June 2021

1. Explain the operation of the hydraulic system shown in figure. (10)

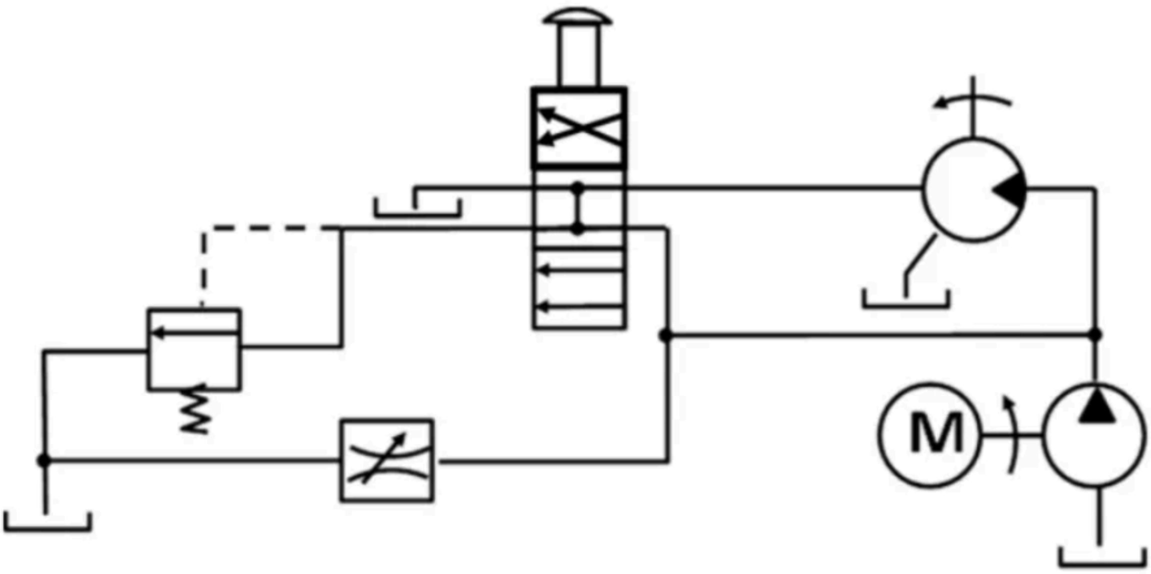

Fig Q1

June 2021

2. With reference to induction motor starters:

   (a) state when a STAR/DELTA starter may be required; (2)

   (b) describe the operation of a STAR/DELTA starter; (5)

   (c) explain why the motor configuration is changed from STAR to DELTA. (3)

June 2021

3. Explain what happens to the output voltage of an a.c. generator from sudden application of a large load to a steady state condition. (10)

June 2021

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June 2021

5. Explain, with the aid of a sketch, the procedure for *vapour* re-charging of a refrigeration plant. (10)

June 2021

6. Describe, with the aid of a sketch, a three-stage air compressor system, suitable for compressed air diving equipment. (SCUBA). (10)

June 2021

7. With reference to the Code of Safe Working Practices for Merchant Seamen and maintenance of lifting equipment:

   (a) state the interval between testing and who should carry out the testing; (2)

   (b) state the name of the document where details of the vessel's lifting gear is kept; (1)

   (c) state the meaning of SWL; (1)

   (d) state the possible reasons for needing to take a piece of lifting equipment out of service, explaining the measures to be taken before it can be returned to service. (6)

June 2021

8. Describe the safety requirements for the electrical installation in a large locker on deck, designated for the carriage of petrol, or vehicles with fuel in their tanks. (10)

June 2021

9. With reference to longitudinal stresses in a vessel's hull:

   (a) state the cause of the stress; (3)

   (b) state the areas where the stress is a maximum; (3)

   (c) describe the structure that resists the stress. (4)

June 2021

10. With reference to transverse stresses in a vessel's hull:

    (a) state the cause of the stress when the vessel is:

    (i) floating in still water; (1)

    (ii) being acted on by waves; (2)

    (iii) drydocked. (1)

    (b) state the areas where the stress is a maximum when the vessel is:

    (i) floating in still water; (1)

    (ii) drydocked; (1)

    (c) describe the structure that resists the stress. (4)

June 2021

1. Explain the operation of the hydraulic system shown in figure. (10)

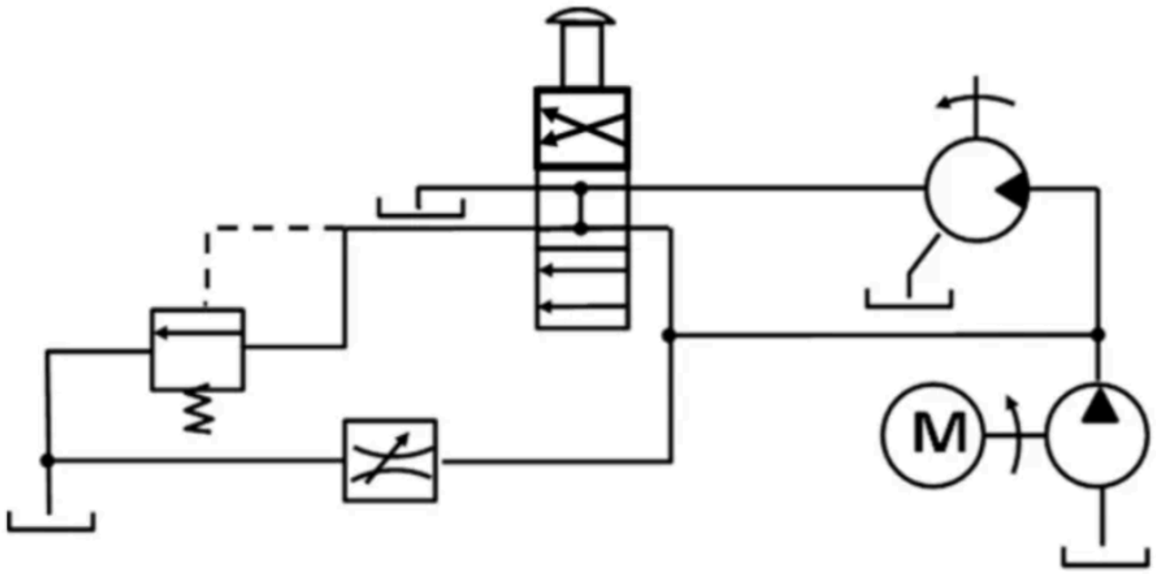
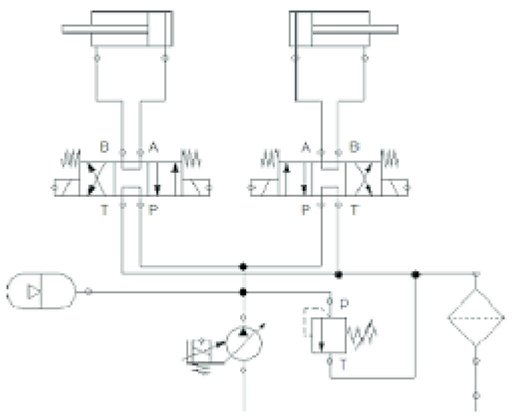


Fig Q1

It appears to be a hydraulic circuit for a single stabilizer fin on a vessel, likely part of a constant pressure system. Here's a breakdown of the components and their operation:



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Hydraulic circuit for stabiliser fin

Components:

1. **Reservoir:** Stores the hydraulic fluid and maintains its level.
2. **Pump:** Continuously pressurizes the fluid in the system (not shown in this diagram but assumed to be present).
3. **Pressure Relief Valve:** Protects the system from overpressure by bypassing excess fluid back to the reservoir (not shown in this diagram but assumed to be present in a constant pressure system).

4. **Filter:** Removes contaminants from the fluid before it reaches the control valve (not shown in this diagram but recommended for system protection).
5. **Solenoid-Operated Directional Control Valve (4/3 Position, Open Center):** This valve controls the flow and direction of pressurized fluid based on electrical signals from the stabilizer control system. It has multiple positions:
   - **Center:** Neutral position, fluid flows freely back to the reservoir from both pump outlet and actuator (open center).
   - **Port A:** Directs fluid from the pump to the "extend" port of the actuator, pushing the stabilizer fin down.
   - **Port B:** Directs fluid from the pump to the "retract" port of the actuator, pulling the stabilizer fin up.
   - **Relief:** In case of excessive pressure, the valve may have a built-in relief function to bypass fluid back to the reservoir (depending on specific valve design).
6. **Hydraulic Cylinder (Double-acting):** This actuator converts pressurized fluid into linear motion to position the stabilizer fin. It has a piston rod connected to the fin linkage.
7. **Position Sensor (not shown):** This sensor (usually linear position transducer) would be mounted on the actuator to provide feedback on the current position of the stabilizer fin to the control system.

Operation:

1. **Control System Input:** The vessel's stabilization control system analyzes sensor data (roll angle, wave motion) and sends electrical signals to the directional control valve.
2. **Valve Actuation:** Based on the electrical signal, the valve moves to the desired position (Port A, Port B, or Center).
   - **Center:** In neutral position, fluid flows freely back to the reservoir from both the pump and the actuator (assuming an open-center valve). The stabilizer fin remains in its current position due to external forces (e.g., spring centering or wave action).
   - **Port A:** When energized, the valve directs pressurized fluid from the pump (not shown) to the "extend" port of the actuator.
   - **Port B:** When energized, the valve directs pressurized fluid from the pump (not shown) to the "retract" port of the actuator.
3. **Actuator Movement:**
   - **Extending the Fin (Port A):** Pressurized fluid entering the "extend" port extends the actuator rod, pushing the stabilizer fin down (counteracting roll in one direction).
   - **Retracting the Fin (Port B):** Pressurized fluid entering the "retract" port extends the other side of the actuator rod, pulling the stabilizer fin up (counteracting roll in the other direction).
4. **Position Feedback (not shown):** In real systems, a position sensor would continuously monitor the actuator rod movement (fin position) and send feedback signals to the control system.
5. **Control Loop:** The control system adjusts the valve position based on the sensor feedback (if applicable) and other sensor data (roll angle, wave motion) to maintain the desired fin position and vessel stability.

Additional Notes:

- This diagram depicts a basic open-center directional control valve. Other valve types with different flow paths might be used in real systems.

- A well-designed system would likely incorporate a filter to remove contaminants from the fluid before it reaches the valve for better protection of components.
- The pressure relief valve, though not shown explicitly in this diagram, is a crucial safety feature in a constant pressure system to prevent overpressure situations.

I hope this explanation clarifies the operation of the hydraulic circuit for the stabilizer fin.

June 2021

2. With reference to induction motor starters:

(a) state when a STAR/DELTA starter may be required; (2)

(b) describe the operation of a STAR/DELTA starter; (5)

(c) explain why the motor configuration is changed from STAR to DELTA. (3)

Induction Motor Star-Delta Starters

Star-delta starters are a type of reduced voltage starter commonly used with three-phase induction motors. Here's a breakdown of their application, operation, and the reason for switching configurations:

(a) When is a Star-Delta Starter Required?

Star-delta starters are particularly beneficial in situations where:

- **The motor has a high starting current:** Induction motors draw a significant surge of current when starting, which can overload the power supply and cause voltage dips. A star-delta starter helps to reduce this starting current.
- **The application doesn't require high starting torque:** While star-delta starters reduce starting current, they also decrease the starting torque compared to a direct online connection. So, they are suitable for applications where the motor doesn't need to overcome a high initial load to get going.
- **Cost-effective solution:** Compared to more sophisticated soft starters, star-delta starters are a relatively inexpensive way to manage high starting currents.

(b) Operation of a Star-Delta Starter:

A star-delta starter has two main components:

1. **Contactors:** These are electromagnetic switches that connect or disconnect the motor windings from the power supply. There are typically three contactors, one for each phase, in both the star and delta configurations.
2. **Timer:** This device controls the switching sequence between star and delta connections.

Here's the typical operation sequence:

1. **Start:** When the motor is turned on, the star contactor energizes, connecting the motor windings in a star configuration.

2. **Reduced Starting Current:** The star connection reduces the voltage applied to each motor winding (by a factor of 1/√3) and consequently reduces the starting current drawn from the supply.
3. **Acceleration:** The motor accelerates with the reduced voltage. The timer is set for a predetermined time based on the motor's characteristics.
4. **Delta Connection:** After the timer elapses, the star contactor de-energizes, and the delta contactor energizes. This connects the motor windings in a delta configuration, applying the full line voltage to each winding.
5. **Running:** The motor operates at its normal speed and torque in the delta connection.

(c) Why Change from Star to Delta?

There are two main reasons for switching the motor configuration from star to delta:

- **Reduced Starting Current:** The primary objective is to limit the high inrush current during motor startup. By initially connecting the windings in a star configuration, the starting current is significantly reduced, protecting the electrical supply from overload.
- **Improved Efficiency at Running Speed:** Once the motor has accelerated and overcome the initial load, the delta connection provides the full line voltage to each winding. This allows the motor to operate at its designed efficiency and full torque capability.

In essence, a star-delta starter offers a balance between protecting the power supply during startup and allowing the motor to run efficiently at its normal operating speed.

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June 2021

3. Explain what happens to the output voltage of an a.c. generator from sudden application of a large load to a steady state condition. (10)

Impact of Sudden Load on AC Generator Output Voltage

When a large load is suddenly applied to a steady-state AC generator, the output voltage will experience a temporary dip before returning to a new steady state. Here's a breakdown of the phenomenon:

Initial State:

- The generator is running at a constant speed, driven by a prime mover (e.g., diesel engine, turbine).
- The magnetic field strength in the generator remains constant.
- The generator is supplying a steady electrical load, resulting in a stable output voltage (V) and frequency (f).

Sudden Load Increase:

- A large additional load is suddenly applied to the generator.
- This creates an increased demand for electrical current (I) from the generator.

Voltage Dip:

- According to Faraday's Law of electromagnetic induction, the generated voltage (V) in an AC generator is proportional to the rate of change of magnetic flux (Φ) linked with the windings: $V = -N * d\Phi/dt$ (where N is the number of turns in the winding).
- Initially, the magnetic field strength remains constant. However, the sudden increase in current demand requires the generator to produce more magnetic flux to maintain the same voltage.
- There's a momentary mismatch between the required and generated magnetic flux.
- Due to this lag, the rate of change of magnetic flux ($d\Phi/dt$) temporarily decreases, resulting in a **dip in the output voltage (V)**.

Generator Response:

- The governor system of the prime mover (e.g., engine governor) senses the decrease in engine speed caused by the increased load.
- The governor responds by increasing the fuel supply to the engine.
- This increases the engine's torque and speed, ultimately leading to a stronger magnetic field in the generator.
- As the magnetic field strength increases, the rate of change of magnetic flux ($d\Phi/dt$) increases, counteracting the initial dip.

New Steady State:

- With the increased engine speed and stronger magnetic field, the generator produces a higher voltage to meet the new load demand.
- The governor eventually reaches a new equilibrium point, adjusting the fuel supply to maintain the desired engine speed and the required generator output voltage.

Overall, the output voltage experiences a transient dip followed by a rise to a new steady-state value to accommodate the increased load.

Additional Notes:

- The severity of the voltage dip depends on the size of the load increase, the generator's capacity, and the governor's response time.
- Large generators with robust governor systems can minimize the voltage dip and quickly recover to a stable output.
- In critical applications, additional voltage regulation systems might be employed to further minimize voltage fluctuations.

June 2021

4. Describe the indications of, and the remedies for, an undercharge on a refrigeration system. (10)

Undercharge in a Refrigeration System: Signs, Causes, and Solutions

An undercharge situation occurs when a refrigeration system has **less refrigerant** than the manufacturer's recommended amount. This missing refrigerant can lead to several issues affecting system performance and efficiency.

Indications of Undercharge:

- **Reduced Cooling Capacity:** The most noticeable sign is a **decrease in the system's ability to cool**. The desired chilled air or water temperature may not be achieved, leading to insufficient cooling in the conditioned space or storage area.
- **Icing on the Evaporator Coil:** Due to insufficient refrigerant flow, the evaporator coil may become excessively cold and start to frost or ice over. This ice buildup restricts airflow across the coil, further reducing cooling capacity.
- **Low Suction Pressure:** With less refrigerant circulating, the pressure on the suction side of the compressor (low pressure) will be lower than normal. This can be monitored using a pressure gauge set.
- **Increased Compressor Running Time:** The compressor may run for longer periods to try and compensate for the reduced cooling capacity, leading to higher energy consumption.
- **Bubbles in the Sight Glass (if applicable):** Some systems have a sight glass, a small window in the liquid line, that allows viewing the refrigerant flow. In an undercharged system, bubbles may be visible in the sight glass, indicating a lack of sufficient liquid refrigerant.

Possible Causes of Undercharge:

- **Refrigerant Leak:** The most common cause is a leak in the refrigerant line, allowing the refrigerant to escape gradually over time. Regular leak detection and repair are crucial.
- **System Service:** If the system has undergone maintenance or repairs that involved opening the refrigerant circuit, there's a chance of improper recharging, leading to an undercharge.

Remedies for Undercharge:

1. **Leak Detection and Repair:** The first step is to identify and repair any leaks in the system. A qualified technician can perform a leak detection test to locate the leak source. Once repaired, the system can be evacuated to remove any non-condensable gases.
2. **Refrigerant Recharge:** After leak repair and system evacuation, a qualified technician can recharge the system with the correct type and amount of refrigerant, following the manufacturer's specifications. They will typically use a refrigerant charging scale and monitor pressure gauges to ensure proper charge level.
3. **System Monitoring:** Once recharged, monitor the system's performance. Observe if the cooling capacity improves, ice buildup on the evaporator coil disappears, and the suction pressure returns to normal levels.

Important Considerations:

- **Safety:** Handling refrigerants can be dangerous. Leave leak detection, system evacuation, and refrigerant charging to a qualified technician certified to handle refrigerants according to local regulations.
- **Professional Service:** For complex systems or if unsure about the process, consider seeking assistance from a qualified refrigeration technician for proper diagnosis and repair of undercharge issues.

By addressing undercharge promptly and adhering to safe practices, you can restore the efficiency and performance of your refrigeration system.

June 2021

5. Explain, with the aid of a sketch, the procedure for *vapour* re-charging of a refrigeration plant. (10)

Recharging Refrigerant in a Refrigeration Plant: A Step-by-Step Guide

Recharging refrigerant in a refrigeration plant is a critical process that requires careful attention to safety protocols and proper procedures. Here's a breakdown of the steps involved:

Preparation:

1. **Safety First: Personal protective equipment (PPE) like safety glasses, gloves, and respiratory protection (if required by the specific refrigerant) must be worn throughout the process. Ensure proper ventilation in the workspace to avoid refrigerant inhalation.**
2. **System Diagnosis: Before recharging, identify and rectify any leaks in the system. A leak detection process using electronic leak detectors or tracer gases is crucial. Repair all leaks to prevent future loss of refrigerant and ensure efficient operation.**
3. **System Evacuation: The refrigeration system needs to be evacuated thoroughly to remove any non-condensable gases (air, moisture) that may be present. Utilize a vacuum pump specifically designed for refrigerant systems. The target vacuum level will depend on the specific refrigerant used but typically reaches below 500 microns (micrometers of mercury). Monitor the vacuum gauge to ensure a good level of evacuation is achieved.**
4. **Refrigerant Recovery (Optional): If the existing refrigerant needs to be replaced or if significant amounts have leaked out, a refrigerant recovery unit should be used to capture and store the existing refrigerant. This recovered refrigerant may be reused after proper cleaning and analysis, following environmental regulations.**

Recharging Process:

1. **Refrigerant Selection: Use the specific refrigerant type designed for the refrigeration plant. Refer to the manufacturer's recommendations and ensure the refrigerant matches the system's design.**
2. **Weighing and Charging: Utilize a calibrated refrigerant charging scale to accurately measure the amount of refrigerant being added. Never charge by guesswork or rely solely on pressure gauges.**
3. **Manifold Gauge Set: Connect a manifold gauge set with hoses to the service ports on the refrigeration system. This allows monitoring of suction and discharge pressures during the charging process.**
4. **Gradual Charging: Open the service valve on the refrigerant cylinder slightly and slowly introduce the refrigerant into the system while monitoring the pressure gauges and**

weighing the refrigerant added. Refer to the manufacturer's charging chart or system specifications for the target charge amount.
5. **Superheat Monitoring: Superheat is the temperature difference between the saturated refrigerant vapor temperature at the evaporator outlet and the actual suction line temperature. Monitor the superheat value using a temperature probe placed on the suction line. The target superheat value depends on the specific system and operating conditions. Maintaining the correct superheat ensures optimal system performance and prevents liquid refrigerant from entering the compressor.**
6. **System Monitoring: Continuously monitor the system's operation during the charging process. Observe pressure gauges, temperatures, and listen for any abnormal noises. Ensure the system operates within the manufacturer's recommended pressure and temperature ranges.**

Completion and Verification:

1. **Leak Check: Once the target refrigerant charge is reached based on weight and superheat, re-check for leaks using a leak detector. Ensure there are no refrigerant leaks after the system has been charged.**
2. **System Performance Verification: Run the refrigeration system and verify its performance. Check for proper cooling capacity, adequate dehumidification (if applicable), and normal operating temperatures and pressures.**
3. **Documentation: Record the type and amount of refrigerant added, the date of service, and any observations made during the process. Maintain proper documentation for future reference and regulatory compliance.**

Important Considerations:

- **Refrigerant Regulations: Be aware of and comply with local and national regulations regarding refrigerant handling, use, and disposal. Some refrigerants may require specific licensing or certifications for handling.**
- **Environmental Responsibility: Minimize refrigerant releases into the atmosphere. Recover and reuse refrigerants whenever possible.**
- **Professional Service: For complex systems or if unsure about the process, consider seeking assistance from a qualified refrigeration technician to ensure safe and proper recharging.**

By following these steps and adhering to safety precautions, you can effectively recharge the refrigerant in your refrigeration plant.

June 2021

6. Describe, with the aid of a sketch, a three-stage air compressor system, suitable for compressed air diving equipment. (SCUBA). (10)

A three-stage air compressor system designed for SCUBA diving applications prioritizes safety, efficiency, and air purity. Here's a breakdown of its key components and functions:

1. Intake and Pre-filtration:

- **Function:** The system draws in ambient air through an intake filter. This filter removes dust, particles, and other airborne contaminants from the incoming air stream.

2. Compression Stages (Three Stages):

- **Function:** The core of the system involves three progressively smaller pistons or compression chambers that work sequentially to compress the air in stages.
  - **First Stage:** The air enters the largest piston chamber and undergoes initial compression. This stage typically uses a relatively cool-running oil-lubricated design.
  - **Second Stage:** The partially compressed air from the first stage is further compressed in the second stage. Interstage cooling (using an air-to-air or water-cooled heat exchanger) may be employed between the first and second stages to remove some heat generated during compression.
  - **Third Stage (High-Pressure Stage):** The air undergoes final compression in the smallest and most robust piston chamber. This stage reaches the highest pressure required for SCUBA diving applications (typically around 3000 psi or 20.7 MPa). High-grade oil-free lubricants or specialized piston ring designs are often used in this stage to minimize oil contamination in the compressed air.

3. Aftercooling and Moisture Separation:

- **Function:** After the final compression stage, the hot, high-pressure air is routed through an aftercooler. This heat exchanger significantly reduces the air temperature, which helps to condense and remove most of the water vapor present in the air.
- **Moisture Separator:** A separator vessel efficiently removes the condensed water from the compressed air stream. This is crucial because excess water vapor can be detrimental for several reasons (see previous answer on contaminant effects).

4. Filtration and Air Purification:

- **Function:** The compressed air then passes through a series of filters to remove any remaining contaminants, including:
  - **Oil Removal Filter:** This filter removes any residual oil vapors that may have escaped the compressor or originated from previous stages. Activated carbon or other specialized media may be used for this purpose.
  - **Carbon Monoxide (CO) Filter:** This filter selectively removes carbon monoxide, a highly toxic gas that can be present in trace amounts in compressed air and pose a significant health risk to divers.
  - **After-filter:** A final high-efficiency particulate air (HEPA) filter may be included to capture any remaining particles or contaminants.

5. Air Storage and Delivery:

- **Function:** The purified, compressed air is then stored in high-pressure SCUBA cylinders designed to safely contain the pressurized air.
- **Filling System:** A compressor filling station equipped with a pressure regulator and pressure gauge allows for safe and controlled filling of the SCUBA cylinders to the appropriate pressure for diving.

Additional Considerations:

- **Safety Features:** Three-stage compressor systems typically incorporate safety features like pressure relief valves, over-temperature shutdowns, and alarms to ensure safe operation.

- **System Monitoring:** Gauges and monitoring systems may be integrated to track air pressure, temperature, and other parameters throughout the compression process.
- **Maintenance:** Regular maintenance of the compressor system, including filter changes, oil changes (if applicable), and system inspections, is crucial to ensure optimal performance and air quality.

By utilizing a three-stage design with proper filtration and cooling, this type of air compressor system delivers the clean, high-pressure air required for safe and enjoyable SCUBA diving experiences.

June 2021

7. With reference to the Code of Safe Working Practices for Merchant Seamen and maintenance of lifting equipment:

   (a) state the interval between testing and who should carry out the testing; (2)

   (b) state the name of the document where details of the vessel's lifting gear is kept; (1)

   (c) state the meaning of SWL; (1)

   (d) state the possible reasons for needing to take a piece of lifting equipment out of service, explaining the measures to be taken before it can be returned to service. (6)

Here's the information you requested referencing the Code of Safe Working Practices for Merchant Seamen (COSWP) and lifting equipment maintenance:

(a) Testing Interval and Tester

The COSWP doesn't specify a single interval for testing all lifting equipment. However, it highlights the importance of following the manufacturer's instructions and relevant regulations. Here's a breakdown:

- **Manufacturer's Instructions:** Lifting equipment should be thoroughly examined and tested at the intervals recommended by the manufacturer. These intervals can vary depending on the equipment type and usage.
- **Regulations:** Some countries or regulatory bodies may have additional mandatory testing requirements that supersede or supplement the manufacturer's recommendations. The Master of the vessel is responsible for ensuring compliance with all relevant regulations.

Who carries out the testing?

- **Competent Person:** The testing should be carried out by a **competent person**. The COSWP doesn't provide a specific definition of "competent person" in this context. However, it's generally understood to be someone with appropriate qualifications, knowledge, and experience in inspecting and testing lifting equipment. This could be a qualified surveyor, shore-based engineer, or a designated crew member with relevant training.

(b) Document for Lifting Gear Details

The COSWP doesn't specify a single document name. However, it's likely referring to the ship's **"Register of Lifting Appliances and Gear"**. This document should contain details of all lifting equipment on board, including:

- Type of equipment (e.g., crane, derrick, winch)
- Safe Working Load (SWL)
- Manufacturer's name and identification number
- Dates of examinations and tests
- Details of any repairs or modifications

(c) SWL Meaning

SWL stands for **Safe Working Load**. This is the maximum rated load that a piece of lifting equipment can safely handle under specified conditions. It's crucial to never exceed the SWL of any equipment.

(d) Reasons for Taking Equipment Out of Service and Returning It

There are several reasons why a piece of lifting equipment might need to be taken out of service:

- **Damage:** Visible signs of wear, tear, cracks, corrosion, or other damage that could compromise the equipment's safety.
- **Failure During Testing:** If the equipment fails to meet the required standards during a periodic inspection or test.
- **Overload:** If the equipment has been subjected to a load exceeding its SWL.
- **Suspicious Activity:** Any unexplained malfunction or unusual behavior during operation.

Measures Before Returning Equipment to Service:

Before returning equipment to service, the following steps should be taken:

- **Identify the Cause:** Investigate and identify the root cause of the problem that took the equipment out of service.
- **Repair or Replacement:** The damaged component(s) should be repaired or replaced with certified parts as needed.
- **Retesting:** The equipment should be thoroughly re-examined and tested by a competent person to ensure it meets the required safety standards before being used again.
- **Documentation:** The Register of Lifting Appliances and Gear should be updated to reflect the repairs, replacements, and retesting.

By following these guidelines and adhering to the COSWP recommendations, merchant seamen can ensure the safe operation and maintenance of lifting equipment on board vessels.

June 2021

8. Describe the safety requirements for the electrical installation in a large locker on deck, designated for the carriage of petrol, or vehicles with fuel in their tanks. (10)

Here are the safety requirements for the electrical installation in a large locker on deck, designated for the carriage of petrol or vehicles with fuel in their tanks:

General Principles:

- **Minimize Electrical Equipment:** The fundamental principle is to minimize the use of electrical equipment within the locker altogether. Petrol vapors are highly flammable, and even a small spark can ignite them, leading to a fire or explosion.
- **Explosion-proof Equipment (if necessary):** If essential electrical equipment must be present (e.g., lighting), it needs to be certified as explosion-proof for hazardous environments containing flammable liquids and vapors. Explosion-proof equipment is specifically designed to prevent sparks or hot surfaces that could ignite flammable atmospheres.

Specific Requirements:

- **Wiring:** If electrical wiring is present, it must be:
  - **Marine-grade cables:** Use only marine-grade cables designed to withstand the harsh marine environment, including moisture, salt spray, and vibration.
  - **Enclosed and protected:** All wiring should be enclosed in sealed conduits or trunking to protect it from physical damage and prevent any potential sparks from igniting vapors.
- **Lighting:** If lighting is required:
  - **Explosion-proof fixtures:** Use only explosion-proof lighting fixtures specifically certified for use in flammable atmospheres. These fixtures are sealed to prevent sparks and hot surfaces.
  - **Low voltage:** Consider low voltage lighting systems (e.g., 12V DC) to further minimize the risk of sparking.
- **Switches and controls:** Any switches or control panels for lighting or other electrical equipment should be located outside the locker in a safe, non-hazardous area.
- **Grounding:** All electrical equipment and metallic components within the locker should be properly grounded to prevent static electricity buildup, which could also be an ignition source.

Additional Considerations:

- **Inspection and Maintenance:** Regularly inspect the electrical installation for any signs of damage, corrosion, or loose connections. Ensure explosion-proof equipment certifications are valid and up-to-date.
- **Alternative Lighting:** Consider alternative lighting options outside the locker, such as deck lights or spotlights, to minimize the need for electrical lighting within the flammable storage area.
- **Ventilation:** Proper ventilation is crucial to remove any potential petrol vapors that could accumulate within the locker. Refer to regulations regarding ventilation requirements for flammable liquid storage lockers.

By following these safety requirements and minimizing the use of electrical equipment, the risk of fire or explosion in a locker designated for petrol or vehicles with fuel tanks can be significantly reduced. It's important to consult the relevant maritime authority or classification society for the most up-to-date and specific requirements for your location and the size and type of your vessel.

June 2021

9. With reference to longitudinal stresses in a vessel's hull:

(a) state the cause of the stress; (3)

(b) state the areas where the stress is a maximum; (3)

(c) describe the structure that resists the stress. (4)

Longitudinal Stresses in a Ship's Hull

(a) Cause of Longitudinal Stress:

Longitudinal stress in a ship's hull arises from forces acting along the length of the vessel that tend to bend or stretch the hull. These forces can be caused by a variety of factors:

- **Vertical Bending:** The primary cause is the **distribution of weight and buoyancy** along the ship's length. The weight of the vessel and its cargo acts downwards, while the hydrostatic pressure of the water exerts an upward buoyancy force. If these forces are not evenly distributed, they can create a bending moment that stresses the hull longitudinally.
- **Hogging and Sagging:** Depending on the distribution of weight and wave action, two main scenarios can occur:
  - **Hogging:** When the vessel is supported on either end by wave crests, with the center unsupported in a wave trough, the hull tends to bend upwards in the center, creating a hogging condition.
  - **Sagging:** Conversely, when the vessel is supported in the center by a wave crest and the ends are in wave troughs, the hull tends to bend downwards in the center, creating a sagging condition.

(b) Areas of Maximum Stress:

The areas where longitudinal stress is a maximum depend on the specific loading condition (hogging or sagging):

- **Hogging:** During hogging, the maximum stress typically occurs at the **amidships** section (middle of the vessel's length) on the **deck** due to the combined effects of weight concentration and upward bending moment.
- **Sagging:** During sagging, the maximum stress typically occurs at the **amidships** section on the **bottom** plating as the hull tends to sag downwards under the weight and the wave action creates a downward bending moment.

(c) Structures Resisting the Stress:

The primary structures that resist longitudinal stresses in a ship's hull are:

- **Double Bottom (if present):** This acts like a horizontal girder, adding vertical and longitudinal strength to the hull. It helps distribute loads more evenly and resists the bending moment.
- **Longitudinal Stiffeners:** These are vertical or horizontal beams running along the length or height of the hull. They act like internal girders, stiffening the hull and resisting bending forces. They are particularly crucial in areas where longitudinal stresses are concentrated.

- **Deck Girders:** These are horizontal beams running across the width of the vessel within the deck structure. They help distribute loads across the deck and contribute to resisting longitudinal bending moments, especially during hogging conditions.
- **Keel:** The keel acts as the main longitudinal stiffener at the bottom of the hull. It provides rigidity and strength against longitudinal bending forces.

Overall Design: The overall design and scantling (thickness) of the hull plates also play a significant role. Thicker plates and strategically placed reinforcements in high-stress areas can significantly improve the hull's resistance to longitudinal bending.

2021

June 2021

10. With reference to transverse stresses in a vessel's hull:

(a) state the cause of the stress when the vessel is:

(i) floating in still water; (1)

(ii) being acted on by waves; (2)

(iii) drydocked. (1)

(b) state the areas where the stress is a maximum when the vessel is:

(i) floating in still water; (1)

(ii) drydocked; (1)

(c) describe the structure that resists the stress. (4)

Transverse Stresses in a Ship's Hull: Causes, Locations, and Resistance

(a) Cause of Transverse Stress:

(i) Floating in Still Water:

- **Cause:** The primary cause of transverse stress in still water is the static pressure of the water acting perpendicular to the hull.
- **Explanation:** As the vessel displaces water, the water exerts an upward buoyant force on the hull bottom. This force is counteracted by the weight of the vessel acting downwards. However, this weight distribution isn't perfectly uniform throughout the length of the vessel. Heavier machinery or cargo may be concentrated in specific areas, creating an uneven distribution of forces and leading to slight bending of the hull in a transverse direction (sideways).

(ii) Being Acted on by Waves:

- **Cause:** Waves generate dynamic forces that act on the hull, causing significant transverse stresses.
- **Explanation:** Wave action can subject the vessel to various forces, including:

  - **Wave Buoyancy:** As the wave profile passes, the hull experiences varying buoyant forces depending on its position relative to the wave crest and trough. This creates a dynamic bending moment that stresses the hull transversely.
  - **Slamming:** In rough seas, the vessel might slam against the wave crest, inducing a sudden and concentrated force that can cause high transient transverse stresses.

(iii) Drydocked:

- **Cause:** When a vessel is drydocked and supported on blocks, the water pressure that normally counteracts its weight is removed.
- **Explanation:** The hull weight is now entirely supported by the keel blocks and bilge blocks at discrete points. This concentrated support creates a significant bending moment that stresses the hull transversely, particularly between the support points.

(b) Areas of Maximum Stress:

(i) Floating in Still Water:

- **Location:** Maximum stress typically occurs at the **amidships** section (middle of the vessel's length) due to the combined effects of weight distribution and overall beam (width) of the hull.

(ii) Drydocked:

- **Location:** Maximum stress occurs at the points where the hull rests on the **support blocks**, particularly between the keel blocks and at the bilges (areas where the hull curves inward towards the bottom).

(c) Structures Resisting the Stress:

The primary structures that resist transverse stresses in a ship's hull are:

- **Double Bottom (if present):** This is a structural strengthening element involving a second inner hull bottom. It provides additional vertical strength and helps distribute loads more evenly, reducing transverse stresses.
- **Longitudinal Stiffeners:** These are vertical or horizontal beams running along the length or height of the hull. They act like internal girders, stiffening the hull and resisting bending forces.
- **Bulkheads:** These are vertical partitions dividing the hull into watertight compartments. They add rigidity to the hull and help resist transverse stresses by acting like transverse beams.
- **Deck Girders:** These are horizontal beams running across the width of the vessel within the deck structure. They help distribute loads across the deck and contribute to resisting transverse bending moments.

Overall Design: The overall design and scantling (thickness) of the hull plates also play a crucial role in resisting transverse stresses. Thicker plates and strategically placed reinforcements in high-stress areas can significantly improve the hull's strength and resistance to deformation.