June 2023

1. Describe, with the aid of a sketch, the operation of a variable delivery axial piston pump. (10)

June 2023

2. (a) Explain why a hydraulic actuator is preferred for a vessel's stabiliser over an electrical actuator. (5)

   (b) Sketch a hydraulic circuit for a single stabiliser, suitable for a constant pressure system. (5)

June 2023

3. With reference to the Electrical Circuit Diagram:

   (a) state the purpose of this circuit; (2)

   (b) describe the functions the areas marked within the dotted lines numbered 1, 2, 3 and 4. (8)

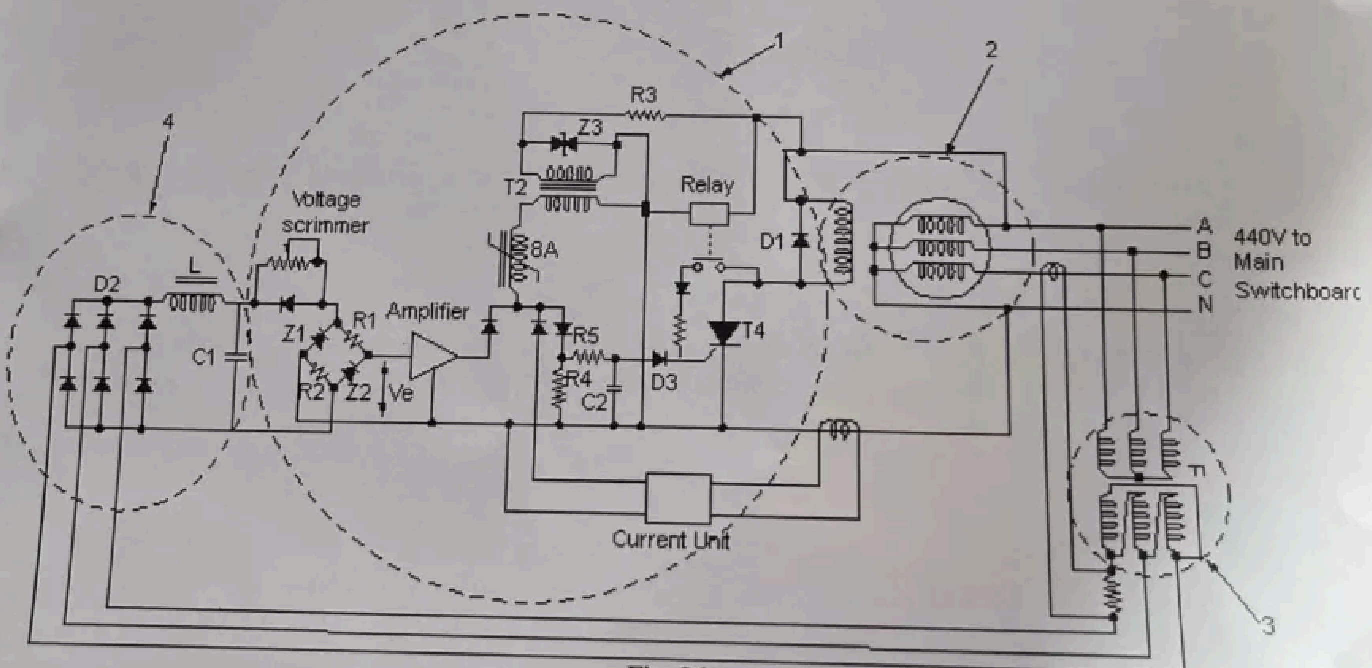

Fig Q3

June 2023

4. With reference to a 440 Volt, 3-phase motor supplied with six terminal connection in the terminal box:

(a) sketch a Delta connection, showing the relationship between phase and line voltages; (2)

(b) sketch a Star connection, showing the relationship between phase and line voltages; (2)

(c) state the relative speed of both connections; (2)

(d) sketch and label the terminal link connections so the motor will run in permanent Delta mode. (4)

June 2023

5. (a) State THREE types of damper that may be used to control the airflow in an air conditioning system. (3)

(b) Describe, with the aid of a sketch, an automatic fire damper installed in a vertical air duct or in those that pass through bulkheads designated as fire boundaries. (7)

June 2023

6. (a) State FOUR properties of refrigeration oil. (4)

(b) Describe the operation of an Oil Separator in a refrigeration system. (4)

(c) State reasons for the employment of an oil separator in refrigeration vapour compression units. (2)

June 2023

7. With reference to the visual inspection of lifting gear before use, state the removal from service criteria for EACH of the following slings when visually inspecting before use:

(a) wire rope; (5)

(b) synthetic fibre. (5)

7. *Note: The slings are within inspection dates, are of the correct SWL and clearly labelled.*

June 2023

8. With reference to the storage of volatile fuels, describe the construction and placement requirements of the storage tanks for aviation fuel, including tank ventilation. (10)

June 2023

9. Sketch the device which allows a cable to pass through a watertight bulkhead, labelling the MAIN components.

(10)

June 2023

10. With reference to longitudinal stresses in a vessel's hull:

(a) state the cause of the stress;

(3)

(b) state the areas where the stress is a maximum;

(3)

(c) describe the structure that resists the stress.

(4)

June 2023

1. Describe, with the aid of a sketch, the operation of a variable delivery axial piston pump. (10)

Core Components:

- **Drive Shaft:** Provides rotational power to the pump.
- **Cylinder Block:** A fixed housing containing cylindrical bores where pistons reside.
- **Pistons:** These are axial pistons, meaning their movement is parallel to the drive shaft axis. They convert rotary motion into reciprocating motion for pumping.
- **Swash Plate:** A flat disc positioned at a variable angle relative to the drive shaft axis. Pistons connect to the swash plate via a slipper or yoke, allowing them to tilt.
- **Distribution Valve/Plate:** This component directs fluid flow within the pump between the high-pressure and low-pressure sides based on piston position.

Operational Cycle:

1. **Rotation and Angled Pistons:** The drive shaft rotates, causing the cylinder block and pistons to spin. Due to the swash plate angle, the pistons undergo a combined rotary and axial motion.
2. **Intake Stroke:** On one side of the cylinder block, the pistons tilt inwards (because of the swash plate angle). This increases their volume, creating a low-pressure zone. Hydraulic fluid from the reservoir flows through an inlet port and into the cylinder bore to fill this space (suction phase).
3. **Sealing and Trapping:** As the piston continues to rotate, the slipper/yoke slides within the swash plate, transitioning the piston from the intake stroke to the discharge stroke. The distribution valve/plate isolates the inlet port, trapping the ingested fluid within the cylinder bore.
4. **Discharge Stroke:** The continued rotation and swash plate angle cause the pistons to tilt outwards, decreasing their volume. This generates a high-pressure zone within the cylinder bore. The trapped fluid is forced out through an outlet port and into the hydraulic system (discharge phase).
5. **Continuous Pumping:** This cycle of intake, sealing, and discharge continuously occurs for each piston as the shaft rotates, delivering a continuous flow of hydraulic fluid.

Variable Displacement Mechanism:

The crux of variable flow lies in the swash plate angle. This angle can be adjusted by external control mechanisms (hydraulic, mechanical, or electrical) depending on the pump design.

- **Minimal Angle:** When the swash plate is nearly perpendicular to the shaft (zero angle), the piston stroke length is minimal. This results in a low volume of fluid displacement per rotation, leading to a 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 displaced per rotation, resulting in a higher flow rate.

Control Mechanisms (Examples):

- **Pressure Compensator:** This device automatically adjusts the swash plate angle to maintain a constant system pressure.
- **Load-Sensing Control:** This system adjusts the swash plate angle based on the external load on the hydraulic actuator, optimizing power delivery.
- **Joystick Control:** In operator-controlled applications, a joystick input can mechanically or electronically adjust the swash plate angle for precise flow control.

By dynamically controlling the swash plate angle, the pump regulates its displacement and tailors the flow rate to meet the specific demands of the hydraulic system. This enables efficient operation and precise control over actuator performance in various engineering applications.

June 2023

2. (a) Explain why a hydraulic actuator is preferred for a vessel's stabiliser over an electrical actuator. (5)

(b) Sketch a hydraulic circuit for a single stabiliser, suitable for a constant pressure system. (5)

Hydraulic Actuators for Vessel Stabilizers

(a) Advantages of Hydraulic Actuators:

Several factors make hydraulic actuators a preferred choice for vessel stabilizers compared to electrical actuators:

- **High Power Density:** Hydraulic systems can generate significantly higher force and torque compared to electrical actuators of similar size and weight. This is crucial for stabilizers that need to counteract large wave forces acting on the vessel.
- **Fast Response:** Hydraulic systems offer faster response times due to the inherent properties of fluids. This allows the stabilizer fins to react quickly to wave motions and provide more effective stabilization.
- **Load Handling:** Hydraulic systems excel at handling high dynamic loads experienced by stabilizers in rough seas. They can absorb shock loads and provide smoother operation compared to electric motors, which can stall under extreme loads.
- **Simplicity and Reliability:** Hydraulic systems are generally simpler in design compared to complex electric motors with gear reduction units. This translates to potentially higher reliability and easier maintenance at sea.
- **Environmental Resistance:** Hydraulic components can be chosen for their resistance to the harsh marine environment, including salt spray and corrosion.

Electrical actuators may be suitable for smaller vessels or applications requiring lower power. However, for most practical applications on larger vessels, the advantages of high power density, fast response, and load handling make hydraulic actuators the preferred choice for vessel stabilizers.

(b) Hydraulic Circuit for a Single Stabilizer (Constant Pressure System):

In a constant pressure hydraulic system for a vessel stabilizer, the following key components are involved:

1. **Reservoir:** Stores the hydraulic fluid and maintains its level.
2. **Pump:** Continuously pressurizes the fluid in the system (driven by an electric motor or diesel engine).
3. **Pressure Relief Valve:** Protects the system from overpressure by bypassing excess fluid back to the reservoir.
4. **Filter:** Removes contaminants from the fluid to protect system components.
5. **Solenoid-operated Directional Control Valve:** This valve controls the flow and direction of pressurized fluid based on electrical signals from the stabilizer control system. It has multiple positions:
    - **Center:** Neutral position, no fluid flow to the actuator.
    - **Port 1:** Directs fluid to extend the actuator rod, pushing the stabilizer fin down.
    - **Port 2:** Directs fluid to retract the actuator rod, pulling the stabilizer fin up.
6. **Hydraulic Cylinder (Double-acting):** This actuator converts pressurized fluid into linear motion to position the stabilizer fin. It has a piston rod connected to the fin linkage.
7. **Position Sensor:** Provides feedback on the current position of the stabilizer fin to the control system.

Operation:

1. **Control System Input:** The vessel's stabilization control system analyzes sensor data (roll angle, wave motion) and sends electrical signals to the directional control valve.
2. **Valve Actuation:** Based on the electrical signal, the valve directs pressurized fluid to either Port 1 (fin down) or Port 2 (fin up) of the actuator.
3. **Actuator Movement:** The pressurized fluid extends or retracts the actuator rod, respectively pushing the stabilizer fin down or pulling it up.
4. **Fin Positioning:** The movement of the fin counteracts the roll motion of the vessel, providing stabilization.
5. **Position Feedback:** The position sensor continuously monitors the fin's position and sends feedback to the control system.
6. **Control Loop:** The control system adjusts the valve position based on the sensor feedback, maintaining the desired fin position and vessel stability.

This is a simplified representation. Additional components like check valves or accumulators might be incorporated for specific system requirements.

June 2023

3. With reference to the Electrical Circuit Diagram:

(a) state the purpose of this circuit; (2)

(b) describe the functions the areas marked within the dotted lines numbered 1, 2, 3 and 4. (8)

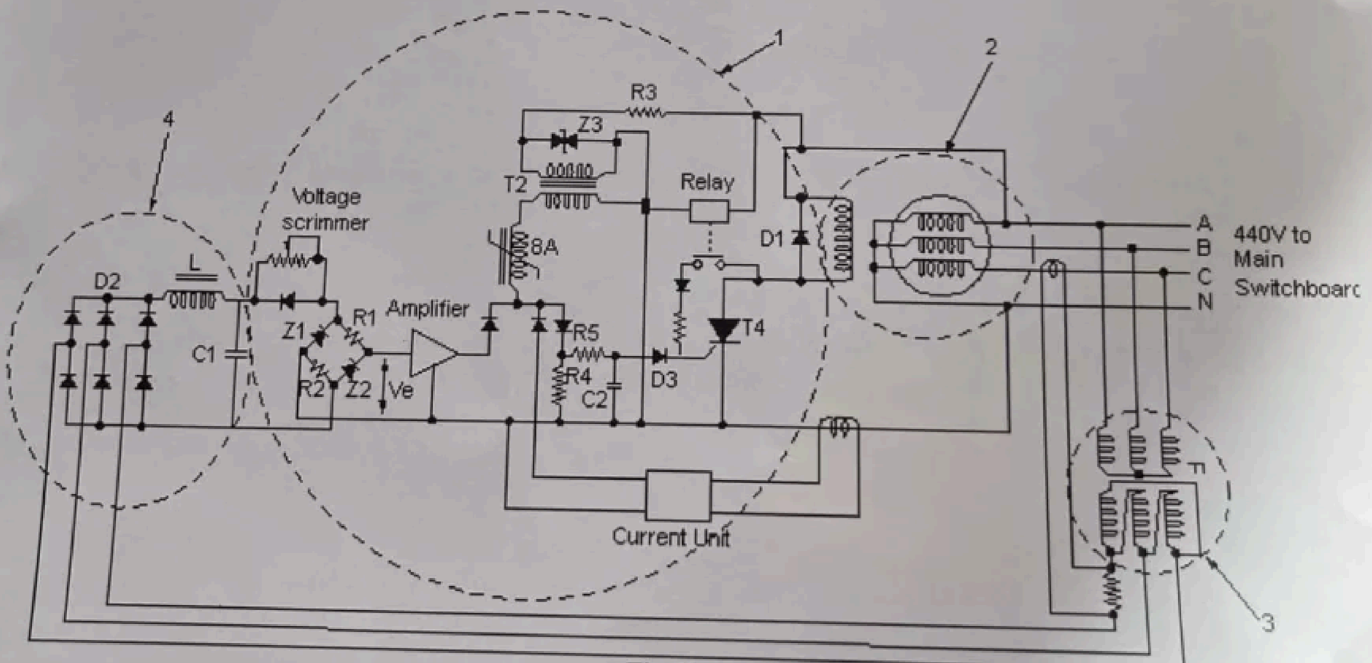

Fig Q3

Based on the circuit diagram labeled "Fig Q3" it appears to be a voltage divider circuit with an amplifier circuit.

(a) The purpose of a voltage divider circuit is to distribute a voltage source across two or more resistors. The output voltage can be calculated based on the ratio of the two resistors. In this specific circuit, the voltage divider seems to be formed by resistors R1 and R2. The purpose of the amplifier circuit appears to be to amplify the signal from the voltage divider circuit.

(b) Here's a description of the functions of the areas marked by dotted lines:

Area 1: This area contains the voltage source (440V) and the voltage divider circuit (R1, R2).

Area 2: This area contains capacitors C1 and C2. Capacitors are used to store electrical energy and block DC current while allowing AC current to pass. In this circuit, they likely function as filters.

Area 3: This area contains resistors R3, Z3, transistor T2, and relay. Transistors are used to amplify or switch electronic signals. Here, T2 appears to act as a switch controlled by the voltage divider circuit. The relay likely functions as a switch that controls a separate circuit.

Area 4: This area contains resistor R4, diode D3 and the current unit. Diodes allow electric current to flow in one direction only. It's likely D3 prevents current from flowing back into the circuit from the current unit. The current unit likely measures the amount of current flowing in the circuit.

June 2023

4. With reference to a 440 Volt, 3-phase motor supplied with six terminal connection in the terminal box:

(a) sketch a Delta connection, showing the relationship between phase and line voltages; (2)

(b) sketch a Star connection, showing the relationship between phase and line voltages; (2)

(c) state the relative speed of both connections; (2)

(d) sketch and label the terminal link connections so the motor will run in permanent Delta mode. (4)

440V, 3-Phase Motor with Six Terminals: Connection Modes

Here's a breakdown of Delta and Star connections for your 440V, 3-phase motor with six terminals, referencing the relationship between voltages and speed, and explaining how to configure it for permanent Delta mode.

(a) Delta Connection:

- **Description:** In a delta connection, the three motor windings are connected end-to-end, forming a triangular loop. Each winding connects between two line terminals.
- **Voltage Relationship:**
  - Line Voltage (VL): This is the voltage measured between any two of the three lines feeding the motor (VAB, VBC, VCA). In your case, the line voltage is 440V.
  - Phase Voltage (VP): This is the voltage measured across each individual winding (between any line terminal and the connection point of the other two windings). In a delta connection, the phase voltage is equal to the line voltage (Vp = VL = 440V). This is because the line voltage is applied directly across each winding.

(b) Star Connection:

- **Description:** In a star connection, the three motor windings are connected at one end (usually internally within the motor), forming a star shape. The other ends of the windings are connected to the three line terminals. This creates a neutral point at the center of the star.
- **Voltage Relationship:**
  - Line Voltage (VL): Same as delta connection (VL = 440V).
  - Phase Voltage (VP): This is the voltage measured between any line terminal and the neutral point. The phase voltage in a star connection is calculated by dividing the line voltage by the square root of 3 ($V_p = V_L / \sqrt{3}$). For a 440V line voltage, the phase voltage is approximately 254V ($V_p \approx 440V / \sqrt{3}$). This is because the windings are connected in series, and the voltage is divided across them.

(c) Relative Speed:

- **Starting Torque:** Delta connections generally offer a higher starting torque compared to star connections for the same motor. This is because the full line voltage is applied directly across each motor winding phase in delta.

- **Running Speed:** The running speed of the motor remains approximately the same in both delta and star connections, assuming the motor is designed for both configurations. This is because the fundamental synchronous speed of the motor is determined by the number of poles and the line frequency. The connection method primarily affects the starting torque and current.

(d) Permanent Delta Connection:

Since your motor has six terminals (likely three for each winding - U1, U2, V1, V2, W1, W2), configuring it for permanent delta doesn't require any jumpers or links. Here's why:

- In a delta connection, each winding connects between two line terminals.
- With six terminals, you already have three individual connection points for each winding.

Therefore, **leave all six terminals unconnected**. The internal configuration of the motor windings will handle the delta connection without any additional modifications.

Important Note: Always refer to the motor's manufacturer's manual or data plate for specific connection instructions. Modifying motor connections without proper knowledge can damage the motor or pose safety risks. Consult a qualified electrician if you're unsure about the connection process.

June 2023

5. (a) State THREE types of damper that may be used to control the airflow in an air conditioning system. (3)

(b) Describe, with the aid of a sketch, an automatic fire damper installed in a vertical air duct or in those that pass through bulkheads designated as fire boundaries. (7)

Air Conditioning Dampers and Fire Safety

(a) Three Types of Dampers for Airflow Control:

1. **Blade Dampers:** These are the most common type. They consist of a metal blade that pivots within the duct to regulate airflow. The blade angle can be manually adjusted or controlled by a motor for automated operation.
2. **Butterfly Dampers:** These resemble a butterfly valve, with a disc-shaped metal plate rotating on a central axis within the duct. The disc position controls the amount of airflow through the duct. They are often used for complete shutoff or to regulate high-pressure airflow.
3. **Volume Control Dampers (VCDs):** These are specially designed dampers that maintain a constant air pressure throughout the duct system regardless of the damper position. They are particularly useful for balancing airflow in complex duct networks.

(b) Automatic Fire Damper in Air Ducts:

An automatic fire damper is a crucial safety device installed in air conditioning systems to prevent the spread of fire and smoke through ventilation ducts. They are typically located:

- **Vertical air ducts:** These are vertical shafts within the building that carry conditioned air to different floors. Fire dampers are installed at regular intervals along the vertical duct to isolate any fire section.
- **Ducts passing through bulkheads designated as fire boundaries:** Bulkheads are vertical walls within a building that can act as fire barriers. Fire dampers are installed where air ducts penetrate these fire-rated bulkheads to prevent flames and smoke from traveling through the duct system to other compartments.

Functioning of a Fire Damper:

- **Normal Operation:** During normal operation, the fire damper blade remains open, allowing conditioned air to flow freely through the duct.
- **Fire Detection:** When a fire is detected (through heat sensors or smoke detectors), a signal is sent to a fusible link or electrical mechanism connected to the damper blade.
- **Automatic Closure:** The fusible link melts or the electrical mechanism activates, causing the damper blade to automatically close and seal the duct opening. This isolates the fire and smoke within the affected zone, preventing them from spreading to other parts of the building through the ductwork.

Importance of Fire Dampers:

Fire dampers play a vital role in building safety by:

- **Compartmentalization:** They compartmentalize the building by isolating fire and smoke within a specific zone, preventing them from traveling through the ventilation system.
- **Life Safety:** By containing the fire and smoke, fire dampers help protect occupants by providing them with more time to evacuate safely.
- **Reduced Property Damage:** Limiting the spread of fire and smoke minimizes damage to unaffected areas of the building.

Note: Fire dampers require regular inspection and maintenance to ensure they function properly in case of a fire emergency.

June 2023

6. (a) State FOUR properties of refrigeration oil. (4)

(b) Describe the operation of an Oil Separator in a refrigeration system. (4)

(c) State reasons for the employment of an oil separator in refrigeration vapour compression units. (2)

Refrigeration Oil Properties and Oil Separator Function:

(a) Four Properties of Refrigeration Oil:

1. **Viscosity:** Refrigeration oil needs to have the proper viscosity to ensure good circulation throughout the compressor and lubricate moving parts effectively. It should be thin enough to flow freely at low temperatures but thick enough to maintain a lubricating film at high operating temperatures.

2. **Miscibility:** The oil needs to be miscible with the refrigerant to some degree. This allows the oil to dissolve some refrigerant gas and return it to the compressor crankcase, preventing its loss within the system. However, excessive miscibility can reduce the oil's lubricating properties.
3. **Chemical Stability:** The oil should be chemically stable and compatible with the refrigerant used in the system. It should not react with the refrigerant or degrade over time, which could lead to sludge formation and system problems.
4. **Low Vapor Pressure:** Refrigeration oil should have a low vapor pressure to minimize the amount of oil vapor entering the compressor and circulating throughout the system. Excessive oil vapor can reduce the efficiency of heat transfer and increase pressure drop within the system.

(b) Operation of an Oil Separator:

An oil separator is a component in a refrigeration vapor compression system designed to remove entrained oil droplets from the refrigerant vapor leaving the compressor. Here's how it works:

1. **Oil-laden refrigerant vapor:** The hot, high-pressure vapor containing entrained oil droplets exits the compressor and enters the oil separator.
2. **Separation:** Due to several factors like:
   - **Sudden change in direction:** The abrupt change in flow direction as the vapor enters the separator disrupts the oil droplets, causing them to coalesce (merge) into larger droplets.
   - **Density difference:** Oil being denser than the refrigerant vapor tends to separate and fall towards the bottom of the separator due to gravity.
   - **Baffles or impingement surfaces:** Some separators use baffles or impingement surfaces that the vapor stream flows around. These surfaces can further aid in separating oil droplets from the vapor.
3. **Oil collection:** The larger oil droplets accumulate at the bottom of the separator in a reservoir.
4. **Oil return:** A mechanism, such as a float valve or differential pressure control, regulates the oil level in the separator reservoir. When the oil level reaches a certain point, the valve opens, allowing the collected oil to return to the compressor crankcase for continued lubrication.
5. **Clean refrigerant vapor:** The oil-free (or nearly oil-free) refrigerant vapor exits the top of the separator and proceeds to the condenser in the system.

(c) Reasons for Employing an Oil Separator:

There are several reasons why oil separators are employed in refrigeration vapor compression units:

1. **Protects the System:** Excessive oil circulation in the system can lead to several problems:
   - **Reduced heat transfer:** Oil coating the condenser and evaporator coils can hinder heat transfer efficiency, reducing system performance.
   - **Increased pressure drop:** Oil can increase the pressure drop within the system, requiring the compressor to work harder.
   - **Varnish formation:** Over time, oil can degrade and form varnish deposits on components, further reducing efficiency and potentially leading to component failure.

2. **Improves Efficiency:** By removing oil from the refrigerant vapor, the oil separator helps maintain optimal heat transfer in the condenser and evaporator, leading to improved overall system efficiency.
3. **Extends Compressor Life:** Reduced oil circulation protects the compressor from excessive wear and tear, contributing to a longer lifespan for this critical component.
4. **Environmental Benefits:** Oil separators help minimize oil contamination of the refrigerant, which can be environmentally harmful if it leaks from the system.

In conclusion, oil separators play a crucial role in maintaining the performance, efficiency, and lifespan of refrigeration systems by ensuring proper oil circulation for lubrication and removing excess oil from the refrigerant vapor stream.

June 2023

7. With reference to the visual inspection of lifting gear before use, state the removal from service criteria for EACH of the following slings when visually inspecting before use:

(a) wire rope; (5)

(b) synthetic fibre. (5)

7. *Note: The slings are within inspection dates, are of the correct SWL and clearly labelled.*

Removal from Service Criteria for Lifting Slings (Pre-Use Inspection):

Even if slings are within inspection dates, have the correct SWL (Safe Working Load), and are clearly labeled, a thorough visual inspection before each use is crucial. Here's a breakdown of the removal from service criteria for wire rope slings and synthetic fiber slings during such an inspection:

(a) Wire Rope Slings:

- **Broken Wires:** Any number of broken wires within a strand, or a total of 6 or more broken wires in one strand within a 3m length of the sling.
- **Severe Corrosion:** Severe general corrosion that reduces the wire diameter by more than one-third of its original diameter, or localized pitting that exposes more than one-third of the wire core.
- **Bird Caging:** When individual wires break and protrude outwards, resembling a birdcage appearance.
- **Distortion or Kinks:** Any permanent distortion or kinks in the wire rope that deform its original lay pattern.
- **Heat Damage:** Discoloration, melting, or brittleness of the wire rope due to excessive heat exposure.
- **Damaged End Fittings:** Any cracks, deformation, excessive wear, or loose attachment of the end fittings to the wire rope.
- **Missing or Illegible Sling Identification Tag:** A sling without a proper tag displaying its SWL, length, and other relevant information.

(b) Synthetic Fiber Slings:

- **Cuts or Snags:** Any deep cuts, tears, snags, or punctures that penetrate more than 10% of the sling's thickness.
- **Abrasion Damage:** Excessive wear or abrasion that significantly reduces the sling's cross-sectional area or exposes underlying yarns.
- **Melting, Charring, or Chemical Damage:** Signs of melting, charring, or deterioration due to heat, chemical exposure, or UV radiation.
- **Acid or Alkali Burns:** Visible damage caused by contact with acids or alkalis.
- **Broken or Worn Stitches:** Broken or excessively worn stitching in the webbing, especially in load-bearing areas.
- **Knots:** Any knots tied in the webbing, as they significantly reduce the sling's strength.
- **Exposed Red Core Yarn (if applicable):** In some slings, a red core yarn indicates internal damage. If the red core is visible, the sling should be removed from service.
- **Distortion or Excessive Wear of Fittings:** Deformation, cracking, or excessive wear of the end fittings attached to the webbing.
- **Missing or Illegible Sling Identification Tag:** Similar to wire rope slings, a synthetic fiber sling without a proper tag for identification needs to be removed from service.

Remember, this is not an exhaustive list, and it's crucial to consult the manufacturer's instructions and relevant regulations for the specific type of sling being used. A sling should be removed from service if the inspector has any doubts about its safety or integrity.

By conducting thorough visual inspections before each use and removing any damaged slings from service, operators can significantly reduce the risk of lifting accidents and ensure the safe operation of lifting equipment.

June 2023

8. With reference to the storage of volatile fuels, describe the construction and placement requirements of the storage tanks for aviation fuel, including tank ventilation. (10)

Aviation Fuel Storage Tanks: Construction, Placement, and Ventilation

Aviation fuel is a highly flammable liquid, and its storage requires strict regulations to ensure safety. Here's a breakdown of the key points regarding construction, placement, and ventilation of aviation fuel storage tanks:

Construction:

- **Material:** Tanks are typically constructed from high-quality, welded steel to ensure strength and minimize leakage. In some cases, fiberglass-reinforced plastic (FRP) may be used for specific applications.
- **Double-walled Design (Preferred):** Double-walled tanks are the preferred option as they provide an extra layer of protection. The inner tank holds the fuel, while the outer wall acts as a secondary containment in case of a leak from the inner tank. The space between the walls is monitored for leaks using leak detection systems.

- **Venting:** Storage tanks require proper venting to allow for:
    - **Pressure relief:** Vents release pressure buildup within the tank due to temperature changes or filling operations.
    - **Fuel vapor displacement:** Vents allow air to enter the tank as fuel is withdrawn, preventing a vacuum and potential tank collapse.
- **Fire Protection:** Tanks may be equipped with fire protection systems such as firewalls, fireproofing materials, and foam suppression systems for added safety.
- **Capacity:** Aviation fuel storage tanks come in various sizes, depending on the airport's needs and refueling requirements.

Placement:

- **Distance from Buildings and Aircraft:** Regulations dictate minimum distances between fuel storage tanks and buildings, aircraft parking areas, and other potential ignition sources. These distances ensure that any fire or explosion incident is contained and minimizes damage to surrounding structures and equipment.
- **Bunding:** Aboveground tanks are often placed within a bund (containment area) designed to hold the entire volume of the tank in case of a leak or rupture. This bund may be constructed from concrete or masonry walls.
- **Drainage:** The bunded area should have a proper drainage system to prevent rainwater accumulation and potential contamination of the surrounding soil or water table.
- **Security:** Fuel storage facilities should have security measures like fences, access control systems, and CCTV monitoring to deter unauthorized access and potential theft.

Tank Ventilation:

- **Types of Vents:** Two main types of vents are commonly used:
    - **Vacuum and Pressure Relief Vents:** These vents automatically open to release pressure or allow air intake as needed to maintain atmospheric pressure within the tank. They are typically set to open and close at specific pressure levels.
    - **Flame Arrestors:** These are installed on vents to prevent flames from entering the tank in case of an external fire. Flame arrestors use a specially designed element that extinguishes flames while allowing air to pass through.
- **Vent Location:** Vents are typically located on the highest point of the tank to allow for proper air exchange and prevent fuel accumulation within the vent system.
- **Vent Discharge:** Vent discharge should be directed away from potential ignition sources and personnel working areas to minimize the risk of vapor inhalation or fires.

Additional Considerations:

- **Regulations:** Storage tank construction, placement, and ventilation must comply with relevant national and international regulations (e.g., NFPA 30, API 653). These regulations specify detailed requirements for materials, capacities, fire protection, and other safety aspects.
- **Inspections and Maintenance:** Regular inspections and maintenance of tanks, vents, and associated equipment are crucial to ensure their integrity, functionality, and compliance with regulations. Leak detection systems, pressure relief valves, and flame arrestors require periodic checks to ensure proper operation.

By adhering to these construction, placement, and ventilation requirements, aviation fuel storage facilities can minimize the risk of fires, spills, and environmental damage, ensuring safe and efficient storage of this vital fuel for aircraft operations.

June 2023

9. Sketch the device which allows a cable to pass through a watertight bulkhead, labelling the MAIN components.

(10)

The device that allows a cable to pass through a watertight bulkhead while maintaining water integrity is called a **watertight cable gland**. Here's a breakdown of its main components:

1. **Body:** This is the main housing of the gland, typically made of a corrosion-resistant material like brass or nickel-plated brass. The body provides a threaded connection for secure mounting to the bulkhead.
2. **Cable Entry Port:** This is an opening in the body sized to allow the specific electrical cable to pass through.
3. **Grommet:** This is a crucial sealing component, usually made of rubber or another elastomeric material. It has a central hole sized for a specific cable diameter. The grommet fits into the cable entry port and creates a tight seal around the cable jacket, preventing water from entering.
4. **Clamping Ring:** This threaded ring screws onto the body of the gland. Tightening the clamping ring compresses the grommet and the cable against the cable entry port, creating a watertight seal.
5. **Locknut (Optional):** Some cable glands may have a separate locknut that threads onto the body behind the clamping ring. Tightening the locknut provides additional security by holding the clamping ring in place and maintaining the compression on the grommet and cable.

Additional components (might not be present in all designs):

- **Internal Terminal Chamber:** Some glands have an internal chamber within the body to accommodate electrical cable terminations (e.g., lugs, crimps) for connecting the cable to other electrical components.
- **Strain Relief Feature:** Some designs incorporate a strain relief mechanism to prevent excessive pulling forces from being transmitted to the electrical connections within the cable.

Benefits of Watertight Cable Glands:

- **Compact design:** Suitable for use in limited space applications.
- **Easy to install and maintain:** Cable glands can be installed and removed relatively easily for cable replacement or maintenance.
- **Versatility:** Available in various sizes and types to accommodate different cable diameters and environmental conditions.

Choosing the right watertight cable gland depends on several factors, including:

- **Cable diameter:** The gland size needs to be compatible with the specific cable being used.

- **Environmental conditions:** Glands may be rated for different levels of water pressure and may have additional features for specific environments (e.g., explosion-proof).
- **Regulations:** Some applications may have specific regulatory requirements for the type of cable gland used.

Always refer to the manufacturer's recommendations and relevant regulations for proper selection, installation, and use of watertight cable glands.

June 2023

10. With reference to longitudinal stresses in a vessel's hull:

(a) state the cause of the stress;

(b) state the areas where the stress is a maximum; (3)

(c) describe the structure that resists the stress. (3)

(4)

Longitudinal Stresses in a Ship's Hull

(a) Cause of Longitudinal Stress:

Longitudinal stress in a ship's hull arises from forces acting along the length of the vessel that tend to bend or stretch the hull. These forces can be caused by a variety of factors:

- **Vertical Bending:** The primary cause is the **distribution of weight and buoyancy** along the ship's length. The weight of the vessel and its cargo acts downwards, while the hydrostatic pressure of the water exerts an upward buoyancy force. If these forces are not evenly distributed, they can create a bending moment that stresses the hull longitudinally.
- **Hogging and Sagging:** Depending on the distribution of weight and wave action, two main scenarios can occur:
  - **Hogging:** When the vessel is supported on either end by wave crests, with the center unsupported in a wave trough, the hull tends to bend upwards in the center, creating a hogging condition.
  - **Sagging:** Conversely, when the vessel is supported in the center by a wave crest and the ends are in wave troughs, the hull tends to bend downwards in the center, creating a sagging condition.

(b) Areas of Maximum Stress:

The areas where longitudinal stress is a maximum depend on the specific loading condition (hogging or sagging):

- **Hogging:** During hogging, the maximum stress typically occurs at the **amidships** section (middle of the vessel's length) on the **deck** due to the combined effects of weight concentration and upward bending moment.

- **Sagging:** During sagging, the maximum stress typically occurs at the **amidships** section on the **bottom** plating as the hull tends to sag downwards under the weight and the wave action creates a downward bending moment.

(c) Structures Resisting the Stress:

The primary structures that resist longitudinal stresses in a ship's hull are:

- **Double Bottom (if present):** This acts like a horizontal girder, adding vertical and longitudinal strength to the hull. It helps distribute loads more evenly and resists the bending moment.
- **Longitudinal Stiffeners:** These are vertical or horizontal beams running along the length or height of the hull. They act like internal girders, stiffening the hull and resisting bending forces. They are particularly crucial in areas where longitudinal stresses are concentrated.
- **Deck Girders:** These are horizontal beams running across the width of the vessel within the deck structure. They help distribute loads across the deck and contribute to resisting longitudinal bending moments, especially during hogging conditions.
- **Keel:** The keel acts as the main longitudinal stiffener at the bottom of the hull. It provides rigidity and strength against longitudinal bending forces.

Overall Design: The overall design and scantling (thickness) of the hull plates also play a significant role. Thicker plates and strategically placed reinforcements in high-stress areas can significantly improve the hull's resistance to longitudinal bending.