Ship's officers must ensure that all firefighting equipment, including fire extinguishers, is always ready for use. Any defects or issues should be reported immediately to the ship's master.
• **Markings Visibility:** Verify that all markings on the extinguisher, including inspection dates, are clearly visible. Faded or illegible markings should be addressed.
• **Recharging:** If an extinguisher has been used or its pressure has dropped, recharge it according to the manufacturer's instructions. Only use recommended agents and techniques for recharging.
• **DCP Agitation:** For Dry Chemical Powder (DCP) extinguishers, invert the, extinguisher occasionally to agitate the powder inside. This prevents the powder from compacting and ensures effective discharge.
• **Hydraulic Testing**: Portable fire extinguishers with propellant cartridges should undergo hydraulic testing at intervals not exceeding 10 years. This ensures that the pressure vessels are still safe and functional.
• **Training**: Conduct regular training sessions for crew members regarding the proper use of portable fire extinguishers. Familiarize them with different types of extinguishers and their appropriate applications.
• **Documentation:** Maintain detailed records of all maintenance activities, inspections, recharges, and tests carried out on each extinguisher. Proper documentation aids in regulatory compliance and accountability.
• **Spare Extinguishers:** Always keep a few spare portable fire extinguishers on board. This ensures that there are replacements available in case of defective or discharged extinguishers.
Inspection and Certification: Engage certified inspectors for periodic inspections and certification of portable fire extinguishers. This adds credibility to the maintenance procedures and ensures compliance with regulations.

(a) Sketch and describe the construction and operation of a life boat winch handbrake and centrifugal brake. (6)
(b) What maintenance do the brakes require. (5)
(c) At what velocity does the centrifugal brake operate. (5)

Sep 22

(a) Most lifeboats are required to be fitted with mechanical disengaging gear that allows both ends of the lifeboat to be released from the falls simultaneously by one person once the boat is in the water. Davit-launched lifeboats must be capable of being launched fully loaded when the ship has up to 10 degrees of trim and a list of up to 15 degrees either way. When lowered for boat drills or maintenance, lifeboats are raised by a winch, using the falls.



(b) Maintenance required for lifeboat brakes are:

• Normal Winch Brake Test:

The brake test involves testing of centrifugal brake and hand brake. Centrifugal brake controls the rate of descent of a boat when the handbrake is not engaged. Brake shoes of calculated weight act on the liner surface of a stationary drum. The shoes are thrown out by the centrifugal effect against restraining springs. Testing is carried out by manually lifting the handle. Lifting the weighted lever releases the hand brake. Once the weighted lever is lifted, the brake lining loses contact with the brake drum and the drum starts rotating. The rotation of the drum lowers the lifeboat. Observe the descent of the boat and ensure that the lowering speed of the boat is not more than 36 meters per minute. This indicates that the centrifugal brake is intact. Once the boat starts descending, release the weighted lever. The boat stops abruptly. This indicates that the hand brake is intact.

• Dynamic Winch Brake Test:

Annual operational testing should be preferably done by lowering the empty boat. When the boat has reached its maximum lowering speed and before the boat enters the water, the brake should be abruptly applied. The five years operational test should be done by lowering the boat loaded to a proof load equal to 1.1 times the weight of the survival craft or rescue boat and its full complement of persons and equipment, or equivalent load. When the boat has reached its maximum lowering speed and before the boat enters the water, the brake should be abruptly applied. Following these tests, the brake parts and stressed structural parts should be re-inspected. In loading the boat for this test, precautions should be taken to ensure that the stability of the boat is not
adversely affected by free surface effects or the raising of the center of gravity.

(c) The centrifugal brake operates to regulate the descent speed of the lifeboat, ensuring it does not exceed **36 meters per minute.**

Explain in detail how you would isolate one section of a water sprinkler system for routine maintenance. Describe all test and inspections you would make and how you would return the system to service. (16)

Oct 23 | Jan 25-1 | Jul 24 | Feb 24 | Sep 23 | Dec 23

Isolating a Water Sprinkler System for Routine Maintenance:

Isolation:

• **Communication**: Inform the bridge about the maintenance activity, outage time, and expected completion time.

• **Main Sectional Valve:** Close the main sectional valve to isolate the specific section of the water sprinkler system.

• **Alarm Disabling:** Disable the alarm for the isolated section either locally or from the bridge. This prevents false alarms during maintenance.

• **Seawater Pump:** Disable the auto start of the seawater pump to prevent unintended water supply to the isolated section.

• **Drain Valve:** Open the drain valve for the isolated section. This allows any water in the section to be drained into the scupper.

Regular Maintenance:

• **Valve Greasing**: Regularly grease the various valves in the system and ensure their freedom of movement.
• **Pressure Gauge:** Log pressure gauge readings before and after each alarm valve. This helps in checking the tightness of the non-return valve.
• **Alarm System Check:** Test the alarm system by opening test valves to verify the functioning of audible and visual alarms.
• **Pressure Tank Check:** Check the level of the pressure tank and recharge it if necessary with fresh water and air.
• **Centrifugal Pump Test:** Test the centrifugal saltwater pump by closing the isolating valve and draining the pressure switch circuit. Check if the pump starts automatically and log the delivery pressure.
• **Sprinkler Head Inspection**: Regularly inspect each sprinkler head for leaks, corrosion of connectors, and salt deposition.
• **Bulb Verification:** Ensure the appropriate temperature-sensitive bulb is fitted to different temperature zones of the sprinkler system.
• **Individual Section Alarm:** Check alarms for individual sections to ensure proper indication of the activated section.
• **Valve Operation Check:** Inspect the isolation valve for the section to ensure proper operation and indication.

Returning to Service:
• **Refill and Pressurize:** Slowly open the section isolation valve to allow water to refill the isolated section. Initially, keep the drain valve slightly open to flush out any debris.
• **Tank Replenishment**: As the section fills, the water tank level will fall. Replenish the tank to the required level only after fully opening the stop valve.

• **Pressure Tank Re-Pressurization:** Re-pressurize the pressure tank with air up to the recommended pressure, typically around 8-8.5 Bar.
• **Seawater Pump:** Put the seawater pump back into auto mode so that it starts and stops as needed.
Alarm Reset: Reset the alarm system to normal mode, ensuring that all alarms are functional.

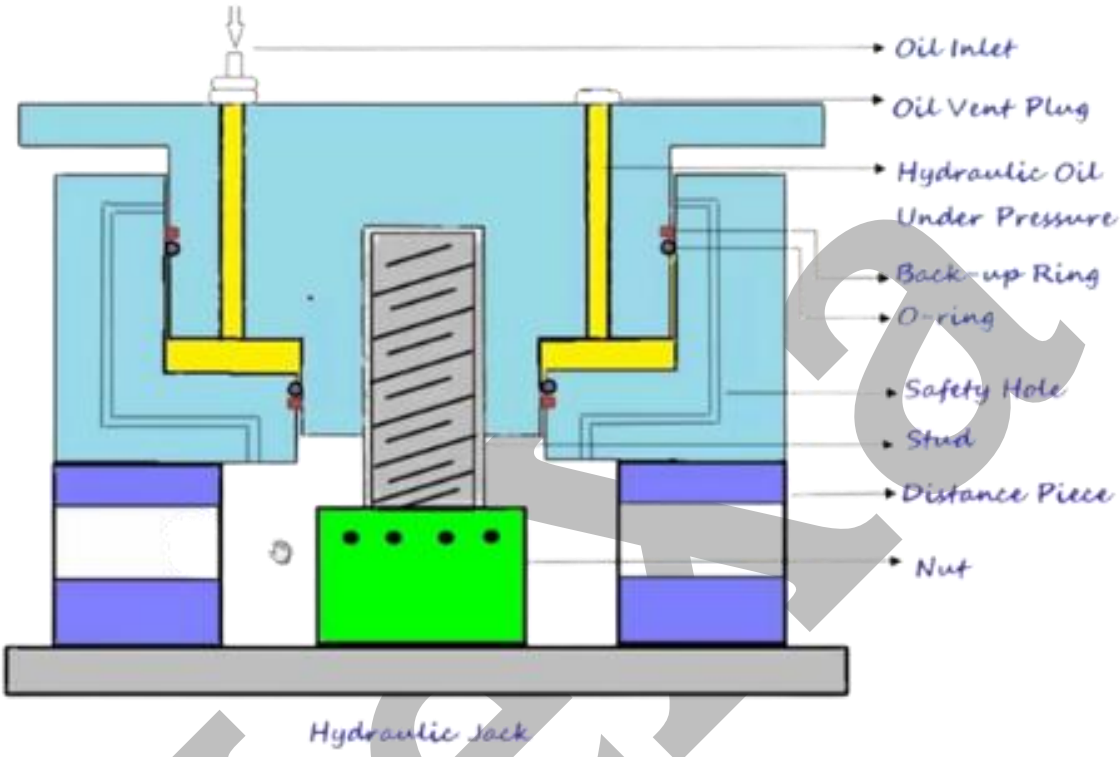
Miscellaneous

- **Notes:**

(a) Describe Hydraulic Jack for large nut tightening used onboard; Draw diagrammatic Sketch of the jack describing each part. (8)
(b) Describe procedure for tightening and unscrewing the nut with Hydraulic Jacks. (8)

Jan 23

(a) Hydraulic Jack for large nut tightening used onboard:



Hydraulic Jack

In principle, a screw can be tightened when nut is screwed in during tensioning of stud by hydraulic force and then release the hydraulic force. This hydraulic tightening method provides easier working and more reliable result than manual tightening in general. Therefore, most of the important or big screws are tightened hydraulically on ships such as cylinder head nuts, exhaust valve nuts, for crank pin bearing, cross head bearing, main bearing, tie bolts, etc. A hydraulic tightened screw always consists of a set of stud and nut which are designed properly for a hydraulic tool set. The nut has pin holes for turning through the hole of support for jack.
The hydraulic tool set consists of a hydraulic pump, hoses and a distributing piece, which are for common use regardless of screw size. Most of the hydraulic screws are tightened in pair, which need distributing piece for same tightening pressure. There are two kinds of distributing piece with different number of ports. Screws on cylinder head need four ports and the others which need two ports use the corresponding distribution piece. Each screw needs own set of hydraulic jack and support for the corresponding screw size. Depending on the working condition, extension screw should be added for the jack.

(b) Hydraulic Jack Tightening Procedure

- Check the pre-tightening of the stud and tighten by wrench, if loosened.
- Clean studs, nuts and around seats.
- Screw the nut manually until the nut contacting the seat closely.
- Check the condition of the hydraulic tool set and make them ready to use.
- Mount support (extension screw) and screw the jack by hand.
- Connect hoses from the pump to the jacks via the distributing piece.
- Close the release valve of the hydraulic pump.

• Open air venting plug of the jack and check air venting by pumping.
• Close the venting plug and pressurize up to the specified pressure for tightening the nut.
• Turn the nut to be screwed firmly by a pin manually through the hole of the support.
• Release the hydraulic pressure by opening the release valve of the hydraulic pump.
• Repeat pressurizing and check the nut loosened.
• Retighten the nut, if loosened.
• If the stud or nut has been replaced by new ones, repeat the tightening three times for the first tightening. This repeat is necessary for the settlement of the threads.

Hydraulic Jack Loosening Procedure:
• Clean seat and threads.
• Check the condition of the hydraulic tool set and make them ready to use.
• Mount support (extension screw) and jack.
• Connect hoses from the pump to the jacks via the distributing piece.
• Turn the piston of jack until contacting the nut and then unscrew the piston by about half turn. This is important to provide space for loosening the nut.
• Close the release valve of the hydraulic pump.
via the distributing piece.
• Turn the piston of jack until contacting the nut and then unscrew the piston by about half turn. This is important to provide space for loosening the nut.
• Close the release valve of the hydraulic pump.
• Open air venting plug of the jack and check air venting by pumping.
• Close the venting plug and pressurize up to the specified pressure for loosening the nut.
• Unscrew the nut by half turn manually by means of a pin through the hole of the support.
• Be sure to check that loosened nut moves freely without contacting the piston of the jack.
• Release the hydraulic pressure and dismount the tool set.

(a) Describe various types of valves used in Engine room. State reasons for their use for particular type of valves. (8)
(b) Describe Materials used for different parts of each design (8)

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(a) 1. Globe Valves: Primarily used for throttling and regulating the flow of fluid in pipelines. They feature a movable plug or disk that adjusts the flow rate. These types of valves are typically used in cooling water, fuel oil, and steam systems.

Advantages:
- Good flow control and throttling capabilities
- Suitable for high-pressure applications
- Customisable to meet the needs of specific applications

Disadvantages:
- High-pressure drop due to the flow path.
- Larger in size and weight compared to other types of valves

2. Ball Valves: Designed to quickly control the on/off function of fluid flow with a minimal drop in pressure. They use a ball with a hole through its centre that aligns with the pipeline and rotates to block when closed. Ball valves are usually used in pneumatic and hydraulic systems.

Advantages:

- Result in a minimal drop in pressure
- Fast and easy to use
- Low maintenance required
- Usable in high-pressure and high-temperature applications

Disadvantages:

- Reduced throttling capabilities
- Leaks may occur in high-temperature applications

3. Gate Valves: This type of valve utilizes a flat or wedge-shaped gate that moves in and out of the flow path and is often used to control the fluid flow in pipelines. Gate valves are often found in ballast, cargo, and fuel transfer systems.

Advantages:

- Minimal pressure drop when opened fully
- Has the capacity to handle viscous fluids and slurries
- Suitable for high-pressure and high-temperature applications

Disadvantages:

- Slow to use
- Not compatible with throttling applications
- Wear down quickly to the sliding action

4. Check Valves: Check valves allow fluid to move in one direction, preventing backflow. They use adjustable components, such as a lift, tilting disk, or swing, that fluid pushes open and automatically closes when the flow reverses. These valves are found in various ship-wide systems, including the bilge and seawater cooling systems.

Advantages:

- Operates automatically without any external control
- Prevents backflow to protect systems and equipment
- Customisable to meet the needs of specific applications

Disadvantages:

- Limited control capabilities
- Potential for water hammer or pressure surges that may damage pipelines

5. Butterfly Valves: Used for throttling, regulating, and isolating fluid flow, butterfly valves feature a circular disk that rotates around an axis, enabling flow control by changing the disk's angle. These valves play a role in seawater cooling, ballast, and ventilation systems.

Advantages:

- Feature a compact and lightweight design
- Result in a low-pressure drop when used
- Quick and easy to operate

Disadvantages:

- Reduced sealing capacity, mainly when used in high-pressure applications
- Potential for erosion or cavitation to occur in throttling applications

6. Diaphragm Valves: Designed to precisely control and regulate fluid flow, these valves often play a role in corrosive and sanitary applications. These types of valves use an adjustable diaphragm that moves up and down to control the flow rate.

Advantages:

- Excellent at sealing and flow control
- Usable for handling viscous fluids, slurries, and corrosive substances
- Low maintenance

Disadvantages:

- Limited temperature and pressure capabilities
- Not usable in high-pressure applications

7. Needle Valves: Used for precise flow control and regulation, especially in low-flow applications. They feature a long, tapered needle that can be adjusted to vary the flow rate. Needle valves are typically used in instrumentation and control systems on ships.

Advantages:

- Excellent flow regulation and control
- Usable in high-pressure applications
- Reduced risk of leaks

Disadvantages:

- Potential to clog
- Not usable in high-flow applications

8. Pressure Relief Valves: Designed to protect equipment and systems by releasing built-up pressure when the application reaches a set threshold.

Advantages:

- Automatic pressure control and protection
- Prevents damage to systems and equipment
- Customisable pressure release settings

Disadvantages:

- Limited capacity for control
- Require regular inspection and maintenance to ensure functionality

9. Control Valves: Automatically regulates fluid flow based on input from control systems or sensors. They work to control the flow rate, pressure, and temperature of the fluid. They are used in propulsion control, temperature regulation, and pressure control systems where the exact adjustments of fluid flow are vital for operating a system safely.

Advantages:

- Precise flow control and regulation
- Can be integrated into different control systems
- Adaptable to meet the needs of various systems

Disadvantages:

- Requires regular maintenance to ensure optimal performance
- Complex design

10. Safety Valves: Safety valves are also designed to protect equipment and systems from the dangers of overpressure by automatically releasing excess pressure when it reaches the set threshold. These valves are usually spring-loaded and open when the pressure forces open the valve. A common type of marine valve, safety valves are used in shipbuilding in pressurized tanks, compressed air systems, and boiler systems to prevent catastrophic equipment failure.

Advantages:

- Provide automatic protection against overpressure
- Works to prevent damage to equipment, systems, and crew
- Customisable to meet the needs of specific applications

Disadvantages:

- Requires frequent testing, maintenance, and inspection to ensure functionality
- Mainly serve a safety function and offer limited control

(b)

- **Globe Valves:** Common materials include carbon steel, stainless steel, bronze, and special alloys for corrosive applications.
- **Ball Valves:** Carbon steel, stainless steel, ductile iron, brass, and other corrosion-resistant alloys2.
- **Butterfly Valves:** Carbon steel, stainless steel, and other corrosion-resistant alloys**.**
- **Gate Valves:** Carbon steel, stainless steel, and other alloys suitable for high-pressure applications.
- **Check Valves:** Common materials include carbon steel, stainless steel, and bronze**.**
- **Diaphragm Valves:** Rubber-lined, plastic-lined, or metal-lined bodies with various elastomers for diaphragms.
- **Needle Valves**: Stainless steel, brass, or other corrosion-resistant alloys.
- **Pressure Relief Valves**: Typically stainless steel, bronze, or other alloys suitable for pressure relief applications.
- **Valve Body:** Common materials include cast iron, ductile iron, carbon steel, stainless steel, and bronze.
- Seals and Gaskets: Materials include rubber, synthetic elastomers (e.g., EPDM, Viton), PTFE (Teflon), and graphite.
- **Valve Seats**: Materials include brass, bronze, stainless steel, and elastomers.

Write short notes on the following:
(i) Low output of a fresh water generator (4)
(ii) Fuel oil purifier overflowing (4)
(iii) Alarming rise in engine room bilge level at sea (4)
(iv) Frequent shearing of pump-motor coupling pad (4)

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(a) Low fresh water production:

- Sea water pressure low because of ship's draft, choked filters, faults in the pump etc.
- The level of brine is too high
- Faulty Ejector nozzle/ nozzle choked
- Incorrect feed

• Scale formation in evaporator or condenser
• Shell temperature is too high condenser cooling water flow is reduced
• Condenser cooling water temp. too high
• Incorrect assembly of pates
• Improper vacuum due to the leakage in plants like from pressure gauge, vent, distillate pump seal etc.

(b) Purifier Overflowing
• Sealing water low
• Excessive back pressure
• Fuel temperature high or low
• Oversized gravity disc
• Orifice plate installed wrongly in the inlet side
• Excessive feed rate
• Excessive sludge deposit inside the bowl
• Sealing ring leakage (Between bowl and hood)
• Low rpm or wrong direction
• Leaking three-way valve.

(c) Alarming rise in engine room bilge level at sea
• Sea water pipe leakage, left unattended, becomes a large rupture, causing sudden outburst of sea water into the engine room.
• Bilges left unattended, alarms reposed, and continuous leakage of water from pump glands. pump glands etc.
• Overboard valves (ship side valves) are at very bad rusted condition, thus giving way, causing rupture of pipeline and sea water entry.
• Sea suction filters not being boxed up properly and opening of the valve after improper tightening, sometimes lifts away the top cover makes sea water to rush inside the engine room.

(d) Frequent shearing of pump-motor coupling pad
• If your pump demonstrates these symptoms, then it could indicate coupling failure:
• Excessive vibration and/or noise
• Increased power consumption
• Bearing failure
• Premature failure of the mechanical seals

(a) Describe the hazards while working on electrical machinery. (4)
(b) What is Lock out / Tag Out system used for safety operation on electrical machinery. (8)
(c) Describe machineries where Lock out / Tag out system will prevent accidents. (4)

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(a) Risk of Electric Shock: On ships, the risk of electric shock is elevated compared to onshore environments when operating electronic or electrical instruments. Factors like high humidity, wetness, and high temperature reduce the contact resistance of the human body, making even voltages less than 60V potentially fatal.
Working on or near energized (live) electrical equipment introduces various hazards, including electric shock, electrical burns, arc flash explosions, and the potential for fire or explosion in flammable or explosive atmospheres.

(b) LOTO (Lock-out-tag-out) is a safety procedure where the work area is marked and secured against power reconnection using locks. This prevents injuries from unexpected energizing, start-up, or the release of stored energy.
Operation procedures are configured to require at least two switches to energize high-voltage circuits. Circuit breakers and disconnects are kept in the open position during permitted work, with foolproof arrangements to avoid inadvertent closing. Lockout or tag out devices must be affixed to each energy-isolating device in a manner that holds them in a safe or off position, clearly indicating that operation or movement from the safe position is prohibited.
Before commencing work on machines or equipment that have been locked out or tagged out, verification of proper isolation and de-energization is necessary to ensure safety.
LOTO involves a tag-out system for administrative control, placing a warning tag on the means of machine or power isolation. Physical locking out of switches, controls, and isolators represents the second tier, preventing re-connection by unauthorized persons.

(c) LOTO (Lock-out-tag-out) Covers electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other energy sources.
Activities: Encompasses machine or instrument construction, installation, set up, adjustment, examination, alteration, maintenance, service, cleaning, lubrication, removing blockages, changing tools, and making adjustments.
Exposure to Hazardous Energy: During these activities, employees may be exposed to sudden energization, release of hazardous energy, or accidental starting of equipment. LOTO ensures their safety by isolating machinery from power sources and providing clear warnings.

(a) Describe with a diagram the sea water cooling system of your ship. Name each part and its function. (12)
(b) Describe defects associated with Sea water Cooling system of your ship. (4)

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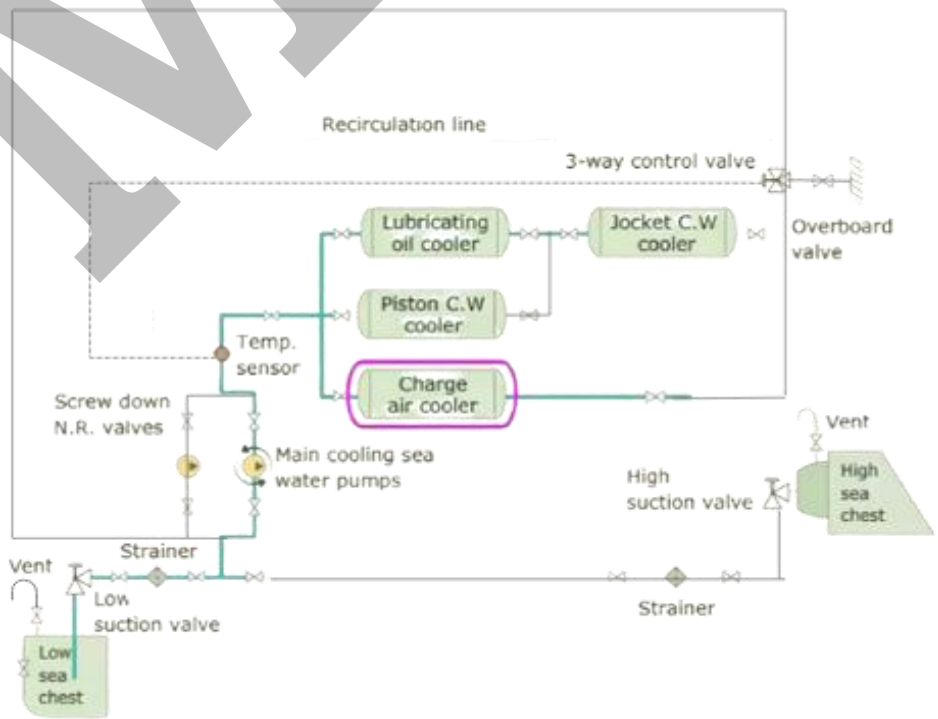
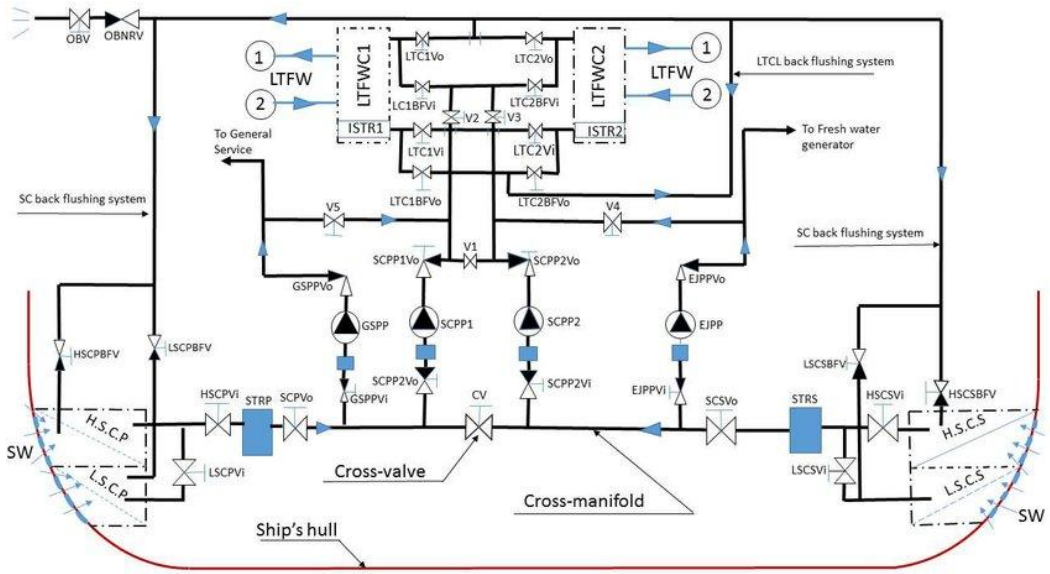
(a) a diagram the sea water cooling system of your ship. Name each part and its function





The various cooling liquids which circulate the engine are themselves cooled by seawater. The usual arrangement uses individual coolers for lubricating oil, jacket water, and the piston cooling system, each cooler being circulated by sea water. A seawater cooling system is shown in the figure above. From the sea suction, one of the pairs of seawater circulating pumps provides sea water which circulates the lubricating oil cooler, the jacket water cooler and the piston water cooler before discharging overboard. Another branch of the seawater main provides seawater to directly cool the charge air (for a direct-drive two-stroke diesel). A pneumatic 3-way valve is controlled by a temperature sensor located at the pump discharge. It controls the quantity of seawater to be recirculated based on the seawater temperature.

(b) As the marine organisms flourish, they block and narrow the passage of cooling water in the ship's system resulting in the following factors:

- Impairing the heat transfer system
- Overheating of several water-cooled machinery
- Increase in the rate of corrosion and thinning of pipes
- Reduced efficiency can lead to loss of vessel speed and loss of time.