March 19th 2021

1. (a) State, with reasons, the type of valve that should be used in EACH of the following situations:

   (i) isolating valve within a fire main; (2)

   (ii) main engine stand-by cooling water circulating pump discharge. (2)

   (b) With reference to a fuel service tank outlet valve:

   (i) describe its operation; (4)

   (ii) state the reason for the operation in part (b)(i). (2)

March 19th 2021

2. With reference to centrifugal pumps:

   (a) explain why it is common practice to start with the discharge valve closed or throttled; (4)

   (b) explain why the delivery valve must not be left closed after starting; (3)

   (c) state why it is not always necessary to fit a relief valve. (3)

March 19th 2021

3. With reference to main air receivers:

   (a) list FOUR safety features, stating the purpose of EACH: (8)

   (b) state the pressure at which the relief valve should lift. (2)

March 19th 2021

4. With reference to pneumatic control systems, explain EACH of the following:

   (a) why having a supply of clean dry air is important; (5)

   (b) how a supply of clean dry air is achieved. (5)

March 19th 2021

5. Sketch a 2-ram type steering gear including the hydraulic circuit, labelling ALL components. (10)

March 19th 2021

6. With reference to a vessel with a single electro/hydraulic controllable pitch propeller, explain EACH of the following:

   (a) how manoeuvring may be maintained if the control system fails; (5)

   (b) the action to be taken should the hydraulic system irreparably fail whilst on route and the blades assume zero pitch. (5)

March 19th 2021

7. With reference to main propulsion shaft hydraulic sleeve type couplings:

   (a) describe, with the aid of a sketch, the tightening procedure; (7)

   (b) state how it is determined that the push fit is complete. (3)

March 19th 2021

8. (a) Explain, with the aid of sketches, how a new motor is aligned with an existing pump. (7)

   (b) State THREE checks which should be made before using the pump after the motor has been aligned. (3)

March 19th 2021

9. With reference to storage batteries:

   (a) explain how the level of charge can be determined in EACH of the following:

      (i) lead acid; (3)

      (ii) alkaline; (2)

   (b) state FIVE reasons that the charge may be reduced. (5)

March 19th 2021

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

   (a) boost charge; (3)

   (b) slow charge; (2)

   (c) trickle charge; (3)

   (d) float charge. (2)

March 19th 2021

1. (a) State, with reasons, the type of valve that should be used in EACH of the following situations:

   (i) isolating valve within a fire main; (2)

   (ii) main engine stand-by cooling water circulating pump discharge. (2)

   (b) With reference to a fuel service tank outlet valve:

   (i) describe its operation; (4)

   (ii) state the reason for the operation in part (b)(i). (2)

Valve Selection and Fuel Service Tank Outlet Valve Operation

(a) Valve Types for Different Applications:

(i) Isolating Valve within a Fire Main:

- **Valve Type: Gate Valve**
- **Reasons:**
  - **Positive Shut-Off:** Gate valves provide a complete closure, critically important for isolating leaks or damaged sections of a fire main.
  - **Low Pressure Drop:** When fully open, the design minimizes resistance to water flow, ensuring minimal impact on overall system pressure in the fire main.
  - **Durability:** Gate valves are known for their robust construction and ability to withstand the high pressures encountered in fire main systems.

(ii) Main Engine Stand-By Cooling Water Circulating Pump Discharge:

- **Valve Type: Globe Valve** (or Butterfly Valve)
- **Reasons:**
  - **Regulation:** A globe valve allows for fine-tuning of the stand-by cooling water flow to the main engine, which might be desirable for temperature control.
  - **Lower Pressure Drop (Optional):** While gate valves offer low pressure drop when fully open, a butterfly valve might be a suitable alternative if minimizing pressure drop across the valve is a primary concern during stand-by cooling operation. However, butterfly valves typically have a higher pressure drop compared to globe valves when fully open.
  - **Cost (Optional):** Butterfly valves are generally less expensive than globe valves. If cost is a major consideration and fine flow control is not essential, a butterfly valve could be a viable option.

(b) Fuel Service Tank Outlet Valve Operation and Reason:

(i) Valve Operation:

A fuel service tank outlet valve is typically a **remotely operated quick closing valve**. Here's how it operates:

1. **Normal Operation:** The valve remains open under normal conditions, allowing fuel to flow from the tank when needed.
2. **Fire Alarm or Sensor Activation:** In case of a fire or a leak detection signal, the fire alarm system or leak detection system transmits a signal.
3. **Remote Closure:** The signal triggers the remote closing mechanism of the valve (e.g., hydraulic, pneumatic, or solenoid).
4. **Rapid Shut-Off:** The mechanism forces the valve shut rapidly, stopping the flow of fuel from the tank. This helps to:
   - **Prevent Fire Spread:** By isolating the fuel source, the valve can prevent the fire from reaching the fuel tank and potentially causing a larger explosion.
   - **Minimize Leakage:** In case of a leak in the fuel line, the quick closure minimizes the amount of fuel released, reducing environmental hazards and potential fire risks.

(ii) Reason for Operation:

The primary reason for the quick closing operation of the fuel service tank outlet valve is to **limit the spread of fire and minimize fuel release** in case of an emergency. By isolating the fuel source, this valve helps to:

- **Enhance Fire Safety:** Quick shut-off reduces the risk of fuel feeding the fire and potentially causing a catastrophic event.
- **Minimize Environmental Impact:** Limiting fuel release minimizes environmental damage from potential spills or leaks.

9th 2021

March 19th 2021

2. With reference to centrifugal pumps:

(a) explain why it is common practice to start with the discharge valve closed or throttled; (4)

(b) explain why the delivery valve must not be left closed after starting; (3)

(c) state why it is not always necessary to fit a relief valve. (3)

Centrifugal Pump Operation and Valve Considerations

(a) Starting with Closed or Throttled Discharge Valve:

It's common practice to start a centrifugal pump with the discharge valve closed or throttled for several reasons:

- **Reduced Starting Load:** When the discharge valve is closed, the pump initially operates against minimal resistance. This reduces the starting torque required by the motor, minimizing strain on the motor and electrical system.
- **Reduced Risk of Cavitation:** A closed discharge valve reduces the flow rate through the pump during startup. This can help prevent cavitation, a phenomenon where bubbles form and collapse due to low pressure at the pump inlet, potentially damaging the impeller.

- **Safer System Startup:** A closed discharge valve allows for a controlled system startup. The pump can be brought up to speed gradually, allowing for any trapped air to purge from the system before full pressure is established.

(b) Not Leaving Discharge Valve Closed After Starting:

Leaving the discharge valve closed after starting the pump can have detrimental effects:

- **Overheating:** With no flow through the pump, the liquid inside the casing cannot circulate and absorb heat generated by the motor and bearings. This can lead to overheating and potential damage to the pump components.
- **Excessive Pressure Build-Up:** If the discharge valve remains closed for an extended period, the pump continues to deliver fluid, leading to a rapid pressure build-up within the system. This can exceed the pressure rating of the pipes or equipment, potentially causing leaks or ruptures.
- **Pump Damage:** In extreme cases, excessive pressure due to a closed discharge valve can lead to mechanical damage to the pump housing or internal components.

(c) Why Relief Valve Might Not Be Necessary:

While relief valves are crucial for positive displacement pumps, they might not always be necessary for centrifugal pumps. Here's why:

- **Self-Limiting Flow:** Centrifugal pumps are not positive displacement pumps. Their flow rate is not constant but increases with increasing discharge pressure. As the discharge pressure rises due to a closed valve, the flow rate through the pump naturally decreases.
- **System Relief Measures:** Some systems might already have pressure relief valves or safety devices installed elsewhere in the piping system. These can act as a safeguard against excessive pressure build-up in case of a closed discharge valve.
- **Application Considerations:** For applications with low-pressure requirements and limited risk of system overpressure, a relief valve might be deemed unnecessary.

However, there are situations where a relief valve is still recommended for centrifugal pumps:

- **High-Pressure Systems:** In systems with high operating pressures, a relief valve provides an extra layer of safety by protecting the pump and piping from exceeding their pressure limitations.
- **Dead-End Systems:** If the discharge line terminates in a dead-end with no pressure relief path, a relief valve on the pump itself is essential to prevent excessive pressure build-up.
- **Variable Speed Pumps:** For pumps with variable speed drives, a relief valve is important to safeguard against unexpected pressure surges in case of control system malfunctions.

Ultimately, the decision to include a relief valve in a centrifugal pump system depends on a risk assessment considering factors like system pressure, potential for closed discharge scenarios, and the presence of other safety measures.

March 19th 2021

3. With reference to main air receivers:

(a) list FOUR safety features, stating the purpose of EACH: (8)

(b) state the pressure at which the relief valve should lift. (2)

Main Air Receiver Safety Features

(a) Four Safety Features and their Purposes:

1. **Pressure Relief Valve:**
   - **Purpose:** This is the primary safety feature and acts as a last line of defense. It automatically releases compressed air if the pressure within the receiver exceeds a predetermined safe limit (typically set pressure + 10%). This prevents the receiver from rupturing due to excessive pressure buildup.
2. **Safety Relief Valve (Optional):**
   - **Purpose:** Provides an additional layer of safety. This valve, typically set at a higher pressure than the pressure relief valve, acts as a backup in case the primary valve malfunctions. It opens automatically to release compressed air if the pressure exceeds its set point, preventing catastrophic failure.
3. **Drain Valve:**
   - **Purpose:** Allows for the removal of accumulated condensate (water) from the bottom of the air receiver. Moisture in the compressed air can cause corrosion and weaken the receiver walls over time. Regularly draining the condensate helps to prevent this and maintain the integrity of the receiver.
4. **Pressure Gauge:**
   - **Purpose:** Provides a visual indication of the air pressure within the receiver. This allows operators to monitor the system pressure and ensure it stays within the safe operating range. It also helps identify potential pressure drops or malfunctions within the compressed air system.

(b) Pressure Relief Valve Lifting Pressure:

The pressure relief valve on a main air receiver should typically be set to lift at a pressure that is **10% higher than the maximum allowable working pressure** of the receiver. This provides a safety margin to prevent the receiver from rupturing in case of sudden pressure surges or malfunctions.

Important Note:

The specific pressure settings for safety devices should be based on the manufacturer's recommendations and relevant safety codes for your region. Never tamper with these settings or bypass safety devices. Regularly inspect and maintain these safety features to ensure they function properly and can protect your compressed air system.

March 19th 2021

4. With reference to pneumatic control systems, explain EACH of the following:

(a) why having a supply of clean dry air is important; (5)

(b) how a supply of clean dry air is achieved. (5)

lean and Dry Air in Pneumatic Control Systems

(a) Why Clean and Dry Air is Important:

A clean and dry air supply is crucial for optimal performance and longevity in pneumatic control systems for several reasons:

- **Prevents Corrosion:** Moisture (water vapor) reacts with metal components in valves, cylinders, and pipelines, leading to rust and premature wear. This can cause leaks, reduced performance, and ultimately system failure. Clean, dry air minimizes water content, preventing corrosion and extending component life.
- **Reduces Friction and Wear:** Compressed air naturally condenses some moisture, which can form a thin film on internal surfaces. However, excessive moisture weakens this film, increasing friction and wear on moving parts like pistons and seals. Clean, dry air ensures proper lubrication and reduces wear.
- **Prevents Malfunctions:** Water can cause valves to stick or malfunction due to internal corrosion or ice formation (in cold environments). Clean, dry air prevents these issues, ensuring reliable and precise control of pneumatic actuators.
- **Protects Downstream Equipment:** Some pneumatic systems have components like sensors and air tools that are sensitive to contamination. Clean, dry air minimizes the risk of oil or dirt contamination from upstream components, protecting these downstream elements.
- **Improves System Efficiency:** Moisture and contaminants can restrict air flow and cause pressure drops. Clean, dry air ensures smooth flow and efficient operation, maximizing system performance.

(b) How a Clean and Dry Air Supply is Achieved:

There are several methods for achieving a clean and dry air supply in pneumatic systems:

1. **Air Filtration:** Multistage air filters are used to remove solid particles like dust, dirt, and rust from the compressed air. These filters typically consist of a pre-filter for larger particles and a coalescing filter for finer particles and water droplets.
2. **Refrigerated Air Dryers:** These dryers cool the compressed air to a temperature below its dew point, causing moisture to condense and separate. The condensate is then drained automatically, leaving behind dry air.
3. **Desiccant Air Dryers:** These dryers utilize desiccant materials that absorb moisture from the compressed air. The desiccant is regenerated by heating it periodically, releasing the absorbed moisture.

4. **Drain Traps:** These automatic traps collect and drain condensate that accumulates in pipelines or low-point areas of the system. This helps prevent water from re-entering the air stream.

The specific method used to achieve clean and dry air depends on factors like the required level of dryness, ambient temperature, and system pressure. Consulting with a compressed air specialist can help determine the most suitable solution for your specific needs.

h 19th 2021

March 19th 2021

5. Sketch a 2-ram type steering gear including the hydraulic circuit, labelling ALL components. (10)

Two-Ram Type Steering Gear with Hydraulic Circuit Breakdown

A two-ram type steering gear utilizes a pair of hydraulic cylinders (rams) to control the movement of the rudder. Here's a breakdown of the hydraulic circuit, explaining all the components:

Main Components:

- **Hydraulic Pump:** This pump, powered by an electric motor or diesel engine, pressurizes the hydraulic fluid within the system.
- **Reservoir:** This tank stores the hydraulic fluid and maintains its proper level. It also allows for air separation and heat dissipation.
- **Pipelines:** High-pressure hoses or steel pipes connect the various components and carry the pressurized fluid.
- **Directional Control Valve:** This valve, located near the bridge control system, receives electrical or mechanical signals and acts as a gatekeeper for the pressurized fluid. Depending on the received signal, it directs the flow to specific rams.
- **Two Hydraulic Rams:** These double-acting cylinders are positioned symmetrically on either side of the vessel's centerline, typically mounted on the hull structure. Each ram consists of a piston rod, cylinder body, and end fittings for connection.
- **Tiller:** The tiller is a lever arm attached to the rudder stock. It acts as the point where the rams apply their force to turn the rudder.

Hydraulic Circuit Operation:

1. **Command Signal:** The helmsman on the bridge operates the steering wheel or controls, sending a signal (electrical or mechanical) to the directional control valve.
2. **Valve Movement:** Based on the signal, the spool or poppet within the directional control valve moves, opening specific ports.
3. **High-Pressure Fluid Flow:** Depending on the desired rudder movement (turn left or right), the valve directs pressurized fluid from the pump to one side of the designated ram's cylinder.
4. **Low-Pressure Fluid Path:** Simultaneously, the valve opens a passage for the hydraulic fluid on the opposite side of the ram to return to the reservoir. This creates a pressure differential across the ram's piston.

5. **Ram Extension/Retraction:** The pressure difference acts on the piston within the ram's cylinder. The high-pressure side pushes the piston rod in the desired direction, either extending or retracting the ram.
6. **Rudder Movement:** The connecting end fitting of the ram's piston rod is attached to the tiller. As the ram extends or retracts, it pushes or pulls on the tiller, causing the rudder stock to rotate and turn the rudder in the desired direction.
7. **Opposite Ram Action:** When turning the rudder, the other ram receives fluid flow to the opposite side of its cylinder, causing its piston rod to move in the opposite direction. This ensures balanced force application on the tiller and minimizes twisting of the rudder stock.
8. **Centering the Rudder:** When the helmsman centers the steering wheel, the directional control valve directs fluid flow to neither side of the rams, or allows fluid flow equally on both sides. This holds the pistons in their centered positions, keeping the rudder centered.

Additional Components (Optional):

- **Pressure Relief Valve:** This safety valve protects the system from excessive pressure buildup by diverting excess fluid back to the reservoir in case of malfunctions.
- **Check Valves (Optional):** In some designs, check valves might be incorporated in the lines between the rams and the directional control valve. These one-way valves allow fluid flow in one direction only, preventing the rams from extending or retracting unintentionally if there's a pressure drop in one circuit.
- **Filters:** Hydraulic fluid filters are essential to remove contaminants from the fluid, protecting pumps, valves, and other components from wear and tear.

Overall, a two-ram steering gear with its hydraulic circuit provides a reliable and efficient way to control the rudder by translating steering commands into precise rudder movements through the coordinated action of pumps, valves, rams, and the tiller.

19th 2021

March 19th 2021

6. With reference to a vessel with a single electro/hydraulic controllable pitch propeller, explain EACH of the following:

   (a) how manoeuvring may be maintained if the control system fails; (5)

   (b) the action to be taken should the hydraulic system irreparably fail whilst on route and the blades assume zero pitch. (5)

Maintaining Maneuverability and Actions During Control System/Hydraulic Failure (Single CPP)

(a) Maintaining Maneuvering with Control System Failure:

Maintaining some level of maneuverability even with a control system failure in a single electro/hydraulic controllable pitch propeller (CPP) system depends on the available backup features:

- **Emergency Pitch Control System (Optional):**
  - Some CPP systems might have a secondary, non-hydraulic control system (electric, mechanical) for limited blade pitch adjustment. This allows the operator to potentially feather the blades (set them to a negative pitch angle) for minimal drag or even adjust them to a low forward thrust setting for basic maneuvering.
- **Manual Pitch Locking Mechanism (Optional):**
  - In some designs, a manual locking mechanism might be available. This allows the crew to secure the blades in a specific pitch position (usually feathered) using tools, even if the control system fails. This would eliminate drag and allow for some steering control with the rudder.
- **Rudder Control:**
  - The rudder remains functional even with control system failure. By skillfully using the rudder, the crew can maintain some degree of directional control, especially at lower speeds.

However, it's important to note that these are limited options, and maneuvering capability will be significantly reduced compared to normal operation.

(b) Action if Hydraulic System Fails and Blades Assume Zero Pitch:

If the hydraulic system fails completely and the blades go to zero pitch while underway, the following actions should be taken:

- **Stop Engine:** Immediately stop the main engine to prevent unnecessary wear and tear on the propeller and drivetrain components due to zero thrust generation.
- **Assess Situation:** Evaluate the vessel's position, surrounding traffic, and weather conditions. This helps determine the most appropriate course of action.
- **Alert Crew and Authorities:** Inform the crew of the situation and activate emergency procedures. Broadcast a distress signal (if necessary) to alert nearby vessels and coastal authorities of the situation and potential need for assistance.
- **Anchor Deployment (Optional):** If conditions allow and the water depth is suitable, consider deploying the anchor to help stabilize the vessel's position and prevent drifting.
- **Activate Backup Systems (if Available):** If the vessel has auxiliary propulsion systems like bow thrusters or stern thrusters, attempt to use them for limited maneuvering capabilities.
- **Prepare for Assistance:** Prepare to receive assistance from tugboats or other vessels if necessary.

Remember: The priority in this situation is to ensure the safety of the crew and vessel. By taking prompt action, maintaining communication, and utilizing available resources, the impact of the failure can be minimized while awaiting assistance.

March 19th 2021

7. With reference to main propulsion shaft hydraulic sleeve type couplings:

(a) describe, with the aid of a sketch, the tightening procedure; (7)

(b) state how it is determined that the push fit is complete. (3)

Main Propulsion Shaft Hydraulic Sleeve Type Couplings: Tightening and Push Fit

Here's a breakdown of the tightening procedure and how to determine a successful push fit for a main propulsion shaft hydraulic sleeve type coupling:

(a) Tightening Procedure:

Tightening a hydraulic sleeve coupling requires careful attention to ensure proper engagement and a secure fit. Here's a general outline:

Preparation:

1. **Cleanliness:** Ensure the coupling components (shaft taper, inner sleeve bore) are clean and free of any debris or contaminants that could affect the fit.
2. **Lubrication (Optional):** Some designs might specify the use of a specific lubricant on the tapered surfaces to aid assembly and prevent fretting corrosion. Follow manufacturer's instructions for lubricant type and application.
3. **Positioning:** Carefully position the inner sleeve onto the shaft taper, ensuring proper alignment.

Tightening:

1. **Hydraulic Pressure Application (Primary Method):** Hydraulic sleeve couplings typically utilize hydraulic pressure to achieve the necessary force for a tight fit. This is achieved through a dedicated hydraulic system integrated into the coupling design.
   - The specific procedure will involve connecting the hydraulic system to the coupling and carefully applying controlled pressure according to the manufacturer's instructions.
   - Pressure gauges and predetermined pressure values are used to ensure the correct force is applied for proper engagement.
2. **Mechanical Tightening (Optional - Some Designs):** In some coupling designs, there might be additional mechanical fasteners (bolts, nuts) that require tightening after hydraulic pressure application. These fasteners further secure the coupling halves together. Tightening torque values and sequence should strictly follow manufacturer's specifications.

Important Notes:

- The specific tightening procedure will vary depending on the coupling design and manufacturer's instructions. Consulting the relevant manuals for detailed steps and safety precautions is crucial.
- It's essential to ensure the hydraulic system is functioning properly and free of leaks before applying pressure.
- During the tightening process, proper safety protocols should be followed to prevent injury from unexpected movement or high-pressure systems.

(b) Determining Push Fit Completion:

Verifying a complete push fit after tightening a hydraulic sleeve coupling is critical for ensuring a secure connection. Here are methods used to determine proper engagement:

1. Pressure Gauge Reading:

- In hydraulically actuated couplings, the pressure gauge used during tightening will typically provide a direct indication of successful engagement. Reaching the designated pressure value specified by the manufacturer indicates the proper force has been achieved for a secure fit.

2. Measurement and Tolerance Checks:

- After tightening, consult the coupling manufacturer's specifications for the required final dimensions of the assembled coupling (e.g., overall length, specific gap measurements).
- Use precision measuring tools (calipers, micrometers) to verify that the achieved dimensions fall within the specified tolerance range. This confirms proper engagement and interference between the shaft and the inner sleeve.

3. Factory-provided Tools (Optional):

- Some coupling manufacturers might provide specialized tools or gauges for verifying the push fit. These tools may measure displacement during the tightening process or utilize other parameters to indicate proper engagement.

4. Visual Inspection:

- While not the sole method, a thorough visual inspection can reveal any obvious gaps or misalignments between the coupling halves after tightening.

Overall:

A combination of these methods is typically used to ensure a complete and secure push fit after tightening a hydraulic sleeve coupling. Following manufacturer's instructions, monitoring pressure readings, and utilizing appropriate measurement tools are crucial for verifying successful assembly.

March 19th 2021

8. (a) Explain, with the aid of sketches, how a new motor is aligned with an existing pump. (7)

(b) State THREE checks which should be made before using the pump after the motor has been aligned. (3)

Aligning a New Motor with an Existing Pump:

Aligning a new motor with an existing pump ensures the shafts of both machines are in proper alignment to minimize vibration, wear, and improve overall efficiency. Here's a breakdown of the process:

Preparation:

1. **Lockout/Tagout:** Implement proper lockout/tagout procedures to isolate the system and ensure safety before starting the alignment process.
2. **Mounting:** Securely mount the new motor on the foundation or frame, following the manufacturer's instructions.
3. **Shaft Cleaning:** Clean the motor and pump shafts to remove any dirt or debris that could affect the alignment process.

Alignment Procedure (There are multiple methods, here's a common one using dial indicators):

1. **Dial Indicators:** Attach dial indicators with magnetic bases to brackets on the pump and motor shafts. These indicators will measure any runout (wobble) or misalignment between the shafts.
2. **Shimming:** Loosen the motor mounting bolts slightly. Use shims (thin wedges of metal) placed strategically between the motor feet and the foundation to adjust the motor's position.
3. **Dial Gauge Readings:** By turning the shafts and observing the dial indicator readings, the technician can adjust the shims to minimize both horizontal and vertical misalignment between the shafts.
4. **Alignment Tolerances:** Tighten the motor mounting bolts to the specified torque values. Re-check the dial indicator readings to ensure they fall within the acceptable alignment tolerances specified by the pump and motor manufacturers.

Additional Techniques:

- **Laser Alignment:** In some cases, laser alignment tools might be used for a more precise alignment process. These systems project laser beams onto targets on the shafts and provide real-time data on misalignment.

Important Notes:

- The specific alignment procedure will vary depending on the type of pump, motor, and the chosen alignment method.

- Always follow the manufacturer's instructions for both the pump and motor regarding alignment procedures and acceptable tolerances.
- The process requires proper training and experience to ensure accurate alignment.

Checks Before Using the Pump After Alignment:

Before operating the pump after motor alignment, it's crucial to perform some final checks to ensure everything is in order:

1. **Recheck Alignment:** While unlikely, it's good practice to perform a final verification of the alignment after tightening the motor mounting bolts. This ensures any slight movement during tightening hasn't affected the alignment.
2. **Lubrication:** Verify that the pump is properly lubricated according to the manufacturer's recommendations. This includes checking oil levels (if applicable) and ensuring grease points are lubricated.
3. **Coupling Inspection:** Visually inspect the coupling between the motor and pump shaft for any signs of damage or wear. Ensure all coupling bolts are tightened to the specified torque values.
4. **Pipework:** Double-check that all piping connections to the pump are secure and free of leaks. Ensure proper venting of any air pockets within the piping system.
5. **Electrical Connections:** Verify that all electrical connections to the motor are secure and meet the required specifications.

By performing these checks before starting the pump, you can help ensure safe and reliable operation.

h 19th 2021

March 19th 2021

9. With reference to storage batteries:

(a) explain how the level of charge can be determined in EACH of the following:

(i) lead acid; (3)

(ii) alkaline; (2)

(b) state FIVE reasons that the charge may be reduced. (5)

Determining State of Charge (SOC) in Storage Batteries:

(a) Methods for Different Battery Types:

** (i) Lead-Acid Batteries:**

There are several methods for determining the state of charge (SOC) in lead-acid batteries:

- **Open-Circuit Voltage (OCV):** This is a simple method where the voltage of the battery is measured without any load connected. A table with corresponding voltage values for different

SOC levels can be used for estimation. However, this method is not very accurate as voltage can vary with temperature.

- **Hydrometer:** This traditional tool measures the specific gravity of the electrolyte solution within the battery. Higher specific gravity indicates a higher state of charge. However, using a hydrometer requires accessing the individual cells, which might not be possible in sealed VRLA (Valve-Regulated Lead Acid) batteries.
- **Battery Management System (BMS):** Modern lead-acid batteries, especially those used in deep-cycle applications, often have built-in BMS that monitor voltage, current, and temperature. The BMS can estimate the SOC based on these parameters and provide a more accurate reading.

** (ii) Alkaline Batteries:**

Unfortunately, there's no single, easy, and reliable method for accurately determining the SOC in alkaline batteries. Unlike lead-acid batteries, alkaline batteries don't exhibit a clear correlation between voltage and state of charge.

However, some approaches can provide a rough indication:

- **Voltage Measurement:** While not as accurate as with lead-acid batteries, measuring the open-circuit voltage can give a general idea. A fresh alkaline battery will have a higher voltage than a partially discharged one. However, the voltage drops steadily as the battery is discharged, making it difficult to pinpoint the exact SOC.
- **Load Tester (Limited Use):** Placing the battery under a controlled load and measuring the voltage drop can sometimes provide an indication of remaining capacity. However, this method should be used with caution, as excessive load testing can damage the battery.

In general, it's recommended to replace alkaline batteries when the device they power starts showing signs of reduced performance, such as dimming lights or slower operation.

(b) Reasons for Reduced Charge in Storage Batteries:

Several factors can contribute to a reduction in the charge of a storage battery, even when not in use:

1. **Self-Discharge:** All batteries exhibit a slow, internal discharge even when not connected to a load. This self-discharge rate varies depending on the battery type, temperature, and age. Lead-acid batteries generally have a higher self-discharge rate compared to alkaline batteries.
2. **Temperature:** Extreme temperatures, both high and low, can accelerate the self-discharge rate of batteries. Storing batteries in a cool, dry place helps minimize self-discharge.
3. **Age:** As batteries age, their internal chemical processes become less efficient, leading to a gradual decrease in capacity and an increased self-discharge rate.
4. **Manufacturing Defects:** In rare cases, manufacturing defects can cause batteries to lose charge at a faster rate than normal.
5. **Improper Storage:** Storing batteries in direct sunlight or near heat sources can accelerate self-discharge. Additionally, storing partially discharged batteries can be more detrimental to their health compared to storing them fully charged.

By understanding these factors and employing proper storage practices (cool, dry place, fully charged if possible), you can help maximize the lifespan and maintain the charge of your storage batteries.

March 19th 2021

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

(a) boost charge; (3)

(b) slow charge; (2)

(c) trickle charge; (3)

(d) float charge. (2)

Battery Charging Stages Explained:

Here's a breakdown of the different charging stages used with storage batteries:

(a) Boost Charge:

- **Purpose:** The boost charge is a rapid charging method used to quickly bring a deeply discharged battery up to a usable voltage level.
- **Process:** A high current is applied to the battery initially. However, this current is typically limited electronically to prevent overheating and damage to the battery.
- **Application:** Boost charging is suitable for situations where a quick recovery of some battery capacity is needed, such as reviving a car battery that's just enough to start the engine. It's not recommended for regular charging due to the potential stress it can put on the battery.

(b) Slow Charge:

- **Purpose:** This method delivers a relatively low and constant current to the battery over an extended period.
- **Process:** The slow charge current is typically limited to around 0.1C to 0.5C, where "C" represents the battery's capacity in Ampere-hours (Ah). This allows for a gentle and complete charge without generating excessive heat.
- **Application:** Slow charging is ideal for lead-acid batteries, especially deep-cycle batteries used in applications like RVs, solar power systems, and off-grid setups. It promotes a full and healthy charge, maximizing battery lifespan.

(c) Trickle Charge:

- **Purpose:** This is a very low current charge intended to compensate for the battery's self-discharge rate.
- **Process:** The trickle charge current is typically much lower than 0.1C, often in the milliampere (mA) range. It provides a small amount of current to maintain the battery's voltage level and prevent it from completely discharging during long periods of storage.
- **Application:** Trickle charging is suitable for batteries used infrequently or stored for extended durations. It's commonly used for car batteries in seasonal vehicles, motorcycle batteries

during winter storage, and alarm systems. However, some battery types, like Lithium-ion, can be damaged by prolonged trickle charging.

(d) Float Charge:

- **Purpose:** This stage maintains a constant voltage level across the battery terminals after a full charge is achieved.
- **Process:** Once the battery reaches its full capacity during the boost or slow charge stage, the charger enters the float charge mode. It continues to supply a small current to the battery to compensate for self-discharge and maintain the voltage at a predetermined level.
- **Application:** Float charging is crucial for batteries used in standby applications where they need to be ready for immediate use, such as UPS systems, emergency lighting, and some medical equipment. It ensures the battery remains fully charged without overcharging.

Important Note: The specific charging methods and parameters (current, voltage, duration) can vary depending on the battery type, chemistry, and manufacturer's recommendations. Always consult the battery datasheet or manufacturer's instructions for the appropriate charging procedures for your specific battery.