July 2021

1. With reference to quick closing valves:

   (a) state where they would be fitted; (2)

   (b) explain how they operate should a fire occur in EACH of the following:

      (i) the machinery space; (4)

      (ii) close proximity to the valve. (4)

July 2021

2. (a) State FOUR types of pumps suitable for use in a hydraulic system. (4)

   (b) Explain why the pumps stated in part (a) are suitable for hydraulic systems. (6)

July 2021

3. With reference to air receivers;

   (a) list FOUR fittings on an air receiver; (4)

   (b) describe the operation of TWO safety devices. (6)

July 2021

4. With reference to the cleanliness of hydraulic systems on board an ocean going vessel:

   (a) list FOUR contaminants; (4)

   (b) describe the steps that should be taken to eliminate the contaminants listed in part(a). (6)

July 2021

5. Sketch a valve operated, rotary vane steering gear, showing the hydraulic system from the directional valve to the rotary vane unit. (10)

July 2021

6. With reference to propellers, explain EACH of the following:

   (a) TWO advantages of having high skew; (5)

   (b) TWO advantages of aft rake. (5)

July 2021

7. Sketch an arrangement for the aft seal of an oil lubricated stern tube bearing. (10)

July 2021

8. Explain how EACH of the following electrical safety devices may be tested for correct operation:

   (a) a generator reverse power trip; (2)

   (b) generator over-current alarm; (2)

   (c) generator over-current trip; (2)

   (d) emergency generator auto start up; (2)

   (e) preferential tripping sequence (2)

July 2021

9. With reference to the connection of shore power supply on a vessel that does not have a shore power converter:

   (a) list the items that would be included on a checklist for supply of power to the vessel; (7)

   (b) state the effects of running a 60Hz vessel on a 50Hz supply. (3)

July 2021

10. With reference to control systems:

   (a) state FIVE advantages of using pneumatics; (5)

   (b) state FIVE advantages of using hydraulics. (5)

July 2021

1. With reference to quick closing valves:

(a) state where they would be fitted; (2)

(b) explain how they operate should a fire occur in EACH of the following:

(i) the machinery space; (4)

(ii) close proximity to the valve. (4)

Quick Closing Valves: Location and Operation in Fire Scenarios

(a) Where They Are Fitted:

Quick closing valves are strategically placed on the **outlet lines** of tanks containing flammable or hazardous liquids, typically in:

- **Fuel oil tanks** within engine rooms, boiler rooms, or near emergency generators.
- Tanks storing other flammable liquids in industrial settings.

(b) Quick Closing Valve Operation in Fire Scenarios:

(i) Fire in the Machinery Space:

In this scenario, the quick closing valve plays a crucial role in isolating the fuel source and preventing the fire from spreading. Here's how it operates:

- **Heat Detectors or Fire Alarm:** Heat detectors or a fire alarm system within the machinery space would trigger a signal.
- **Remote Activation:** The fire alarm signal activates the remote closing mechanism of the quick closing valve (e.g., hydraulic, pneumatic, or solenoid).
- **Valve Closure:** The remote activation pushes a piston or releases pressurized air/fluid, forcing the valve shut rapidly. This isolates the fuel supply to the machinery space, preventing further feeding of the fire.

(ii) Fire Close to the Valve:

If a fire occurs near the quick closing valve itself (e.g., due to a fuel line leak), the valve's operation becomes even more critical. Here's what might happen:

- **Heat Exposure:** The intense heat from the fire could potentially melt or damage the electrical wiring or control mechanisms for remote actuation (if applicable).
- **Manual override:** In such cases, the valve design typically incorporates a **manual override** feature. This allows firefighters or personnel on-site to manually close the valve using a lever or wheel mechanism, even if the remote actuation system is compromised by the fire.
- **Automatic Closure (Optional):** Some quick closing valves may have **built-in temperature sensors** or **fusible links**. When exposed to excessive heat from a nearby fire, these mechanisms trigger an automatic closure of the valve, isolating the fuel source without relying on remote activation.

Note: The specific operation and fail-safe mechanisms of quick closing valves may vary depending on the valve design, fire detection system, and manufacturer's specifications.

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July 2021

2. (a) State FOUR types of pumps suitable for use in a hydraulic system. (4)

   (b) Explain why the pumps stated in part (a) are suitable for hydraulic systems. (6)

Pumps for Hydraulic Systems: Types and Suitability

(a) Four Types of Pumps Suitable for Hydraulic Systems:

1. **Gear Pump:**
   - This positive displacement pump utilizes meshing gears to trap and move fluid.
   - **Suitability:** Gear pumps offer high efficiency, simple design, and good reliability at moderate pressures. They are a popular choice for hydraulic systems due to their affordability and robustness.
2. **Piston Pump:**
   - This positive displacement pump uses a reciprocating piston within a cylinder to create high-pressure fluid flow.
   - **Suitability:** Piston pumps can achieve very high pressures, making them suitable for demanding hydraulic applications requiring precise control. They offer good efficiency and can be single or double-acting for higher flow rates.
3. **Vane Pump:**
   - This positive displacement pump utilizes sliding vanes within a rotor to move fluid.
   - **Suitability:** Vane pumps offer a good balance between pressure and flow capabilities, along with a relatively simple design. They are compact, efficient, and can be self-priming to a certain extent, making them suitable for various hydraulic applications.
4. **Axial Piston Pump:**
   - This positive displacement pump uses pistons arranged around a swashplate to create high-pressure fluid flow. The angle of the swashplate determines the pump displacement and flow rate.
   - **Suitability:** Axial piston pumps offer excellent flow control and high efficiency. Their ability to vary flow rate makes them suitable for hydraulic systems requiring precise control and variable power demands.

(b) Why These Pumps are Suitable for Hydraulic Systems:

Hydraulic systems require pumps that can deliver a **controlled flow of fluid** at a **specific pressure**. The pumps listed above share key characteristics that make them well-suited for this purpose:

- **Positive Displacement:** These pumps deliver a constant volume of fluid with each cycle, regardless of the discharge pressure. This ensures consistent performance and predictable flow within the hydraulic system.

- **Pressure Capability:** All these pumps can generate sufficient pressure to operate hydraulic actuators and overcome system resistance. Gear pumps are suitable for moderate pressures, while piston pumps excel at very high pressures.
- **Efficiency:** These pumps convert a significant portion of the input mechanical power into hydraulic power, minimizing energy losses.
- **Controllability:** Some pumps, like axial piston pumps with variable swashplate designs, offer good control over flow rate, which is crucial for precise positioning of hydraulic actuators.
- **Durability:** Hydraulic pumps are designed to withstand the demanding operating conditions of hydraulic systems, including high pressures and constant use.

The specific choice of pump for a hydraulic system depends on factors like required pressure, flow rate, desired controllability, system size, and budget.

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3. With reference to air receivers;

(a) list FOUR fittings on an air receiver; (4)

(b) describe the operation of TWO safety devices. (6)

Air Receiver Fittings and Safety Devices

(a) Four Fittings on an Air Receiver:

1. **Inlet Connection:** This fitting allows compressed air from the compressor to enter the receiver for storage.
2. **Outlet Connection:** This fitting allows compressed air to flow out of the receiver to supply downstream equipment.
3. **Drain Valve:** This valve allows for manual or automatic draining of condensate (water) that accumulates at the bottom of the receiver due to moisture in the compressed air.
4. **Pressure Relief Valve:** A safety device that automatically releases compressed air if the pressure within the receiver exceeds a preset safe limit.

(b) Description of Two Air Receiver Safety Devices:

1. **Pressure Relief Valve:**

- **Function:** This valve acts as a last line of defense to prevent the air receiver from rupturing due to excessive pressure.
- **Operation:** The relief valve remains closed under normal operating pressure. If the pressure within the receiver rises above the set point due to a malfunctioning pressure regulator, compressor over-pressurization, or other issues, the valve opens. This allows compressed air to escape from the receiver until the pressure falls below the set point. The valve then automatically closes and seals again.

2. **Safety Relief Valve (Optional):**

- **Function:** In some cases, an additional safety relief valve might be used alongside the pressure relief valve. This valve typically has a higher pressure rating than the pressure relief valve and serves as a backup safety measure.
- **Operation:** The safety relief valve functions similarly to the pressure relief valve. It remains closed under normal operation and opens automatically to release compressed air if the pressure exceeds its much higher set point. This additional layer of safety ensures the receiver doesn't rupture even in case of a malfunctioning pressure relief valve.

Additional Note:

Some air receivers may have additional fittings depending on the specific application. These might include:

- **Level Gauge:** Provides a visual indication of the condensate level within the receiver.
- **Temperature Gauge:** Monitors the temperature of the compressed air within the receiver.
- **Pressure Gauge:** Indicates the air pressure within the receiver for monitoring purposes.

It's crucial to maintain these safety devices and fittings properly to ensure the safe and reliable operation of the compressed air system.

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4. With reference to the cleanliness of hydraulic systems on board an ocean going vessel:

(a) list FOUR contaminants; (4)

(b) describe the steps that should be taken to eliminate the contaminants listed in part(a). (6)

Contaminants and Cleaning in Hydraulic Systems on Ocean Vessels

Maintaining clean hydraulic systems is crucial for the smooth operation of machinery on an ocean vessel. Here's a look at some common contaminants and how to eliminate them:

(a) Four Contaminants:

1. **Water:** A major enemy of hydraulic systems, water causes corrosion, reduces lubrication, and promotes sludge formation.
2. **Dirt and Dust:** Airborne particles can enter through leaks or during maintenance, causing abrasion and jamming components.
3. **Wear Debris:** As components wear, tiny metal particles can circulate in the fluid, accelerating wear and damaging other parts.
4. **Microbial Growth:** In warm, moist environments, bacteria and fungi can grow in the hydraulic fluid, degrading its properties and potentially causing blockages.

(b) Steps to Eliminate Contaminants:

1. **Fluid Filtration:** Utilize high-quality filters with the appropriate micron rating to remove particles like dirt, dust, and wear debris. Regular filter changes are essential.

2. **Fluid Analysis:** Periodically analyze the hydraulic fluid to check for water content, viscosity, and contamination levels. This helps identify problems early on.
3. **System Flushing:** If significant contamination is suspected, flushing the system with clean fluid can remove water, debris, and microbial growth. Specialized flushing procedures might be required.
4. **Breather Maintenance:** Breather filters prevent external contamination from entering the system. Regularly inspect and replace breather elements to ensure proper function.
5. **Sealing Practices:** Utilize proper sealing techniques during maintenance to prevent leaks that could allow water or dirt ingress.
6. **Reservoir Maintenance:** Regularly clean the hydraulic fluid reservoir to remove any settled contaminants or sludge buildup.
7. **Moisture Control:** Implement measures to minimize condensation in the system, such as using moisture-absorbent breather elements or maintaining proper operating temperatures.
8. **Biocide Treatment:** In some cases, biocides might be added to the fluid to control microbial growth. However, this should be done under the guidance of a qualified technician to ensure compatibility with the system and avoid harming components.

By implementing these steps and maintaining a good preventive maintenance program, you can significantly reduce contamination in your vessel's hydraulic systems, ensuring reliable operation and extending equipment life.

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5. Sketch a valve operated, rotary vane steering gear, showing the hydraulic system from the directional valve to the rotary vane unit. (10)

In a valve-operated rotary vane steering gear, the hydraulic system translates electrical or mechanical control signals from the bridge into precise rudder movements. Here's a breakdown of the hydraulic system's operation from the directional control valve to the rotary vane unit:

Components:

- **Directional Control Valve:** Located near the bridge control system, this valve receives electrical or mechanical signals and acts as a gatekeeper for pressurized hydraulic fluid flow.
- **Hydraulic Pump:** Driven by an electric motor or diesel engine, this pump pressurizes the hydraulic fluid within the system.
- **Reservoir:** This tank stores the hydraulic fluid and maintains its proper level.
- **Pipelines:** High-pressure hoses or steel pipes connect the various components and carry the pressurized fluid.
- **Rotary Vane Unit:** This is the core component responsible for converting hydraulic pressure into rotary motion to turn the rudder.

Operation:

1. **Directional Control Valve Movement:** The helmsman's actions on the bridge (turning the steering wheel or using controls) send a signal to the directional control valve.

2. **Valve Spool/Poppet Movement:** Based on the received signal, the valve's internal spool or poppet moves within the valve body. This movement opens specific ports to direct hydraulic fluid flow.
3. **High-Pressure Fluid Path:** With the valve positioned correctly, pressurized fluid from the pump is directed to one side of the rotary vane unit's chamber.
4. **Low-Pressure Fluid Path:** Simultaneously, the valve also opens a passage for the hydraulic fluid on the opposite side of the rotary vane unit to return to the reservoir. This creates a crucial pressure differential across the unit.
5. **Rotary Vane Movement:** The pressure difference acts upon a set of vanes housed within a cylindrical rotor inside the rotary vane unit. The higher pressure pushes against these vanes, causing the rotor to rotate in a specific direction.
6. **Rudder Movement:** The rotating shaft of the rotor is typically connected to the rudder stock through a reduction gear mechanism. This translates the rotary motion of the vane unit into the desired angular movement of the rudder.

Additional Considerations:

- **Pressure Relief Valve (Optional):** A pressure relief valve might be incorporated to protect the system against excessive pressure buildup due to malfunctions.
- **Pilot-operated Valves:** In some designs, pilot-operated directional control valves might be used. These valves utilize a smaller, separate hydraulic circuit to control the main valve spool, offering more precise control over fluid flow.

Overall, the valve-operated rotary vane steering gear utilizes a directional control valve to direct pressurized hydraulic fluid, creating a pressure differential within the rotary vane unit. This differential drives the rotation of the vanes, ultimately resulting in the desired movement of the rudder.

021

July 2021

6. With reference to propellers, explain EACH of the following:

(a) TWO advantages of having high skew; (5)

(b) TWO advantages of aft rake. (5)

Propeller Advantages: Skew and Rake

(a) Advantages of High Skew:

High skew refers to a propeller blade design where the cross-section of each blade is angled significantly off-axis relative to the rotational plane of the propeller. Here are two advantages of using propellers with high skew:

1. **Reduced Cavitation:** Cavitation is the formation and collapse of vapor bubbles around a propeller blade, which can cause noise, vibration, and damage to the blade. High skew

disrupts the smooth flow of water across the blade face, making it more difficult for cavitation bubbles to form and persist. This is particularly beneficial for propellers operating at high speeds or with high blade loads.
2. **Improved Efficiency at Oblique Angles:** Unlike a straight-bladed propeller, which is most efficient when pushing water directly aft, a high skew propeller can maintain better efficiency even when the vessel is not traveling in a straight line. This is because the angled blades can still grip the water effectively even at oblique angles, reducing efficiency losses during maneuvers or when steering.

However, it's important to note that high skew designs also have some drawbacks, such as increased drag at low speeds and slightly reduced overall propulsive efficiency compared to lower skew propellers.

(b) Advantages of Aft Rake:

Aft rake refers to the design where the tips of the propeller blades are angled slightly backward relative to the plane of rotation. Here are two advantages of using propellers with aft rake:

1. **Reduced Shaft Vibration:** Propeller rotation can induce vibrations that travel through the shaft and into the vessel. Aft rake helps to mitigate these vibrations by altering the way the blades interact with the water. The angled blades tend to enter and exit the water more smoothly, reducing the forces that contribute to shaft vibrations.
2. **Improved Clearance:** In vessels with limited propeller clearance between the hull and the bottom of the propeller, aft rake can provide some additional clearance. The angled blades are positioned slightly higher relative to the shaft axis, reducing the risk of the blade tips striking the hull, especially during rolling or pitching motions.

Aft rake also has some minor drawbacks. For example, it can result in a slight decrease in propulsive efficiency compared to a straight rake design.

In conclusion, both high skew and aft rake offer specific advantages for propeller design. High skew is beneficial for reducing cavitation and improving efficiency at oblique angles, while aft rake helps minimize shaft vibration and provide additional clearance. The choice of propeller design with specific skew and rake angles will depend on the vessel's operational needs and priorities.

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7. Sketch an arrangement for the aft seal of an oil lubricated stern tube bearing. (10)

Aft Seal Arrangement for Oil-Lubricated Stern Tube Bearing

The aft seal in an oil-lubricated stern tube bearing plays a critical role in preventing seawater ingress and oil leakage. Here's a breakdown of a typical arrangement:

Components:

1. **Housing:** A robust housing is securely attached to the stern tube bossing of the vessel. This housing provides a secure enclosure for the sealing elements.

2. **Liner:** This is a wear ring made from a low-friction material (often white metal or a suitable plastic) that is fixed onto the propeller hub. The sealing elements make contact with the liner to create a tight seal.
3. **Primary Seal:** This is the first line of defense against seawater ingress. It can be one of several designs, such as:
   - **Lip seal:** A spring-loaded lip makes contact with the liner to create a sealing effect.
   - **Mechanical seal:** This utilizes rotating faces and a lubricating film to achieve a tight seal.
4. **Secondary Seal:** This provides additional protection against seawater ingress. It can be similar in design to the primary seal or might utilize a different sealing mechanism like a labyrinth seal with a series of grooves and clearances to impede water ingress.
5. **Oil Buffer Chamber:** This is a chamber within the aft seal housing located between the primary and secondary seals. The chamber is filled with oil at a pressure slightly higher than the seawater pressure outside. This creates a pressure barrier that helps prevent seawater from entering the stern tube.
6. **Drain Line:** A drain line allows any leakage from the primary or secondary seals to be collected and returned to the oil lubrication system. This prevents oil accumulation within the aft seal housing.
7. **Ventilation:** In some designs, a ventilation system might be incorporated to remove any moisture or vapors that could accumulate within the aft seal housing.

Operation:

As the propeller shaft rotates, the liner rotates with it. The primary and secondary seals make contact with the liner, creating a barrier against seawater. The oil buffer chamber maintains a slight positive pressure to further prevent seawater intrusion. Any leakage past the primary seal is collected and drained back to the oil system.

Importance of Maintenance:

Regular inspection and maintenance of the aft seal arrangement are crucial. Monitoring oil pressure in the buffer chamber, checking for leaks, and inspecting the condition of the liner and seals are essential to ensure continued functionality and prevent potential seawater contamination of the lubricating oil or oil leakage into the environment.

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8. Explain how EACH of the following electrical safety devices may be tested for correct operation:

(a) a generator reverse power trip; (2)

(b) generator over-current alarm; (2)

(c) generator over-current trip; (2)

(d) emergency generator auto start up; (2)

(e) preferential tripping sequence (2)

Here's how you can test each electrical safety device for correct operation:

(a) Generator Reverse Power Trip:

- **Manual Test (Safeguards Required):** With **proper lockout/tagout procedures** in place to isolate the generator from the main power supply and ensure safety, briefly force a reverse power condition. This can be done by supplying power to the generator terminals from an external source while the generator itself is not running. The reverse power trip should activate, interrupting the external power supply. **Extreme caution is advised** for this test due to the risk of unexpected energy backfeed. It's generally recommended to consult a qualified electrician for this test.
- **Secondary Test (Recommended):** A safer alternative is to simulate the reverse power condition using a dedicated test instrument that injects a pre-determined reverse power signal into the generator's control system. This method verifies the trip functionality without actually backfeeding power.

(b) Generator Over-Current Alarm:

- **Load Bank Test:** Apply a controlled load to the generator using a load bank. Gradually increase the load until the over-current alarm activates at the pre-set threshold. This verifies the alarm functionality and ensures it triggers at the correct overload level.
- **Secondary Test (Limited):** In some cases, injecting a pre-determined current signal through a test instrument into the generator's control system might simulate an overload condition and trigger the alarm. However, this method doesn't involve actual load application and may not fully validate system behavior under real overload conditions.

(c) Generator Over-Current Trip:

- **Load Bank Test:** Similar to the over-current alarm test, apply a controlled load using a load bank. Gradually increase the load until the over-current trip activates, interrupting power output from the generator. This verifies the trip functionality and ensures it protects the generator from excessive current.
- **Important Note:** **Extreme caution** is advised during this test as it involves a real overload condition. Ensure proper safety procedures are followed, and the load bank capacity is sufficient to handle the expected trip current without damage.

(d) Emergency Generator Auto Start-Up:

- **Simulated Power Loss:** Briefly simulate a power loss by disconnecting the main power supply (with proper safety precautions). The emergency generator's auto start-up system should detect the power outage and initiate engine starting procedures. This verifies the functionality of the auto start-up sequence.
- **Secondary Test (Limited):** A test switch might be available on the emergency generator control panel to simulate a power loss and initiate a start-up sequence without actually disconnecting the main power supply. This method offers a safer alternative but may not fully validate system behavior during a real power outage scenario.

(e) Preferential Tripping Sequence:

- **Simulated Overload:** Apply a controlled overload to a non-critical circuit while ensuring all other circuits are functional. The preferential trip system should isolate the overloaded circuit while maintaining power supply to critical circuits. Gradually increase the overload until the expected trip point is reached for the non-critical circuit.
- **Secondary Test (Limited):** Using a dedicated test instrument, specific circuits within the preferential trip system can be selectively loaded or bypassed to simulate overload conditions and verify the trip sequence. However, this method might not fully replicate the behavior under real overload scenarios involving multiple circuits.

Important Notes:

- Always consult the manufacturer's instructions and relevant safety regulations before performing any testing procedures on electrical safety devices.
- Some tests, particularly those involving real overload conditions, require qualified personnel and proper safety protocols to be implemented.
- Consider using secondary test methods whenever possible to minimize risks associated with actual load application or reverse power scenarios.
- Regularly testing these devices is crucial to ensure their proper operation and the overall safety and reliability of the electrical system.

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9. With reference to the connection of shore power supply on a vessel that does not have a shore power converter:

   (a) list the items that would be included on a checklist for supply of power to the vessel; (7)

   (b) state the effects of running a 60Hz vessel on a 50Hz supply. (3)

Shore Power Connection Checklist (No Shore Power Converter)

(a) Pre-Connection Checks:

A checklist for supplying shore power to a vessel without a shore power converter should include the following critical checks to ensure compatibility and safety:

- **Shore Supply Details:**
    - **Voltage:** Verify that the shore supply voltage matches the rated voltage of the vessel's electrical system (e.g., 120V or 240V). Supplying incorrect voltage can damage electrical equipment onboard.
    - **Frequency:** Confirm that the shore supply frequency (50 Hz or 60 Hz) is compatible with the vessel's electrical system. Running on an incompatible frequency can have serious consequences (see part (b) below).
    - **Phase Sequence (Three-Phase Systems):** For three-phase systems, ensure the phase sequence of the shore supply matches the phase sequence of the vessel's system. Incorrect phase sequence can damage motors and other equipment.
- **Vessel Compatibility:**
    - **Earthing Arrangement:** Verify that the earthing arrangements of the shore supply and the vessel are compatible. This ensures proper grounding and minimizes the risk of electrical shock.
    - **Amperage Rating:** Check the shore supply's amperage rating and ensure it can provide sufficient current for the vessel's needs without overloading the shore supply or the vessel's internal distribution system.
- **Visual Inspection:**
    - **Shore Power Cable:** Inspect the shore power cable for any signs of damage or wear and tear before connecting it.
    - **Shore Power Inlet:** Visually inspect the vessel's shore power inlet for any damage or corrosion before connecting the cable.

Additional Checks (Recommended):

- **Isolation Transformer (if available):** If the vessel has a portable isolation transformer, verify it's properly rated for the shore supply and vessel electrical system before connecting it. An isolation transformer can provide some level of protection against grounding issues and potential stray currents.
- **Ground Fault Protection:** Ensure the vessel's electrical system has ground fault protection devices (GFCIs) installed, particularly for critical circuits or equipment used in damp or wet locations.

(b) Effects of Running 60Hz Vessel on 50Hz Supply:

Running a 60 Hz vessel on a 50 Hz shore supply can have several negative consequences:

- **Frequency Mismatch:** AC motors and transformers are designed for a specific frequency (60 Hz in this case). Operating them on a different frequency (50 Hz) will cause them to run at a slower speed.
- **Reduced Efficiency:** Motors will operate at a lower speed than intended, leading to reduced efficiency and potentially higher operating temperatures. This can increase energy consumption and shorten the lifespan of the motors.
- **Overheating:** Reduced efficiency can lead to increased heat generation in motors and transformers. In severe cases, this can cause overheating and potential equipment failure.
- **Flickering and Noise:** Frequency mismatch can cause flickering lights and abnormal operation of electronic equipment onboard. It might also generate audible humming or buzzing noises from transformers and motors.

- **Damage:** In some cases, prolonged operation on an incompatible frequency can lead to permanent damage to motors, transformers, and other electrical equipment designed for 60 Hz operation.

It's crucial to ensure the shore supply frequency matches the vessel's electrical system to avoid these problems and maintain safe and reliable operation. If a compatible shore supply is not available, alternative power sources like generators might be necessary.

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July 2021

10. With reference to control systems:

(a) state FIVE advantages of using pneumatics; (5)

(b) state FIVE advantages of using hydraulics. (5)

Advantages of Pneumatic and Hydraulic Control Systems:

(a) Advantages of Pneumatics:

1. **Simplicity:** Pneumatic systems are generally simpler in design and construction compared to hydraulic systems. They use compressed air, a readily available and inexpensive medium, and have fewer moving parts. This often translates to lower initial cost and easier maintenance.
2. **Cleanliness:** Air is a clean and non-polluting fluid. There's no risk of oil spills or contamination, making pneumatics ideal for applications requiring cleanliness, such as food processing or clean room environments.
3. **Speed:** Compressed air can travel very quickly through pipelines, resulting in fast response times and actuation of pneumatic cylinders. This is advantageous for applications requiring high speed and rapid movement.
4. **Safety:** Compressed air poses less of a fire hazard compared to hydraulic fluids. Additionally, leaks in a pneumatic system simply release air, which is harmless, unlike hydraulic leaks that can cause slippery conditions or environmental concerns.
5. **Versatility:** Pneumatic components are available in a wide variety of sizes and configurations, making them suitable for a broad range of applications. From simple actuators to complex control valves, pneumatics offer a versatile solution for various control needs.

(b) Advantages of Hydraulics:

1. **High Power Density:** Hydraulic systems can transmit significantly higher forces compared to pneumatic systems for a given actuator size. This allows them to handle heavier loads and perform more powerful operations.
2. **Precision Control:** Hydraulic systems offer excellent control over force, speed, and positioning of actuators. This precise control is crucial for applications requiring accurate and repeatable movements, such as robotic arms or machine tools.
3. **Overload Protection:** Hydraulic fluids are virtually incompressible. This characteristic allows hydraulic systems to handle sudden overload conditions without significant pressure

fluctuations. The system can simply stall or bypass excess pressure, protecting components from damage.

4. **Efficiency:** Hydraulic systems can be very efficient, especially at higher pressures. The minimal compressibility of hydraulic fluids minimizes energy losses due to compression and expansion within the system.
5. **Heat Dissipation:** Hydraulic fluids can absorb and transfer heat effectively. This allows hydraulic systems to operate continuously under heavy loads without overheating, making them suitable for demanding industrial applications.

The choice between pneumatics and hydraulics for a control system depends on the specific requirements of the application. Consider factors like required force, speed, precision, operating environment, and budget when making the decision.