March 26th 2021

1. State, with reasons, a suitable application for EACH of the following types of valve:

   (a) butterfly; (2)

   (b) diaphragm; (2)

   (c) screw-down, non-return; (2)

   (d) 3-way; (2)

   (e) quick closing, screw lift. (2)

March 26th 2021

2. With reference to centrifugal pumps used for bilge/ballast purposes:

   (a) explain the specific problems which may arise using the pumps for these purposes; (4)

   (b) explain TWO methods used to improve pump performance when used for these purposes. (6)

March 26th 2021

3. With reference to compressed air systems, explain the purpose of EACH of the following:

   (a) fusible plug on compressor discharge; (4)

   (b) fusible plug on air receiver; (3)

   (c) bursting disc on water cooled air compressor. (3)

March 26th 2021

4. Describe TWO methods of drying compressed air for use in a pneumatic control system. (10)

March 26th 2021

5. With reference to two ram steering gears which incorporate spherical bearings:

   (a) sketch an arrangement of rams and tiller, including fittings; (6)

   (b) explain why spherical bearings are required on the ram ends. (4)

March 26th 2021

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

(a) skew; (2)

(b) rake; (2)

(c) pitch; (2)

(d) slip. (4)

March 26th 2021

7. (a) Sketch a flexible coupling that could be used for a main propulsion drive. (7)

(b) State THREE reasons for using a flexible coupling in propulsion drives. (3)

March 26th 2021

8. (a) Explain how propeller thrust is transmitted to a vessel's hull. (3)

(b) Describe the mounting arrangements of a thrust block to the hull. (4)

(c) Explain why the clearance between the thrust block pads and collar is critical. (3)

March 26th 2021

9. State FIVE safety features of a battery locker, explaining why EACH feature is required. (10)

March 26th 2021

10. (a) Describe the construction of a *salient pole* a.c. generator rotor. (6)

(b) Explain how many poles would be required for a 50Hz supply, rotational speed of 750rpm. (4)

March 26th 2021

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   (d) 3-way; (2)

   (e) quick closing, screw lift. (2)

Suitable Applications for Different Valve Types:

Here's a breakdown of suitable applications for each valve type, along with the reasons for their suitability:

(a) Butterfly Valve:

- **Application: Large diameter pipelines for air, gas, or low-pressure liquids.**
- **Reasons:**
  - **Low Pressure Drop:** The butterfly valve design minimizes resistance to flow when fully open, making it ideal for large diameter pipelines where maintaining flow rate is crucial.
  - **Cost-Effective:** Butterfly valves are generally less expensive than other valve types, making them a cost-effective choice for large-scale applications.
  - **Quick Operation:** Some butterfly valve designs allow for relatively quick opening and closing compared to other valves.

(b) Diaphragm Valve:

- **Application: Handling corrosive or viscous fluids, sterile applications.**
- **Reasons:**
  - **Leak-Proof Design:** The flexible diaphragm isolates the fluid completely from the valve body and stem, preventing leaks and contamination. This is ideal for corrosive or hazardous fluids.
  - **Gentle on Fluids:** The diaphragm opening and closing mechanism minimizes shear stress on the fluid, making it suitable for viscous fluids or applications requiring delicate handling of the fluid.
  - **Cleanability:** The simple design with minimal internal crevices facilitates easy cleaning and sterilization, making it suitable for hygienic applications.

(c) Screw-Down, Non-Return Valve:

- **Application: Preventing backflow in pipelines, positive shutoff with check valve functionality.**
- **Reasons:**
  - **Check Valve Functionality:** The screw-down mechanism allows for adjusting the cracking pressure (minimum pressure required to open the valve) and ensures the

valve remains closed during normal flow but opens to allow flow in the intended direction.
    - **Positive Shut-Off:** The screw mechanism can be tightened to achieve a positive shut-off, isolating the flow completely when needed. This is useful for maintenance or emergencies.
    - **Durability:** Screw-down, non-return valves are known for their robust construction and ability to withstand high pressures.

(d) 3-Way Valve:

- **Application: Mixing or diverting fluids in pipelines, controlling flow direction.**
- **Reasons:**
    - **Flow Control:** The 3-way valve allows for mixing two fluids (e.g., hot and cold water) or diverting flow between two outlets, making it versatile for various flow control applications.
    - **Compact Design:** Compared to using separate valves for mixing or diverting, 3-way valves offer a more compact and space-saving solution.
    - **Simplicity:** The operating mechanism of a 3-way valve is often relatively simple, making it easy to use and maintain.

(e) Quick Closing, Screw Lift Valve:

- **Application: Emergency shut-off in pipelines carrying flammable liquids or hazardous materials.**
- **Reasons:**
    - **Rapid Closure:** The screw lift mechanism allows for quick and reliable shut-off of the valve in case of an emergency.
    - **High Pressure Capability:** Screw lift valves are often designed to handle high pressures commonly encountered in pipelines carrying hazardous materials.
    - **Positive Shut-Off:** The screw mechanism ensures a positive seal when closed, preventing leaks of hazardous materials.

Note: These are general recommendations, and the specific application suitability may vary depending on the valve design, pressure rating, and material of construction.

March 26th 2021

2. With reference to centrifugal pumps used for bilge/ballast purposes:

(a) explain the specific problems which may arise using the pumps for these purposes; (4)

(b) explain TWO methods used to improve pump performance when used for these purposes. (6)

Centrifugal Pumps for Bilge and Ballast Duties: Challenges and Solutions

(a) Specific Problems Using Centrifugal Pumps for Bilge/Ballast:

While centrifugal pumps are widely used for bilge and ballast purposes, they encounter specific challenges in these applications:

- **Debris Handling:** Bilge water can contain debris like rags, plastic, or other objects. Centrifugal pumps with enclosed impellers can clog easily when encountering such debris, hindering their ability to pump effectively.
- **Air Entrapment:** During bilge pumping, air can become entrapped in the volute casing or around the impeller. This air can hinder pump performance by reducing the amount of liquid being moved (air pockets occupy space meant for water) and can also lead to cavitation.
- **Self-Priming:** Centrifugal pumps typically require priming (filling the casing with liquid) before they can operate efficiently. This can be inconvenient or impractical in bilge applications where the water level might be low initially.

(b) Two Methods to Improve Pump Performance:

Here are two methods used to address these challenges and improve the performance of centrifugal pumps for bilge and ballast duties:

1. **Vortex Impeller Pumps:**
- **Design:** These pumps utilize a specifically designed impeller with a large open passage. This open design allows for better passage of solids and debris compared to enclosed impellers, reducing the risk of clogging.
- **Bilge Applications:** Vortex impellers are well-suited for bilge pumping due to their ability to handle debris. They can also help evacuate air trapped within the bilge water.
2. **Submersible Bilge Pumps:**
- **Placement:** These pumps are designed to be completely submerged within the bilge well. This allows them to operate even with low water levels, eliminating the need for priming.
- **Automatic Operation:** Submersible bilge pumps often incorporate automatic float switches that activate the pump when the water level rises above a certain point and turn it off when the level falls below a set point. This automatic operation simplifies bilge pumping and ensures continuous operation until the bilge is dry.

Additional Considerations:

- **Material Selection:** Bilge pumps are often constructed with corrosion-resistant materials like stainless steel or composite materials to withstand the harsh environment within the bilge well.
- **Pump Sizing:** Selecting the appropriate pump size for the bilge volume and desired pumping rate is crucial for effective bilge dewatering.

By implementing these solutions, centrifugal pumps can be adapted for bilge and ballast purposes, providing reliable and efficient operation for critical onboard operations.

March 26th 2021

3. With reference to compressed air systems, explain the purpose of EACH of the following:

(a) fusible plug on compressor discharge; (4)

(b) fusible plug on air receiver; (3)

(c) bursting disc on water cooled air compressor. (3)

Fusible Plugs and Bursting Discs in Compressed Air Systems

Compressed air systems utilize safety devices to prevent catastrophic failures due to excessive pressure or temperature. Here's a breakdown of the purpose of each component you mentioned:

(a) Fusible Plug on Compressor Discharge:

- **Purpose:** This acts as a last line of defense against overheating within the compressor itself. The plug is made of a low-melting-point metal alloy. If the temperature within the compressor exceeds a predetermined safe limit due to:
    - **Internal component failure:** Seized bearings, broken pistons, etc., can generate excessive heat.
    - **Loss of cooling:** Malfunctioning cooling system (water pump, clogged radiator) causing internal overheating.
    - **Accidental overheating:** Operator error or external factors leading to excessive heat buildup.
- The fusible plug melts and releases compressed air, preventing pressure buildup and potential explosion of the compressor casing.

(b) Fusible Plug on Air Receiver:

- **Purpose:** While less common, a fusible plug in the air receiver can offer additional protection in specific scenarios:
    - **Overheating:** If excessively hot compressed air enters the receiver due to inadequate inter/aftercooling or a malfunctioning pressure relief valve, the receiver could overheat. The fusible plug might melt and release pressure to prevent rupture.
    - **Fire Exposure:** In the unfortunate event of a fire near the air receiver, the external heat could melt the fusible plug. This would release compressed air and potentially prevent the receiver from exploding due to excessive internal pressure.

Important Note: Fusible plugs are a last resort safety measure. It's crucial to maintain proper cooling and functioning pressure relief valves in the compressor and receiver to prevent situations that would trigger the fusible plug. Early detection and addressing the root cause of overheating is key.

(c) Bursting Disc on Water Cooled Air Compressor:

- **Purpose:** A bursting disc is a pressure relief device typically used in conjunction with a pressure relief valve, especially in water-cooled systems.
- **Location:** It can be located in various places within the system, depending on the specific design and potential failure points. Common locations include:
    - **Aftercooler Outlet:** Protects the aftercooler and downstream piping from excessive pressure due to a blocked discharge line or malfunctioning pressure regulator.
    - **Compressor Discharge Line:** Provides a safety measure close to the pressure source in case of a sudden pressure surge or regulator failure.
- **Function:** The bursting disc ruptures and releases compressed air if the pressure within the system exceeds a predetermined safe limit. This can occur due to:
    - **Malfunctioning pressure regulator:** The regulator fails to maintain the desired pressure, leading to pressure buildup.
    - **Blocked discharge line:** Debris or ice buildup restricts the flow of compressed air, causing pressure to rise rapidly.
    - **Sudden system surge:** A temporary pressure spike within the system due to unexpected demand.
- **Difference from Relief Valve:** A Bursting Disc typically has a higher pressure rating compared to a pressure relief valve. The relief valve is the primary pressure relief device, while the bursting disc acts as a backup safety measure in case the relief valve fails to function properly.

March 26th 2021

4. Describe TWO methods of drying compressed air for use in a pneumatic control system. (10)

Here are two common methods for drying compressed air used in pneumatic control systems:

1. **Refrigerated Air Dryers:**

This method utilizes refrigeration technology to remove moisture from the compressed air. Here's how it works:

- **Cooling Process:** The compressed air passes through a heat exchanger where it's cooled by a refrigerant. This cooling process lowers the air temperature to a point below its dew point, the temperature at which water vapor condenses into liquid water.
- **Moisture Condensation:** As the air cools below its dew point, the water vapor present in the air condenses and forms droplets.
- **Separation and Drainage:** The condensed water droplets are separated from the air stream using a separator. This separator can be a cyclone separator that utilizes centrifugal force or a coalescing filter that allows water droplets to merge into larger drops, facilitating easier separation.
- **Dry Air Output:** The separated water is automatically drained from the system, leaving behind dry air that exits the dryer.

Refrigerated dryers are a popular choice for pneumatic control systems due to their:

- **Simplicity:** They have a relatively simple design with readily available components.
- **Reliability:** They offer reliable operation and require minimal maintenance compared to other methods.

- **Cost-Effectiveness:** They are a cost-effective solution for applications requiring moderate levels of dryness.

However, refrigerated dryers have limitations:

- **Energy Consumption:** The refrigeration process requires continuous energy input, adding to the operating cost.
- **Temperature Dependence:** Their effectiveness depends on the ambient temperature. In very cold environments, additional measures like pre-heating the air might be needed to prevent excessive moisture from reaching the dryer.
- **Dew Point Limitations:** Refrigerated dryers typically achieve a dew point in the range of 35°F to 50°F (2°C to 10°C). For applications requiring extremely dry air, other methods might be necessary.

2. **Desiccant Air Dryers:**

This method utilizes desiccant materials to remove moisture from the compressed air. Here's the basic process:

- **Desiccant Adsorption:** The compressed air is passed through a vessel containing a desiccant material, a highly hygroscopic substance that readily absorbs moisture from its surroundings. As the air comes in contact with the desiccant, the water vapor is adsorbed (attracted and held on the surface) by the desiccant.
- **Dry Air Output:** The dehydrated air exits the vessel, now significantly drier than before entering.
- **Desiccant Regeneration:** Over time, the desiccant becomes saturated with moisture and loses its effectiveness. Desiccant dryers typically employ a regeneration cycle where the desiccant is heated. This heating process drives off the absorbed moisture, allowing the desiccant to be reused.

Desiccant dryers offer several advantages:

- **Lower Dew Points:** They can achieve much lower dew points than refrigerated dryers, reaching dew points below -100°F (-73°C) in some cases. This makes them ideal for applications requiring extremely dry air.
- **Temperature Independence:** They are less affected by ambient temperature fluctuations compared to refrigerated dryers.

However, desiccant dryers also have some drawbacks:

- **Complexity:** They can be more complex and require more maintenance compared to refrigerated dryers. The regeneration process needs to be carefully controlled to ensure efficient operation and prevent desiccant degradation.
- **Higher Initial Cost:** They typically have a higher initial cost than refrigerated dryers.
- **Energy Consumption:** While they don't require continuous energy input like refrigeration, the regeneration cycle does consume energy.

The choice between these two methods depends on the specific needs of your pneumatic control system. Consider factors like the required level of dryness, ambient temperature, energy consumption, budget, and maintenance requirements when making your decision.h 26th 2021 26th

March 26th 2021

5. With reference to two ram steering gears which incorporate spherical bearings:

(a) sketch an arrangement of rams and tiller, including fittings; (6)

(b) explain why spherical bearings are required on the ram ends. (4)

Two-Ram Steering Gear with Spherical Bearings

(a) Arrangement of Rams and Tiller, Including Fittings:

A two-ram steering gear utilizes two hydraulic cylinders (rams) positioned symmetrically on either side of the vessel to control the movement of the rudder. Here's a breakdown of a typical arrangement, including fittings:

- **Rams:**
  - Mounted on the hull structure, typically using brackets or pedestals.
  - Each ram consists of a piston rod, cylinder body, and end fittings.
- **Tiller:**
  - A forged or fabricated steel lever arm attached to the rudder stock.
  - Acts as the point where the rams apply their force to turn the rudder.
- **Ram End Fittings (Connecting Rams to Tiller):** Options include:
  - **Clevises:** U-shaped yokes with a pin connecting them to the tiller. Allow for some angular movement at the connection point.
  - **Fork Heads:** A forked end on the piston rod that connects directly to a pin on the tiller.
  - **Trunnion Mounts:** The piston rod is supported on a fixed pin on the tiller, allowing for some rotational movement.

Additional Considerations:

- **Tie Bar (Optional):** In some configurations, a tie bar may connect the two piston rods at their ends. This ensures they move in unison and distribute the load evenly across the rudder stock.
- **Spherical Bearings:** These are incorporated at the connection points between the ram end fittings (clevises, fork heads, or trunnion mounts) and the tiller.

(b) Why Spherical Bearings are Required on Ram Ends:

Spherical bearings are essential on the ram ends connecting to the tiller for several reasons:

- **Angular Misalignment:** Ships experience flexing and torsional movements due to wave action and hull stresses. Spherical bearings allow for a small degree of angular misalignment between the ram and the tiller, accommodating these movements without binding or placing undue stress on the rams or tiller.
- **Self-Alignment:** These bearings can automatically adjust to slight variations in alignment between the ram and the tiller, ensuring smooth and efficient force transfer.
- **Reduced Friction:** Spherical bearings have a low coefficient of friction, minimizing friction losses at the connection point and maximizing the effectiveness of the hydraulic force.

- **Increased Load Capacity:** They can handle high radial and axial loads, making them suitable for the forces exerted by the rams.
- **Reduced Maintenance:** Compared to plain bearings, spherical bearings require minimal maintenance due to their enclosed design and self-lubricating properties (in some types).

Overall, spherical bearings provide flexibility, reduce friction, and handle high loads, making them crucial components for a reliable and efficient two-ram steering gear system. They allow for some degree of misalignment and self-adjustment, ensuring smooth operation and minimizing wear and tear on the rams and tiller under demanding sea conditions.

March 26th 2021

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

(a) skew; (2)

(b) rake; (2)

(c) pitch; (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.

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March 26th 2021

7. (a) Sketch a flexible coupling that could be used for a main propulsion drive. (7)

(b) State THREE reasons for using a flexible coupling in propulsion drives. (3)

Flexible Couplings for Main Propulsion Drives

(a) Flexible Coupling for Main Propulsion:

A common type of flexible coupling used for main propulsion drives is a **gear-type flexible coupling**. Here's a breakdown of its components and function:

- **Gear Teeth:** Each half of the coupling has interlocking gear teeth machined onto its outer circumference. These gear teeth are not designed for transmitting high torque like gears in a transmission, but rather to allow for some degree of misalignment between the shafts.
- **Elastomeric Sleeve:** A flexible elastomeric sleeve (often made from high-strength polyurethane or rubber) is sandwiched between the gear teeth of the two halves. This sleeve provides the flexibility needed to accommodate misalignment.

How it Works:

As the shafts rotate, the gear teeth on one half of the coupling mesh with the teeth on the other half. However, the elastomeric sleeve allows for slight relative movement between the two halves, accommodating:

- **Angular Misalignment:** This occurs when the shafts are not perfectly aligned along the same axis.
- **Parallel Misalignment:** This occurs when the shafts are not perfectly parallel but slightly offset.
- **Axial Misalignment:** This occurs when there is a slight axial (end-to-end) movement between the shafts.

(b) Reasons for Using Flexible Couplings in Propulsion Drives:

There are three main reasons for using flexible couplings in propulsion drives:

1. **Accommodate Misalignment:** Engine and gearbox alignment can be challenging to achieve perfectly, and slight misalignment can occur due to thermal expansion or hull flexing. Flexible couplings allow for some misalignment, preventing excessive loads and wear on bearings and shaft components.

2. **Dampen Vibration:** Marine engines and propellers can generate vibrations. Flexible couplings with elastomeric elements can help to dampen these vibrations, reducing noise and protecting other components from fatigue.
3. **Protect from Overload:** In some cases, sudden shock loads or overloads might occur in the drivetrain. The elastomeric element in a flexible coupling can absorb some of this shock, protecting the engine, gearbox, and propeller shaft from damage.

Additional Notes:

- While offering advantages, flexible couplings typically have a lower torque capacity compared to some rigid couplings.

The specific design and material selection of the flexible coupling will depend on the power output of the engine and the specific application.

March 26th 2021

8. (a) Explain how propeller thrust is transmitted to a vessel's hull. (3)

(b) Describe the mounting arrangements of a thrust block to the hull. (4)

(c) Explain why the clearance between the thrust block pads and collar is critical. (3)

Propeller Thrust Transmission and Thrust Block Mounting:

(a) How Propeller Thrust is Transmitted to the Vessel's Hull:

The propeller, rotating underwater, generates thrust as it pushes water backwards. Here's how this thrust is transmitted to the vessel's hull:

1. **Propeller Shaft:** The rotating propeller is connected to a long shaft that runs through the stern tube of the vessel. This shaft is supported by bearings within the stern tube.
2. **Thrust Block:** At the forward end of the propeller shaft, inside the hull, there's a specialized bearing called a thrust block. This thrust block absorbs the axial thrust force generated by the propeller.
3. **Hull Structure:** The thrust block is securely mounted to the strong, transverse bulkheads or the keel of the vessel's hull. This transmits the propeller thrust force from the shaft to the entire hull structure, propelling the vessel forward.

(b) Thrust Block Mounting Arrangements:

The specific mounting arrangement of a thrust block will vary depending on the size and design of the vessel. However, here are some general principles:

1. **Solid Foundation:** The thrust block needs a robust and rigid foundation to handle the significant thrust forces. This is typically achieved by mounting it directly onto the main transverse bulkheads or the keel plate of the vessel.
2. **Hold-Down Bolts:** The thrust block is secured to the hull structure using high-tensile hold-down bolts. These bolts are carefully tightened to a specific torque value to ensure the thrust block can withstand the forces without movement.

3. **Chocks and Wedges (Optional):** In some cases, additional support structures like chocks or wedges might be used around the thrust block to provide extra stability and prevent lateral movement.
4. **Grouting (Optional):** For some thrust block designs, epoxy grouting material might be used to fill any gaps between the block and the hull structure. This further enhances rigidity and ensures proper load distribution.

(c) Why Clearance Between Thrust Block Pads and Collar is Critical:

The clearance between the thrust block pads (typically made from white metal or lined steel) and the thrust collar on the propeller shaft is crucial for several reasons:

- **Minimizing Friction:** Excessive clearance would allow for unnecessary movement between the shaft and the pads, increasing friction and wear. However, too little clearance could cause binding and hinder smooth shaft rotation.
- **Lubrication:** A proper clearance allows for a thin film of lubricant (oil or water) to form between the pads and the collar. This lubrication film reduces friction and wear while enabling efficient heat dissipation.
- **Thermal Expansion:** As the engine operates, the propeller shaft and thrust block components will experience some thermal expansion. The proper clearance accommodates this expansion without binding or excessive wear.
- **Vibration Control:** Maintaining the correct clearance helps dampen vibrations that might be transmitted from the propeller shaft to the hull structure.

Maintaining the optimal clearance is crucial for the efficient and reliable operation of the propulsion system. Regular inspections and adjustments of the thrust block and shaft components are essential to ensure proper clearance and minimize wear.

March 26th 2021

9. State FIVE safety features of a battery locker, explaining why EACH feature is required. (10)

Five Safety Features of a Battery Locker:

1. **Ventilation:** A battery locker should have a ventilation system to remove hydrogen gas buildup.
    - **Reason:** During charging, lead-acid batteries can emit hydrogen gas, which is highly flammable and explosive. Proper ventilation prevents gas accumulation and minimizes the risk of fire or explosion.
2. **Acid-Resistant Flooring:** The locker floor should be constructed from acid-resistant materials.
    - **Reason:** Battery acid leaks or spills can occur during handling or due to damaged battery casings. An acid-resistant floor prevents the acid from corroding the locker structure and protects personnel from accidental contact.

3. **Eye Wash Station:** An eye wash station should be readily accessible within the vicinity of the battery locker.
    - **Reason:** Battery acid is corrosive and can cause severe eye damage if splashed. An easily accessible eye wash station allows for immediate flushing of the eyes in case of an acid splash accident.
4. **Fire Extinguisher (Suitable for Electrical Fires):** A fire extinguisher with a rating suitable for electrical fires should be located near the battery locker.
    - **Reason:** Batteries can overheat and potentially ignite surrounding materials. Having a fire extinguisher readily available allows for quick response to small fires before they escalate. Using an extinguisher rated for electrical fires ensures it's safe for use on electrical equipment.
5. **Emergency Shut-Off Switch:** The locker might have an emergency shut-off switch to disconnect the battery bank from the main electrical supply in case of a serious incident.
    - **Reason:** In the event of a major malfunction or safety hazard, the emergency shut-off switch allows for a quick and complete isolation of the battery bank from the electrical system. This can help prevent further damage and facilitate safe intervention.

These are just five key safety features for a battery locker. Additional features may be present depending on the specific application and regulations. Always follow the manufacturer's recommendations and local safety codes for proper battery storage and handling.

March 26th 2021

10. (a) Describe the construction of a *salient pole* a.c. generator rotor. (6)

    (b) Explain how many poles would be required for a 50Hz supply, rotational speed of 750rpm. (4)

Salient Pole A.C. Generator Rotor Construction:

(a) Components:

A salient pole rotor consists of a central steel shaft for structural support and several poles radially extending outwards from the shaft. Here's a breakdown of its key components:

- **Shaft:** Made of solid steel to ensure strength and rigidity. It transmits the mechanical torque from the prime mover (engine, turbine) to the rotor.
- **Poles:** These are typically constructed from laminated electrical steel to minimize eddy current losses within the rotor. Each pole has a specific polarity (north or south) and they alternate around the rotor circumference.
- **Pole Shoes:** Attached to the tips of the poles, these are often made of solid steel or cast iron for better mechanical strength and to concentrate the magnetic field. They may also have slots to accommodate the field windings.
- **Field Windings:** Copper wires wrapped around the pole shoes or embedded in slots within the pole shoes. When a DC current flows through these windings, it magnetizes the poles, creating a rotating magnetic field in the stator.

- **End Rings:** Two conductive rings at each end of the rotor that connect the ends of the field windings on all the poles. These rings allow for current flow through the windings in series or parallel, depending on the desired magnetic field strength configuration.

(b) Number of Poles for 50Hz at 750rpm:

The number of poles (P) required for a specific AC generator can be calculated using the following formula:

P = (120 * f) / rpm

where:

- P = number of poles
- f = frequency of the AC supply (50 Hz in this case)
- rpm = rotational speed of the rotor (750 rpm)

Plugging in the values:

P = (120 * 50 Hz) / 750 rpm = 8 poles

Therefore, a salient pole rotor with **8 poles** would be required to generate a 50Hz AC supply at a rotational speed of 750 rpm.