

## Sept 2021

1. With reference to tank quick closing valves:
  - (a) describe, with the aid of sketches, TWO methods for remote operation; (6)
  - (b) state where they would be fitted; (2)
  - (c) explain why they are fitted. (2)

## Sept 2021

2. (a) Sketch a vane type pump, labelling ALL components. (6)
- (b) Explain the operation of the pump sketched in part (a). (4)

## Sept 2021

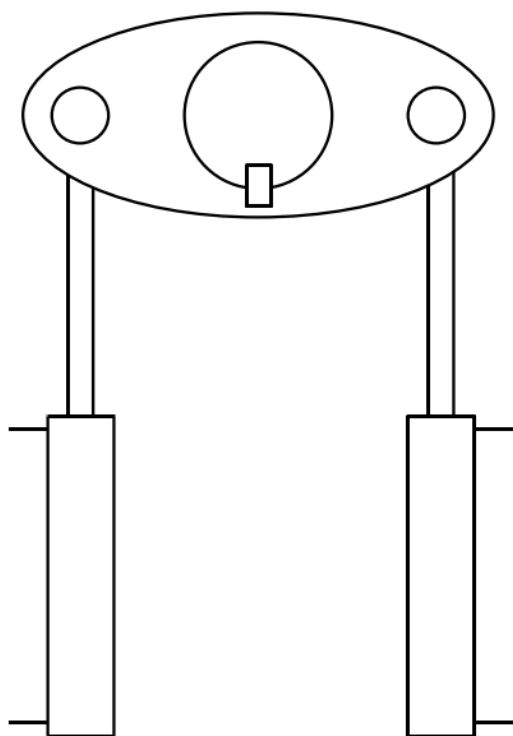
3. (a) State THREE requirements for compressed air to be utilised for control instrumentation. (3)
- (b) Using the Worksheet Q3, identify ALL the components shown for a system suitable for the production of compressed air for control instrumentation. (7)

## Sept 2021

4. With reference to hydraulic systems:
  - (a) state FOUR applications for a hydraulic system on board a vessel; (4)
  - (b) state the effects and possible causes of EACH of the following:
    - (i) air in the system; (2)
    - (ii) dirt and foreign particles in the system; (2)
    - (iii) separated water in the system. (2)

## Sept 2021

5. Using the Worksheet Q5, sketch the hydraulic system for the two ram steering gear shown. The system should be capable of ensuring that steering may be maintained should hydraulic pipe failure occur at any point. (10)



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6. With reference to controllable pitch propellers:
- describe a mechanism that changes the pitch of the blades; (7)
  - explain how the pitch of the blades is indicated. (3)

## Sept 2021

7. With reference to comparing modern water lubricated stern tube bearings with those that are oil lubricated:
- state THREE advantages; (3)
  - state THREE disadvantages, explaining how EACH may be overcome. (7)

## Sept 2021

8. With reference to main propulsion shaft hydraulic sleeve type couplings:
- (a) describe, with the aid of a sketch, the removal procedure; (7)
  - (b) state how it is determined, during reassembly, that the push fit is complete. (3)

## Sept 2021

9. With reference to electrical maintenance:
- (a) explain the procedure for proving a motor circuit is dead using a multimeter; (5)
  - (b) explain the procedure for testing the insulation resistance and earth bonding of the motor, giving examples of acceptable readings. (5)

## Sept 2021

10. (a) Sketch a block diagram of the layout of a vessel electrical distribution system, including the main and emergency generators and detailing the main consumers supplied by the emergency board. (7)
- (b) Describe the MCA recommended procedure for testing the Emergency Alternator. (3)

## Sept 2021

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### Tank Quick Closing Valves

#### (a) Remote Operation Methods:

1. **Hydraulic or Pneumatic Activation:** This method uses pressurized fluid (hydraulic) or air (pneumatic) to remotely close the valve. An activation signal triggers the release of pressurized fluid/air which pushes a piston within the valve, forcing it to shut.

2. **Wire Rope Release:** A wire rope connects the valve to a remote release mechanism. Pulling the wire lever at the remote location activates a mechanism within the valve, causing it to close rapidly.

**(b) Where they are Fitted:**

Quick closing valves are typically fitted on the outlet line of tanks containing flammable liquids like fuel oil. This includes:

- **Settling and service tanks** within engine rooms.
- Tanks in the **boiler room**.
- Tanks supplying the **emergency generator**.

**(c) Why They Are Fitted:**

These valves are crucial safety features for several reasons:

- **Emergency Shut-Off:** In case of fire or other emergencies, the valve can be shut remotely to prevent the flow of flammable liquid to the fire, potentially stopping its spread.
- **Isolation:** The valve can isolate a leaking or ruptured tank, preventing further flow of liquid and minimizing damage.
- **Remote Operation:** Since emergencies can make the tank area inaccessible, remote operation allows shutting off the flow from a safe location.

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2. (a) Sketch a vane type pump, labelling ALL components. (6)
- (b) Explain the operation of the pump sketched in part (a). (4)

## Vane Pump: Components and Operation

**(a) Components of a Vane Pump:**

A vane pump is a positive displacement pump that utilizes sliding vanes within a rotor to move fluid. Here's a breakdown of its key components:

- **Housing:** The main body of the pump, typically made of cast iron or aluminum for strength and weight considerations.
- **Rotor:** A cylindrical or elliptical shaped rotor with slots machined along its circumference. The rotor is positioned eccentrically within the housing, meaning its center is not aligned with the center of the housing.
- **Vaness:** Flat, rectangular-shaped plates inserted into the slots of the rotor. The vanes are made from a wear-resistant material like spring steel or composite materials, and they slide freely within the slots. Spring mechanisms, centrifugal force, or a combination of both can be used to keep the vanes in contact with the housing wall.

- **Cam Ring (Optional):** In some vane pump designs, a circular inner lining within the housing surrounds the rotor. This cam ring provides a smooth surface for the vanes to slide against and can improve sealing efficiency.
- **Inlet Port:** The opening on the housing wall where fluid enters the pump chamber.
- **Outlet Port:** The opening on the housing wall where pressurized fluid exits the pump.

### (b) Operation of a Vane Pump:

1. **Rotation:** The rotor is driven by a shaft or motor, causing it to rotate eccentrically within the housing.
2. **Vane Movement:** As the rotor rotates, the centrifugal force and/or spring mechanisms push the vanes outward, making them slide against the inner wall of the housing (or the cam ring, if present).
3. **Suction Creation:** The eccentric positioning of the rotor creates increasing volume spaces between adjacent vanes on the inlet side of the pump. This decrease in volume generates a low-pressure zone at the inlet port, drawing fluid into the pump chamber.
4. **Trapping Fluid:** The sliding vanes act as seals, trapping the fluid within the expanding chambers between them.
5. **Displacement and Pressure Build-Up:** Continued rotation forces the trapped fluid around the outside of the rotor and towards the outlet port. The decreasing volume between the vanes and the housing progressively increases the pressure of the trapped fluid.
6. **Discharge:** The high-pressure fluid is expelled from the pump through the outlet port.

### Key Points:

- **Positive Displacement:** The fixed volume between the vanes and the housing ensures a constant amount of fluid is delivered with each rotation, regardless of the discharge pressure.
- **Self-Priming:** Vane pumps can be self-priming to a certain extent due to their ability to evacuate air from the inlet chamber.
- **Variable Flow:** Some vane pump designs allow for adjusting the angle of the vanes, enabling flow rate control.

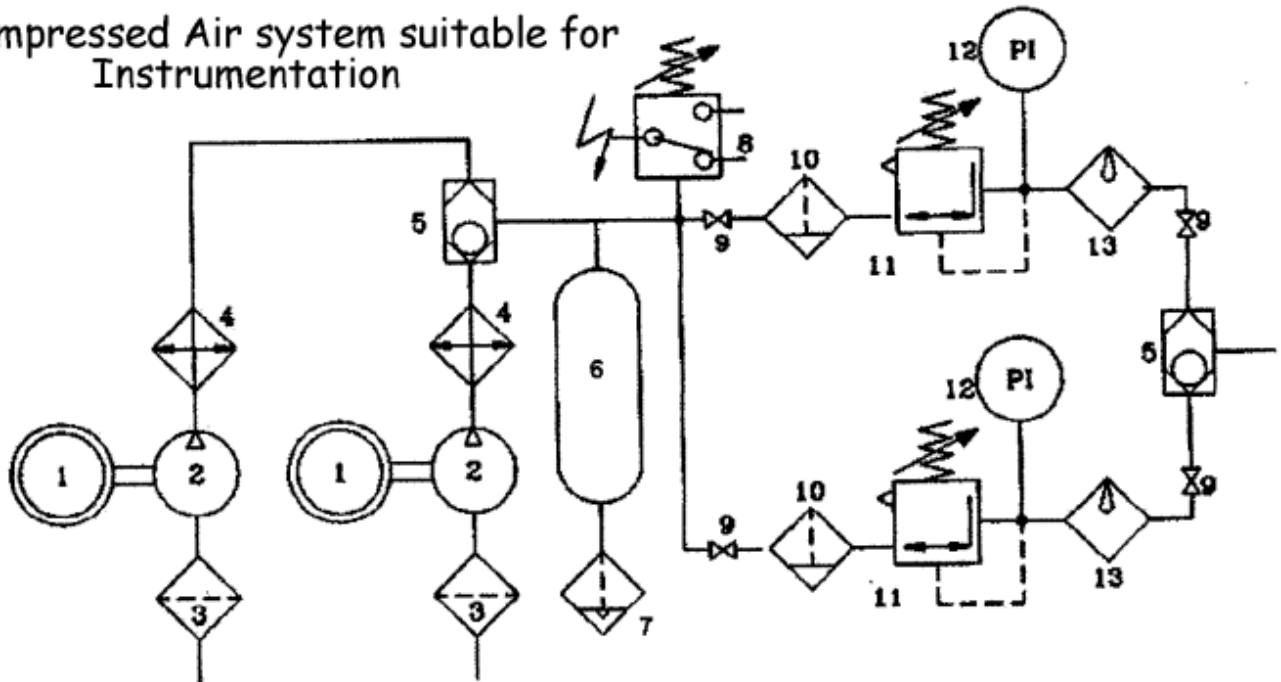
This explanation provides a general overview of vane pump components and operation. Specific designs and functionalities may vary depending on the manufacturer and application.

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3. (a) State THREE requirements for compressed air to be utilised for control instrumentation. (3)
- (b) Using the Worksheet Q3, identify ALL the components shown for a system suitable for the production of compressed air for control instrumentation. (7)

**Compressed Air system suitable for Instrumentation**



Item	Description
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**Compressed Air for Control Instrumentation**

**(a) Three Requirements for Compressed Air:**

For reliable and safe operation of control instrumentation, compressed air needs to meet the following three requirements:

1. **Cleanliness:** The air must be free from contaminants like dust, oil, and moisture. These contaminants can clog control valves, damage instrument components, and interfere with accurate signal transmission.
2. **Dryness:** Excessive moisture in the air can lead to corrosion within the piping and instrumentation. It can also form ice crystals at low temperatures, causing malfunction of control valves and instruments.
3. **Consistent Pressure:** The air pressure needs to be consistent and within the specified operating range for the control equipment. Fluctuations in pressure can lead to inaccurate readings and unreliable operation of control systems.

**(b) Identifying Components in Worksheet Q3 (Assuming the Worksheet depicts a system for control instrumentation compressed air):**

\*\*Based on the information you provided, I cannot directly access or see the contents of Worksheet Q3. However, I can give you a list of typical components found in a system for producing compressed air for control instrumentation: \*\*

- **Air Compressor:** This is the main component that compresses atmospheric air to a higher pressure.
- **Intake Filter:** Filters air entering the compressor to remove dust and other contaminants.
- **Air Intake Silencer:** Reduces noise generated by the air intake process.
- **Intercooler (Optional):** Cools the compressed air between compression stages, improving efficiency.
- **Aftercooler:** Cools the compressed air after final compression to remove moisture and reduce condensation.
- **Separator:** Separates condensed water and oil droplets from the compressed air stream.
- **Air Receiver:** A storage tank that holds the compressed air and helps maintain a constant pressure for the system.
- **Drain Valve:** Automatically removes accumulated condensate from the air receiver.
- **Pressure Regulator:** Regulates the air pressure to a specific level required for the control instrumentation.
- **Line Filter:** Provides additional filtration for the compressed air before it reaches the control equipment.
- **Lubricator (Optional):** Injects a small amount of oil mist into the air stream for lubrication of certain pneumatic components (if required by the system design).

**Note:** The actual components used in a specific system might vary depending on factors like the required air quality, flow rate, and pressure. The worksheet might also include additional components or show them in a different configuration.

Based on the revised image you sent, where you circled number 13 in red, it appears to be a **Safety Relief Valve**.

Here's why:

- **Safety Relief Valve Placement:** Safety relief valves are typically installed in compressed air systems to protect them from excessive pressure build-up. In the diagram, component number 13 is located on the pipe leading out of the air receiver (component number 6). This is a common location for a safety relief valve in such systems.



- **Function of Safety Relief Valve:** If the pressure in the system rises above a preset limit, the safety relief valve opens automatically, releasing compressed air to prevent the system from exceeding its pressure rating and potentially rupturing pipes or equipment.

While not explicitly labelled in the diagram, considering its location and function, component number 13 most likely represents a safety relief valve.

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4. With reference to hydraulic systems:

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  - (iii) separated water in the system. (2)

## Hydraulic Systems on Board a Vessel

### (a) Four Applications for Hydraulic Systems on a Vessel:

Hydraulic systems are widely used on board vessels due to their ability to transmit high power efficiently through pressurized fluids. Here are four common applications:

1. **Deck Machinery:** Hydraulic systems power various deck machinery essential for cargo handling and operations. This includes:
  - **Cargo winches and cranes:** For lifting and lowering cargo containers, anchors, and other equipment.
  - **Mooring winches:** Used for mooring and maneuvering the vessel during docking procedures.
  - **Hatch covers:** Hydraulic systems operate mechanisms for opening and closing large hatch covers on cargo holds.
2. **Steering Gear:** Modern ships often utilize hydraulic steering gear systems. These systems use high-pressure hydraulic fluid to move the rudder, providing precise control over the vessel's direction.
3. **Stabilizers:** Hydraulically powered stabilizers are deployed to reduce a ship's roll in rough seas, improving passenger comfort and stability during cargo operations.
4. **Auxiliary Systems:** Hydraulics can be used for various auxiliary functions on board, such as:
  - **Door opening mechanisms:** For watertight doors, engine room doors, etc.
  - **Lifeboat davits:** Hydraulic systems can power the davits used to launch lifeboats during emergencies.
  - **Windlass:** Used for raising and lowering the anchor chain.

### (b) Effects and Possible Causes of Contaminants in Hydraulic Systems:



**Contamination within a hydraulic system can lead to several problems and malfunctions. Here's a breakdown of three common contaminants and their effects:**

**(i) Air in the System:**

- **Effects:** Air entering the hydraulic system can cause problems like:
  - **Spongy Operation:** Air compresses more readily than hydraulic fluid, leading to a spongy or unresponsive feel in hydraulically operated equipment. This can make precise control difficult.
  - **Cavitation:** Air bubbles can collapse under pressure within the system, creating shockwaves that damage pump components and reduce overall efficiency.
  - **Increased Noise:** Air in the system can cause excessive noise during operation.
- **Possible Causes:** Air can enter the system through:
  - **Leaking connections:** Improperly sealed connections, loose fittings, or worn seals can allow air to be sucked into the system.
  - **Low fluid level:** If the hydraulic fluid reservoir is not properly filled, air can be drawn in as the pump operates.
  - **Air entrainment during refilling:** Introducing new hydraulic fluid too quickly can trap air bubbles within the system.

**(ii) Dirt and Foreign Particles in the System:**

- **Effects:** Dirt and foreign particles can cause significant damage to hydraulic components:
  - **Abrasive Wear:** Dirt particles act like sandpaper, accelerating wear on pump components, valves, and cylinders. This reduces efficiency and shortens the lifespan of components.
  - **Sticking Valves:** Contaminants can jam or stick valves, preventing proper operation of hydraulic equipment.
  - **Increased System Friction:** Dirt particles can increase friction within moving parts, leading to reduced performance and overheating.
- **Possible Causes:** Dirt and foreign particles can enter the system through:
  - **Contaminated new fluid:** Using dirty or unfiltered hydraulic fluid can introduce contaminants.
  - **Improper maintenance:** Failure to replace filters or maintain proper fluid cleanliness can allow dirt to accumulate within the system.
  - **External leaks:** Leaks in the system can allow dirt and debris from the surrounding environment to enter.

**(iii) Separated Water in the System:**

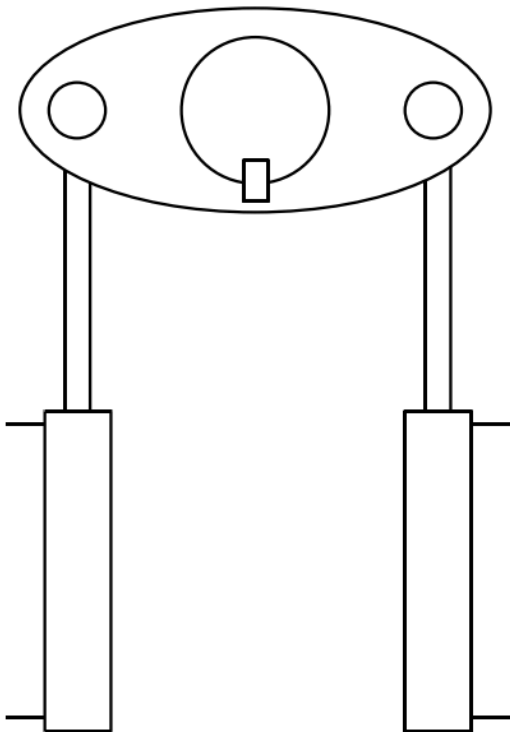
- **Effects:** Water contamination in hydraulic systems can have various detrimental effects:
  - **Corrosion:** Water can cause corrosion of metal components within the system, leading to premature wear and failure.
  - **Hydrolysis:** Water can react with the hydraulic fluid, breaking it down and reducing its lubricating properties. This increases wear and tear on components.
  - **Freezing:** In cold environments, separated water can freeze within the system, causing blockages and potentially damaging components.
- **Possible Causes:** Water can enter the system through:

- **Condensation:** Moisture in the air can condense within the system, especially in environments with significant temperature fluctuations.
- **Contaminated new fluid:** Using hydraulic fluid that already contains water can introduce contamination.
- **Coolant leaks:** In systems where the hydraulic fluid is cooled by a separate water-based system, a leak in the heat exchanger can allow water to mix with the hydraulic fluid.

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5. Using the Worksheet Q5, sketch the hydraulic system for the two ram steering gear shown. The system should be capable of ensuring that steering may be maintained should hydraulic pipe failure occur at any point.

(10)



### Two-Ram Steering Gear with Redundancy:

This system utilizes two separate hydraulic circuits, each powering one of the two rams (cylinders) that control the rudder. Key features of this design for redundancy include:

- **Dual Pumps and Reservoirs:** The system incorporates two separate hydraulic pumps and reservoirs. Each pump and reservoir supplies fluid to its respective steering ram, creating independent circuits.
- **Directional Control Valves:** Two directional control valves, one for each circuit, control the flow of hydraulic fluid to each ram. These valves are typically solenoid-operated, receiving electrical signals to direct fluid flow.
- **Isolation Valves:** Isolation valves are strategically placed in each circuit, typically located near the reservoirs or pumps. These valves can be manually closed to isolate a specific circuit in case of a failure.

- **Priority Valve (Optional):** An optional priority valve can be incorporated to prioritize one circuit over the other in case of a pressure drop in one system. This ensures that at least one steering ram remains operational.

### Operation:

During normal operation, both hydraulic circuits function simultaneously. When the directional control valves are actuated, they direct hydraulic fluid flow to either side of their respective rams, causing the rams to extend or retract, turning the rudder accordingly.

### Maintaining Steerage During Hydraulic Pipe Failure:

If a hydraulic pipe failure occurs in one circuit, the isolation valve in that circuit can be manually closed to isolate the leak. The remaining operational circuit can then continue to provide hydraulic power to its corresponding ram, allowing the rudder to be controlled with reduced steering capability.

### Benefits of Redundant System:

- **Improved Reliability:** The dual-circuit design offers a higher level of reliability compared to a single-circuit system. Even with a pipe failure, steerage can potentially be maintained.
- **Enhanced Safety:** Redundancy helps ensure better maneuverability and control of the vessel in case of a hydraulic system malfunction, reducing the risk of accidents.

### Limitations:

- **Increased Complexity:** Redundant systems involve more components, leading to increased complexity and potentially higher maintenance costs.
- **Weight and Space:** The additional pumps, reservoirs, and valves add weight and require more space for installation.

In conclusion, a two-ram steering gear with a redundant hydraulic system provides a reliable solution for steering control while offering a safety measure in case of hydraulic pipe failure.

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6. With reference to controllable pitch propellers:

- (a) describe a mechanism that changes the pitch of the blades; (7)
- (b) explain how the pitch of the blades is indicated. (3)

## Controllable Pitch Propeller Mechanisms and Indication

### (a) Mechanism for Changing Blade Pitch:

Controllable pitch propellers (CPP) allow for adjusting the angle of the propeller blades while the engine is running. Here's a breakdown of a typical mechanism for changing blade pitch:

### Components:

- **Hub:** The central part of the propeller that houses the pitch change mechanism.
- **Blades:** Hydrofoils that rotate and generate thrust. They can pivot within the hub to change their pitch angle.
- **Pitch Change Rod:** A shaft or linkage that connects the blade root to the pitch change mechanism within the hub.
- **Pitch Control Mechanism:** This mechanism is located inside the hub and can be:
  - **Hydraulic System:** The most common type. Uses pressurized hydraulic fluid to actuate pistons or cylinders that push or pull on the pitch change rods, adjusting the blade angles.
  - **Electric System:** Less common but gaining traction. Uses electric motors to drive gear mechanisms that rotate the pitch change rods.

### Operation:

1. **Command Signal:** The operator on the bridge sends a signal (electrical or mechanical) to the pitch control system. This signal indicates the desired blade pitch angle.
2. **Hydraulic or Electric Actuation:** Depending on the system type, the signal activates either a hydraulic pump or an electric motor within the pitch control mechanism.
3. **Hydraulic Fluid Flow (Hydraulic System):** In a hydraulic system, pressurized fluid is directed to specific chambers within pistons or cylinders based on the desired pitch change.
4. **Rod Movement:** The pressurized fluid pushes or pulls on pistons or cylinders, which in turn transmit the force through the pitch change rods.
5. **Blade Pitch Adjustment:** The pitch change rods are connected to the blade roots, and their movement causes the blades to pivot within the hub, adjusting their pitch angle.
6. **Electric Motor and Gear Mechanism (Electric System):** In an electric system, the activated motor drives gears that rotate the pitch change rods, achieving the desired blade pitch adjustment.

### (b) Pitch Blade Indication:

The operator needs to know the actual pitch angle of the propeller blades for optimal performance and control. Here are two common methods for indicating blade pitch:

- **Mechanical Pitch Indicator:** This is a dial gauge located near the bridge control system. It's connected to the pitch control mechanism via linkages or cables. As the blades move, the linkages rotate the gauge, displaying the actual pitch angle on the dial.
- **Electronic Pitch Indicator:** This is a more modern system that uses sensors within the hub to measure the actual blade angle. The sensor data is transmitted electronically to a display on the bridge, providing a real-time and accurate indication of the blade pitch.

### Additional Considerations:

- Safety features like blade position interlocks might be incorporated to prevent unintended blade movement during engine start-up or shutdown.
- Redundant systems (e.g., backup pumps) could be included in critical applications to ensure continued pitch control even in case of a malfunction.

By employing mechanisms like hydraulics or electrics, controllable pitch propellers offer precise control over blade pitch, enhancing vessel maneuverability, efficiency, and performance across

various operational scenarios. The use of either mechanical or electronic pitch indicators ensures the operator has accurate information about the actual blade angle for optimal control.

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7. With reference to comparing modern water lubricated stern tube bearings with those that are oil lubricated:
- (a) state THREE advantages; (3)
  - (b) state THREE disadvantages, explaining how EACH may be overcome. (7)

## Modern Water Lubricated vs. Oil Lubricated Stern Tube Bearings

Here's a comparison of modern water-lubricated stern tube bearings with oil-lubricated designs:

### (a) Advantages of Water-Lubricated Bearings:

1. **Environmental Friendliness:** Water-lubricated bearings eliminate the risk of oil spills into the environment, which can be devastating to marine ecosystems. This is becoming increasingly important with stricter environmental regulations.
2. **Lower Maintenance:** Water-lubricated bearings generally require less maintenance compared to oil-lubricated systems. Since they don't rely on oil changes and filter replacements, there's a reduction in associated costs and downtime.
3. **Simplicity:** Water-lubricated bearings often have a simpler design with fewer components compared to oil systems. This can make them lighter and potentially less expensive to manufacture.

### (b) Disadvantages of Water-Lubricated Bearings and How to Overcome Them:

1. **Lower Load Capacity:** Water, as a lubricant, has a lower lubricating capacity compared to oil. This can limit the maximum load a water-lubricated bearing can handle.
  - **Overcoming Lower Load Capacity:** Advances in bearing materials and designs are continuously improving the load capacity of water-lubricated bearings. Additionally, careful propeller design and optimization of shaft diameters can help manage loads within acceptable limits for water lubrication.
2. **Stricter Shaft Tolerance Requirements:** Water-lubricated bearings require tighter clearances between the shaft and the bearing material to maintain proper hydrodynamic lubrication with water. This necessitates more precise shaft manufacturing and maintenance tolerances.
  - **Overcoming Stricter Tolerances:** Modern manufacturing techniques allow for the production of shafts with tighter tolerances. Regular shaft inspections and wear monitoring programs can help ensure clearances remain within acceptable ranges.
3. **Potential for Corrosion:** Exposure to seawater can lead to corrosion of bearing materials.
  - **Overcoming Potential Corrosion:** Modern water-lubricated bearings often utilize special corrosion-resistant materials or coatings to minimize this risk. Additionally, proper sacrificial anode systems can be implemented to provide further protection against corrosion.

**In Conclusion:**

While water-lubricated bearings have some limitations, advancements in materials, design, and manufacturing are making them a more viable and environmentally friendly alternative to oil-lubricated systems for stern tube applications. Careful engineering considerations and maintenance practices can address potential drawbacks, making water lubrication a promising technology for the future of marine propulsion.

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8. With reference to main propulsion shaft hydraulic sleeve type couplings:
- (a) describe, with the aid of a sketch, the removal procedure; (7)
  - (b) state how it is determined, during reassembly, that the push fit is complete. (3)

## Main Propulsion Shaft Hydraulic Sleeve Type Couplings: Removal and Reassembly

### (a) Removal Procedure:

Removing a hydraulic sleeve type coupling requires careful planning and execution to ensure safety and prevent damage to the coupling components. Here's a general outline:

#### Preparation:

- **Lockout and Tagout:** Implement proper lockout/tagout procedures to isolate the shaft and prevent accidental energization of the hydraulic system.
- **Support the Shaft:** Utilize appropriate jacking screws or other support methods to prevent the shaft from dropping or misalignment during the removal process.
- **Disconnect Hydraulic Lines:** Following the manufacturer's instructions, carefully disconnect any hydraulic lines supplying pressure to the coupling. Ensure proper containment for any residual hydraulic fluid.

#### Disassembly:

1. **Pressure Release:** Slowly release the hydraulic pressure applied to the coupling using the dedicated pressure release valve. Monitor gauges to confirm pressure has been fully released.
2. **Mechanical Fasteners (if applicable):** For some designs, there might be additional mechanical fasteners (bolts, nuts) securing the coupling halves. These need to be loosened and removed following the manufacturer's specified sequence and torque values.
3. **Sleeve Movement:** Once pressure is released and any mechanical fasteners are removed, utilize the manufacturer's recommended procedures for separating the coupling halves. This might involve using dedicated puller tools or wedges specifically designed for the coupling.

#### Important Notes:



- The specific removal procedure will vary depending on the coupling design and manufacturer's instructions. Consulting the relevant manuals for detailed steps and safety precautions is crucial.
- During disassembly, handle the coupling components with care to prevent damage to the sealing surfaces or other critical parts.
- Ensure the work area is clean and free of debris to prevent contamination during disassembly and reassembly.

### **(b) Determining Push Fit Completion During Reassembly:**

Verifying a complete and secure push fit after reassembling a hydraulic sleeve coupling is essential. Here are the methods used to ensure proper engagement:

#### **1. Pressure Gauge Reading:**

- In hydraulically actuated couplings, the pressure gauge used during tightening will typically provide a direct indication of successful engagement. Reaching the designated pressure value specified by the manufacturer indicates the proper force has been achieved for a secure fit.

#### **2. Measurement and Tolerance Checks:**

- After tightening, consult the coupling manufacturer's specifications for the required final dimensions of the assembled coupling (e.g., overall length, specific gap measurements).
- Use precision measuring tools (calipers, micrometers) to verify that the achieved dimensions fall within the specified tolerance range. This confirms proper engagement and interference between the shaft and the inner sleeve.

#### **3. Factory-provided Tools (Optional):**

- Some coupling manufacturers might provide specialized tools or gauges for verifying the push fit. These tools may measure displacement during the tightening process or utilize other parameters to indicate proper engagement.

#### **4. Visual Inspection:**

- While not the sole method, a thorough visual inspection can reveal any obvious gaps or misalignments between the coupling halves after tightening.

#### **Overall:**

A combination of these methods is typically used to ensure a complete and secure push fit after reassembling a hydraulic sleeve coupling. Following manufacturer's instructions, monitoring pressure readings, and utilizing appropriate measurement tools are crucial for verifying successful

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9. With reference to electrical maintenance:

- (a) explain the procedure for proving a motor circuit is dead using a multimeter; (5)
- (b) explain the procedure for testing the insulation resistance and earth bonding of the motor, giving examples of acceptable readings. (5)

## Electrical Maintenance Procedures:

### (a) Proving a Dead Motor Circuit Using a Multimeter:

**Safety First:** Before proceeding, ensure the following safety precautions are taken:

- **Lockout/Tagout:** Implement proper lockout/tagout procedures to isolate the motor circuit from the power source and prevent accidental energization.
- **Visual Inspection:** Verify that the circuit breaker or disconnect switch for the motor circuit is in the off position.

#### Procedure:

1. **Set Multimeter to AC Voltage:** Set your multimeter to the AC voltage range that is higher than the rated voltage of the motor circuit (e.g., if the motor is 240V, set the meter to 400V AC).
2. **Test Points:** Touch the multimeter probes to appropriate test points on the motor circuit. Ideally, test between the following points:
  - **Live and Neutral:** Touch one probe to a live terminal on the motor disconnect switch and the other probe to the neutral terminal.
  - **Live and Earth:** Touch one probe to a live terminal and the other probe to a grounded point on the motor frame or enclosure (assuming the motor is properly earthed).
3. **Meter Reading:** If the circuit is dead, the multimeter should display a reading of zero volts (0V) AC.
4. **Repeat for All Phases (if applicable):** For three-phase motors, repeat the test procedure between each live terminal and neutral, and between each live terminal and earth.

**Important Note:** The specific test points might vary depending on the motor circuit configuration. Always refer to the motor and electrical installation documentation for guidance on safe and appropriate testing points.

**Never rely solely on the multimeter reading to confirm a dead circuit. Always follow proper lockout/tagout procedures.**

### (b) Testing Motor Insulation Resistance and Earth Bonding:

#### Safety Precautions:

- The motor must be completely disconnected from the power source using lockout/tagout procedures.
- Ensure the motor is clean and dry before testing.

### Testing Insulation Resistance:

1. **Instrument Selection:** Use a dedicated insulation tester (also called a Megger) with a voltage rating appropriate for the motor's voltage class (e.g., 500V for a 415V motor).
2. **Test Points:** For basic testing, perform the following measurements:
  - **Phase to Earth:** Disconnect all motor windings from each other and from the terminal box. Test the insulation resistance between each individual phase winding and the motor's earth terminal.
  - **Phase to Phase (Optional):** If further testing is desired, measure the insulation resistance between each pair of motor phases with all phases disconnected from each other and the terminal box.
3. **Test Procedure:** Follow the manufacturer's instructions for the specific insulation tester being used. This typically involves connecting the tester leads to the appropriate test points and applying a high DC voltage for a set time. The tester will display the measured insulation resistance value in Mega Ohms (M $\Omega$ ).
4. **Acceptable Readings:** There's no universally accepted standard for minimum acceptable insulation resistance values. However, a general guideline suggests readings above 1 Mega Ohm (M $\Omega$ ) are considered good. Readings below 1 M $\Omega$  might indicate potential insulation degradation and warrant further investigation or motor rewinding. The motor manufacturer's recommendations or relevant electrical codes might provide more specific values for acceptable insulation resistance based on the motor's voltage rating and application.

### Testing Earth Bonding:

1. **Multimeter Setting:** Set the multimeter to the continuity (resistance) setting.
2. **Test Points:** Touch one probe of the multimeter to the motor's earth terminal and the other probe to a known good earth point on the building structure or grounding system.
3. **Meter Reading:** A low resistance reading (ideally close to 0  $\Omega$ ) indicates a good earth bond connection between the motor and the earth. A high resistance reading or an open circuit could indicate a faulty earth bond, which requires immediate attention.

**Remember:** These are general procedures. Always refer to the motor manufacturer's recommendations, relevant electrical codes, and safety regulations for specific testing guidelines and acceptable values for your particular application.

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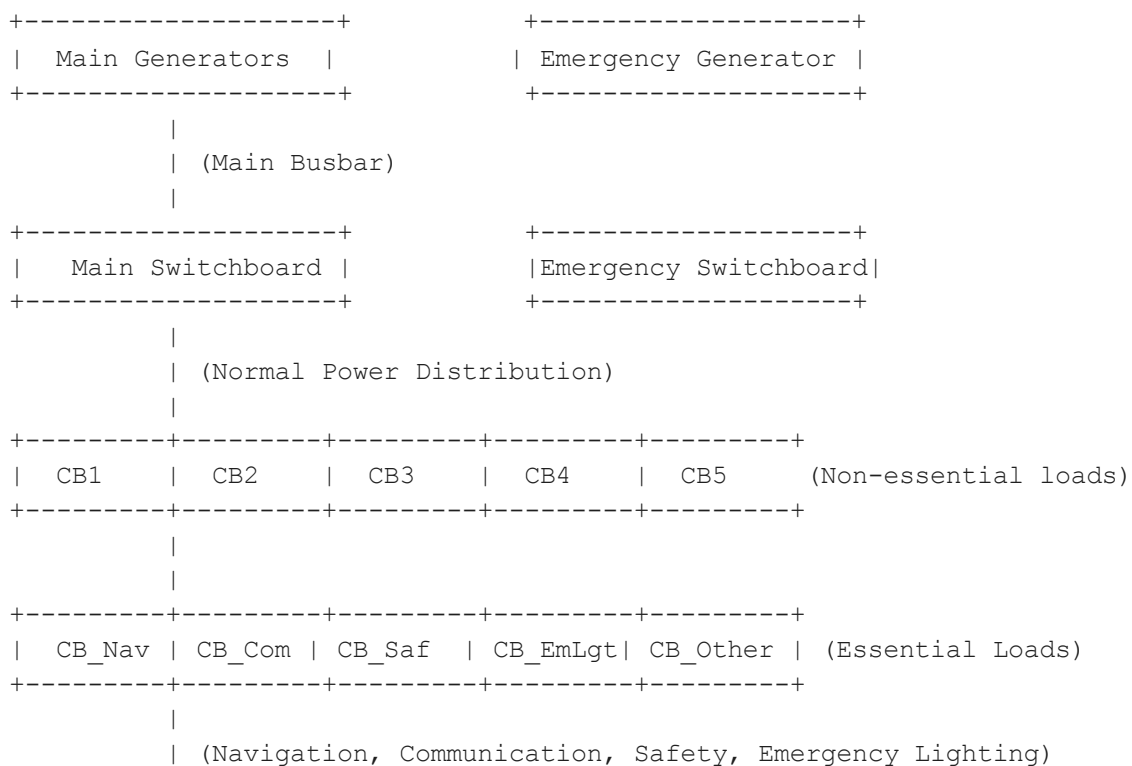
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- (b) Describe the MCA recommended procedure for testing the Emergency Alternator. (3)

## (a) Block Diagram of Vessel Electrical Distribution System

### Components:

- **Main Generators (MG):** One or more generators that supply electrical power for the vessel's normal operation.
- **Emergency Generator (EMRG):** A dedicated generator that provides electrical power for critical systems in case of a main power outage.
- **Main Switchboard (MSB):** Distributes power from the main generators to various sections of the vessel.
- **Emergency Switchboard (EMSB):** Distributes power from the emergency generator to critical systems.
- **Busbars:** Conducting bars used for power distribution within the switchboards.
- **Circuit Breakers (CB):** Protect circuits from overload and short circuits.
- **Essential Loads:** Critical systems requiring power during a blackout, such as navigation, communication, safety equipment, and emergency lighting.

### Block Diagram Layout:



### Explanation:

- The main generators supply power to the main busbar within the main switchboard.
- The main switchboard distributes power through circuit breakers (CB) to various non-essential sections of the vessel.
- The emergency generator supplies power to the emergency switchboard.
- The emergency switchboard distributes power through dedicated circuit breakers to essential loads like navigation, communication, safety equipment, and emergency lighting.
- The emergency switchboard and its connected essential loads are completely separate from the main power distribution system, ensuring their functionality during a power outage.

## (b) MCA Recommended Procedure for Emergency Alternator Testing (Brief Overview)

The Maritime and Coastguard Agency (MCA) recommends a structured approach for testing emergency alternators on vessels. Here's a simplified overview of the procedure:

1. **Pre-Test Preparations:** Ensure the emergency switchboard is isolated from the main power supply. Verify that essential loads are not connected or powered from another source during the test.
2. **Engine Start and Load Application:** Start the emergency generator engine and allow it to reach normal operating temperature and speed. Gradually apply a load to the emergency alternator using a load bank or suitable alternative method, ensuring the load doesn't exceed the alternator's rated capacity.
3. **Voltage and Frequency Monitoring:** Monitor the output voltage and frequency of the emergency alternator under load. They should remain within the specified operating range for stable power supply to critical systems.
4. **Voltage Regulation and Governor Performance:** Observe the performance of the voltage regulator and governor. They should maintain proper voltage and speed control of the alternator despite changes in load.
5. **Overload and Short Circuit Protection:** Simulate overload and short circuit conditions using the load bank or testing equipment. Verify that the emergency switchboard's circuit breakers trip correctly to protect the circuits and connected equipment.
6. **Cool Down and Post-Test Inspection:** After testing, gradually remove the load and allow the engine to cool down. Perform a visual inspection of the emergency alternator and switchboard for any signs of abnormalities.
7. **Record Keeping:** Document the test results, including voltage, frequency, load levels, and any observations made during the test. This record helps maintain a history of the emergency alternator's performance and facilitates future maintenance decisions.

**Note:** This is a simplified overview. The actual MCA recommendations might involve additional details, specific testing procedures, and safety precautions. Always refer to the latest MCA guidelines and manufacturer's instructions for the proper testing procedures for your particular emergency alternator.