1. (a) Sketch a flexible diaphragm valve. (6)

(b) Describe how the diaphragm is replaced, stating the precautions that should be taken. (4)

2. (a) Sketch a vane type pump, labelling ALL components. (6)

(b) Explain the operation of the pump sketched in part (a). (4)

3. With reference to reciprocating air compressors:

(a) state the meaning of the term *bump clearance*; (2)

(b) explain the effects on operation if the bump clearance is:

(i) too large; (3)

(ii) too small. (3)

(c) explain how an aftercooler helps remove moisture from the air. (2)

4. Outline the safety precautions which should be taken when carrying out repairs or maintenance on hydraulic systems. (10)

5. Describe, with the aid of a block diagram, the control of an automatic steering system, including auto-pilot and valve operated steering gear. (10)

6. With reference to controllable pitch propellers:

(a) explain why they should maintain a small amount of pitch when in the neutral position; (3)

(b) state, with reasons, the failsafe position; (4)

(c) explain how pitch may be restored should hydraulic system failure occur. (3)

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)

8. With reference to propulsion shaft intermediate bearings of the plain bearing type, explain EACH of the following:

(a) how change of alignment due to vessel condition is allowed for; (2)

(b) why the shaft must be able to move longitudinally; (4)

(c) why the aftmost bearing requires a complete bush but other bearings may have the bush only in the lower half. (4)

9. (a) State the requirements for the positioning of the emergency source of electrical power. (4)

(b) List EIGHT areas that must have emergency lighting services. (6)

10. Outline the necessary precautions, as stated in the Code of Safe Working Practices for Merchant Seamen, for working near live electrical equipment, when it is essential for the safety of the ship or for testing purposes. (10)

1. (a) Sketch a flexible diaphragm valve. (6)

(b) Describe how the diaphragm is replaced, stating the precautions that should be taken. (4)

Flexible Diaphragm Valve

(a) Description:

A flexible diaphragm valve is a type of valve that uses a flexible membrane (diaphragm) to control the flow of fluid. The diaphragm is typically made of elastomeric materials like rubber or synthetic polymers and is located between the body of the valve and the bonnet. Here's a breakdown of its key components:

- **Valve Body:** The main housing of the valve, typically made of metal or plastic.
- **Diaphragm:** The flexible membrane that seals the opening between the inlet and outlet ports.
- **Bonnet:** The part that secures the diaphragm to the valve body.
- **Actuator:** The mechanism that creates the force to open or close the diaphragm (manual, pneumatic, hydraulic, etc.).
- **Seat:** The surface within the valve body that the diaphragm seals against.

When the valve is closed, the actuator applies pressure to the diaphragm, pushing it against the seat and blocking the flow path. Conversely, when the valve needs to be opened, the actuator pressure is released, allowing the diaphragm to flex back and open the passage for fluid flow.

**(b) Diaphragm Replacement and Precautions:

Replacing a diaphragm requires careful handling to avoid damaging the valve or the new diaphragm. Here's a general process with important precautions:

Process:

1. **Isolating the Valve:** Close and lock out any isolation valves upstream and downstream of the diaphragm valve to prevent accidental pressurization during the replacement procedure.
2. **Relieving Pressure:** Ensure any residual pressure within the valve body is released through designated vent or bleed valves according to the manufacturer's instructions.
3. **Disassembly:** Following the manufacturer's guide, disassemble the valve components, carefully removing the bonnet to access the diaphragm.
4. **Diaphragm Removal:** Inspect the used diaphragm for signs of wear, tear, or damage. Gently remove it from the valve body and discard it properly.
5. **Cleaning the Seat:** Clean the sealing surface (seat) on the valve body to remove any dirt or debris that might hinder a proper seal with the new diaphragm.
6. **New Diaphragm Installation:** Inspect the new diaphragm for any defects. Carefully position it within the valve body, ensuring proper alignment with the seat.
7. **Reassembly:** Following the manufacturer's instructions in reverse order, reassemble the valve components, paying close attention to proper tightening torques for bolts and connections.

Precautions:

- **Follow Manufacturer's Instructions:** Always refer to the specific manufacturer's guide for the diaphragm valve you're working on. The disassembly, cleaning, and reassembly procedures may vary depending on the valve design.
- **Use Appropriate Tools:** Utilize the proper tools for disassembly and reassembly to avoid damaging the valve components.
- **Inspect the New Diaphragm:** Before installation, thoroughly inspect the new diaphragm for any cuts, tears, or imperfections that could compromise its sealing ability.
- **Handle with Care:** Avoid excessive stretching, pinching, or puncturing the diaphragm during handling and installation.
- **Proper Disposal:** Dispose of the used diaphragm according to local regulations for waste disposal, especially if it was exposed to hazardous materials.

By following these steps and precautions, you can replace a diaphragm in a diaphragm valve safely and effectively.

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.
- **Vanes:** 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. With reference to reciprocating air compressors:

(a) state the meaning of the term *bump clearance*; (2)

(b) explain the effects on operation if the bump clearance is:

(i) too large; (3)

(ii) too small. (3)

(c) explain how an aftercooler helps remove moisture from the air. (2)

Reciprocating Air Compressor: Bump Clearance and Temperature Control

(a) Bump Clearance:

Bump clearance refers to the minimum distance between the piston and the cylinder head, or between the piston crown and the discharge valve on the cylinder head, at the top dead center (TDC) of the piston stroke. It's essentially the closest the piston gets to the head or valve at the end of its upward movement.

(b) Effects of Bump Clearance:

(i) Bump Clearance Too Large:

- **Reduced Efficiency:** Excessive clearance allows for a larger volume of compressed air to remain in the cylinder after discharge, which expands during the intake stroke. This reduces

the amount of fresh air that can be drawn into the cylinder, lowering the compressor's overall efficiency.
- **Increased Wear:** With a larger gap, the piston experiences increased impact forces against the cylinder head at the end of its stroke, accelerating wear and tear on both components.

(ii) Bump Clearance Too Small:

- **Premature Contact and Damage:** If the clearance is too tight, the piston might come into contact with the head or valve prematurely during operation. This can cause severe damage to the piston, head, and valve components.
- **Increased Friction:** A very small clearance creates excessive friction between the piston and cylinder head, leading to increased power consumption and potential overheating.

(c) Aftercooler and Moisture Removal:

An aftercooler is a heat exchanger located after the final compression stage of a reciprocating compressor. It functions similarly to an intercooler but cools the compressed air to a lower temperature than what's achievable with intercooling alone. This helps to:

- **Reduce Condensation:** By lowering the air temperature, the aftercooler reduces the risk of water vapor in the compressed air condensing into liquid water. This is crucial because water droplets can cause corrosion within the system and damage downstream equipment that relies on clean, dry air.
- **Improve Efficiency:** Cooler air is denser and requires less energy for further processing or use.

Additional Moisture Removal:

Aftercooling alone might not be sufficient to remove all moisture, especially in humid environments. In such cases, additional equipment like separators or dryers might be used to further remove condensed water from the compressed air stream.

4. Outline the safety precautions which should be taken when carrying out repairs or maintenance on hydraulic systems. (10)

Here are some safety precautions that should be taken when carrying out repairs or maintenance on hydraulic systems:

Before Starting Work:

- **Lock Out/Tag Out (LOTO):** Always follow proper Lock Out/Tag Out procedures before beginning any work on the hydraulic system. This ensures that the system is isolated from its energy source and no one can accidentally activate it while you're working.
- **Pressure Relief:** Release all residual pressure within the system before starting any work. This can be done by following the manufacturer's instructions for bleeding pressure from specific components or using a designated pressure relief valve.

- **System Drainage:** Drain the hydraulic fluid from the system as much as possible, following proper disposal procedures for the used fluid. This minimizes the risk of exposure to hot oil and reduces the amount of fluid that could escape during repairs.
- **System Cleaning (Optional):** In some cases, depending on the nature of repairs or the severity of contamination, the system might require cleaning before disassembly. This could involve flushing the system with a cleaning solution or using specialized cleaning procedures outlined by the manufacturer.
- **Personal Protective Equipment (PPE):** Wear appropriate personal protective equipment (PPE) when working on hydraulic systems. This includes:
    - **Safety glasses:** To protect eyes from splashes of hydraulic fluid or debris.
    - **Gloves:** Chemical-resistant gloves to protect hands from hot oil and potential contamination.
    - **Coveralls:** Oil-resistant coveralls to protect clothing from spills and contamination.
    - **Foot protection:** Safety boots with proper slip resistance to prevent falls on potentially oily surfaces.

During Repairs and Maintenance:

- **Follow Service Manuals:** Always refer to the manufacturer's service manuals or maintenance instructions for the specific equipment. These will provide detailed procedures for disassembly, inspection, repair, and reassembly of the hydraulic components.
- **Use Proper Tools:** Use the correct tools specifically designed for working on hydraulic systems. This will help prevent damage to components and ensure proper tightening of fittings.
- **Beware of High-Pressure Components:** Be aware of high-pressure lines and components within the system. Avoid any actions that could put stress on these components or lead to accidental fluid leaks.
- **Maintain a Clean Work Area:** Keep the work area clean and organized to avoid tripping hazards or losing track of tools and components.
- **Work Buddy System:** Consider working with a partner for certain tasks, especially when dealing with high-pressure components or heavy equipment.
- **Safe Lifting Practices:** Use proper lifting techniques and equipment when handling heavy components within the hydraulic system.

After Completing Work:

- **Reassembly and Inspection:** Carefully reassemble the system components according to the manufacturer's instructions. Double-check all connections and ensure everything is tightened properly.
- **System Refill and Bleeding:** Refill the system with clean, fresh hydraulic fluid of the recommended type and viscosity. Follow the manufacturer's procedures for bleeding air from the system to ensure proper operation without trapped air pockets.
- **Test and Verification:** Once the system is refilled and bled, conduct a test run to verify proper operation and identify any leaks or malfunctions before placing the system back into full service.
- **Safety Checks:** Perform final safety checks to ensure all LOTO procedures are reversed, no tools are left behind, and the system is functioning safely and without leaks.

Additional Tips:

- **Training and Experience:** Ensure you have the proper training and experience necessary for the specific repairs or maintenance tasks being performed on the hydraulic system.
- **Waste Disposal:** Dispose of used hydraulic fluid and any other waste materials generated during maintenance according to local environmental regulations.
- **Proper Record Keeping:** Maintain records of the maintenance procedures performed, parts replaced, and any safety concerns encountered.

By following these safety precautions, you can minimize the risk of accidents and injuries when working on hydraulic systems. Remember, hydraulic systems operate under high pressure and contain hazardous fluids. It's crucial to prioritize safety throughout the entire maintenance process.

5. Describe, with the aid of a block diagram, the control of an automatic steering system, including auto-pilot and valve operated steering gear. (10)

Block Diagram of an Automatic Steering System with Auto-Pilot and Valve Operated Steering Gear

An automatic steering system, also known as autopilot, utilizes various components to maintain a set course for a vessel. Here's a block diagram outlining its operation:

Blocks:

1. **Course Reference System (CRS):**
   - This block provides a reference for the desired course. It can be a:
     - **Gyrocompass:** Senses the vessel's heading based on Earth's rotation.
     - **GPS (Global Positioning System):** Provides highly accurate position information.
     - **Combination of both:** For enhanced accuracy and redundancy.
2. **Course Setter:**
   - This allows the operator to input the desired course (heading) for the autopilot to follow.
3. **Heading Sensor:**
   - Senses the vessel's actual heading information. This can be:
     - **Gyrocompass output** (if separate from CRS).
     - **GPS derived heading:** Utilizing position data and course over ground (COG).
4. **Autopilot Controller:**
   - This is the "brain" of the system. It compares the desired course (from CRS and Course Setter) with the actual heading (from Heading Sensor).
   - Based on the difference (course error), the controller calculates the necessary rudder adjustments to minimize the error and maintain the desired course.
   - Common control algorithms used include Proportional-Integral-Derivative (PID) control.
5. **Rudder Command Signal:**
   - The autopilot controller generates a control signal based on the calculated rudder adjustment. This signal can be:
     - **Electrical signal:** Sent to a servo motor driving a valve.
     - **Hydraulic signal:** Controls a pilot valve in a hydraulic system.
6. **Valve Operated Steering Gear:**
   - This block translates the control signal from the autopilot into physical movement of the rudder. It can be:

- **Electro-hydraulic system:** An electric motor drives a pump that pressurizes hydraulic fluid. A servo valve, controlled by the autopilot's signal, directs the fluid flow to rams that move the rudder.
- **Electro-pneumatic system:** A solenoid valve, controlled by the autopilot's electrical signal, directs compressed air to actuators that move the rudder.

7. **Feedback Loop:**
    - The actual rudder position (often sensed by a rudder angle sensor) can be fed back to the autopilot controller. This feedback helps to ensure accurate and precise rudder adjustments.

Overall Operation:

1. The operator sets the desired course using the Course Setter.
2. The CRS and Heading Sensor provide continuous information about the desired and actual headings, respectively.
3. The autopilot controller compares these headings and calculates the course error.
4. Based on the error, the controller generates a rudder command signal.
5. The valve-operated steering gear translates this signal into rudder movement.
6. (Optional) The actual rudder position is fed back to the controller for improved accuracy.

This continuous cycle of comparison, calculation, and adjustment allows the autopilot to maintain the set course automatically, reducing workload for the crew and improving navigational efficiency.

6. With reference to controllable pitch propellers:

(a) explain why they should maintain a small amount of pitch when in the neutral position; (3)

(b) state, with reasons, the failsafe position; (4)

(c) explain how pitch may be restored should hydraulic system failure occur. (3)

Controllable Pitch Propellers: Pitch in Neutral, Failsafe, and Restoration

(a) Maintaining Small Pitch in Neutral Position:

Controllable pitch propellers (CPP) shouldn't be completely flat (zero pitch) when in the neutral position (blades not actively generating thrust). Here's why:

- **Minimum Drag:** A small pitch angle (slightly positive) helps minimize drag on the propeller when the engine is running but not actively propelling the vessel. With zero pitch, the blades act like a flat plate against the water, creating unnecessary drag and reducing efficiency.
- **Improved Maneuverability:** A slight positive pitch provides a small amount of braking effect, aiding maneuverability at low speeds or during stopping procedures. It helps slow the vessel down more effectively compared to a completely flat blade.
- **Faster Engine Response:** When transitioning from neutral to forward thrust, a small positive pitch angle allows the engine to respond quicker and generate thrust more rapidly. It reduces the time needed for the blades to reach the desired positive pitch for forward propulsion.

(b) Failsafe Position:

In the event of a complete hydraulic system failure in a CPP system, the blades should move to a failsafe position. This position is typically:

- **Full Feathered Pitch:** The blades are rotated to a position with a large negative pitch angle. This essentially puts the blades parallel to the water flow, offering minimal resistance and preventing them from creating drag or reverse thrust.
- **Reasoning:** This position minimizes the negative impact on the vessel's performance and maneuverability in case of hydraulic failure. It prevents the blades from acting like a brake or creating unwanted reverse thrust, which could be dangerous or hinder control.

(c) Restoring Pitch after Hydraulic System Failure:

Several methods can be employed to restore the pitch of the propeller blades in case of hydraulic system failure, depending on the specific design and available backup systems:

- **Emergency Pitch Control System:** Some CPP systems might incorporate a backup, non-hydraulic system (e.g., electric, mechanical) for controlling blade pitch. This allows the operator to adjust the pitch to a limited extent, even with a failed hydraulic system.
- **Manual Pitch Locking Mechanism:** In some designs, a manual locking mechanism might be available. This allows the crew to secure the blades in a specific pitch position (usually feathered) using manual tools, even with a hydraulic system failure.
- **Alternative Propulsion Systems:** Some vessels with CPP systems might have auxiliary propulsion systems (e.g., bow thrusters, stern thrusters) that can be used for limited maneuvering capabilities even if the main propeller is inoperable due to hydraulic failure.

It's important to note that the specific methods for restoring pitch and the available backup systems will vary depending on the design and complexity of the CPP system. Crew training on emergency procedures for handling hydraulic system failures is crucial for maintaining some level of control and ensuring vessel safety in such situations.

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.

8. With reference to propulsion shaft intermediate bearings of the plain bearing type, explain EACH of the following:

(a) how change of alignment due to vessel condition is allowed for; (2)

(b) why the shaft must be able to move longitudinally; (4)

(c) why the aftmost bearing requires a complete bush but other bearings may have the bush only in the lower half. (4)

With reference to propulsion shaft intermediate bearings of the plain bearing type, explain EACH of the following:

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(c) why the aftmost bearing requires a complete bush but other bearings may have the bush only in the lower half

Intermediate Plain Bearings on Propulsion Shafts:

Here's a breakdown of the functionalities of intermediate plain bearings on a propulsion shaft:

(a) How Change of Alignment Due to Vessel Condition is Allowed For:

While designed for optimal performance with minimal misalignment, intermediate plain bearings can accommodate some degree of change in shaft alignment due to vessel condition. Here are two main factors that contribute to this:

- **Bearing Material:** Plain bearings typically use materials like white metal or lined steel that offer a certain degree of **conformability**. This allows the bearing surface to slightly deform and accommodate minor variations in shaft alignment.
- **Bearing Clearance:** Intermediate shaft bearings are designed with a specific **clearance** between the shaft and the bearing bush. This clearance allows for a thin film of lubricant to form and for some limited **movement** of the shaft within the bearing.

However, it's important to note that excessive misalignment can lead to increased wear, reduced bearing life, and potential damage. Maintaining proper shaft alignment through regular checks and adjustments is crucial for optimal bearing performance.

(b) Why the Shaft Must be able to Move Longitudinally:

There are two main reasons why the shaft needs some degree of longitudinal (axial) movement in a propulsion system:

- **Thermal Expansion:** As the engine operates, the propeller shaft and other components will experience thermal expansion. A small amount of axial movement in the shaft allows for this expansion and contraction without binding or putting excessive stress on the bearings and couplings.
- **Propeller Thrust:** The propeller generates thrust as it rotates, pushing the vessel forward. This thrust creates a small **axial force** on the shaft. The ability of the shaft to move slightly allows for this force to be transmitted without putting undue stress on the bearings.

Important Note:

While some axial movement is necessary, excessive movement can lead to problems like whipping of the shaft or propeller walk (propeller causing the vessel to steer off course). The design of the shaft line and bearings should allow for some controlled axial movement within acceptable limits.

(c) Why the Aftmost Bearing Requires a Complete Bush but Other Bearings May Have the Bush Only in the Lower Half:

The design of the intermediate shaft bearings often differs, specifically for the aftmost bearing compared to the forward bearings. Here's the reasoning:

- **Aftmost Bearing (Complete Bush):** This bearing experiences the greatest load from the propeller thrust. A complete bush provides better support for the shaft and helps distribute the load more evenly. Additionally, the complete bush design offers better shaft stability and helps prevent whipping.
- **Forward Bearings (Lower Half Bush):** These bearings experience less load compared to the aftmost bearing. A lower half bush allows for easier installation and removal of the shaft during maintenance or repairs. Additionally, with proper shaft alignment and support from the aftmost bearing, the lower half bush design is sufficient for these locations.

Summary:

The design of intermediate shaft plain bearings considers several factors to ensure optimal performance and longevity. Their ability to accommodate some misalignment and allow for controlled axial movement is crucial for proper shaft operation. Additionally, the design differences between the aftmost and forward bearings reflect the varying loads and maintenance considerations in the propulsion system.

9. (a) State the requirements for the positioning of the emergency source of electrical power. (4)

(b) List EIGHT areas that must have emergency lighting services. (6)

Emergency Electrical Power in Marine Applications

(a) Emergency Source Positioning:

International Maritime Organization (IMO) regulations dictate the positioning of the emergency source of electrical power in marine applications:

- **Location:** It must be situated above the uppermost continuous deck, readily accessible from an open deck. This ensures the emergency power source remains operational even if lower decks are flooded or damaged.
- **Collision Bulkhead:** Ideally, the emergency power source should be located aft (behind) the collision bulkhead. This positioning minimizes the risk of damage from a head-on collision. Exceptions may be granted in specific circumstances.

(b) Emergency Lighting Requirements:

Eight critical areas require emergency lighting services on marine vessels:

1. **Accommodation, Alleyways, Stairs, Exits, Lifts, and Lift Trunks:** To ensure safe evacuation of crew and passengers during an emergency.
2. **Machinery Spaces and Main Generating Stations:** For crew to safely operate essential equipment or conduct repairs in case of a main power outage.
3. **Emergency Control Room (ECR), Central Control Room (CCR), Main and Emergency Switchboards:** For crew to maintain control and monitor vital systems during a blackout.
4. **Fire Control Stations:** To enable efficient firefighting operations in low-light conditions.

5. **Locations of Emergency Equipment:** This includes areas housing fire pumps, sprinkler pumps, and other critical equipment used during emergencies.
6. **Cargo Pump Rooms:** To facilitate safe operation of cargo pumps in case of a power outage, minimizing potential spills or hazards.
7. **Navigation Bridge:** To maintain essential navigation functions and ensure safe vessel operation during a blackout.
8. **Engine Room:** Similar to machinery spaces, for crew to safely monitor and operate essential engines during a power loss.

10. Outline the necessary precautions, as stated in the Code of Safe Working Practices for Merchant Seamen, for working near live electrical equipment, when it is essential for the safety of the ship or for testing purposes. (10)

Working Near Live Electrical Equipment on Marine Vessels (As per Code of Safe Working Practices for Merchant Seamen):

The Code emphasizes prioritizing alternative methods whenever possible. However, if working near live electrical equipment becomes essential for ship safety or testing, these precautions are paramount:

Preparation and Planning:

1. **Permit to Work:** Obtain a formal permit detailing the task, potential hazards, and required safety measures.
2. **Competent Person:** Ensure a qualified electrician, or someone designated by a competent person, supervises the work directly.
3. **Risk Assessment:** Conduct a thorough risk assessment to identify electrical hazards, potential for shock, and actions to mitigate them.
4. **Isolation Attempts:** If feasible, attempt to isolate the equipment electrically using approved switches or lockout/tagout procedures.
5. **Personal Protective Equipment (PPE):** Wear properly rated insulated gloves, sleeves, footwear, and eye protection based on the voltage and potential risks.
6. **Safe Working Area:** Establish a safe working zone with clear boundaries to prevent accidental contact with live components.
7. **Warning Signs:** Post clear warning signs at the work area to alert others of the ongoing work and potential electrical hazards.
8. **Tools and Equipment:** Use only electrically insulated tools and equipment specifically designed for working near live electrical equipment.

Work Procedure:

1. **Single Person Rule:** Only one person should be directly involved in the work near live components, with a designated observer present for safety.
2. **Minimum Movement:** Movements should be deliberate and controlled to minimize the risk of accidental contact.
3. **One Hand Rule:** Maintain one hand behind your back or in a pocket to prevent accidental contact with both conductors simultaneously.
4. **Test Equipment:** Use properly rated test equipment to verify de-energized status before proceeding (if applicable).
5. **Continuous Monitoring:** The supervising electrician or observer must continuously monitor the worker and the situation for any signs of danger.

6. **Immediate Shutdown:** Have a clear and immediate plan to de-energize the equipment in case of an emergency or unexpected situation.

Completion:

1. **Final Inspection:** Once work is complete, the supervising electrician must verify the equipment is secure, tools are removed, and the work area is left in a safe condition.
2. **Permit Cancellation:** Cancel the work permit, ensuring all safety measures are terminated.

Remember:

- Working near live electrical equipment should always be considered a last resort.
- If discomfort or uncertainty arises, stop work immediately and re-evaluate the situation.

Note: This is not an exhaustive list, and it's crucial to consult the latest version of the Code of Safe Working Practices for Merchant Seamen for the most up-to-date and comprehensive guidelines.