June 2020

1. Describe, with the aid of sketches, how an axial piston pump can vary the volume of liquid it displaces. (10)

June 2020

2. The operating hydraulic circuit for a luffing cylinder for a deck crane is shown in the figure. Explain the purpose and describe the operation of EACH item A, B and C. (10)

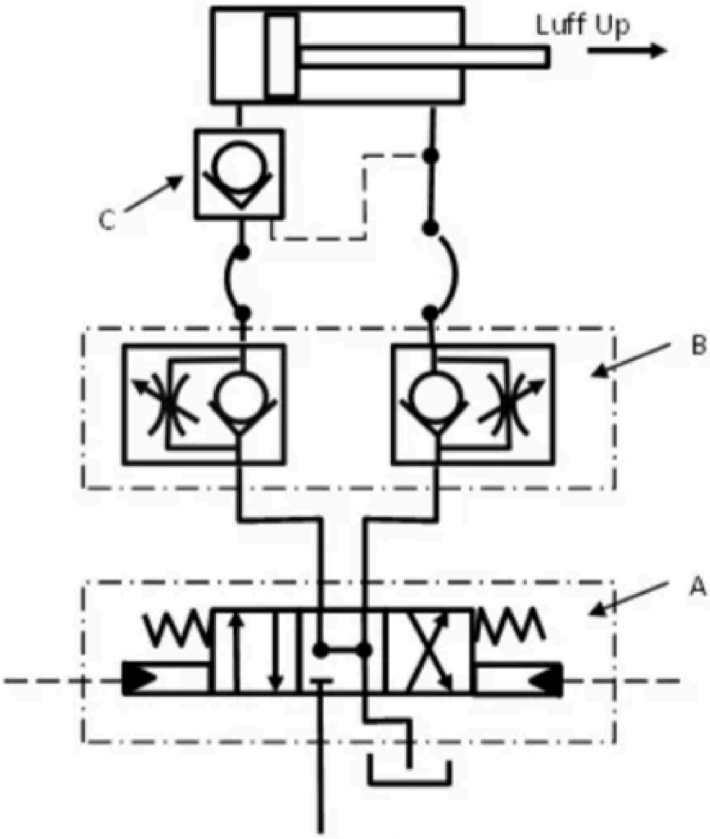

Fig Q2

June 2020

3. 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 2020

4. With reference to AVRs:

(a) explain their purpose; (4)

(b) explain the effects that would be observed should an AVR give a low output when the generator is:

(i) running on its own; (2)

(ii) running in parallel with a second generator whose AVR has no fault. (4)

June 2020

5. Describe EACH of the following vapour compression refrigeration faults, outlining a possible cause for EACH:

(a) undercharge; (3)

(b) overcharge; (3)

(c) short cycling. (4)

June 2020

6. Describe, with the aid of a sketch, the procedure for *Liquid Charging* a refrigeration plant, stating all safety procedures and checks to be carried out. (10)

June 2020

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 2020

8. State the requirements for the stowage of hand portable petrol containers, in small lockers on open deck. (10)

June 2020

9. With reference to surface preparation for the painting of a vessels hull in dry-dock, list the advantages and disadvantages of EACH of the following methods:

(a) abrasive blasting; (5)

(b) hydroblasting. (5)

June 2020

10. (a) Define the term *sheer stress*. (3)

(b) Explain how the hull of a vessel may be subject to *sheer stress* in EACH of the following:

(i) while in a seaway; (4)

(ii) while in still water. (3)

June 2020

1. Describe, with the aid of sketches, how an axial piston pump can vary the volume of liquid it displaces. (10)

Axial piston pumps achieve variable displacement through a clever mechanism involving a swash plate and pistons arranged around it. Here's a breakdown focusing on the key aspects relevant to an engineering exam:

Key Players:

- **Drive Shaft:** Rotates to provide power to the pump.
- **Cylinder Block:** Stationary housing with cylindrical bores where pistons reside.
- **Pistons:** These are axial pistons, meaning their movement is parallel to the drive shaft axis.
- **Swash Plate:** A flat disk positioned at a variable angle relative to the drive shaft axis. Pistons connect to the swash plate via a slipper or yoke, allowing them to tilt.

Varying Displacement with Swash Plate Angle:

1. **Swash Plate Angle:** The angle of the swash plate directly affects the piston stroke length.

2. **Zero Angle:** When the swash plate is perpendicular to the drive shaft (zero angle), the pistons move almost straight up and down with minimal stroke. This results in the **lowest** displacement (volume of liquid moved per rotation).
3. **Increased Angle:** Tilting the swash plate creates an angle between the piston and cylinder block axes. As the angle increases, the piston stroke length grows. This allows for a **larger volume** of fluid to be drawn in and expelled per rotation, leading to higher displacement.

Control Mechanisms (Examples):

- **Hydraulic/Mechanical/Electrical Input:** Depending on the pump design, an external control system adjusts the swash plate angle. This control system can be:
  - **Pressure compensator:** Maintains constant system pressure by adjusting the angle.
  - **Load-sensing control:** Optimizes power delivery by adjusting the angle based on external load.
  - **Joystick control:** Allows for operator control of flow rate by adjusting the angle mechanically or electronically.

Benefits of Variable Displacement:

- **Adjustable Flow Rate:** By controlling the swash plate angle, the pump can deliver a wide range of flow rates to meet the varying demands of the hydraulic system. This improves efficiency and allows for precise control over actuator performance.
- **Energy Saving:** When lower flow rates are required, the pump can adjust its displacement to avoid unnecessary energy consumption.

By understanding the relationship between swash plate angle and piston stroke length, you can grasp how axial piston pumps achieve variable displacement and cater to the dynamic flow requirements in hydraulic systems.

June 2020

2. The operating hydraulic circuit for a luffing cylinder for a deck crane is shown in the figure. Explain the purpose and describe the operation of EACH item A, B and C. (10)

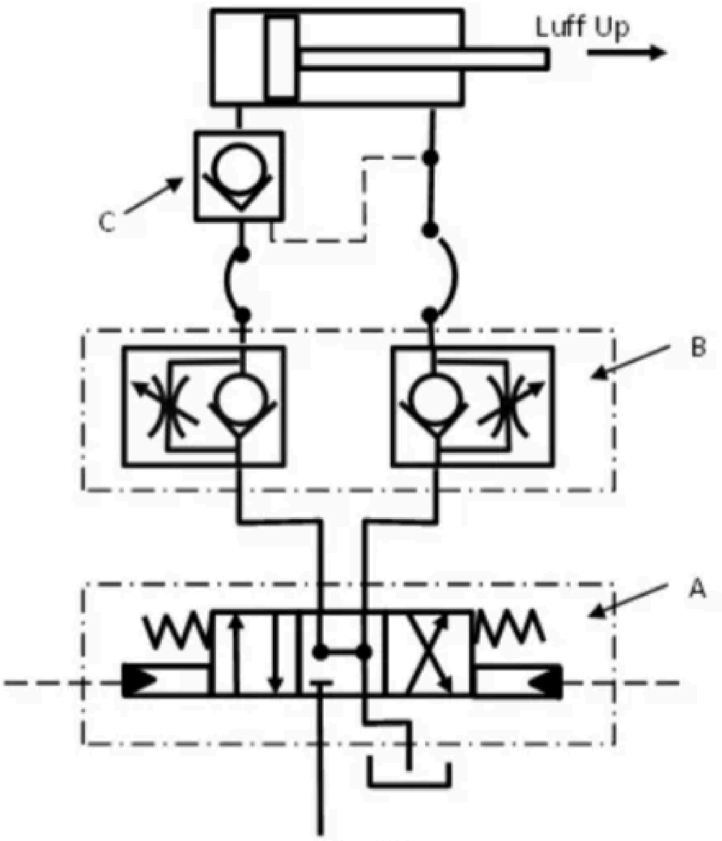

Fig Q2

Item A: Solenoid-Operated Directional Control Valve

- **Purpose:** This valve controls the flow and direction of pressurized hydraulic fluid to the luffing cylinder, ultimately raising or lowering the boom of the deck crane.
- **Operation:** The valve is likely a 4/3 position, solenoid-operated directional control valve. It has multiple spool positions that can be controlled by electrical signals from the crane operator's controls. Here's a breakdown of possible positions:
  - **Center:** Neutral position, fluid flow is blocked within the valve. The luffing cylinder holds its position (usually due to internal pressure).
  - **Port 1:** Directs pressurized fluid from the pump (not shown in the diagram) to the "extend" port of the luffing cylinder. This extends the cylinder rod, causing the boom to raise.
  - **Port 2:** Directs pressurized fluid from the pump (not shown) to the "retract" port of the luffing cylinder. This retracts the cylinder rod, causing the boom to lower.
  - **Relief:** The valve might have a built-in pressure relief function (depending on the specific design) to bypass excess fluid back to the reservoir in case of pressure surges.

Item B: Luffing Cylinder (Double-Acting)

- **Purpose:** This hydraulic actuator converts pressurized fluid into linear motion to raise or lower the crane's boom.

- **Operation:** The cylinder has a piston rod connected to the crane's boom lifting mechanism. By controlling the direction of pressurized fluid flow using the directional control valve (Item A), the cylinder rod can be extended or retracted:
  - **Boom Up (Port 1 Energized):** When Port 1 of the directional control valve is energized, pressurized fluid flows into the "extend" port of the cylinder. This extends the piston rod, pushing the boom upwards through the lifting mechanism.
  - **Boom Down (Port 2 Energized):** When Port 2 of the directional control valve is energized, pressurized fluid flows into the "retract" port of the cylinder. This retracts the piston rod, pulling the boom downwards through the lifting mechanism.

Item C: Pressure Relief Valve

- **Purpose:** This safety valve protects the hydraulic system from excessive pressure build-up.
- **Operation:** The pressure relief valve is usually set to a specific pressure threshold. If the system pressure exceeds this limit (due to pump malfunction or other factors), the valve opens and bypasses excess fluid back to the reservoir, preventing damage to components.

Overall System Operation:

The crane operator controls the boom movement (up or down) through a control panel that sends electrical signals to the solenoid-operated directional control valve (Item A). The valve then directs pressurized fluid to the appropriate port of the luffing cylinder (Item B), causing the piston rod to extend or retract. This extension or retraction translates to boom movement through the crane's lifting mechanism. The pressure relief valve (Item C) acts as a safety measure to safeguard the system in case of pressure spikes.

Note:

- This is a simplified explanation based on the limited information in the black and white diagram. Real systems might incorporate additional valves for specific functions (e.g., check valves for holding pressure) or other components depending on the crane's design and complexity.

June 2020

3. 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.e 2020**e 2020**e 2020

June 2020

4. With reference to AVRs:

(a) explain their purpose; (4)

(b) explain the effects that would be observed should an AVR give a low output when the generator is:

(i) running on its own; (2)

(ii) running in parallel with a second generator whose AVR has no fault. (4)

Automatic Voltage Regulator (AVR) in Generators:

(a) Purpose:

An AVR (Automatic Voltage Regulator) is a vital component in a generator that automatically regulates the output voltage. It ensures the generator maintains a consistent voltage level within a specified range, regardless of changes in load or engine speed. Here's how it works:

- The AVR continuously monitors the generator's output voltage.
- It compares the monitored voltage to a setpoint value (desired voltage level).
- Based on the difference between the actual voltage and the setpoint, the AVR sends a control signal to the generator's voltage regulator (e.g., field current regulator).
- The voltage regulator adjusts the generator's excitation system (e.g., field current) to increase or decrease the output voltage and bring it closer to the setpoint.

This closed-loop control system ensures the generator maintains a stable and predictable voltage output, which is crucial for powering electrical equipment without damaging them due to voltage fluctuations.

(b) Effects of Low AVR Output:

A low output from an AVR can have different consequences depending on whether the generator is running alone or in parallel with another healthy generator:

(i) Generator Running Alone:

- **Reduced Output Voltage:** The generator's output voltage will drop below the desired setpoint. This can lead to:
  - **Dimming of lights:** Lights powered by the generator will become dimmer.
  - **Reduced performance of electrical equipment:** Motors and other equipment may struggle to operate efficiently or may not start at all if the voltage drops significantly.
  - **Potential damage to sensitive electronics:** Extremely low voltage could damage sensitive electronic equipment.

(ii) Generator Running in Parallel with a Healthy Generator:

- **Unequal Load Sharing:** The generator with the faulty AVR will contribute less real power (kW) to the total load because of its lower voltage output.
- **Increased Load on Healthy Generator:** The healthy generator with a functioning AVR will have to compensate for the low output of the faulty one, taking on a larger share of the total load.
- **Potential System Instability:** If the load imbalance is significant, it can lead to voltage and frequency fluctuations in the entire system, potentially causing further problems.

Additional Considerations:

- In some cases, a very low AVR output might cause the generator to completely lose voltage regulation, leading to a rapid rise or fall in voltage depending on the specific fault.
- Modern AVR systems may have built-in alarms or fault indicators to alert operators to potential issues with voltage regulation.

By understanding the purpose and potential consequences of low AVR output, operators can identify potential problems early on and take necessary actions to maintain a stable and reliable power supply. This may involve taking the faulty generator offline for repair or adjusting the load distribution between generators in a parallel system.

June 2020

5. Describe EACH of the following vapour compression refrigeration faults, outlining a possible cause for EACH:

(a) undercharge; (3)

(b) overcharge; (3)

(c) short cycling. (4)

Vapour Compression Refrigeration Faults and Causes:

(a) Undercharge (Insufficient Refrigerant):

- **Description: An undercharge situation occurs when there is less refrigerant in the refrigeration system than the manufacturer's recommended amount.**
- **Possible Cause:**
  - **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 to prevent undercharge.**

(b) Overcharge (Excessive Refrigerant):

- **Description: An overcharge situation exists when there is more refrigerant in the system than recommended.**
- **Possible Cause:**
  - **Improper Charging: Adding too much refrigerant during the charging process is a primary cause. Always use a refrigerant scale and follow the manufacturer's charging guidelines.**

(c) Short Cycling:

- **Description: Short cycling refers to a condition where the compressor starts and stops frequently, failing to complete a full refrigeration cycle. This can significantly reduce efficiency and shorten compressor life.**
- **Possible Causes:**
  - **Low Suction Pressure: As mentioned earlier, a low suction pressure can trigger the compressor to shut down prematurely. Refer to the explanation in the previous answer (b) of question 4 for possible causes of low suction pressure.**
  - **Defective Thermostat: A faulty thermostat that cycles on and off too frequently can cause short cycling. The thermostat may need to be replaced.**
  - **Defrost Timer Issue (if applicable): In systems with automatic defrost cycles, a malfunctioning defrost timer can lead to short cycling if the defrost cycle is not properly initiated or terminated.**

June 2020

6. Describe, with the aid of a sketch, the procedure for *Liquid Charging* a refrigeration plant, stating all safety procedures and checks to be carried out. (10)

Liquid Charging Procedure for a Refrigeration Plant: Safety and Steps

Liquid charging a refrigeration plant involves adding liquid refrigerant to the system to ensure proper operation and maintain desired cooling capacity. Here's a breakdown of the procedure, emphasizing safety and essential checks:

Safety Precautions:

- **Personal Protective Equipment (PPE):** Always wear appropriate PPE like safety glasses, gloves, and respiratory protection (if working with harmful refrigerants).
- **System Shutdown and Lockout:** Ensure the refrigeration system is completely turned off and lockout procedures are implemented to prevent accidental startup during charging.
- **Refrigerant Identification:** Clearly identify the type of refrigerant used in the system. Consult the system manual or equipment labels for this information.
- **Refrigerant Handling:** Handle refrigerant cylinders carefully. Secure them upright and avoid exposure to excessive heat sources.
- **Leak Detection:** Before charging, inspect the system for any leaks using a leak detector suitable for the specific refrigerant. Repair any leaks before proceeding.
- **Ventilation:** Maintain proper ventilation in the area where you're working to avoid refrigerant vapor buildup.

Charging Procedure:

1. **Preparation:**
   - **Purge Lines:** Purge the charging hoses and manifold gauges connected to the system with dry nitrogen to remove any air or moisture that could contaminate the refrigerant.

- **Evacuate System (Optional):** In some cases, depending on the system and service procedure, you may need to evacuate the system using a vacuum pump to remove any non-condensable gases that could affect performance. However, consult the manufacturer's instructions or a qualified technician for this step.

2. **Charging Process:**
   - **Connect Hoses:** Connect the charging hoses to the appropriate service ports on the refrigeration system, following the manufacturer's recommendations. Refrigerant lines typically have a liquid line and a suction line. Ensure proper connections to avoid leaks.
   - **Open Liquid Line Valve (Partially):** Crack open the valve on the charging cylinder containing the liquid refrigerant slowly. This helps to purge any residual non-condensable gases from the line.
   - **Monitor Pressures:** Observe the pressure readings on the manifold gauge set. The high-pressure gauge will indicate the pressure in the condenser side of the system, while the low-pressure gauge will show the pressure in the evaporator side.
3. **Charging and Monitoring:**
   - **Liquid Charging:** Slowly open the liquid charging valve on the refrigerant cylinder to allow liquid refrigerant to enter the system.
   - **Superheat Monitoring:** Monitor the superheat temperature at the outlet of the evaporator using a temperature probe. Superheat is the difference between the saturated refrigerant temperature at the current system pressure and the actual discharge temperature of the refrigerant vapor leaving the evaporator. It's a crucial parameter for ensuring proper refrigerant flow and avoiding evaporator flooding.
   - **Target Superheat:** Maintain the superheat within the manufacturer's recommended range (typically around 5-15°F). Adjust the charging rate based on the superheat reading.
   - **Liquid Sight Glass (Optional):** If the system has a liquid sight glass, observe the flow of refrigerant. It should be clear with some bubbles, indicating proper circulation. A cloudy sight glass or lack of bubbles might indicate overcharging or insufficient flow.
4. **Stopping the Charge:**
   - **Target Reached:** Once the desired superheat and system pressure are achieved, stop charging the refrigerant.
   - **Close Valves:** Close the valve on the refrigerant cylinder and the liquid charging valve on the system.
5. **System Verification:**
   - **System Operation:** Turn on the refrigeration system and monitor its operation. Ensure proper cooling performance and component functionality.
   - **Leak Check:** Recheck the system for any leaks after charging, especially around the connection points.

Additional Considerations:

- **Manufacturer's Instructions:** Always refer to the specific equipment manufacturer's instructions and service manuals for detailed procedures and charging recommendations for your particular refrigeration plant.
- **Experience and Training:** Liquid charging, particularly for complex systems or those using environmentally hazardous refrigerants, should ideally be performed by a qualified technician with refrigeration experience.

By following these safety precautions and steps, you can perform liquid charging on a refrigeration plant in a controlled and efficient manner. Remember, consulting a qualified professional for service and maintenance of refrigeration systems is always recommended, especially for complex systems or those using environmentally sensitive refrigerants.

2020

June 2020

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 prescribe a single testing interval for all lifting equipment. It emphasizes following two key sources for determining the testing schedule:

- **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?

The testing should be carried out by a **competent person**. The COSWP doesn't provide a specific definition, but it's generally understood to be someone with:

- **Appropriate qualifications:** Relevant certifications or training in inspecting and testing lifting equipment.
- **Knowledge:** Understanding of the specific equipment, its operation, and potential hazards.
- **Experience:** Practical experience in conducting inspections and tests.

This could be a qualified surveyor, shore-based engineer, or a designated crew member with relevant training certified by the appropriate authority.

(b) Document for Lifting Gear Details

The COSWP doesn't specify a single document name, but it likely refers 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 2020

8. State the requirements for the stowage of hand portable petrol containers, in small lockers on open deck. (10)

Here are the requirements for the stowage of hand portable petrol containers in small lockers on an open deck:

Location and Construction:

- **Lockers:** The containers should be stored in small, dedicated lockers specifically designed for flammable liquids. These lockers should be:
  - **Constructed from non-combustible materials:** This could be sheet metal, fiberglass reinforced plastic (GRP), or other approved materials that resist fire and heat.
  - **Located away from high-risk areas:** Keep the lockers away from heat sources like engines, exhausts, or electrical equipment. Open flames and welding areas should also be far from these lockers.
  - **Clearly marked:** The lockers should be clearly labeled with signage indicating "Flammable Liquids" or "Petrol" to warn of the contents.

Ventilation:

- **Natural ventilation:** The lockers must have natural ventilation openings at the top and bottom to allow for air circulation and prevent the buildup of petrol fumes. These openings should be designed to prevent sparks or flames from entering.
- **No forced ventilation:** Avoid using forced ventilation systems within the lockers, as they could ignite any petrol vapors present.

Securing Containers:

- **Means of securing:** The lockers should have a way to secure the petrol containers to prevent them from shifting or tipping over during rough seas. This could involve straps, hooks, or shelves designed to hold the containers in place.

Quantity Limitations:

- **Maximum quantity:** Regulations may limit the total amount of petrol allowed to be stored in such lockers on the open deck. This will depend on the specific regulations of your country or governing body. 50 liters or 13.2 gallons is a common maximum limit, but it's best to check the relevant regulations.

Additional Considerations:

- **Drainage:** The lockers may require a drainage system to channel away any spills or leaks. This drainage should not lead directly overboard but to a designated collection point to prevent environmental contamination.
- **Firefighting Equipment:** Consider having a portable fire extinguisher suitable for fighting petrol fires readily available near the lockers.

By following these requirements, you can ensure the safe storage of hand portable petrol containers on the open deck of a vessel, minimizing the risk of fire hazards and environmental damage. It's important to consult the relevant regulations of your country's maritime authority for the most up-to-date and specific requirements for stowing petrol on board a vessel.

June 2020

9. With reference to surface preparation for the painting of a vessels hull in dry-dock, list the advantages and disadvantages of EACH of the following methods:

(a) abrasive blasting; (5)

(b) hydroblasting. (5)

Here's a breakdown of the advantages and disadvantages of abrasive blasting and hydroblasting for surface preparation of a vessel hull in dry dock:

(a) Abrasive Blasting:

Advantages:

- **Effective cleaning:** Abrasive blasting is a highly effective method for removing paint, rust, scale, and other contaminants from the steel surface.
- **Surface profile creation:** The blasting process creates a roughened surface profile that provides good adhesion for the new paint coating.
- **Relatively fast process:** Abrasive blasting can be a quicker method compared to hydroblasting, especially for heavily coated surfaces.

Disadvantages:

- **Environmental impact:** Abrasive blasting creates a significant amount of dust that requires proper containment and disposal, raising environmental concerns.
- **Health hazards:** Abrasive blasting exposes workers to dust and potentially hazardous blasting media, requiring strict safety precautions.
- **Surface damage:** If not controlled properly, abrasive blasting can damage the underlying steel substrate, especially on thinner plates.
- **Media selection:** Choosing the wrong blasting media can be detrimental, potentially leaving embedded particles or causing excessive etching.

(b) Hydroblasting:

Advantages:

- **Environmentally friendly:** Hydroblasting uses only water, eliminating dust generation and associated environmental concerns.
- **Safer for workers:** Hydroblasting minimizes worker exposure to dust and blasting media, improving safety conditions.
- **Reduced risk of surface damage:** Hydroblasting is gentler on the steel compared to abrasive blasting, minimizing the risk of damaging the substrate.
- **Removal of soluble contaminants:** The high-pressure water can effectively remove water-soluble salts left behind by previous blasting or marine environments, which can compromise paint adhesion.

Disadvantages:

- **Slower process:** Hydroblasting can be slower than abrasive blasting, especially for removing thick coatings.
- **Limited profile creation:** Hydroblasting may not create as pronounced a surface profile as abrasive blasting, potentially requiring additional surface preparation steps for optimal paint adhesion.
- **Flash rust:** Exposure of the cleaned steel to air can lead to rapid formation of flash rust, requiring immediate priming or application of a rust converter to prevent further corrosion.
- **Wastewater management:** The high-pressure water used in hydroblasting creates a large volume of wastewater that may require treatment before discharge, depending on regulations.

Choosing the Right Method:

The selection between abrasive blasting and hydroblasting depends on several factors:

- **Severity of surface contamination:** For heavily coated or heavily rusted surfaces, abrasive blasting might be quicker and more effective for initial cleaning.
- **Environmental regulations:** In areas with stricter environmental regulations, hydroblasting may be the preferred option due to its minimal dust generation.
- **Steel substrate thickness:** For thinner plates, hydroblasting is a safer choice to avoid damaging the steel.
- **Desired surface profile:** If a very rough profile is required for specific paint systems, abrasive blasting might be necessary.
- **Project timelines and budget:** Abrasive blasting may be faster but may have higher disposal costs, while hydroblasting may be slower but potentially more environmentally friendly.

Consulting with a qualified blasting contractor and considering all these factors will help determine the most suitable surface preparation method for your specific vessel painting project in dry dock.

June 2020

10. (a) Define the term *sheer stress*. (3)

(b) Explain how the hull of a vessel may be subject to *sheer stress* in EACH of the following:

(i) while in a seaway; (4)

(ii) while in still water. (3)

Sheer Stress in a Ship's Hull

(a) Sheer Stress Definition:

Sheer stress is a tangential force acting parallel to the surface of a material that tends to cause the material to deform by sliding along internal planes. Imagine two layers of material trying to slide past each other in opposite directions.

(b) Sheer Stress in a Ship's Hull:

(i) Sheer Stress While in a Seaway:

- **Causes:** Wave action can subject a ship's hull to various forces that induce sheer stress:
  - **Wave Bending:** As waves pass, the hull experiences a dynamic bending moment. This bending can cause a shearing action within the hull structure, particularly at locations where the curvature changes rapidly (e.g., bow and stern sections).
  - **Slamming:** In rough seas, the hull might slam against the wave crest. This sudden impact can create a localized shearing force along the bottom plating, concentrated at the point of contact.
  - **Torsional Loads:** Waves can also induce twisting forces (torsion) on the hull, especially when encountering waves at an angle. This torsional loading creates a shearing action within the hull structure.

(ii) Sheer Stress While in Still Water:

- **Causes:** While less prominent than in a seaway, sheer stress can still occur in still water under certain circumstances:
  - **Uneven Cargo Distribution:** Uneven distribution of cargo weight within the vessel can create a twisting moment that translates to shearing forces within the hull structure.
  - **Maneuvering:** During maneuvers (turning or changing course), the rudder generates a lateral force that can induce a twisting moment and cause shearing stresses in the hull, particularly concentrated towards the stern.

Important Note:

While sheer stress can occur in still water, the dynamic nature of waves in a seaway significantly amplifies the potential for, and severity of, sheer stress within the ship's hull.