

CERTIFICATE OF COMPETENCY EXAMINATION

EXAMINATIONS ADMINISTERED BY THE
SCOTTISH QUALIFICATIONS AUTHORITY
ON BEHALF OF
MARITIME AND COASTGUARD AGENCY
SMALL VESSEL EOOW

060-03 - AUXILIARY EQUIPMENT PART I

FRIDAY, 03 May 2024

1400-1600 hrs

Examination paper inserts:

Notes for the guidance of candidates:

1. Candidates should note that 100 marks are allocated to this paper. To pass candidates must achieve 50 marks.
2. Non-programmable calculators may be used
3. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook

AUXILIARY EQUIPMENT PART I

Attempt ALL questions
 Marks for each part question are shown in brackets

1. (a) Sketch a globe type screw lift valve suitable for sea water service. 10 (7) 7
 (b) State, with reasons, the materials used for the valve sketched in part (a). 8 (3) 2 (9)

2. (a) Explain how cavitation damage occurs within a pump. 5 (6) 3
 (b) State, with reasons, TWO operational causes of increased cavitation within a pump. 4 (4) 2 (5)

3. Explain why EACH of the following may have fusible plugs fitted:
 - (a) air compressor; 10 (5) 4 8
 - (b) air receiver. (5) 4 8

4. With reference to hydraulic systems: 8
 - (a) state THREE possible contaminations; (3) 2
 - (b) state possible causes of the contaminations stated in part (a). (6) (3) 2 (6)
 - (c) explain how the contaminants stated in part (a) are prevented from affecting the system. (4) 2

5. Sketch a 2-ram type steering gear including the hydraulic circuit, labelling ALL components. 5 (10) 7 (10)

6. With reference to propellers, explain EACH of the following terms:
 - (a) skew; (2)
 - (b) rake; (2)
 - (c) pitch; 8 (2) (10)
 - (d) slip. (4)

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

- ✓ (a) describe, with the aid of a sketch, the tightening procedure;
- ✓ (b) state how it is determined that the push fit is complete.

(4) (7)
(2) (3) (6)

8. (a) ✓ Explain, with the aid of sketches, how a new motor is aligned with an existing pump. (7) (3) (5)

(b) ✓ State THREE checks which should be made before using the pump after the motor has been aligned. (3) (2)

9. Explain EACH of the following electrical terms:

(a) preferential tripping;

(2) 1

(b) sequential starting; ✓

(2)

(c) fuse back up protection; ✓

(2)

(d) discrimination; ✓

(2)

(e) non-essential consumer. ✓

(2)

10. List TEN routine maintenance checks that should be carried out on a vented type lead acid engine starting battery system. (10)



1. (a) Sketch a globe type screw lift valve suitable for sea water service.
- (b) State, with reasons, the materials used for the valve sketched in part (a).

Globe Type Screw Lift Valve for Seawater Service

(a) Description:

A globe type screw lift valve suitable for seawater service is a valve designed to regulate or isolate flow within a pipeline conveying seawater. Here's a breakdown of its key features:

- **Valve Body:** The main housing of the valve, typically made of **cast iron** or **bronze**. Cast iron offers good strength and affordability, while bronze provides excellent corrosion resistance in saltwater environments. Some high-performance valves might use **stainless steel** for the body for its superior corrosion resistance but at a higher cost.
- **Screw Mechanism:** A threaded spindle (screw) connected to a handwheel or actuator for manual or automated control of the valve. The screw mechanism allows for **precise positioning** of the internal disc, enabling fine-tuned flow regulation.
- **Disc:** A circular plate within the body that controls the flow path. The disc can be made of various materials depending on the specific application and pressure rating. For seawater service, materials like **bronze**, **stainless steel**, or **rubber coated discs** might be used. Bronze offers good corrosion resistance and wear resistance, while stainless steel provides superior corrosion resistance but might be more expensive. Rubber-coated discs can improve sealing and offer good wear resistance but might not be suitable for high-pressure applications.
- **Seat Ring(s):** Sealing surfaces within the body that the disc comes in contact with to form a tight closure. For seawater service, the seat ring(s) are typically made of **bronze** or **stainless steel**. These materials offer good wear resistance and corrosion resistance to create a reliable seal.
- **Packing:** Sealing material around the spindle to prevent seawater leakage along the shaft. **Graphite** or **PTFE (Teflon)** are common packing materials due to their good sealing properties and wear resistance in a saltwater environment.
- **Bonnet:** A bolted or screwed cover that secures the top of the valve body and provides access to the packing for maintenance. The bonnet material typically matches the body material (cast iron, bronze, or stainless steel) for strength and compatibility.

(b) Material Selection and Reasons:

- **Valve Body:** Cast iron or bronze (primary choices).
 - **Reason:** Cast iron offers a good balance between affordability and strength, while bronze provides excellent corrosion resistance in saltwater environments.
- **Screw Mechanism:** Stainless steel (preferred).
 - **Reason:** Stainless steel offers good strength and superior corrosion resistance compared to cast iron, ensuring smooth operation and longevity in a saltwater environment.
- **Disc:** Bronze, stainless steel, or rubber-coated (depending on specific application and pressure).

- **Reason:** These materials offer a balance between wear resistance, corrosion resistance, and flow control characteristics depending on the specific needs of the seawater service application.
- **Seat Ring(s):** Bronze or stainless steel.
 - **Reason:** These materials provide good wear and corrosion resistance, ensuring a leak-proof seal against the disc.
- **Packing:** Graphite or PTFE (Teflon).
 - **Reason:** These materials offer good sealing properties and are relatively resistant to wear and tear in a saltwater environment.
- **Bonnet:** Material matching the valve body (cast iron, bronze, or stainless steel).
 - **Reason:** Ensures strength and compatibility with the body material for a secure closure.

Note: This is a general description, and the specific materials used for each component may vary depending on the valve design, pressure rating, and manufacturer's specifications.

- | | | | |
|----|--|---|-------|
| 2. | (a) Explain how cavitation damage occurs within a pump. | 5 | (6) |
| | (b) State, with reasons, TWO operational causes of increased cavitation within a pump. | | 4 (4) |

Question 2. Many still mentioning air bubbles, some even saying that boiling causes air bubbles to form. Hardly any make any reference to NPSH or vapour pressure.

Cavitation Damage in Pumps

(a) How Cavitation Damage Occurs:

Cavitation damage within a pump is a destructive process caused by the formation, growth, and collapse of vapor bubbles in the liquid being pumped. Here's a breakdown of the phenomenon:

1. **Pressure Drop:** As liquid flows through the pump, pressure decreases in specific areas, particularly at the inlet of the impeller or around the leading edges of the impeller vanes.
2. **Bubble Formation:** When the pressure drops below the liquid's vapor pressure at a specific temperature, dissolved gases and vapor pockets within the liquid begin to form small vapor bubbles.
3. **Bubble Growth:** As the low-pressure zone persists, the vapor bubbles expand in size.
4. **Bubble Collapse:** When the liquid flows to a higher pressure zone within the pump (e.g., discharge side of the impeller), the pressure on the bubbles rapidly increases. This causes the vapor bubbles to implode violently.
5. **Shockwaves and Erosion:** The rapid collapse of the bubbles generates intense shockwaves that travel through the liquid. These shockwaves can damage the pump components, particularly the impeller vanes and housing, by causing erosion, pitting, and material fatigue.

Over time, continuous cavitation can lead to significant wear and tear on the pump, reducing its efficiency, increasing noise and vibration, and potentially causing complete pump failure.

(b) Operational Causes of Increased Cavitation:

(i) Low Suction Pressure:

- **Reason:** If the pressure at the pump inlet (suction side) drops too low, it creates a larger pressure differential within the pump, promoting more extensive bubble formation and collapse. This can occur due to:
 - **Clogged inlet filter or piping:** Restrictions on the suction side increase resistance to flow, leading to a lower pressure at the pump inlet.
 - **Pumping from a deep sump:** The higher the suction lift (vertical distance between the pump and the liquid source), the lower the pressure at the pump inlet.
 - **Insufficient available NPSH (Net Positive Suction Head):** NPSH is a parameter that considers the available pressure head at the pump inlet and the vapor pressure of the liquid. If the available NPSH is lower than the pump's required NPSH, cavitation is more likely to occur.

(ii) High Operating Speed:

- **Reason:** Increasing the pump speed (RPM) can also exacerbate cavitation. At higher speeds, the pressure drop across the impeller vanes becomes more significant, creating conditions more favorable for bubble formation and collapse. This can happen due to:
 - **Operating the pump above its design speed:** Running the pump faster than recommended can lead to cavitation issues.
 - **Increased system demand requiring higher flow rates:** If the system demands a higher flow rate than the pump's design capacity, the pump might need to operate at a higher speed to compensate. This can increase the risk of cavitation.

3. Explain why EACH of the following may have fusible plugs fitted:

(a) air compressor;

(b) air receiver.

10

(5)

6

(5)

Fusible Plugs in Air Compressors and Air Receivers

Fusible plugs are safety devices designed to melt and release compressed air when the temperature inside the equipment exceeds a predetermined safe limit. Here's why they might be fitted in:

(a) Air Compressor:

- **Internal Component Failure:** If a component within the compressor, such as bearings or pistons, seizes or malfunctions, it can generate excessive heat. This heat can melt the fusible plug, releasing pressure and preventing catastrophic failure of the compressor itself. Examples include:
 - Seized piston rings causing excessive friction
 - Broken connecting rod leading to internal impact
- **Loss of Cooling:** If the compressor's cooling system fails due to a water pump malfunction, clogged radiator, or other issues, the internal temperature can rise significantly. A melted fusible plug would then vent the pressure before overheating damages the compressor.

- **Accidental Overheating:** In rare cases, operator error or external factors might lead to overheating of the compressor. A fusible plug can act as a last line of defense by releasing pressure and potentially preventing an explosion.

(b) Air Receiver:

- **Overheating:** While less common than in the compressor itself, the air receiver could experience overheating if the compressed air entering it is excessively hot (lack of proper intercooling or aftercooling) or if there's a malfunction in the pressure relief valve. The fusible plug would then melt and release pressure to prevent the air receiver from rupturing.
- **Fire Exposure:** In the unfortunate event of a fire near the air receiver, the fusible plug could melt due to the external heat. This would release the compressed air and potentially prevent the receiver from exploding due to excessive internal pressure caused by the fire.

Important Note:

While fusible plugs provide a safety measure, they are considered a last line of defense. It's crucial to maintain the compressor and air receiver properly, ensuring proper cooling and functioning pressure relief valves, to prevent situations that would trigger the fusible plug. Early detection and addressing the root cause of overheating is essential for safe operation.

4. With reference to hydraulic systems:

8

- (a) state THREE possible contaminations; (3)
- (b) state possible causes of the contaminations stated in part (a). (3)
- (c) explain how the contaminants stated in part (a) are prevented from affecting the system. (4)

Hydraulic System Contamination and Prevention

Hydraulic systems rely on clean fluid for efficient and reliable operation. However, contamination can pose a significant threat. Here's a breakdown of three common contaminants and methods to prevent them:

(a) Three Possible Contaminations:

1. **Dirt and Foreign Particles:** These can include dust, sand, metal shavings, or any foreign debris that enters the system.
2. **Air:** Air entering the hydraulic system can cause problems like spongy operation, cavitation, and increased noise.
3. **Water:** Water contamination can lead to corrosion, hydrolysis (breakdown of hydraulic fluid), and freezing in cold environments.

(b) Possible Causes of Contamination:

- **Dirt and Foreign Particles:**
 - Contaminated new fluid: Using dirty or unfiltered hydraulic fluid can introduce contaminants.
 - Improper maintenance: Failure to replace filters or maintain proper fluid cleanliness allows dirt to accumulate.
 - External leaks: Leaks in the system can allow dirt and debris from the surrounding environment to enter.
- **Air:**
 - Leaking connections: Improperly sealed connections, loose fittings, or worn seals can allow air to be sucked into the system.
 - Low fluid level: If the hydraulic fluid reservoir is not properly filled, air can be drawn in as the pump operates.
 - Air entrainment during refilling: Introducing new hydraulic fluid too quickly can trap air bubbles within the system.
- **Water:**
 - Condensation: Moisture in the air can condense within the system, especially in environments with significant temperature fluctuations.
 - Contaminated new fluid: Using hydraulic fluid that already contains water can introduce contamination.
 - Coolant leaks: In systems where the hydraulic fluid is cooled by a separate water-based system, a leak in the heat exchanger can allow water to mix with the hydraulic fluid.

(c) Preventing Contamination in Hydraulic Systems:

Several methods can be implemented to prevent contamination and protect your hydraulic system:

- **High-Quality Filtration:** Using high-quality filters at the reservoir inlet, return line, and potentially within critical components like valves helps trap dirt and foreign particles before they can enter the system. Regularly changing filters is crucial.
- **Proper Maintenance:** A well-maintained system is less prone to contamination. This includes regular inspections for leaks, timely replacement of worn seals and components, and maintaining proper fluid cleanliness levels through fluid analysis and changes when necessary.
- **Sealing and Breather Selection:** Using proper seals and breathers on components can prevent leaks and minimize air intake from the environment. Breathers should be equipped with filters to prevent dust ingress.
- **Reservoir Design:** Reservoirs with proper baffling and breathers help minimize air intake and allow for settling of contaminants at the bottom, where they can be drained periodically.
- **Fluid Management:** Using clean, high-quality hydraulic fluid and following proper storage and handling practices minimizes contamination risks.

- **Closed-Loop Systems:** Where feasible, designing closed-loop systems can significantly reduce the risk of contamination from external sources.

By implementing these preventative measures, you can maintain the cleanliness and integrity of your hydraulic system, ensuring reliable operation and extended lifespan for your equipment.

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

6. With reference to propellers, explain EACH of the following terms:

- | | |
|------------|-------|
| (a) skew; | (2) |
| (b) rake; | (2) |
| (c) pitch; | 8 (2) |
| (d) slip. | (4) |

Propeller Terminology Explained:

(a) Skew:

- Skew refers to the **angle** at which the propeller blade sections are twisted relative to the plane of rotation. Imagine looking at the propeller from the front. In a propeller with no skew, the blade sections would appear flat. With skew, the blade sections are angled **off-axis**, typically leaning either forward or aft.

(b) Rake:

- Rake refers to the **angle** of the propeller blades relative to a line perpendicular to the propeller shaft axis. There are three main types of rake:
 - **Zero Rake:** The blades are perpendicular to the shaft axis.
 - **Aft Rake:** The tips of the blades are angled slightly **backward** relative to the shaft axis.
 - **Forward Rake:** The tips of the blades are angled slightly **forward** relative to the shaft axis.

(c) Pitch:

- Pitch is a concept similar to the lead of a screw. Imagine the propeller advancing through a solid medium like a giant corkscrew. The **pitch** is the theoretical distance the propeller would advance in one revolution **if there were no water slippage** (explained in term (d) below). A higher pitch angle results in a larger theoretical advance per revolution, but requires more torque from the engine.

(d) Slip:

- In reality, propellers operate in water, which yields and does not provide a solid medium for perfect forward thrust. **Slip** refers to the difference between the theoretical advance (pitch) and the actual distance the vessel travels forward in one revolution of the propeller. Slip is expressed as a percentage of the pitch. For example, a propeller with 10% slip would travel 90% of its theoretical pitch distance per revolution. Slip is inevitable, but a well-designed propeller aims to minimize it for optimal efficiency.

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

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

(4) (7)

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

(2) (3)

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

(a) Tightening Procedure:

Tightening a main propulsion shaft hydraulic sleeve coupling requires careful attention to ensure proper engagement and a secure fit. Here's a general outline of the procedure:

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.

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)

(a) 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 and Tagout:** Implement proper lockout/tagout procedures to ensure safety and prevent accidental energization.
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):

1. **Dial Indicators:** Attach dial indicators 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.

(b) 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.

9. Explain EACH of the following electrical terms:

(a) preferential tripping;	(2)
(b) sequential starting; ✓	(2)
(c) fuse back up protection; ✓	(2)
(d) discrimination; ✓	(2)
(e) non-essential consumer. ✓	(2)

(a) Preferential Tripping:

In an electrical circuit with multiple protective devices (like fuses or circuit breakers), preferential tripping ensures that the device closest to the fault (overload or short circuit) trips first. This isolates the faulty section while keeping the rest of the circuit operational. It minimizes downtime and protects equipment further down the line from excessive current.

(b) Sequential Starting:

This technique involves starting multiple electrical motors in a controlled sequence, rather than all at once. This strategy helps to:

- Reduce the inrush current surge that occurs when motors start, preventing voltage dips that could affect other equipment.
- Limit the overall demand on the power supply, avoiding overloading during motor startup.

The sequence can be based on factors like motor size, starting current, or process requirements.

(c) Fuse Back-Up Protection:

This is not a common term in electrical protection. It's possible it might refer to a scenario where a fuse is used as a backup to another protective device, such as a circuit breaker. However, this is generally not recommended practice. Fuses are typically used for one-time overload protection, while circuit breakers can be reset after tripping. Using a fuse as backup could lead to unnecessary downtime if the main device malfunctions.

(d) **Discrimination:**

In a protective device system with multiple levels (like a distribution panel with branch circuit breakers feeding from a main breaker), discrimination ensures that only the device closest to the fault trips. This prevents unnecessary tripping of upstream breakers and maintains power to unaffected parts of the circuit. Selective coordination of tripping currents and time delays achieves discrimination.

(e) **Non-Essential Consumer:**

A non-essential consumer is an electrical load that is not critical for the core operation of a system. These loads might be turned off during emergencies or peak demand periods to reduce overall power consumption. Examples include lighting in non-critical areas, air conditioners, or electric heaters.

10. List TEN routine maintenance checks that should be carried out on a vented type lead acid engine starting battery system.

(10)

Here are ten routine maintenance checks that should be carried out on a vented type lead-acid engine starting battery system:

1. **Visual Inspection:** Inspect the battery case for cracks, leaks, or signs of corrosion around the terminals. Clean any corrosion using a baking soda and water solution, following proper safety precautions.
2. **Terminal Tightness:** Ensure the battery terminals are clean and securely tightened. Loose terminals can lead to poor starting performance and increased resistance.
3. **Electrolyte Level:** For vented batteries, check the electrolyte level in each cell. The level should be between the upper and lower level indicators on the battery case. If low, top up with distilled water only, not battery acid.
4. **Electrolyte Condition:** Visually inspect the electrolyte for any discoloration or cloudiness. A clear, light brown or straw color is normal. Cloudy or dark electrolyte might indicate internal issues.
5. **Terminal Voltage:** Measure the battery's terminal voltage with a voltmeter. A fully charged battery should read around 12.6 - 12.8 volts DC. A significantly lower voltage might indicate a discharge or internal fault.
6. **Load Test (Optional):** Periodically perform a load test using a dedicated battery tester. This simulates the high current draw during engine starting and provides a more accurate assessment of the battery's health and cranking capability.
7. **Cleaning:** Keep the battery top and surrounding area clean and free of dirt, debris, or moisture build-up. This helps prevent corrosion and potential leakage currents.
8. **Ventilation:** Ensure proper ventilation around the battery, especially for vented types. These batteries release hydrogen gas during charging, and adequate ventilation is crucial for safety.

9. **Storage:** If the battery will be stored unused for an extended period, it's recommended to disconnect it from the electrical system and store it in a cool, dry place. Periodic charging during storage might be necessary to prevent excessive self-discharge.
10. **Age and Service History:** Maintain records of battery age and previous maintenance performed. Lead-acid batteries have a limited lifespan, and regular checks become even more critical as the battery ages.

By following these routine maintenance checks, you can help ensure the optimal performance, reliability, and lifespan of your vented lead-acid engine starting battery system.