Nov 2018 23rd

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2. Describe, with the aid of a sketch, a constant pressure hydraulic power system for a vessel's Anchor Windlass, showing safety features and labelling ALL components of the system. (10)

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3. With reference to storage batteries, explain EACH of the following:

   (a) the term UPS; (3)

   (b) the operation of an inverter, stating why it may be required; (4)

   (c) the term 150 Ah. (3)

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4. (a) Using Worksheet, sketch how an a.c. motor would be connected in EACH of the following:

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   (ii) Delta. (3)

   (b) State the probable consequences of connecting a motor in star instead of delta. (4)

Nov 2018 23rd

5. Describe the indications of, and the remedies for, an undercharge on a refrigeration system. (10)

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6. Describe, with the aid of a sketch, a vapour-compression refrigeration cycle, showing clearly the physical state and condition of the refrigerant in the system. (10)

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7. (a) A crane is being fitted to deploy and recover a load from a vessel. With reference to the present regulations, state the standards that the crane must comply with before being used on board. (7)

(b) State the information entered on a Proof Load Test certificate. (3)

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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)

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9. (a) Describe, with the aid of a sketch, the securing arrangement for a pipe passing through a watertight bulkhead. (5)

(b) Sketch an arrangement for a watertight electric cable gland labelling ALL components. (5)

Nov 2018 23rd

10. With reference to stresses and strain in vessels, describe, with the aid of a sketch, EACH of the following:

(a) panting; (2)

(b) pounding; (2)

(c) racking; (2)

(d) hogging; (2)

(e) sagging; (2)

Nov 2018 23rd

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.

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2. Describe, with the aid of a sketch, a constant pressure hydraulic power system for a vessel's Anchor Windlass, showing safety features and labelling ALL components of the system. (10)

Constant Pressure Hydraulic System for Anchor Windlass (Labeled Diagram)

This system utilizes pressurized hydraulic fluid to efficiently operate a vessel's anchor windlass for raising and lowering the anchor. Here's a breakdown of the components and their functions:

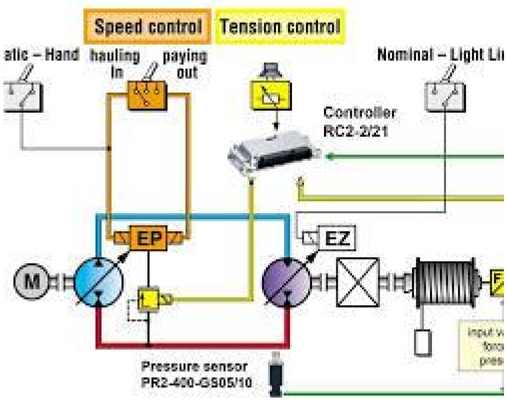
Components:

1. **Reservoir:** This tank stores the hydraulic fluid (usually oil) and maintains its level. It may incorporate a breather filter to allow air exchange and prevent contamination.
2. **Electric Motor:** This motor drives the hydraulic pump.
3. **Fixed Displacement Pump:** This positive displacement pump continuously draws fluid from the reservoir and pressurizes it. The pump displacement (fixed volume per revolution) determines the system pressure.
4. **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.
5. **Filter:** A hydraulic filter removes contaminants from the fluid before it reaches the control valve, protecting system components from wear and tear.
6. **Solenoid-Operated Directional Control Valve (4/3 Position, Center-Closed):** This valve controls the flow and direction of pressurized fluid based on electrical signals from the windlass control panel. It has multiple positions:
   - **Center:** Neutral position, fluid flow is blocked within the valve (closed-center), holding the anchor windlass in position (due to internal pressure or external braking).
   - **Port A:** Directs fluid to extend the windlass motor cylinder, raising the anchor.
   - **Port B:** Directs fluid to retract the windlass motor cylinder, lowering the anchor.
   - **Relief:** In case of excessive pressure, the valve may have a built-in relief function to bypass fluid back to the reservoir (depending on specific valve design).
7. **Windlass Motor Cylinder (Double-Acting):** This hydraulic actuator converts pressurized fluid into linear motion to operate the anchor windlass. It has a piston rod connected to the windlass mechanism, raising or lowering the anchor based on fluid flow direction.
8. **Pressure Gauge:** Provides a visual indication of the system pressure to the operator.
9. **Level Gauge (on Reservoir):** Allows monitoring of the hydraulic fluid level in the reservoir for proper system operation.
10. **Check Valve (Optional):** This one-way valve can be placed strategically in the system to prevent flow reversal in specific situations (e.g., preventing anchor drift due to pressure loss).

Safety Features:

- **Pressure Relief Valve:** Protects the system from overpressure.
- **Solenoid-Operated Directional Control Valve (Center-Closed):** Holds the anchor windlass in position when in neutral, preventing accidental movement.
- **Check Valve (Optional):** Prevents unintended anchor drift due to pressure loss.
- **Low-Fluid Level Shutdown (Optional):** System can be designed to automatically shut down in case of insufficient fluid level in the reservoir.

Labeled Diagram:



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Constant Pressure Hydraulic System for Anchor Windlass

Note: This is a simplified representation. Real systems might incorporate additional valves for specific functions (e.g., pressure control valves, sequence valves) or other components depending on the windlass design and complexity.

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3. With reference to storage batteries, explain EACH of the following:

(a) the term UPS; (3)

(b) the operation of an inverter, stating why it may be required; (4)

(c) the term 150 Ah. (3)

Constant Pressure Hydraulic Power System for Anchor Windlass

A constant pressure hydraulic power system provides a reliable and powerful solution for operating a vessel's anchor windlass. Here's a breakdown of its components, operation, and safety features:

Components:

1. **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.
2. **Pump:** A positive displacement pump (e.g., gear pump, vane pump) is the heart of the system. It continuously draws fluid from the reservoir and pressurizes it. Electric motors, diesel engines, or even a shaft from the main engine can drive the pump.
3. **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.
4. **Filter:** A hydraulic filter removes contaminants from the fluid to prevent wear and tear on system components.
5. **Directional Control Valve:** This valve controls the direction of the fluid flow, directing it to the appropriate actuator (e.g., hydraulic motor) based on operator commands (usually through levers or buttons). It can be a solenoid-operated valve for precise control.
6. **Hydraulic Motor:** This motor converts the pressurized hydraulic fluid into rotary motion to drive the windlass. Different motor types (e.g., radial piston, axial piston) can be chosen based on torque and speed requirements.
7. **Piping and Hoses:** These connect the components, carrying the pressurized fluid throughout the system. They are designed for high pressure and chosen for compatibility with the hydraulic fluid.
8. **Actuator (Optional):** In some systems, an additional actuator (e.g., hydraulic cylinder) might be used for functions like raising/lowering the anchor chain gypsy or deploying an anchor brake.

Operation:

1. **Power Source:** The pump is activated by its designated power source (electric motor, diesel engine, etc.).
2. **Fluid Flow:** The pump continuously draws fluid from the reservoir and pressurizes it.
3. **Pressure Relief Valve:** The pressure relief valve ensures the system pressure stays within safe limits by bypassing excess fluid back to the reservoir if needed.
4. **Filter:** The fluid passes through a filter to remove contaminants before reaching the control valve.
5. **Directional Control Valve:** The operator controls the directional control valve, directing pressurized fluid to specific ports on the valve.
6. **Hydraulic Motor:** Based on the valve position, the pressurized fluid flows to the hydraulic motor, causing it to rotate in a specific direction (hoisting or lowering the anchor).
7. **Anchor Windlass:** The rotating shaft of the hydraulic motor drives the windlass gears, raising or lowering the anchor chain.

Safety Features:

- **Pressure Relief Valve:** As mentioned earlier, this valve prevents overpressure and protects the system from damage.
- **Check Valves (Optional):** In some systems, check valves can be placed strategically to prevent unintended flow reversal or pressure loss in specific situations.
- **Low-Level Sensor (Optional):** This sensor can be used to warn of low fluid levels in the reservoir, preventing pump damage due to cavitation.
- **Fluid Selection:** Choosing the appropriate hydraulic fluid with proper viscosity and fire resistance is crucial for safe operation.

- **Regular Maintenance:** Regular inspection, maintenance, and replacement of filters and worn components ensure system reliability and safety.

Benefits of Constant Pressure System:

- **Reliable Power:** The constant pressure ensures consistent power delivery for anchor handling operations.
- **Precise Control:** Directional control valves offer precise control over the windlass operation.
- **Scalability:** The system can be sized based on the specific windlass requirements and anchor size of the vessel.
- **Efficiency:** Modern hydraulic components offer good efficiency in converting engine power to usable work at the windlass.

In conclusion, a constant pressure hydraulic power system provides a robust and efficient solution for operating a vessel's anchor windlass. By incorporating safety features and proper maintenance, this system ensures safe and reliable anchor handling operations.

Nov 2018 23rd

4. (a) Using Worksheet, sketch how an a.c. motor would be connected in EACH of the following:

(i) Star; (3)

(ii) Delta. (3)

(b) State the probable consequences of connecting a motor in star instead of delta. (4)

AC Motor Connections: Star vs. Delta

Here's a breakdown of how to connect an AC motor in both Star and Delta configurations, along with the consequences of using the wrong connection:

(a) AC Motor Connections:

(i) Star Connection:

1. **Terminals:** Most three-phase motors with star-delta capability have six terminals, likely designated U1, U2, V1, V2, W1, and W2 (one set for each winding).
2. **Connection:** Connect the three ends of the motor windings together at a single point. This creates a "star" shape.
3. **Line Connections:** Connect the remaining terminal of each winding (U1, V1, W1) to the three individual lines (L1, L2, L3) from the power supply.

(ii) Delta Connection:

1. **Terminals:** Use the same six terminals (U1, U2, V1, V2, W1, W2).
2. **Connection:** Connect the end of winding U1 (U1) to the end of winding V2 (V2). Similarly, connect the end of V1 (V1) to W2 (W2), and the end of W1 (W1) to U2 (U2). This forms a closed triangular loop (delta) with the windings.

3. **Line Connections:** Connect each corner point of the delta formed by the windings (U1-V2, V1-W2, W1-U2) to the three individual lines (L1, L2, L3) from the power supply.

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.

(b) Consequences of Star vs. Delta Connection:

Connecting a motor in star instead of delta, or vice versa, can have significant consequences:

- **Incorrect Voltage:** If a motor designed for delta is connected in star, each winding will only receive a fraction (1/√3) of the intended voltage. This will lead to:
  - **Reduced Speed:** The motor will not be able to achieve its full designed speed because it's not receiving the necessary voltage to generate the required magnetic field strength.
  - **Lower Torque:** The motor will also have a significantly lower torque output, making it incapable of handling the intended load. This could lead to overloading and potential motor damage.
- **Overheating:** In some cases, if the motor is forced to operate under a heavy load in a star connection, it may try to draw excessive current to compensate for the lower voltage. This can lead to overheating and potential damage to the motor windings.

Conversely, connecting a motor designed for star in delta can be even more dangerous:

- **High Starting Current:** The motor windings will be subjected to the full line voltage, resulting in a much higher starting current than intended. This can overload the power supply and potentially damage the motor windings due to excessive current flow.

Therefore, it's crucial to ensure the motor connection (star or delta) matches the configuration it's designed for to avoid compromising performance, safety, and motor longevity.

Nov 2018 23rd

5. Describe the indications of, and the remedies for, an undercharge on a refrigeration system. (10)

Undercharge in a Refrigeration System: Signs and Solutions

An undercharge situation occurs in a refrigeration system when there's insufficient refrigerant circulating within the system. This can lead to several issues affecting performance and efficiency.

Indications of Undercharge:

- **Reduced Cooling Capacity:** The most noticeable sign is a decrease in the system's ability to cool effectively. The desired temperature within the cooled space (e.g., refrigerator compartment) may not be reached or maintained.
- **Increased Compressor Running Time:** The compressor may run for longer periods to try and compensate for the lack of refrigerant by circulating the existing refrigerant more frequently.

- **Suction Line Frosting:** Frosting may appear on the suction line, which carries the low-pressure refrigerant vapor from the evaporator to the compressor. This is because the reduced refrigerant flow can lead to a lower suction pressure and a drop in the temperature of the refrigerant in the suction line. Under normal conditions, the suction line should feel cool but not frosty.
- **Low Suction Pressure Gauge Reading:** The pressure gauge on the suction line will indicate a lower pressure than usual. Refer to the system's manual for the expected pressure range.
- **High Discharge Pressure Gauge Reading (Sometimes):** In some cases, the compressor may work harder to overcome the reduced refrigerant flow, leading to a higher discharge pressure on the high-pressure side (condenser side) of the system. However, this is not always the case.

Remedies for Undercharge:

- **Leak Detection and Repair:** The first step is to identify the source of the leak and repair it. A leak detection tool suitable for the specific refrigerant can be used to find leaks. Once the leak is fixed, the system needs to be evacuated to remove any air or non-condensable gases that may have entered.
- **Refrigerant Recharge:** After leak repair and system evacuation, a qualified technician can recharge the system with the appropriate type and amount of refrigerant. Following the manufacturer's recommended charging procedures and using a refrigerant charging scale are crucial. Overcharging should also be avoided as it can lead to other problems.
- **System Performance Monitoring:** Once recharged, monitor the system's performance to ensure proper cooling capacity and pressure readings.

Important Considerations:

- **Safety:** Handling refrigerants can be hazardous. It's recommended to consult a qualified technician with proper training and equipment for leak detection, system evacuation, and refrigerant charging, especially for larger or environmentally sensitive refrigerants.
- **Manufacturer's Instructions:** Always refer to the specific system's manual for troubleshooting steps, recommended pressure ranges, and proper charging procedures.

By addressing an undercharge situation promptly, you can restore the cooling performance of your refrigeration system and ensure its efficient operation.

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6. Describe, with the aid of a sketch, a vapour-compression refrigeration cycle, showing clearly the physical state and condition of the refrigerant in the system. (10)

The Vapor-Compression Refrigeration Cycle: Following the Refrigerant's Journey

The vapor-compression refrigeration cycle utilizes a circulating refrigerant to absorb heat from a low-temperature area (e.g., a refrigerator compartment) and reject it to a high-temperature area (e.g., the surrounding environment). Here's a breakdown of the cycle, highlighting the refrigerant's state and condition at each stage:

1. **Evaporator (Low-Pressure, Low-Temperature):**
   - **State: Saturated Vapor (low pressure, low temperature)**
   - **Condition:** The refrigerant enters the evaporator as a low-pressure, low-temperature vapor.
   - **Process:** It absorbs heat from the warm environment inside the refrigerator compartment, causing the refrigerant to evaporate (change from a liquid to a vapor) and its temperature to decrease further.

2. **Suction Line:**
   - **State: Saturated Vapor (low pressure, low temperature)**
   - **Condition:** The low-pressure, low-temperature refrigerant vapor travels through the suction line towards the compressor.

3. **Compressor:**
   - **State: Superheated Vapor (increased pressure, slightly increased temperature)**
   - **Condition:** The compressor increases the pressure of the refrigerant vapor. This compression work also causes the temperature of the vapor to rise slightly (becomes superheated vapor).

4. **Discharge Line:**
   - **State: Superheated Vapor (high pressure, moderate temperature)**
   - **Condition:** The high-pressure, moderately hot refrigerant vapor travels through the discharge line towards the condenser.

5. **Condenser (High-Pressure, High-Temperature):**
   - **State: Saturated Liquid (high pressure, high temperature)**
   - **Condition:** The hot, high-pressure refrigerant vapor enters the condenser. Here, it rejects heat to the surrounding environment (typically air or water) through the condenser coils. As it loses heat, the vapor condenses (changes from a vapor to a liquid) and its temperature decreases.

6. **Liquid Line:**
   - **State: Subcooled Liquid (high pressure, slightly lower temperature)**
   - **Condition:** The high-pressure refrigerant, now in a liquid state, exits the condenser. It may pass through an additional heat exchanger (depending on the system design) to further reduce its temperature (becomes subcooled liquid). This subcooling improves efficiency by ensuring the refrigerant enters the evaporator as a cooler liquid.

7. **Expansion Device (Capillary Tube or Thermostatic Expansion Valve):**
   - **State: Flash Gas & Saturated Liquid (reduced pressure, lower temperature)**
   - **Condition:** The high-pressure liquid refrigerant passes through an expansion device (either a capillary tube or a thermostatic expansion valve). This device restricts the flow of the refrigerant, causing a sudden pressure drop. The pressure drop results in a partial flashing of the liquid into a low-pressure, low-temperature vapor-liquid mixture.

8. **Return Line:**

- **State: Two-Phase Mixture (liquid & vapor, low pressure, low temperature)**
- **Condition:** The mixture of liquid and low-pressure vapor travels through the return line back to the evaporator.

The cycle then repeats:

The chilled liquid and vapor mixture from the return line reaches the evaporator, where the refrigerant absorbs heat again, and the cycle continues. By continuously circulating through these stages, the refrigerant acts as a heat transfer medium, removing heat from the low-temperature area and releasing it to the high-temperature area, achieving the desired cooling effect.

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7. (a) A crane is being fitted to deploy and recover a load from a vessel. With reference to the present regulations, state the standards that the crane must comply with before being used on board. (7)

(b) State the information entered on a Proof Load Test certificate. (3)

Crane Regulations and Proof Load Test Certificates for Vessel Use

(a) Crane Standards for Vessel Use:

Before a crane can be used to deploy and recover a load from a vessel, it must comply with several international and national regulations. Here are some key standards to consider:

- **International Maritime Organization (IMO):**
  - **Code of Safe Practice for Ships in Cargo Handling (CSS Code):** This code outlines various safety requirements for cargo handling operations, including the use of cranes onboard ships. It addresses aspects like crane design, stability considerations, operator training, and safe working practices.
  - **Safe Work at Height (SWAH) Code:** This code provides recommendations for working at heights onboard ships, including safe access and egress for crane operators when using elevated cabs.
- **International Organization for Standardization (ISO):**
  - **ISO 4878 - Cranes - Principles of design and verification:** This standard establishes general principles for the design and verification of cranes, including structural strength, stability, and fatigue considerations.
  - **ISO 14439 - Cranes - Lifting performance - Part 1: General:** This standard specifies requirements for the determination of lifting performance of cranes, including proof load testing and load charts.
- **National Regulations:** In addition to international standards, many countries have their own national regulations governing the use of cranes onboard vessels. These regulations may adopt or modify international standards and may include additional requirements specific to the country's maritime industry.

It's crucial to consult the relevant classification society (e.g., American Bureau of Shipping (ABS), Lloyd's Register) and the national maritime authority for the specific regulations applicable to your location and the type of vessel the crane will be used on.

(b) Information on a Proof Load Test Certificate:

A Proof Load Test Certificate documents the results of a load test performed on a crane to verify its lifting capacity and structural integrity. Here's some of the information typically included on a Proof Load Test Certificate:

- **Crane Identification:** This includes details like the crane manufacturer, model number, and serial number.
- **Test Date and Location:** Date and location where the proof load test was conducted.
- **Test Authority:** Information about the accredited testing company or organization that performed the test.
- **Test Conditions:** This may include details like ambient temperature, wind speed, and any special test configurations used.
- **Test Loads:** The certificate will specify the test loads applied to the crane during the test, typically expressed as a percentage of the crane's rated lifting capacity (e.g., 110% of SWL).
- **Test Results:** The certificate will record the outcome of the test, confirming whether the crane passed or failed the test with respect to its rated capacity.
- **Inspector's Signature:** The certificate will be signed by a qualified inspector who witnessed the test and reviewed the results.

The specific format and content of a Proof Load Test Certificate may vary depending on the testing company and the regulations they follow. Always ensure the certificate is issued by a reputable testing organization and meets the requirements of the relevant classification society and national maritime authority.

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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. Some may use fiberglass for specific applications.
- **Double-walled Design (Preferred):** Double-walled tanks 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.
- **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.
- **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.
- **Drainage:** The bunded area should have a proper drainage system to prevent rainwater accumulation and potential contamination.
- **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.
  - **Flame Arrestors:** These are installed on vents to prevent flames from entering the tank in case of an external fire.
- **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.

Additional Considerations:

- **Regulations:** Storage tank construction, placement, and ventilation must comply with relevant national and international regulations (e.g., NFPA 30, API 653).
- **Inspections and Maintenance:** Regular inspections and maintenance of tanks, vents, and associated equipment are crucial to ensure their integrity and functionality.

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.

Nov 2018 23rd

9. (a) Describe, with the aid of a sketch, the securing arrangement for a pipe passing through a watertight bulkhead. (5)

(b) Sketch an arrangement for a watertight electric cable gland labelling ALL components. (5)

Securing Arrangements for Penetrations in a Watertight Structure

Here's a breakdown of securing arrangements for two common penetrations in a watertight structure:

(a) Pipe Passing Through a Watertight Bulkhead:

To maintain watertight integrity, a pipe passing through a watertight bulkhead requires a special securing arrangement. Here's a typical setup:

1. **Watertight Bulkhead Flange:** A flange is welded or bolted to the bulkhead on either side of the opening. This flange has a machined surface to create a tight seal with the pipe penetration system.
2. **Pipe Penetration Plate:** This plate, often made of steel, is sandwiched between the two bulkhead flanges. It has a central hole sized to accommodate the pipe with some clearance.
3. **Packing Material:** A compressible packing material, like a braided flax or synthetic fiber gasket, is placed in the annular space between the pipe and the penetration plate hole. This packing material is compressed to create a watertight seal around the pipe.
4. **Gland Flange and Follower:** A gland flange with a follower ring is bolted onto one side of the bulkhead flange. The follower ring applies pressure to the packing material, compressing it against the pipe and the penetration plate.
5. **Studs and Nuts:** Studs or bolts secure the gland flange and follower ring to the bulkhead flange, creating the clamping force on the packing material.

Benefits:

- Simple and reliable design.
- Easy to disassemble for pipe maintenance or replacement.

Limitations:

- Requires space on both sides of the bulkhead for flange installation.
- May require retightening of the gland bolts over time as the packing material compresses.

(b) Watertight Electric Cable Gland:

A watertight electric cable gland provides a sealed passage for an electrical cable through a watertight structure like a bulkhead or deck. Here are the key components:

1. **Body:** The main body of the gland is typically made of brass or nickel-plated brass for corrosion resistance. It houses the sealing mechanism and provides a threaded connection for mounting to the bulkhead.

2. **Cable Entry Port:** This sized opening allows the electrical cable to pass through the gland.
3. **Grommet:** A rubber or elastomeric grommet with a central hole sized for the specific cable diameter is inserted into the cable entry port. The grommet creates a tight seal around the cable jacket, preventing water ingress.
4. **Clamping Ring:** A threaded clamping ring is screwed onto the body, compressing the grommet and the cable against the cable entry port, creating a watertight seal.
5. **Locknut:** A locknut is tightened against the body to secure the clamping ring and maintain the compression on the grommet and cable.
6. **Terminal Chamber:** The body may have an internal chamber to accommodate electrical cable terminations (e.g., lugs, crimps) for connecting the cable to other electrical components.

Benefits:

- Compact design, suitable for limited space applications.
- Easy to install and maintain.
- Various sizes and types available for different cable diameters and environmental conditions.

Limitations:

- Limited reusability depending on the type of grommet used.
- May not be suitable for very large cables.

Choosing the right securing arrangement depends on several factors, including the size and type of pipe or cable, the pressure rating required, and the available space. Always consult with the manufacturer's recommendations and relevant regulations for proper installation and use.

Nov 2018 23rd

10. With reference to stresses and strain in vessels, describe, with the aid of a sketch, EACH of the following:

(a) panting; (2)

(b) pounding; (2)

(c) racking; (2)

(d) hogging; (2)

(e) sagging; (2)

Stresses and Strains in Vessels: A Breakdown of Key Terms

(a) Panting:

- **Description:** Panting refers to the rapid **inward and outward flexing** of the forward hull plating, particularly at the bow and forepeak (compartment at the extreme forward end). It resembles a bellows effect, with the flexing synchronized with the wave encounter frequency.
- **Cause:** The primary cause is the **dynamic pressure difference** acting along the length of the hull as the vessel encounters waves. The bow section experiences alternating high and low

pressures as it rides over wave crests and troughs. This pressure variation causes the relatively flexible plating at the bow to flex inwards (when encountering a wave trough) and outwards (when encountering a wave crest).

- **Stress:** The rapid flexing creates **dynamic stresses** (time-varying forces) in the plating, causing it to bend and potentially fatigue over time.

(b) Pounding:

- **Description:** Pounding refers to the **violent impact** of the vessel's forward sections (bow) against the water surface when driven hard in a head sea (waves directly ahead). This typically occurs in rough seas with large waves and high vessel speeds.
- **Cause:** As the vessel encounters a wave crest, the bow rises and may emerge partially out of the water. When the bow descends rapidly towards the next wave trough, it can slam against the water surface with significant force.
- **Stress:** The impact creates a localized **high-intensity, short-duration dynamic stress** concentrated at the point of contact. This can damage the bow plating and transmit shockwaves through the hull structure, potentially affecting other areas.

(c) Racking:

- **Description:** Racking refers to a **distortion** of the ship's hull structure caused by **transverse stresses** acting in a horizontal plane. Imagine the hull twisting slightly out of shape, like a rectangle warping into a parallelogram.
- **Cause:** Racking typically occurs when a vessel is subjected to forces that act perpendicular to the longitudinal axis (length) of the hull. These forces can arise from wave action in rough seas (uneven buoyant forces on different sides), shifting cargo within the vessel, or grounding on the seabed unevenly on one side.
- **Stress:** The twisting motion creates **transverse stresses** within the hull structure, putting strain on bulkheads, longitudinal stiffeners, and other structures designed to resist such forces.

(d) Hogging:

- **Description:** Hogging refers to a **longitudinal bending** condition in a vessel's hull where the **midsection rises** and the **ends dip down**. Imagine the vessel bending upwards in the center like an inverted U-shape.
- **Cause:** The primary cause is the **distribution of weight and buoyancy** along the ship's length. When the vessel is supported on wave crests at either end, with the center unsupported in a wave trough, the bending moment created by these forces causes hogging.
- **Stress:** Hogging induces **longitudinal stresses** in the hull. The deck experiences a **tensile stress** (pulling force) on the topside and a **compressive stress** (pushing force) on the underside in the amidships section.

(e) Sagging:

- **Description:** Sagging refers to a **longitudinal bending** condition in a vessel's hull where the **midsection dips down** and the **ends rise**. Imagine the vessel bending downwards in the center like a U-shape.
- **Cause:** Sagging occurs when the **opposite** scenario of hogging takes place. The vessel is supported in the center by a wave crest, while the ends are in wave troughs. This creates a bending moment that causes the hull to sag downwards.

- **Stress:** Sagging also induces **longitudinal stresses** in the hull. The deck experiences a **compressive stress** (pushing force) on the topside and a **tensile stress** (pulling force) on the underside in the amidships section.