Nov 2023

1. Describe, with the aid of sketches, the operating principle of an axial variable delivery hydraulic pump. ✓ (10)

Nov 2023

2. Describe, with the aid of a sketch, a hydraulic rack and pinion starting system, labelling the MAIN components. ✓ (10)

Nov 2023

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. Rheat! (4)

Nov 2023

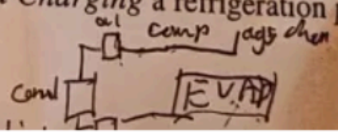
4. With reference to two identical generators operating in parallel supplying a switchboard that automatically shares load equally, explain EACH of the following:

   (a) the effect of the excitation of <u>one</u> generator reducing while the load remains constant; (5)

   (b) the possible effects of closing the main circuit breaker when frequency and voltage are equal but phases are out of phase. damage (5)

Nov 2023

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



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6. With reference to blended refrigerants, explain EACH of the following terms, stating the refrigerant state required for charging:

(a) azeotrope; (3)

(b) zeotrope; (4)

(c) near-azeotrope. (3)

Nov 2023

7. (a) Sketch a Chemical Filter tower supplying air suitable for breathing and diving, labelling ALL elements. (6)

(b) Explain the purpose of TWO of the filter elements sketched in part(a). (4)

Nov 2023

8. (a) State the maximum time periods between EACH of the following lifting equipment requirements:

(i) inspection; (1)

(ii) testing. (1)

(b) Describe the inspection routine for lifting gear. (6)

(c) State the procedure for recording the results of the inspection and tests. (2)

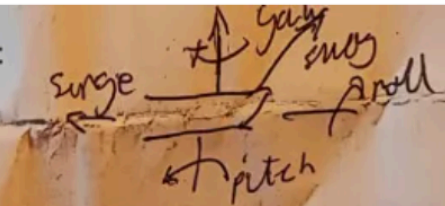
Nov 2023

9. State the safety requirements for small lockers on open deck storing petrol and other highly inflammable liquids in hand portable containers. (10)

Nov 2023

10. 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)

Nov 2023

1. Describe, with the aid of sketches, the operating principle of an axial variable delivery hydraulic pump. (10)

An axial variable displacement hydraulic pump uses a combination of pistons, a cylinder block, and a swash plate to convert rotational input from a drive shaft into variable fluid flow. Here's a breakdown of its operation:

Components:

- **Drive Shaft:** Rotates to provide power to the pump.
- **Cylinder Block:** Contains cylindrical chambers where pistons reside.
- **Pistons:** Cylindrical plungers that slide within the cylinder block, creating the pumping action.
- **Swash Plate:** A flat plate angled relative to the drive shaft. Pistons connect to the swash plate through a slipper or yoke.

Operating Principle:

1. **Rotation:** The drive shaft rotates, causing the cylinder block and pistons to rotate along with it.
2. **Angled Swash Plate:** The swash plate is not perpendicular to the drive shaft, but tilted at a specific angle.
3. **Piston Movement:** Due to the angle of the swash plate, the pistons move in an axial direction (parallel to the drive shaft) as they rotate with the cylinder block. The piston stroke length depends on this angle.
4. **Intake and Discharge:** During each rotation:
   - On one side of the cylinder block, the pistons tilt inwards (due to the swash plate angle), increasing their volume and creating a low-pressure zone. Hydraulic fluid flows from the reservoir to fill this space (intake).
   - On the opposite side, the pistons tilt outwards, decreasing their volume and creating a high-pressure zone. This pushes fluid out of the pump towards the hydraulic system (discharge).

Variable Displacement:

The key to variable flow lies in the swash plate angle. This angle can be adjusted through external controls (hydraulic, mechanical, or electrical) depending on the pump design.

- **Minimum Angle:** When the swash plate is nearly perpendicular to the drive shaft (minimal angle), the piston stroke length is minimal. This results in a low volume of fluid being drawn in and expelled per rotation (low flow rate).
- **Increased Angle:** Tilting the swash plate to a greater angle increases the piston stroke length. This allows for a larger volume of fluid to be moved per rotation, leading to a higher flow rate.

By controlling the swash plate angle, the pump can adjust its displacement (volume of fluid delivered per rotation) and consequently, the flow rate delivered to the hydraulic system. This allows for precise control over actuator speed and force in applications like construction equipment, mobile machinery, and industrial automation.

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2. Describe, with the aid of a sketch, a hydraulic rack and pinion starting system, labelling the MAIN components. (10)

A hydraulic rack and pinion starting system offers an alternative to traditional electric starter motors for large internal combustion engines, particularly in heavy machinery and industrial applications. Here's a breakdown of its main components and operation:

Main Components:

1. **Hydraulic Pump:** This is the heart of the system. It can be driven by an electric motor, a dedicated diesel engine, or even connected to the host machine's hydraulic system if available. The pump takes fluid from the reservoir and pressurizes it.
2. **Reservoir:** This tank stores the hydraulic fluid (usually oil) and maintains its level. It may also incorporate a breather filter to allow air exchange and prevent contamination.
3. **Directional Control Valve (Start Valve):** This valve controls the flow of pressurized fluid and directs it to the starter motor based on operator input (usually a start button or control system). It can be a solenoid-operated valve for precise control.
4. **Hydraulic Accumulator (Optional):** This component acts as a pressure accumulator and stores pressurized hydraulic fluid. It can provide a surge of high-pressure fluid during starting, especially beneficial for cold starts or large engines.
5. **Pressure Relief Valve:** This safety valve protects the system from excessive pressure build-up. It bypasses excess fluid back to the reservoir if the pressure exceeds a set limit.
6. **Hydraulic Starter Motor:** This is a specialized motor designed for high torque output using pressurized hydraulic fluid. It often uses a rack and pinion mechanism for gear reduction and increased torque output.
   - **Rack:** A linear gear that translates the hydraulic force into a linear motion.
   - **Pinion:** A circular gear that meshes with the rack and converts the linear motion into rotary motion to crank the engine.
7. **Engagement Mechanism:** This mechanism ensures proper engagement of the pinion gear with the engine's flywheel ring gear during starting. It might involve a spring-loaded mechanism or a solenoid for automatic engagement/disengagement.

Operation:

1. **Engine Stopped:** The hydraulic pump is inactive, and the system is pressurized (either by the running engine's hydraulic system or a dedicated pump if separate).
2. **Start Command:** When the operator presses the start button, the directional control valve opens.
3. **Pressurized Fluid Flow:** Pressurized fluid from the reservoir (or accumulator) flows to the hydraulic starter motor.

4. **Engagement:** The engagement mechanism ensures proper meshing of the pinion gear with the engine's flywheel ring gear.
5. **Engine Cranking:** The pressurized fluid acting on the rack and pinion mechanism within the starter motor generates high torque, which is used to crank the engine's flywheel and initiate combustion.
6. **Engine Starts:** Once the engine reaches sufficient speed, the operator releases the start button, and the directional control valve closes.
7. **Disengagement:** The engagement mechanism automatically disengages the pinion gear from the flywheel ring gear to prevent unnecessary wear and tear.

Benefits of Hydraulic Rack and Pinion Starting System:

- **High Starting Torque:** The system provides exceptional cranking power for large engines, even in cold weather conditions.
- **Reduced Electrical Load:** Compared to electric starters, this system puts less strain on the electrical system, which can be beneficial for applications with limited battery capacity.
- **Durability:** Hydraulic components are generally robust and can withstand high loads, offering a longer lifespan compared to electric starters in demanding applications.
- **Scalability:** The system can be adapted to various engine sizes by selecting appropriate pump and starter motor capacities.

In conclusion, the hydraulic rack and pinion starting system offers a reliable and powerful solution for starting large internal combustion engines, particularly in heavy machinery and industrial settings.

Nov 2023

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: Why Both Voltage and Frequency Matter

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 leads to a significant decrease in starting torque, making it difficult for the motor to overcome initial load.
- **Increased Current Draw:** In an attempt to maintain torque at lower voltages, the motor will draw higher current. This can lead to overheating and potential motor damage.
- **Poor Efficiency at Low Speeds:** At very low speeds with reduced voltage, the motor's efficiency drops significantly, resulting in wasted energy.

(ii) Variable Frequency, Constant Voltage:

- **Flux Saturation at High Speeds:** If the voltage remains constant while increasing frequency, the motor's magnetic field strength can become excessively strong (flux saturation) at high speeds. This can lead to:
  - **Increased Iron Losses:** Energy wasted due to heating in the motor's iron core.
  - **Increased Noise:** Higher operating noise levels due to the stronger magnetic field interacting with the motor's structure.
  - **Potential Motor Damage:** In extreme cases, flux saturation can damage the motor's insulation.

(b) Importance of Variable Voltage and Frequency:

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 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.
  - **Reduced Current Draw:** Operating at the appropriate voltage for the speed prevents excessive current draw, improving 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.

Modern Variable Speed Drives:

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.

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4. With reference to two identical generators operating in parallel supplying a switchboard that automatically shares load equally, explain EACH of the following:

(a) the effect of the excitation of one generator reducing while the load remains constant; (5)

(b) the possible effects of closing the main circuit breaker when frequency and voltage are equal but phases are out of phase. (5)

damage

Two Identical Generators in Parallel with Automatic Load Sharing

Here's an explanation of the effects you requested regarding two identical generators operating in parallel with a load-sharing switchboard:

(a) Effect of Reduced Excitation on One Generator:

If the excitation (field current) of one generator reduces while the total load remains constant, the following will happen:

- **Reduced Voltage Generation:** The generator with reduced excitation will start producing less voltage due to a weaker magnetic field in its rotor.
- **Automatic Load Sharing:** The switchboard's load-sharing mechanism will detect the voltage difference between the generators.
- **Increased Load on Other Generator:** To compensate for the reduced output of the first generator, the switchboard will automatically adjust to shift more of the load onto the second generator. This ensures the total power delivered to the switchboard remains constant.
- **Increased Current in Second Generator:** As the second generator takes on a larger share of the load, the current flowing through its windings will increase.
- **Governor Response (Potential):** If the engine speed of the second generator starts to drop due to the increased load, its governor system might react by increasing fuel supply to maintain the desired speed. This will indirectly compensate for the reduced excitation in the first generator.

Important Note: The specific response of the system may vary depending on the design and control characteristics of the generators and the switchboard.

(b) Closing Main Circuit Breaker with Out-of-Phase Conditions:

Closing the main circuit breaker (MCB) that connects the generators to the switchboard when the frequency and voltage are equal but the phases are out of sync can have several detrimental effects:

- **Circulating Currents:** Due to the phase difference, the currents generated by the two machines will not be perfectly aligned. This can create circulating currents between the generators. These circulating currents do not contribute to useful power delivery and can cause:

- **Increased Heating:** Excessive heat generation in the windings of both generators due to the additional current flow.
- **Reduced Efficiency:** Wasted energy as heat instead of being delivered as usable power.
- **Potential Damage:** In extreme cases, the circulating currents can lead to mechanical stress and potential damage to the generators.

- **System Instability:** Depending on the severity of the phase difference and the system's capacity, the out-of-sync connection can lead to voltage and frequency instability, potentially causing disruptions or equipment damage.

Safety Precaution:

- Modern synchronization systems are designed to ensure the generators are in phase before connecting them to the switchboard. These systems prevent connecting the MCB when the phases are out of sync.

In conclusion, maintaining proper excitation and synchronizing phases are crucial for safe and efficient operation of generators running in parallel.2023

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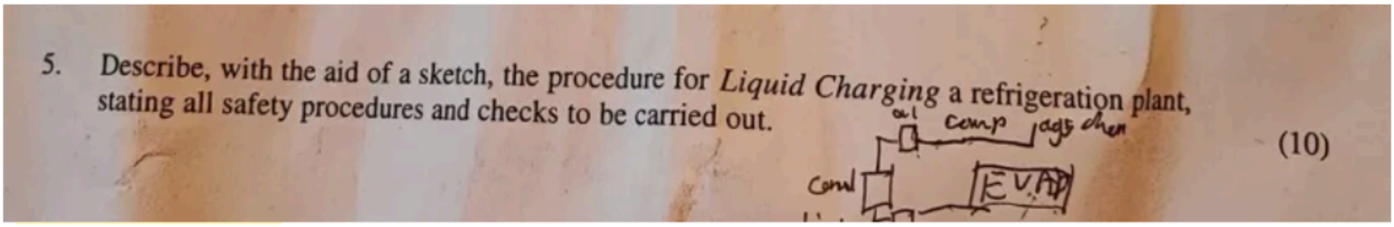
5. Describe, with the aid of a sketch, the procedure for *Liquid Charging* a refrigeration plant, stating all safety procedures and checks to be carried out. (10)

Liquid Charging Procedure for a Refrigeration Plant: Safety and Steps

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

Safety Precautions:

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

Charging Procedure:

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

Additional Considerations:

- **Manufacturer's Instructions:** Always refer to the specific equipment manufacturer's instructions and service manuals for detailed procedures and charging recommendations for your particular refrigeration plant.

- **Experience and Training:** Liquid charging, particularly for complex systems or those using environmentally hazardous refrigerants, should ideally be performed by a qualified technician with refrigeration experience.

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

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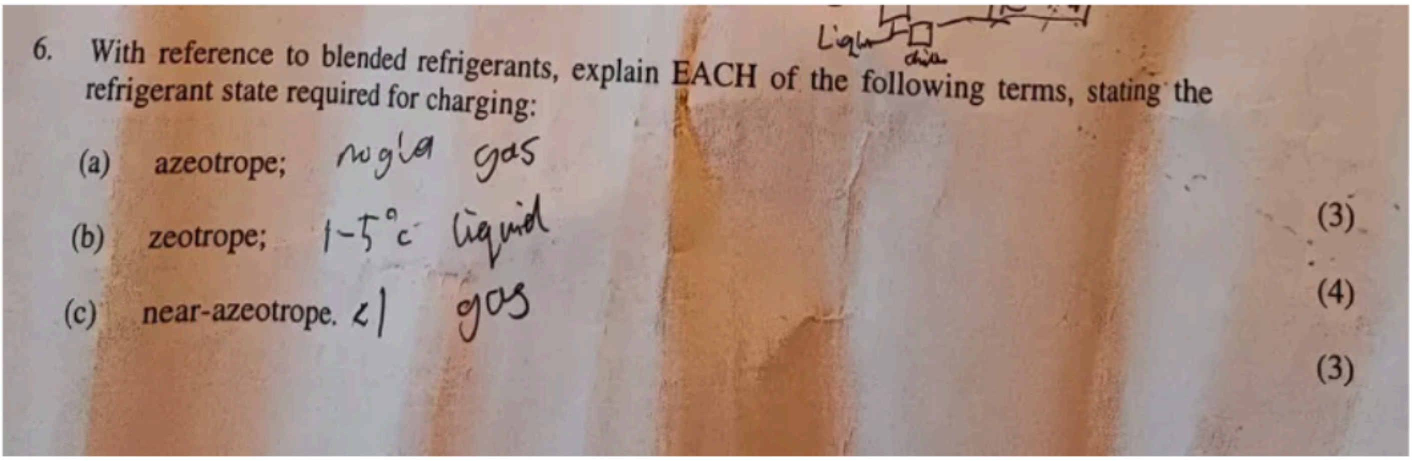

6. With reference to blended refrigerants, explain EACH of the following terms, stating the refrigerant state required for charging:

(a) azeotrope; (3)

(b) zeotrope; (4)

(c) near-azeotrope. (3)

Blended Refrigerant Terminology and Charging States:

Blended refrigerants are mixtures of two or more pure refrigerants. Here's an explanation of each term and the refrigerant state required for charging:

(a) Azeotrope & NGL (Natural Gas Liquids):

- **Azeotrope:**
  - Definition: An azeotropic blend is a mixture of refrigerants that behaves like a single-component refrigerant.
  - Charging State: **Liquid**
    Azeotropic blends can be charged in the liquid phase because, at a specific pressure, the liquid and vapor phases have the same composition. This simplifies charging as there's no need to worry about compositional changes during the process.
- **NGL (Natural Gas Liquids):**
  - Not directly related to azeotropic blends. NGL is a broad term referring to hydrocarbon liquids extracted from natural gas processing.
  - Charging State: **Depends on the specific NGL**
    Some NGL components, like propane, can be used as refrigerants or blended with other refrigerants. The charging state (liquid or vapor) would depend on the specific NGL being used and the overall blend composition. It's crucial to consult the specific refrigerant blend's technical data sheet for charging instructions.

(b) Zeotrope:

- **Zeotrope:**

- Definition: A zeotropic blend is a mixture of refrigerants where the liquid and vapor phases have different compositions at a given pressure.
- Charging State: **Liquid (special considerations)**
  Zeotropic blends require a specific charging technique to maintain the desired blend composition within the system. They cannot be simply charged like azeotropes.
    - **Liquid Line Charging with Vapor Recovery:** One method involves charging the system with liquid refrigerant while simultaneously recovering some vapor from the system to maintain the original blend composition.
    - **Component Charging:** In some cases, zeotropic blends may be charged by individually adding each component based on specific ratios. However, this method requires specialized equipment and expertise.

(c) Near-azeotrope:

- **Near-azeotrope:**
    - Definition: A near-azeotrope is a zeotropic blend with a very small temperature difference between the boiling points of its components. This difference is typically less than 10°F (5.6°C).
    - Charging State: **Liquid (generally)**
      Due to the minimal difference in boiling points, near-azeotropic blends can often be charged in the liquid phase similar to azeotropes. However, it's advisable to consult the specific refrigerant blend's data sheet for any specific charging recommendations.

Key Points:

- Azeotropic blends offer the advantage of simple liquid charging, while zeotropic blends require more specialized techniques.
- Near-azeotropic blends offer a compromise between the two, often allowing for liquid charging but referring to the manufacturer's instructions is crucial.
- Always consult the specific refrigerant blend's technical data sheet and manufacturer's recommendations for proper charging procedures to ensure optimal performance and system integrity.

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7. (a) Sketch a Chemical Filter tower supplying air suitable for breathing and diving, labelling ALL elements. (6)

(b) Explain the purpose of TWO of the filter elements sketched in part(a). (4)

(a) Chemical Filter Tower for Breathing Air: Elements Explained

A chemical filter tower used for purifying compressed air for breathing and diving applications typically consists of several key elements:

1. **Pre-filter:** This is the first stage and typically uses a high-efficiency particulate air (HEPA) filter. It removes dust, particles, and other airborne contaminants from the incoming air stream.
2. **Moisture Separator (Optional):** In some systems, a moisture separator may be included before the chemical filters. This separator removes excess moisture from the air, which can help prevent corrosion within the system and improve the effectiveness of the subsequent chemical filters.
3. **Carbon Monoxide (CO) Filter:** This filter media contains specialized materials that selectively adsorb carbon monoxide (CO) from the air stream. This is crucial as CO can be highly dangerous for divers, reducing the blood's ability to carry oxygen.
4. **Hydrocarbon (Oil Vapor) Remover:** This filter element utilizes media that absorbs or chemically reacts with hydrocarbon vapors, such as those from compressor oil. These vapors can irritate the respiratory system and pose health risks to divers.
5. **After-filter:** The final stage often includes another HEPA filter to capture any residual contaminants that may have passed through the previous stages.
6. **Pressure Regulator:** This valve regulates the compressed air pressure to a level suitable for breathing applications (typically around 3000 psi or 20.7 MPa).
7. **Pressure Gauge:** This gauge indicates the pressure of the compressed air leaving the filter tower, allowing divers to verify the air supply is within the safe operating range.

(b) Purpose of Two Filter Elements:

1. **Carbon Monoxide (CO) Filter:**
   - **Purpose:** This filter selectively removes carbon monoxide (CO) from the air stream. CO is a highly toxic gas that binds to hemoglobin in the blood more readily than oxygen. This reduces the blood's ability to carry oxygen to vital organs, leading to dizziness, confusion, unconsciousness, and even death in severe cases. Even low levels of CO exposure can impair a diver's judgment and coordination, increasing the risk of accidents. The CO filter media typically contains specialized materials like activated alumina or zeolites impregnated with specific chemicals that react with and trap CO molecules as the air passes through.
2. **Hydrocarbon (Oil Vapor) Remover:**
   - **Purpose:** This filter element removes harmful hydrocarbon vapors, primarily from compressor lubricants, that can contaminate the compressed air. These vapors 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). The specific media used in this filter may vary, but it often involves activated carbon or other adsorbent materials that trap the hydrocarbon molecules on their large surface area.

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8. (a) State the maximum time periods between EACH of the following lifting equipment requirements:

(i) inspection; yearly (1)

(ii) testing. 5 yearly (1)

(b) Describe the inspection routine for lifting gear. (6)

(c) State the procedure for recording the results of the inspection and tests. (2)

Here's a breakdown of the maximum time periods between lifting equipment requirements:

(a) Inspection and Testing Intervals:

The specific intervals for inspection and testing of lifting equipment can vary depending on the regulations in your region. Here's a general guideline based on some common standards:

- **Inspection:** Inspections are typically required **more frequently** than testing. Common intervals for thorough inspections range from:
  - **Daily:** This is often recommended for frequently used equipment or equipment subjected to harsh conditions.
  - **Weekly or Monthly:** This is a common frequency for many lifting equipment types.
  - **Six Months:** This might be applicable for specific equipment with lower usage or less critical applications.
- **Testing:** Testing is usually performed **less frequently** than inspections. Common intervals for thorough examinations and load testing may include:
  - **Every 12 Months:** This is a common standard for many lifting equipment types.
  - **Every 6 Months:** This might be required for lifting equipment used to lift people or for critical applications.

It's crucial to consult the relevant regulations and manufacturer's recommendations for the specific equipment you're using to determine the exact required inspection and testing intervals.

(b) Lifting Gear Inspection Routine:

A thorough inspection of lifting gear should typically include the following steps:

1. **Visual Inspection:** Carefully examine all components of the lifting equipment for any signs of damage, wear and tear, corrosion, cracks, or deformation. This includes checking:
   - Chains, slings, and ropes for broken links, excessive wear, or deterioration.
   - Hooks and shackles for cracks, distortion, or missing safety pins.
   - Lifting beams and other structural components for bends, cracks, or loose connections.
   - Labels and markings for legibility and compliance with regulations.
   - Any safety devices like overload protection systems for proper operation.

2. **Operational Checks:** Verify the functionality of all moving parts, ensuring smooth operation and proper engagement of mechanisms. This might involve:
   - Testing the operation of brakes and locking mechanisms.
   - Checking the functionality of winches or hoists.
   - Verifying the smooth operation of sheaves and rollers.
3. **Documentation Review:** Ensure all relevant documentation is present and up-to-date, including:
   - Inspection reports from previous inspections.
   - Manufacturer's certificates and user manuals.
   - Proof load test certificates if applicable.

(c) Recording Inspection and Test Results:

The results of inspections and tests of lifting equipment should be documented and kept readily available for future reference. This documentation typically includes:

- **Equipment Identification:** Unique identifier of the lifting equipment.
- **Date of Inspection/Test:** Record the date the inspection or test was carried out.
- **Inspector/Tester Information:** Details of the qualified inspector or testing personnel.
- **Detailed Findings:** A detailed record of all observations made during the inspection, including any defects or issues identified.
- **Test Results:** If a load test was performed, record the test results and confirm compliance with lifting capacity.
- **Actions Taken:** Record any actions taken following the inspection or test, such as repairs, replacements, or taking the equipment out of service.

The specific format for recording inspection and test results may vary depending on your organization's procedures and regulations. It's important to maintain a clear and organized system for documenting these critical records.

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9. State the safety requirements for small lockers on open deck storing petrol and other highly inflammable liquids in hand portable containers. (10)

Here are the safety requirements for small lockers on open deck storing petrol and other highly flammable liquids in hand portable containers:

Locker Construction and Placement:

- **Non-combustible materials:** The lockers must be constructed from fire-resistant materials like sheet metal, fiberglass reinforced plastic (GRP), or other approved materials that can withstand heat and flames.
- **Away from heat sources:** Position the lockers away from potential ignition sources such as engines, exhausts, electrical equipment, open flames, and welding areas.
- **Clearly marked:** Label the lockers prominently with signage indicating "Flammable Liquids" or "Petrol" to warn of the contents.

Ventilation:

- **Natural ventilation:** The lockers need to have natural ventilation openings at both the top and bottom to allow air circulation and prevent flammable vapor build-up. These openings should be designed with spark arrestors or mesh to prevent sparks or flames from entering.
- **No forced ventilation:** Avoid using forced ventilation systems inside the lockers. Electric fans or other forced ventilation could ignite any present petrol vapors.

Securing Containers:

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

Quantity Limitations:

- **Maximum quantity:** Regulations may limit the total amount of petrol allowed for storage in such lockers on the open deck. The specific limit will depend on the governing body or country's regulations. A common maximum is 50 liters (13.2 gallons), but it's crucial to consult the relevant regulations for your situation.

Additional Considerations:

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

Other Safety Measures:

- **Electrical Safety:** Ensure no electrical wiring or components are present within the lockers to eliminate any potential ignition sources.
- **No Smoking:** Clearly display "No Smoking" signs around the lockers to prevent any smoking activity near the flammable materials.
- **Maintenance:** Regularly inspect the lockers, ventilation openings, and securing mechanisms for proper functionality and any signs of damage.

By adhering to these safety requirements, you can significantly reduce the risk of fires, explosions, and environmental hazards associated with storing flammable liquids in small lockers on open decks. It's important to remember that regulations can vary, so consult the relevant maritime authority in your area for the most up-to-date and specific requirements for your location.

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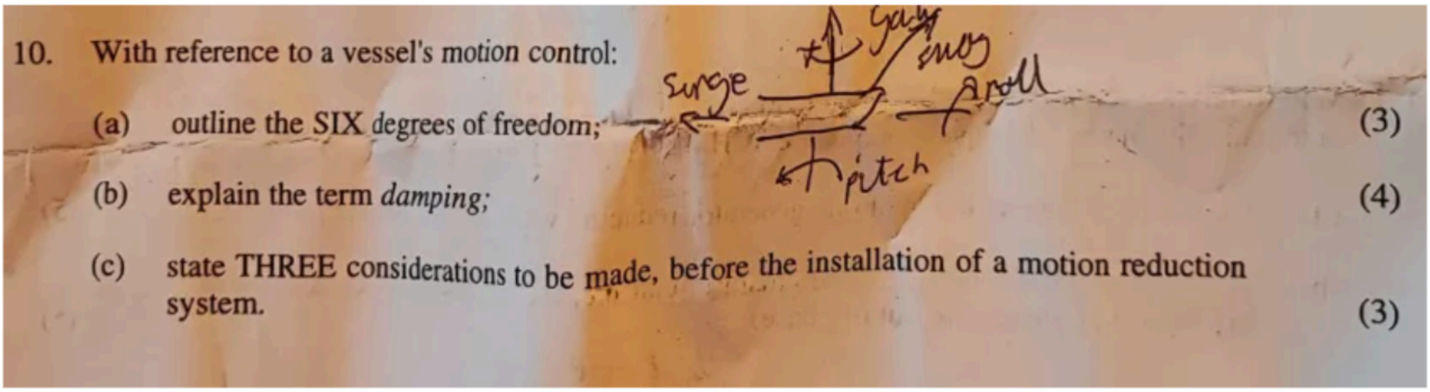
10. With reference to a vessel's motion control:

(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.