March 2021

1. With reference to a crane operated by a constant pressure hydraulic system incorporating unidirectional, fixed displacement pumps that run continuously, explain EACH of the following:

   (a) the purpose of the accumulator; (2)

   (b) how the hydraulic pressure is regulated; (2)

   (c) how the speed and direction of the hoist motor is varied; (3)

   (d) how the torque available from the hoist motor can be varied. (3)

March 2021

2. Describe, with the aid of a sketch, a variable frequency drive for speed control of a three phase motor. (10)

March 2021

3. With reference to variable speed control of a 3 phase ac induction motors:

   (a) explain why EACH of the following is not preferred:

      (i) variable voltage, constant frequency; (3)

      (ii) variable frequency, constant voltage. (3)

   (b) explain why voltage and frequency should both be varied. (4)

March 2021

4. Describe, with the aid of a sketch, a Direct Expansion Regrigeration System for an air cooler in an air conditioning installation. (10)

March 2021

5. Describe, with the aid of a sketch, how the relative humidity may be controlled in an Air Conditioning System. (10)

March 2021

6. Describe the effects of EACH of the following contaminants when found in air required for breathing and diving use:

   (a) oil vapour; (4)

   (b) water vapour; (4)

   (c) overheated oil. (2)

March 2021

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

   (a) outline FIVE maintenance procedures to be carried out on lifting equipment; (5)

   (b) state who should carry out the examination of the lifting equipment, the interval between examinations and the defects that may be found. (5)

March 2021

8. Describe the procedure that should be followed if an outboard motor has been submerged in sea water. (10)

March 2021

9. With reference to a vessel's motion control:

   (a) outline the SIX degrees of freedom; (3)

   (b) explain the term *damping;* (4)

   (c) state THREE considerations to be made, before the installation of a motion reduction system. (3)

March 2021

10. With reference to the International Convention for the Safe and Environmentally Sound Recycling of Ships:

    (a) state the operational requirements for compliance; (4)

    (b) list FOUR prohibited hazardous materials; (4)

    (c) list TWO hazardous materials whose use should be restricted. (2)

March 2021

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Hydraulic Crane System with Unidirectional Pumps:

Here's a breakdown of the functionalities you requested in a constant pressure system with fixed displacement pumps:

(a) Purpose of the Accumulator:

In this system, the accumulator serves two crucial purposes:

- **Peak Flow Demands:** With fixed displacement pumps continuously running, the accumulator acts as a reservoir for pressurized hydraulic fluid. During moments when the crane requires a sudden surge of flow for lifting heavy loads or rapid lowering, the accumulator can supplement the pump's output and provide the extra fluid needed. This helps maintain consistent system pressure and prevents performance dips during peak demands.
- **Smoothing Pressure Fluctuations:** Even with continuous pump operation, there can be minor fluctuations in pressure due to pump inefficiencies or varying flow demands. The accumulator helps absorb these pressure fluctuations by acting as a buffer. It provides a steadier flow of pressurized fluid to the crane's actuators (hoist motor, luffing cylinder, etc.).

(b) How Hydraulic Pressure is Regulated:

A constant pressure system maintains a set pressure level throughout the circuit. Here's how it's achieved:

- **Pressure Relief Valve:** This safety valve is the primary pressure regulation mechanism. It's set to a specific pressure threshold. If the system pressure exceeds this limit due to pump output, the pressure relief valve opens and diverts excess fluid back to the reservoir. This bypass mechanism ensures the pressure doesn't climb above the safe operating limit.
- **Pump Unloading Valve (Optional):** Some systems might incorporate an additional pump unloading valve. This valve can be controlled by the system pressure. When the pressure reaches the desired level, the valve unloads the pump by diverting its output back to the reservoir. This prevents unnecessary energy consumption when the system doesn't require full pump capacity.

(c) How Speed and Direction of the Hoist Motor are Varied:

The speed and direction of the hoist motor (responsible for raising and lowering loads) are typically controlled using a **solenoid-operated directional control valve**. This valve has multiple positions that can be activated by electrical signals from the crane operator's controls. Here's how it works:

- **Center:** Neutral position, fluid flow is blocked within the valve. The hoist motor remains stationary.
- **Port 1:** Directs pressurized fluid to one side of the hoist motor, causing it to rotate in a specific direction (raising the load).
- **Port 2:** Directs pressurized fluid to the opposite side of the hoist motor, causing it to rotate in the opposite direction (lowering the load).
- **Relief:** The valve might have a built-in pressure relief function to bypass excess pressure if needed.

By controlling the direction of fluid flow using the solenoid valve, the operator can change the rotation direction of the hoist motor, achieving raising or lowering of the load. The speed of the motor is primarily controlled by the flow rate of the pressurized fluid. A higher flow rate translates to a faster motor speed (faster lifting or lowering). This flow rate can be indirectly controlled by adjusting the engine speed of the prime mover driving the pump (assuming a variable-speed engine is used).

In some systems, additional components like flow control valves might be introduced to offer more precise control over the flow rate and, consequently, the hoist motor speed.

(d) How Torque Available from the Hoist Motor Can be Varied:

The torque available from the hoist motor is primarily determined by the system pressure and the displacement of the motor itself. In this constant pressure system:

- **System Pressure:** Since the pressure is maintained at a constant level by the pressure relief valve, it cannot be directly adjusted to vary torque.
- **Hoist Motor Displacement:** The displacement of the hoist motor is a fixed design parameter. A larger displacement motor can inherently generate higher torque compared to a smaller one at the same pressure.

Therefore, in this specific system configuration, the torque available from the hoist motor is limited and cannot be easily varied during operation.

However, some crane designs might incorporate additional features to achieve variable torque, such as:

- **Multiple Speed Motors:** Using a multi-speed hoist motor with different displacement settings allows for selecting a gear that offers the desired torque for the specific load.
- **Variable Displacement Pump (if not a fixed displacement pump):** If the system utilizes a variable displacement pump, the pump output (flow rate and pressure) can be adjusted, indirectly affecting the torque available at the hoist motor.

It's important to note that the specific methods for controlling speed, direction, and torque can vary depending on the crane's design and the manufacturer's chosen control system.2021

March 2021

2. Describe, with the aid of a sketch, a variable frequency drive for speed control of a three phase motor. (10)

A Variable Frequency Drive (VFD), also known as an Adjustable Speed Drive (ASD), is a device that controls the speed of a 3-phase AC induction motor. It achieves this by manipulating both the frequency and voltage of the power supply delivered to the motor. Here's a breakdown of its operation:

Components:

1. **Rectifier:** This circuit converts the incoming 3-phase AC mains supply into a pulsating DC voltage.
2. **DC Link Capacitor:** This capacitor stores the DC voltage from the rectifier and smooths out the pulsations, providing a more stable DC voltage level.
3. **Inverter:** This section converts the DC voltage back into a 3-phase AC output, but with variable frequency and voltage control. It employs switching devices like Insulated-Gate Bipolar Transistors (IGBTs).
4. **Control Unit:** This is the brain of the VFD. It receives a control signal (e.g., from a potentiometer, keypad, or external control system) representing the desired motor speed. The control unit processes this signal and generates control pulses that determine the switching pattern of the inverter's IGBTs.
5. **Gate Drive Circuit:** This circuit amplifies and isolates the control unit's low-power signals and uses them to control the switching of the IGBTs in the inverter.
6. **Motor:** The 3-phase AC induction motor whose speed is being controlled by the VFD's variable frequency and voltage output.

Operation:

1. The AC mains supply (3-phase) is fed into the VFD.
2. The rectifier converts the AC voltage into a pulsating DC voltage.
3. The DC link capacitor stores the DC voltage and smooths out the pulsations.
4. The control unit receives a speed control signal and generates control pulses based on the desired motor speed.
5. The gate drive circuit uses these control pulses to rapidly switch the IGBTs in the inverter on and off.
6. By varying the switching pattern of the IGBTs, the inverter generates a new 3-phase AC output with a controlled frequency and voltage. This output follows the V/f (voltage-to-frequency) ratio principle, ensuring the motor's magnetic field strength remains relatively constant for optimal torque across a wide speed range.
7. The controlled 3-phase AC output from the inverter is then supplied to the motor, which adjusts its speed based on the applied frequency and voltage.

Benefits of VFDs:

- **Precise Speed Control:** VFDs offer precise control over the speed of 3-phase AC induction motors, allowing for more efficient operation in applications requiring variable speeds.
- **Improved Efficiency:** By operating the motor at its optimal speed for the load, VFDs can significantly improve overall system efficiency and reduce energy consumption.
- **Soft Start and Reduced Stress:** VFDs can provide a "soft start" function, gradually increasing the motor's speed and voltage during startup. This reduces the inrush current and mechanical stress on the motor and driven equipment.
- **Extended Motor Life:** Improved control and reduced stress during operation contribute to a longer lifespan for the motor.

In summary, VFDs play a crucial role in various industrial applications where precise control and efficient operation of 3-phase AC induction motors are critical.

March 2021

3. With reference to variable speed control of a 3 phase ac induction motors:

(a) explain why EACH of the following is not preferred:

(i) variable voltage, constant frequency; (3)

(ii) variable frequency, constant voltage. (3)

(b) explain why voltage and frequency should both be varied. (4)

Variable Speed Control for 3-Phase AC Induction Motors: Importance of V/f Ratio

Here's a breakdown of why neither constant voltage nor constant frequency is ideal for variable speed control of 3-phase AC induction motors, and why both should be varied for optimal operation:

(a) Limitations of Single Variable Control:

(i) Variable Voltage, Constant Frequency:

- **Reduced Starting Torque:** While reducing voltage can lower motor speed, it also weakens the magnetic field strength in the motor. This directly impacts the motor's ability to generate torque. The motor will struggle to overcome the initial load (starting torque) at lower speeds due to the weaker magnetic field.
- **Increased Current Draw:** To compensate for the weakened magnetic field and maintain torque at lower voltages, the motor will try to draw a higher current. This excessive current can lead to:
    - **Overheating:** Increased current flow generates more heat in the motor's windings, potentially causing damage if not properly managed.
    - **Reduced Efficiency:** A significant portion of the electrical energy gets wasted as heat due to the higher current draw, decreasing overall efficiency.

(ii) Variable Frequency, Constant Voltage:

- **Flux Saturation at High Speeds:** If the voltage remains constant while increasing frequency, the motor's magnetic field strength will also increase proportionally. However, at high speeds, this can lead to a phenomenon called "flux saturation." The iron core of the motor can no longer effectively support the increasing magnetic field, leading to several problems:
    - **Increased Iron Losses:** Energy is wasted due to increased eddy current and hysteresis losses in the motor's iron core.
    - **Increased Noise:** The stronger magnetic field interacting with the motor's structure can cause higher operating noise levels.
    - **Potential Motor Damage:** In extreme cases, severe flux saturation can damage the motor's insulation.

(b) Importance of Variable Voltage and Frequency (V/f Ratio):

To achieve efficient and controllable variable speed operation in a 3-phase AC induction motor, both voltage and frequency need to be adjusted in a specific relationship:

- **Constant V/f Ratio:** This principle states that the ratio of voltage (V) to frequency (f) should be maintained constant for optimal motor operation. As you vary the frequency to adjust the speed, you must also proportionally adjust the voltage to maintain the magnetic field strength within a desirable range.
- **Benefits:**
    - **Consistent Torque:** By maintaining the V/f ratio, the motor's magnetic field strength remains relatively constant, resulting in consistent torque across a wide speed range. This ensures the motor has the necessary power to handle the load even at varying speeds.
    - **Reduced Current Draw:** Operating at the appropriate voltage for the speed prevents excessive current draw at lower speeds and avoids flux saturation at higher speeds. This improves overall efficiency and motor health.
    - **Reduced Iron Losses and Noise:** Maintaining the V/f ratio avoids flux saturation at high speeds, minimizing iron losses and noise generation, leading to quieter operation.

In conclusion, modern variable speed drives (VSDs) or inverters utilize this principle. They convert the fixed-frequency AC supply into a variable-frequency and voltage output to control the speed of the AC induction motor efficiently. They ensure the V/f ratio is maintained throughout the speed range for optimal performance.

arch 2021

March 2021

4. Describe, with the aid of a sketch, a Direct Expansion Regrigeration System for an air cooler in an air conditioning installation. (10)

In an air conditioning system, a Direct Expansion (DX) refrigeration system plays a critical role in cooling air for an air cooler. Here's how it works:

Components:

- **Compressor:** The heart of the system, it compresses low-pressure, low-temperature refrigerant vapor into a high-pressure, high-temperature gas.
- **Condenser:** A heat exchanger where the hot, high-pressure refrigerant gas releases its heat to the surrounding air (air-cooled condenser) or water (water-cooled condenser). During this process, the refrigerant condenses back into a liquid state.
- **Expansion Valve (or Throttling Device):** This valve regulates the pressure of the refrigerant. As the high-pressure liquid refrigerant passes through the expansion valve, it experiences a sudden pressure drop. This pressure drop causes the refrigerant to partially vaporize (flashing) and its temperature to decrease significantly.
- **Evaporator Coil:** Another heat exchanger located within the air cooler unit. The low-pressure, cold refrigerant liquid from the expansion valve absorbs heat from the warm, humid air passing over the evaporator coil. This absorbed heat causes the refrigerant to evaporate completely and turn back into a gas. The cooled air is then distributed throughout the conditioned space.
- **Piping:** Connects all the components, allowing the refrigerant to circulate through the closed-loop system.

The Cycle:

1. **Compression:** The compressor draws in low-pressure refrigerant vapor from the evaporator coil. It then compresses the vapor, increasing its pressure and temperature.
2. **Condensation:** The hot, high-pressure refrigerant gas enters the condenser. Here, the refrigerant releases its heat to the surrounding air (or water) through the condenser coils. As it loses heat, the refrigerant condenses back into a high-pressure liquid state.
3. **Expansion:** The high-pressure liquid refrigerant passes through the expansion valve. The sudden pressure drop causes the liquid to partially vaporize (flashing) and its temperature to decrease significantly. This creates a cold liquid-vapor mixture.
4. **Evaporation:** The cold refrigerant mixture enters the evaporator coil within the air cooler. Warm, humid air is drawn across the evaporator coil by a fan. The refrigerant absorbs heat from the air, causing it to cool down. The cooled air is then distributed through the ductwork to the conditioned space.
5. **Repeat:** The low-pressure, low-temperature refrigerant vapor from the evaporator is then drawn back into the compressor, and the cycle repeats continuously.

Benefits of DX Systems for Air Coolers:

- **Simple and Compact:** DX systems have a relatively simple design with fewer components compared to other cooling systems. This makes them compact and easier to integrate into air cooler units.
- **Efficient:** DX systems can be quite efficient in terms of energy consumption, especially when compared to chilled water systems.
- **Zonal Cooling:** Individual air coolers with DX systems allow for more control over temperature in different zones of a building.

Overall, Direct Expansion refrigeration systems offer a reliable and efficient solution for cooling air in air conditioning installations.

March 2021

5. Describe, with the aid of a sketch, how the relative humidity may be controlled in an Air Conditioning System. (10)

Air conditioning systems can control relative humidity through a combination of dehumidification and humidification processes. Here's how:

Dehumidification (Moisture Removal):

- **Cooling and Condensation:** The most common method utilizes the air conditioner's cooling cycle. As warm, humid air passes over the cold evaporator coil, the moisture condenses on the coil due to the lower dew point temperature. This condensed water is then drained away, effectively removing moisture from the air and reducing its relative humidity.
- **Desiccant Dehumidification:** This method uses a desiccant material (a moisture-absorbing substance) to attract and hold water vapor from the air. The desiccant is then regenerated by heating it, releasing the captured moisture and allowing it to be reused. This method is typically used in specialized applications or when very low humidity levels are required.

Humidification (Moisture Addition):

In some cases, particularly in dry climates, air conditioning can lead to excessively dry air, which can be uncomfortable and cause health problems. To address this, humidification strategies can be employed:

- **Steam Humidifiers:** These devices boil water to create steam, which is then released into the air, increasing the moisture content.
- **Evaporative Humidifiers:** These work by passing dry air through a water-saturated filter. As the air passes through, it absorbs moisture, increasing the relative humidity.

Controlling Humidity Levels:

- **Humidistats:** These are control devices similar to thermostats but for humidity. They sense the relative humidity in the air and send signals to the air conditioning system to activate dehumidification or humidification processes as needed to maintain a desired humidity level.
- **Integrated Systems:** Modern air conditioning systems may have built-in dehumidification and humidification capabilities. These systems can automatically adjust both temperature and humidity based on user settings and sensor readings.

Choosing the Right Method:

The specific method used for humidity control depends on several factors, including:

- **Desired indoor climate:** Target comfort levels and any specific humidity requirements.
- **Climate:** Whether the primary concern is removing moisture (humid climates) or adding moisture (dry climates).
- **System capabilities:** The features and functionalities of the air conditioning system.

By employing these methods and controls, air conditioning systems can effectively maintain comfortable and healthy indoor environments by regulating both temperature and relative humidity.

March 2021

6. Describe the effects of EACH of the following contaminants when found in air required for breathing and diving use:

(a) oil vapour; (4)

(b) water vapour; (4)

(c) overheated oil. (2)

Contaminant Effects in Breathing Air for Diving:

(a) Oil Vapour:

- **Effect:** Oil vapors from compressor lubricant can irritate the respiratory system, causing coughing, wheezing, and shortness of breath. In severe cases, they can lead to fluid buildup in the lungs (pulmonary edema).
- **Mechanism:** Oil molecules can coat the delicate lining of the lungs, hindering the normal exchange of oxygen and carbon dioxide. Additionally, some oil components can trigger an inflammatory response in the lungs, leading to fluid buildup and breathing difficulties.

(b) Water Vapour:

- **Effect:** At normal diving depths, moderate levels of water vapor in compressed air are not a significant health concern. However, excessive water vapor can:
    - **Reduce Oxygen Availability:** High humidity in the air reduces the partial pressure of oxygen, potentially leading to a lower oxygen concentration available for divers at depth. This can increase the risk of hypoxia (oxygen deficiency) and its associated symptoms like dizziness, confusion, and unconsciousness.
    - **Corrosion:** Excess moisture can contribute to corrosion within the diving equipment, including regulators and cylinder valves.
    - **Frost Formation:** At very cold water temperatures, high water vapor content in the breathing air can lead to frost formation within the regulator, potentially hindering airflow and compromising breathing performance.

(c) Overheated Oil:

- **Indirect Effect:** While overheated oil itself won't be present in the breathing air, it's an indicator of a potential problem with the compressor. Overheated oil can decompose and generate harmful byproducts like hydrocarbons and aldehydes. These contaminants can then enter the compressed air stream through leaks or inefficiencies in the filtration system, posing similar health risks as oil vapor exposure (irritation, inflammation, pulmonary edema).
- **Additional Concern:** Overheated oil may also reduce the effectiveness of the lubrication process, leading to increased wear and tear on the compressor components. This can increase the risk of component failure and potential leakage of oil or other contaminants into the air stream.

Key Takeaway:

Maintaining clean, dry, and contaminant-free breathing air is crucial for diver safety. Regular maintenance of the compressor system and proper filtration are essential to minimize the presence of harmful vapors and ensure divers have a safe and reliable air supply during their dives.

June 2021

March 2021

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

   (a) outline FIVE maintenance procedures to be carried out on lifting equipment; (5)

   (b) state who should carry out the examination of the lifting equipment, the interval between examinations and the defects that may be found. (5)

Lifting Equipment Maintenance Procedures (based on COSWP):

The COSWP emphasizes following manufacturer's instructions for specific equipment. However, here are five general maintenance procedures applicable to most lifting equipment:

1. **Pre-Operational Checks:** Before each use, a designated crew member should perform a visual inspection of the equipment, looking for:
   - Visible signs of damage (cracks, corrosion, wear)
   - Missing or loose pins, bolts, or fasteners
   - Proper lubrication of moving parts
   - Functionality of brakes and safety devices
2. **Regular Cleaning and Lubrication:** At regular intervals (daily, weekly, or as per manufacturer's instructions), the equipment should be cleaned of dirt, grease buildup, and debris. Lubrication points should be refilled with the recommended grease or oil to ensure smooth operation and minimize wear.
3. **Periodic Inspections:** More comprehensive inspections should be carried out periodically by a competent person (e.g., qualified crew member, shore-based engineer, or surveyor) as recommended by the manufacturer. These inspections may involve:
   - Non-destructive testing (NDT) techniques like ultrasonic testing to identify internal cracks or flaws.
   - In-depth examination of wire ropes, slings, and chains for wear, breaks, or deterioration.
   - Verification of the functionality of limit switches, overload protection devices, and other safety features.
4. **Wire Rope Maintenance:** Wire ropes are critical components and require special attention. This may include:
   - Regular inspection for broken wires, corrosion, or loss of strand diameter.
   - Proper lubrication to minimize wear and corrosion.
   - Reversal of the ends on a regular basis to ensure even wear.
   - Replacement when reaching the manufacturer's recommended discard criteria.
5. **Record Keeping:** All maintenance activities, inspections, and repairs should be documented in the ship's "Register of Lifting Appliances and Gear". This record should include:
   - Date of maintenance/inspection
   - Description of work performed
   - Details of any defects found
   - Name of the person who carried out the work

Lifting Equipment Examinations:

(a) Who: The COSWP doesn't provide a specific definition of "competent person" but generally refers to someone with qualifications, knowledge, and experience in inspecting lifting equipment. This could be a qualified surveyor, shore-based engineer, or a designated crew member with relevant training.

(b) Interval: The interval between examinations depends on the type of equipment, its frequency of use, and any relevant regulations. The primary sources for determining the interval are:

- **Manufacturer's Instructions:** Lifting equipment should be thoroughly examined and tested at the intervals recommended by the manufacturer.
- **Regulations:** Some countries or regulatory bodies may have additional mandatory testing requirements that supersede or supplement the manufacturer's recommendations.

(c) Defects: During examinations, a competent person might find various defects, including:

- **Wire rope damage:** Broken wires, corrosion, or excessive wear.
- **Cracks or deformations:** In metal components like hooks, shackles, or crane booms.
- **Malfunctioning safety devices:** Faulty brakes, limit switches, or overload protection systems.
- **Loose or missing fasteners:** Pins, bolts, or nuts that could compromise the equipment's integrity.
- **Improper lubrication:** Lack of grease or oil in critical areas leading to increased wear.

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

March 2021

8. Describe the procedure that should be followed if an outboard motor has been submerged in sea water. (10)

Here's the procedure you should follow if an outboard motor has been submerged in seawater:

Immediate Actions:

1. **Safety First:** Ensure your own safety and the safety of others by turning off the engine (if still running) and disconnecting the battery to prevent electrical hazards.
2. **Retrieve the Engine:** If possible, retrieve the outboard motor from the water as soon as possible. Saltwater exposure can accelerate corrosion.

Prevent Further Damage:

1. **Do Not Start the Engine:** Resist the urge to start the engine. Starting a submerged engine can cause internal damage by forcing saltwater through the system.
2. **Flush with Fresh Water:** As soon as possible, thoroughly flush the outboard motor with clean, fresh water. This will help remove saltwater residue and prevent corrosion. You can use a garden hose with a moderate spray pattern to avoid damaging internal components.

Detailed Cleaning and Inspection:

1. **Drain Fluids:** Drain the engine oil, gear oil, and any other fluids that may have been contaminated with saltwater.
2. **Spark Plugs:** Remove the spark plugs and allow the cylinders to drain any trapped water. You can crank the engine slowly with the spark plugs removed to further expel water.

3. **Air Intake:** Inspect the air intake for any water ingress. Remove any water or debris that may have entered the air filter.
4. **Corrosion Prevention:** Apply a light coating of corrosion inhibitor spray to all metal surfaces after rinsing with fresh water.

Maintenance and Restart:

1. **Professional Inspection:** It's highly recommended to have a qualified outboard mechanic inspect the engine for any internal damage caused by the submersion. They can assess the condition of bearings, seals, and other critical components.
2. **Oil Change:** Replace the engine oil and gear oil with fresh lubricants after the inspection.
3. **Refill Fluids:** Refill any other fluids that were drained during the cleaning process.
4. **Test and Restart:** Only after a thorough inspection and any necessary repairs, attempt to restart the engine. Follow the manufacturer's recommended procedures for starting the engine after submersion.

Additional Considerations:

- **Freshwater vs. Saltwater Submersion:** While these steps provide a general guideline, the specific actions might differ slightly depending on whether the submersion occurred in freshwater or saltwater. Saltwater is more corrosive, so a more meticulous freshwater flush and inspection may be necessary.
- **Severity of Submersion:** The extent of the cleaning and inspection procedure may also depend on the severity of the submersion. A complete submersion for an extended period will likely require a more comprehensive inspection than a brief dunk.
- **Manufacturer's Recommendations:** Always refer to the owner's manual for your specific outboard motor model for any specific instructions or recommendations regarding submersion and recovery procedures.

Following these steps promptly after submersion can help minimize damage to your outboard motor and increase the chances of a successful recovery. However, a professional inspection by a qualified mechanic is highly recommended to ensure the engine's safety and performance after a saltwater submersion.

March 2021

9. With reference to a vessel's motion control:

(a) outline the SIX degrees of freedom; (3)

(b) explain the term *damping;* (4)

(c) state THREE considerations to be made, before the installation of a motion reduction system. (3)

Vessel Motion Control:

(a) Six Degrees of Freedom:

A vessel at sea can move in six degrees of freedom. These six independent motions are crucial to understand when considering a vessel's motion control:

1. **Surge:** Movement forward and backward (along the vessel's longitudinal axis).
2. **Sway:** Movement sideways (to port or starboard, along the vessel's transverse axis).
3. **Heave:** Vertical movement (up and down).
4. **Roll:** Rotational movement about the longitudinal axis (vessel tilting to port or starboard).
5. **Pitch:** Rotational movement about the transverse axis (vessel tilting forward or aft).
6. **Yaw:** Rotational movement about the vertical axis (vessel turning left or right).

(b) Damping:

In vessel motion control, damping refers to the process of reducing or suppressing the amplitude of a vessel's motion. This can be achieved through various methods, including:

- **Hydrodynamic damping:** The inherent resistance of the water to the vessel's movement.
- **Bilge keels:** Protruding fins attached to the hull that increase drag and reduce roll.
- **Active fins or rudders:** Controllable fins or rudders that generate opposing forces to counteract wave-induced motions.
- **Stabilizers:** Retractable fins or tanks filled with liquid that extend outward and move in opposition to wave motions, reducing roll.

(c) Considerations Before Installing a Motion Reduction System:

Before installing a motion reduction system on a vessel, several factors need to be carefully considered:

1. **Operational Needs:** The specific needs of the vessel's operation should be evaluated. For example, a research vessel might prioritize minimizing roll for stable sensor readings, while a passenger ferry might focus on reducing pitch for passenger comfort.
2. **Sea State Conditions:** The typical sea state conditions the vessel will encounter should be considered. Different systems may be more effective in specific wave types or frequencies.
3. **Cost and Size:** Motion reduction systems can be complex and expensive. The size and weight of the system need to be compatible with the vessel and its available space.
4. **Impact on Performance:** Some systems, like active fins or rudders, may require additional power consumption or introduce drag that could affect vessel speed or fuel efficiency.
5. **Maintenance Requirements:** The complexity of the system will determine its maintenance needs. These costs and crew expertise requirements should be factored in.

By carefully evaluating these considerations along with the specific vessel and its operational profile, choosing the most suitable motion reduction system can significantly improve seaworthiness, crew and passenger comfort, and operational efficiency.

March 2021

10. With reference to the International Convention for the Safe and Environmentally Sound Recycling of Ships:

(a) state the operational requirements for compliance; (4)

(b) list FOUR prohibited hazardous materials; (4)

(c) list TWO hazardous materials whose use should be restricted. (2)

The International Convention for the Safe and Environmentally Sound Recycling of Ships, also known as the Hong Kong Convention (HKC), aims to ensure responsible ship recycling practices. While not yet in effect, here's what it entails:

(a) Operational Requirements for Compliance:

The HKC outlines several requirements for ship owners and recycling facilities to achieve compliant ship recycling:

- **Inventory of Hazardous Materials (IHM):** Ships must maintain a detailed IHM that identifies the type, location, and quantity of hazardous materials onboard. This allows for safe handling and removal during recycling.
- **Ship Recycling Plan (SRP):** A specific plan for each ship's recycling process needs to be developed. This plan should consider factors like waste management, worker safety, and environmental protection.
- **Recycling Facility Requirements:** Recycling facilities must be authorized and operate according to the HKC guidelines. This includes having proper equipment, trained personnel, and procedures for handling hazardous materials and pollutants.
- **Flag State and Recycling State Cooperation:** The flag state (country of registration) and the recycling state (country where the ship is recycled) have responsibilities to ensure the recycling process adheres to the Convention.

(b) Four Prohibited Hazardous Materials:

The HKC strictly prohibits the presence of certain hazardous materials in ships destined for recycling. These include:

1. **Polychlorinated Biphenyls (PCBs):** These organic chemicals were used in various applications like transformers and capacitors but are now banned due to their environmental and health risks.
2. **Hexachlorobenzene (HCB):** This persistent organic pollutant was used as a fungicide but is now banned due to its toxicity and bioaccumulation potential.
3. **Lightweight halogenated hydrocarbons (LBHs):** This category includes certain ozone-depleting substances like chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) used in refrigeration and fire suppression systems.
4. **Lead compounds:** Lead is a toxic metal historically used in paints, coatings, and other materials. Its presence requires special handling during ship recycling.

(c) Two Hazardous Materials with Restricted Use:

The HKC also restricts the use of certain materials in ships, requiring careful management during recycling:

1. **Asbestos:** This fibrous mineral was used for insulation but can cause serious health problems like lung cancer. Ships containing asbestos need specific removal and disposal procedures.
2. **Polybrominated Biphenyl Ethers (PBDEs):** These flame retardants were used in various ship materials but are now restricted due to concerns about their environmental persistence and potential health effects.

By adhering to these regulations, the HKC aims to minimize the environmental and health hazards associated with ship recycling.

Sources

www.vesselfinder.com/news/19825-Seaspan-Fleet-Achieves-IHM-Certification