May 2021

1. (a) Sketch a flexible diaphragm valve. (6)

   (b) Describe how the diaphragm is replaced, stating the precautions that should be taken. (4)

Question 1. Mostly well answered.

May 2021

2. With reference to positive displacement pumps:

   (a) explain the need for a relief valve, stating where it would be fitted; (5)

   (b) explain when a pulsation damper may be fitted to the delivery line, stating how it works. (5)

Question 2. The question asks to explain why a relief valve is needed, it does not ask what a relief valve does or how it works. Just stating that a positive displacement pump can deliver high pressure is not an explanation. Just stating that the relief valve is on the delivery side of the pump is not specific enough.

May 2021

3. With reference to a fully automatic, water cooled starting air compressor:

   (a) state the alarms that should be fitted; (4)

   (b) explain how damage from overpressure is prevented in EACH of the following:

      (i) intercoolers; (3)

      (ii) water jackets. (3)

Question 3. Many candidates state such things as High Temperature, High Pressure. Without mentioning the medium being measured then these are meaningless.

May 2021

4. With reference to hydraulic systems:

(a) state TWO functions of an accumulator; (2)

(b) describe, with the aid of a sketch, a gas charged diaphragm or bladder accumulator; (6)

(c) describe how the bladder is prevented from being extruded from the accumulator described in part (b). (2)

Question 4. The question asks for a description of an accumulator, several give no description, many explain how it works – which is not asked for – instead.

May 2021

5. With reference to an electro-hydraulic steering gear, explain EACH of the following:

(a) how steering may be maintained should the telemotor system fail; (5)

(b) how steering may be achieved should there be total failure of the hydraulic system. (5)

Question 5. Few mention procedures. Many continue to use the steering gear hydraulically using manual pump etc, even though the question says that there is complete hydraulic system failure.

May 2021

6. Describe, with the aid of a sketch, the operation of a transverse thruster that is hydraulically driven. (10)

Question 6. Generally poor answers. Several just describe the hydraulic control, describing operation must include how thrust is varied in magnitude and direction as well as control.

May 2021

7. With reference to intermediate shaft bearings of the roller type, describe, with the aid of a sketch, EACH of the following:

(a) how some angular misalignment of the shaft is accommodated; (5)

(b) how longitudinal movement of the shaft is accommodated. (5)

Question 7. The question is all about roller type intermediate bearings. Many candidates describe thrust block and shaft alignment methods.

May 2021

8. (a) Describe the operation of a preferential trip. (5)

(b) State the type of circuits that *cannot* be connected to the preferential trip, listing THREE examples. (5)

Question 8. Many explain what a preference trip is rather than explaining its operation. Stating 'Essential services' is not sufficient – what makes a service essential is what is important.

May 2021

9. (a) Describe, with the aid of a sketch, a cartridge type fuse. (7)

(b) State why a fuse used in a motor circuit differs from a fuse used in a lighting circuit. (3)

Question 9. Many descriptions are superficial, basically just describing a fuse wire.

May 2021

10. Describe TWO methods for detecting earth faults within a distribution system. (10)

Question 10. Many struggle with a method other than lamps. The few that do give a valid second method do not say what is being measured to give the earth indication.

May 2021

1. (a) Sketch a flexible diaphragm valve. (6)

(b) Describe how the diaphragm is replaced, stating the precautions that should be taken. (4)

Question 1. Mostly well answered.

Flexible Diaphragm Valve

(a) Description:

A flexible diaphragm valve is a type of valve that uses a flexible membrane (diaphragm) to control the flow of fluid. The diaphragm is typically made of elastomeric materials like rubber or synthetic polymers and is located between the body of the valve and the bonnet. Here's a breakdown of its key components:

- **Valve Body:** The main housing of the valve, typically made of metal or plastic.
- **Diaphragm:** The flexible membrane that seals the opening between the inlet and outlet ports.
- **Bonnet:** The part that secures the diaphragm to the valve body.
- **Actuator:** The mechanism that creates the force to open or close the diaphragm (manual, pneumatic, hydraulic, etc.).
- **Seat:** The surface within the valve body that the diaphragm seals against.

When the valve is closed, the actuator applies pressure to the diaphragm, pushing it against the seat and blocking the flow path. Conversely, when the valve needs to be opened, the actuator pressure is released, allowing the diaphragm to flex back and open the passage for fluid flow.

**(b) Diaphragm Replacement and Precautions:

Replacing a diaphragm requires careful handling to avoid damaging the valve or the new diaphragm. Here's a general process with important precautions:

Process:

1. **Isolating the Valve:** Close and lock out any isolation valves upstream and downstream of the diaphragm valve to prevent accidental pressurization during the replacement procedure.
2. **Relieving Pressure:** Ensure any residual pressure within the valve body is released through designated vent or bleed valves according to the manufacturer's instructions.
3. **Disassembly:** Following the manufacturer's guide, disassemble the valve components, carefully removing the bonnet to access the diaphragm.
4. **Diaphragm Removal:** Inspect the used diaphragm for signs of wear, tear, or damage. Gently remove it from the valve body and discard it properly.
5. **Cleaning the Seat:** Clean the sealing surface (seat) on the valve body to remove any dirt or debris that might hinder a proper seal with the new diaphragm.
6. **New Diaphragm Installation:** Inspect the new diaphragm for any defects. Carefully position it within the valve body, ensuring proper alignment with the seat.
7. **Reassembly:** Following the manufacturer's instructions in reverse order, reassemble the valve components, paying close attention to proper tightening torques for bolts and connections.

Precautions:

- **Follow Manufacturer's Instructions:** Always refer to the specific manufacturer's guide for the diaphragm valve you're working on. The disassembly, cleaning, and reassembly procedures may vary depending on the valve design.
- **Use Appropriate Tools:** Utilize the proper tools for disassembly and reassembly to avoid damaging the valve components.
- **Inspect the New Diaphragm:** Before installation, thoroughly inspect the new diaphragm for any cuts, tears, or imperfections that could compromise its sealing ability.
- **Handle with Care:** Avoid excessive stretching, pinching, or puncturing the diaphragm during handling and installation.
- **Proper Disposal:** Dispose of the used diaphragm according to local regulations for waste disposal, especially if it was exposed to hazardous materials.

By following these steps and precautions, you can replace a diaphragm in a diaphragm valve safely and effectively.

021

May 2021

2. With reference to positive displacement pumps:

(a) explain the need for a relief valve, stating where it would be fitted; (5)

(b) explain when a pulsation damper may be fitted to the delivery line, stating how it works. (5)

Question 2. The question asks to explain why a relief valve is needed, it does not ask what a relief valve does or how it works. Just stating that a positive displacement pump can deliver high pressure is not an explanation. Just stating that the relief valve is on the delivery side of the pump is not specific enough.

Positive Displacement Pumps and Ancillary Equipment

(a) Relief Valve:

Need for a Relief Valve:

Positive displacement pumps deliver a constant volume of fluid with each rotation regardless of the discharge pressure. If the discharge pressure in the system exceeds the pump's design pressure due to a blocked outlet, closed valve, or other restriction, it can cause several problems:

- **Overload on Pump Components:** Excessive pressure can put undue stress on the pump's internal components like bearings, gears, or vanes, leading to premature wear and potential failure.
- **Pipe Rupture:** The high pressure can exceed the pressure rating of the piping system, leading to pipe bursts and potential safety hazards.
- **Pump Damage:** In extreme cases, very high pressure can cause permanent damage to the pump housing or internal components.

Placement of Relief Valve:

To prevent these issues, a **relief valve** is installed on the discharge line of a positive displacement pump. This valve acts as a safety mechanism by:

- **Sensing Pressure:** The relief valve continuously monitors the pressure in the discharge line.
- **Pressure Relief:** When the pressure exceeds a pre-set level (cracking pressure), the relief valve opens, bypassing a portion of the flow back to the pump inlet (internal bypass) or to a reservoir (external bypass).
- **Pressure Regulation:** By diverting excess flow, the relief valve helps to maintain the pressure within the system at a safe operating level.

Typical Location:

The relief valve is typically installed as close to the pump discharge port as possible to minimize the volume of the system exposed to excessive pressure in case of a pressure surge.

(b) Pulsation Damper:

Pulsation Damper Function:

Positive displacement pumps, due to their operating principle, can generate pulsating flow. This means the flow rate is not constant but varies with each rotation of the pump's internal element (gear, vane, piston, etc.). These pulsations can cause several problems in the piping system:

- **Vibration and Noise:** The pulsating flow can induce vibration in pipes and connected equipment, leading to increased noise levels and potential fatigue failure in components.
- **Pressure Spikes and Drops:** The rapid changes in flow rate can translate to pressure spikes and drops within the system, stressing components and potentially affecting the performance of pressure-sensitive equipment.

Pulsation Damper Operation:

A **pulsation damper** is a device installed on the discharge line of a positive displacement pump to mitigate these pulsations. It functions similarly to a shock absorber in a car:

- **Bladder or Diaphragm:** The pulsation damper typically contains a flexible bladder or diaphragm that separates two chambers - a gas chamber pre-charged with an inert gas (e.g., nitrogen) and a fluid chamber connected to the discharge line.
- **Energy Absorption:** During the high-flow phase of the pump cycle, the pulsating pressure in the fluid chamber compresses the gas in the gas chamber. The gas acts as a spring, absorbing the excess energy of the pulsating flow.
- **Energy Release:** During the low-flow phase of the pump cycle, the compressed gas in the gas chamber expands, pushing fluid back into the discharge line and smoothing out the pulsations in the flow rate.

Overall Effect: By absorbing and releasing the pulsating pressure, the pulsation damper helps to create a more steady and consistent flow of fluid within the system. This reduces vibration, noise, and pressure fluctuations, protecting components and improving overall system performance.

Note: The selection and sizing of a relief valve and pulsation damper depend on the specific pump characteristics, system pressure rating, and desired performance outcomes.

May 2021

3. With reference to a fully automatic, water cooled starting air compressor:

(a) state the alarms that should be fitted; (4)

(b) explain how damage from overpressure is prevented in EACH of the following:

(i) intercoolers; (3)

(ii) water jackets. (3)

Question 3. Many candidates state such things as High Temperature, High Pressure. Without mentioning the medium being measured then these are meaningless.

Alarms and Overpressure Protection in a Starting Air Compressor

(a) Alarms for a Fully Automatic, Water-Cooled Starting Air Compressor:

A fully automatic, water-cooled starting air compressor should be equipped with several alarms to ensure safe operation and prevent potential damage. Here are some essential alarms:

- **High Discharge Pressure Alarm:** Alerts operators if the compressed air discharge pressure exceeds a predetermined safe limit. This can indicate a problem with the pressure regulator, blocked discharge line, or other issues.
- **Low Discharge Pressure Alarm:** Warns operators if the compressed air discharge pressure falls below the minimum required level. This can be due to insufficient compressor performance, leaks in the system, or other problems.
- **High Cooling Water Temperature Alarm:** Signals an issue if the water temperature in the cooling jackets or intercooler exceeds a safe limit. This can be caused by insufficient water flow, malfunctioning cooling system components, or excessive heat generation within the compressor.
- **Low Cooling Water Level Alarm:** Alerts operators if the water level in the cooling system reservoir falls below a safe minimum level. This can lead to overheating of the compressor and potential damage.
- **Low Starting Air Reservoir Pressure Alarm:** Warns operators if the pressure in the starting air reservoir falls below the minimum level required for engine starting. This can indicate leaks in the system or insufficient compressor operation.
- **Compressor Running Time Alarm:** May be used to alert operators when the compressor has been running continuously for an extended period. This can be helpful for preventative maintenance purposes.

(b) Overpressure Protection:

(i) Intercoolers:

- **Pressure Relief Valve:** Intercoolers are typically equipped with a pressure relief valve set to a specific pressure limit. If the pressure within the intercooler exceeds this limit due to a blocked

discharge line or other issues, the relief valve opens and releases excess compressed air, preventing the intercooler from rupturing.
- **Bursting Disc (Optional):** In some cases, an additional bursting disc can be installed as a secondary safety measure. This disc will rupture at a higher pressure than the relief valve, providing a final line of defense in case the relief valve fails to function properly.

(ii) Water Jackets:

- **Pressure Relief Valve (Less Common):** Water jackets are generally less susceptible to overpressure compared to intercoolers. However, in some high-pressure applications, a pressure relief valve might be used on the water jacket circuit. This valve would open and release excess pressure if the water system experiences a blockage or malfunction.
- **Temperature Monitoring and Alarms:** The primary protection for water jackets is continuous monitoring of the cooling water temperature. High-temperature alarms alert operators to potential overheating before pressure becomes a critical issue. By addressing the cause of the high temperature (e.g., low water flow, clogged passages), overpressure in the water jackets can be prevented.

Additional Considerations:

- **Safety Valves Settings:** The pressure relief valves on the intercoolers and water jackets (if used) need to be set at appropriate pressure levels. These settings should be based on the manufacturer's recommendations and the pressure rating of the equipment they are protecting.
- **Regular Maintenance:** Regular inspection and maintenance of the pressure relief valves and bursting discs (if used) are crucial to ensure their proper operation in case of an overpressure event.

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May 2021

4. With reference to hydraulic systems:

(a) state TWO functions of an accumulator; (2)

(b) describe, with the aid of a sketch, a gas charged diaphragm or bladder accumulator; (6)

(c) describe how the bladder is prevented from being extruded from the accumulator described in part (b). (2)

Question 4. The question asks for a description of an accumulator, several give no description, many explain how it works – which is not asked for – instead.

Hydraulic Accumulators and Bladder Design

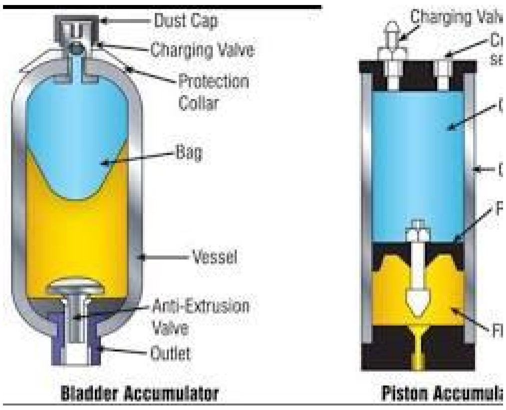
(a) Two Functions of an Accumulator:

Hydraulic accumulators serve two primary functions within a hydraulic system:

1. **Energy Storage:** Accumulators can store hydraulic fluid under pressure, acting as a reservoir of potential energy. This stored energy can be used to:
   - **Supplement Pump Flow:** During sudden demands for hydraulic power, the accumulator can release stored fluid to meet the temporary surge in demand, reducing the workload on the pump.
   - **Dampen Pressure Shocks:** Accumulators can absorb pressure spikes caused by rapid load changes or actuator movements, protecting other components from damage and providing smoother system operation.
2. **Maintaining System Pressure:** In some applications, accumulators can help maintain a relatively constant system pressure, even during fluctuations in pump flow or demand. This can be beneficial for systems with sensitive components requiring consistent pressure.

(b) Gas Charged Diaphragm or Bladder Accumulator (Sketch and Description):

A gas charged diaphragm or bladder accumulator is a common type of accumulator that utilizes a flexible bladder to separate the hydraulic fluid from a compressed gas pre-charge. Here's a description with a corresponding sketch:



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Bladder Accumulator Hydraulic System

Components:

1. **Shell:** A sturdy metal housing that contains the entire accumulator assembly.
2. **Hydraulic Fluid Port:** The connection point for the hydraulic fluid to enter and exit the accumulator.
3. **Bladder:** A flexible, gas-impermeable membrane made of high-strength elastomeric material. It separates the hydraulic fluid from the compressed gas.
4. **Pre-Charged Gas:** Inert gas (typically nitrogen) at a predetermined pressure that fills the space above the bladder.
5. **Diaphragm (Optional):** Some designs may incorporate a diaphragm plate to provide additional support for the bladder and prevent excessive bulging.

Operation:

- When hydraulic fluid enters the accumulator through the port, it pushes against the bladder, causing it to expand and compress the pre-charged gas in the upper chamber.
- The compressed gas provides a counterforce that balances the pressure of the incoming hydraulic fluid.
- As more fluid enters, the pressure within the accumulator increases until it reaches a predetermined level.
- When the demand for hydraulic fluid exceeds the pump's capacity, the stored energy in the accumulator pushes the bladder back, releasing pressurized fluid back into the system.
- The pre-charged gas pressure determines the accumulator's pre-charge pressure and influences the response characteristics of the accumulator.

(c) Preventing Bladder Extrusion:

To prevent the bladder from extruding or rupturing from the accumulator shell, several design features are employed:

- **High-Strength Bladder Material:** The bladder is made of a robust elastomeric material that can withstand high pressures and resist bulging or tearing.
- **Pre-Charge Pressure Setting:** The pre-charge gas pressure is carefully chosen to be lower than the maximum pressure rating of the bladder and accumulator shell. This ensures the bladder remains within its safe operating range.
- **Diaphragm Support (Optional):** Some designs utilize a diaphragm plate to provide additional support for the bladder, preventing excessive bulging and potential extrusion.
- **Safety Features:** Certain accumulators may incorporate pressure relief valves to automatically vent excess pressure in case of malfunctions, protecting the bladder from overpressure.

By implementing these design considerations, bladder accumulators can operate safely and reliably within hydraulic systems.

2021

May 2021

5. With reference to an electro-hydraulic steering gear, explain EACH of the following:

   (a) how steering may be maintained should the telemotor system fail; (5)

   (b) how steering may be achieved should there be total failure of the hydraulic system. (5)

Question 5. Few mention procedures. Many continue to use the steering gear hydraulically using manual pump etc, even though the question says that there is complete hydraulic system failure.

Maintaining Steering in an Electro-Hydraulic Steering Gear

Here's how steering can be maintained in an electro-hydraulic steering gear system in case of failures:

(a) Telemotor System Failure:

Modern electro-hydraulic steering gear systems typically incorporate a backup steering method in case the telemotor system (electrical control system) fails. This backup can be:

- **Local Control Station:** A manual control station located near the steering gear allows the helmsman to directly control the hydraulic valves using levers or a joystick. This bypasses the telemotor system and provides direct mechanical control of the rams.
- **Alternative Control System:** Some systems might have a secondary electronic control system independent of the main telemotor. This redundancy allows for continued operation even if the primary control system fails.
- **Emergency Steering Gear (Optional):** In some vessels, a completely separate emergency steering gear system might be available. This system could be:
  - **Hydraulic (non-electro):** Powered by a dedicated pump and reservoir, it uses manual controls to operate the valves.
  - **Non-hydraulic:** A mechanical steering gear operated by a wheel or tiller, independent of the main hydraulic system.

(b) Total Hydraulic System Failure:

If there's a complete failure of the hydraulic system, maintaining steering becomes very challenging. However, some options might be available depending on the vessel's design:

- **Emergency Steering Gear:** As mentioned earlier, if an emergency steering gear system is present, it becomes the primary means of control.
- **Rudder Bracing (Last Resort):** In extreme situations, if no other steering option is available, the rudder might be physically braced in a near-amidships position using chains or cables. This would severely limit maneuverability but could provide some directional control in calm seas.

Important Considerations:

- Crew training is crucial for effectively utilizing backup steering methods in case of failure. Regular drills and familiarization with alternative control systems are essential.
- The effectiveness of backup steering methods (especially emergency gear) can be limited compared to the primary electro-hydraulic system.
- Maintenance plays a vital role. Regularly servicing the telemotor system, hydraulic components, and backup steering gear helps ensure their functionality when needed.

By incorporating redundant control systems and emergency options, electro-hydraulic steering gear systems aim to maintain some level of control even in case of failures, enhancing overall vessel safety and maneuverability.

May 2021

6. Describe, with the aid of a sketch, the operation of a transverse thruster that is hydraulically driven. (10)

Question 6. Generally poor answers. Several just describe the hydraulic control, describing operation must include how thrust is varied in magnitude and direction as well as control.

A hydraulically driven transverse thruster utilizes pressurized hydraulic fluid to generate a lateral thrust force, aiding in vessel maneuvering. Here's a breakdown of its operation:

Components:

- **Electric Motor:** This motor, typically located below deck, drives the hydraulic pump.
- **Hydraulic Pump:** Converts electrical energy from the motor into pressurized hydraulic fluid.
- **Reservoir:** Stores the hydraulic fluid and maintains its proper level.
- **Pipelines:** High-pressure hoses or steel pipes carry the pressurized fluid to and from the thruster unit.
- **Directional Control Valve:** Located near the bridge control system, this valve receives electrical or mechanical signals from the operator and directs the flow of hydraulic fluid.
- **Transverse Thruster Unit:** This underwater unit houses the propeller and the hydraulic motor that drives it.

Operation:

1. **Command Signal:** The helmsman on the bridge operates the controls (joystick, buttons) to activate the thruster. This sends a signal (electrical or mechanical) to the directional control valve.
2. **Valve Movement:** Based on the received signal, the spool or poppet within the directional control valve moves, opening specific ports to direct the flow of hydraulic fluid.
3. **Hydraulic Fluid Flow:** The valve directs pressurized fluid from the pump to one side of the hydraulic motor within the thruster unit. Simultaneously, it opens a passage for the fluid on the opposite side of the motor to return to the reservoir. This creates a pressure differential across the motor.
4. **Hydraulic Motor Rotation:** The pressure difference acts on the internal components of the hydraulic motor, causing it to rotate in a specific direction. This rotation is typically clockwise or counter-clockwise depending on the desired thruster direction.
5. **Propeller Rotation:** The shaft of the hydraulic motor is directly connected to the propeller within the thruster unit. As the motor rotates, it drives the propeller to spin in the same direction.
6. **Lateral Thrust Generation:** The spinning propeller pushes water perpendicular to the vessel's direction of travel, creating a lateral thrust force. Depending on the propeller rotation direction (clockwise or counter-clockwise), the thrust will push the vessel's stern to port or starboard, aiding in maneuvering during docking, station keeping, or low-speed maneuvering situations.
7. **Stopping the Thruster:** When the helmsman centers the control or selects "stop," the directional control valve moves to a neutral position, blocking the flow of fluid to the hydraulic motor. This brings the thruster to a halt.

Additional Considerations:

- **Pressure Relief Valve (Optional):** A pressure relief valve might be incorporated within the system to protect against excessive pressure buildup due to malfunctions.
- **Flow Control Valve (Optional):** In some designs, a flow control valve may be used to regulate the flow of hydraulic fluid and adjust the thruster's power output.

Overall, a hydraulically driven transverse thruster offers a reliable and efficient way for precise maneuvering by converting electrical energy into a controllable lateral thrust force through the use of hydraulics and a dedicated propeller unit.

2021

May 2021

7. With reference to intermediate shaft bearings of the roller type, describe, with the aid of a sketch, EACH of the following:

   (a) how some angular misalignment of the shaft is accommodated; (5)

   (b) how longitudinal movement of the shaft is accommodated. (5)

Question 7. The question is all about roller type intermediate bearings. Many candidates describe thrust block and shaft alignment methods.

Intermediate Shaft Roller Bearings: Misalignment and Movement

Here's a breakdown of how intermediate shaft roller bearings handle:

(a) Angular Misalignment:

Intermediate shaft roller bearings can tolerate some degree of angular misalignment between the shaft and the bearing housing. However, the extent of this tolerance depends on the specific type of roller bearing:

- **Cylindrical Roller Bearings:** These bearings have cylindrical rollers aligned parallel to the shaft axis. They can accommodate a **limited** amount of angular misalignment (typically within a few degrees). This is achieved by allowing the rollers to **tilt slightly** within the bearing cage. This tilting action distributes the load more evenly across the rollers despite minor misalignment.
- **Spherical Roller Bearings:** These bearings offer a higher tolerance for angular misalignment compared to cylindrical roller bearings (up to around 15 degrees). They incorporate **barrel-shaped rollers** that rest on a **concave bearing race**. This design allows for **self-alignment**. The rollers can tilt within the raceway, accommodating slight shaft angularity.

Important Points:

- Exceeding the recommended angular misalignment limits for these bearings can lead to:
  - Increased wear
  - Reduced bearing life

    - Potential damage
- Maintaining proper shaft alignment is crucial for optimal bearing performance and longevity.

(b) Longitudinal Movement of the Shaft:

Intermediate shaft roller bearings are generally **not** designed to accommodate significant longitudinal (axial) movement of the shaft for several reasons:

- **Roller Design:** Roller bearings rely on **line contact** between rollers and races for smooth rolling and load-carrying capacity. This design is optimized for **radial loads** (perpendicular to the shaft axis). Axial movement could cause the rollers to **rub** against the ends of the races, increasing friction and damaging the bearing.
- **Internal Clearance:** Roller bearings have a specific internal clearance between rollers and races. This clearance allows for proper **lubrication flow** and **heat dissipation**. Excessive axial movement could reduce or eliminate this clearance, leading to:
    - Binding
    - Increased friction
    - Bearing failure

Limited Accommodation Methods (Specific Cases):

In some specific applications, intermediate shaft arrangements might incorporate features for **limited** axial movement:

- **Thrust Bearings:** A separate **thrust bearing** (ball or roller) might be installed alongside the roller bearing. This dedicated bearing handles **axial loads**, allowing the roller bearing to focus on radial loads.
- **Specialized Roller Bearings:** Some manufacturers offer specialized roller bearing designs with features like **crowned rollers** or **tapered flanges** that can tolerate a small degree of axial movement. These are used in specific applications where limited axial movement is unavoidable.

In Conclusion:

While intermediate shaft roller bearings offer some tolerance for angular misalignment, they are generally not designed for significant longitudinal movement.** Proper shaft design and alignment practices are crucial to minimize axial loads and ensure optimal performance and longevity of these bearings.

May 2021

8. (a) Describe the operation of a preferential trip. (5)

(b) State the type of circuits that *cannot* be connected to the preferential trip, listing THREE examples. (5)

Question 8. Many explain what a preference trip is rather than explaining its operation. Stating 'Essential services' is not sufficient – what makes a service essential is what is important.

Preferential Trip Operation and Excluded Circuits

(a) Preferential Trip Operation:

A preferential trip system is designed to prioritize the operation of critical circuits in an electrical system during overload or fault conditions. Here's how it works:

1. **Multiple Protective Devices:** The system utilizes multiple circuit breakers or fuses, each protecting a specific circuit. These protective devices are set with different trip thresholds.
2. **Critical Circuits:** Circuits considered essential for the safe operation of the vessel (navigation, propulsion, emergency equipment) are protected by devices with higher trip current ratings.
3. **Non-Critical Circuits:** Circuits for less critical functions (lighting, air conditioning, galley equipment) are protected by devices with lower trip current ratings.
4. **Overload or Fault:** If an overload or fault occurs on a circuit, the corresponding protective device will trip first, interrupting current flow to that specific circuit.
5. **Prioritization:** As long as the overload or fault is contained within a single circuit, the preferential trip system ensures that critical circuits with higher trip thresholds remain operational.
6. **System Protection:** If the overload or fault is severe enough to exceed the trip rating of the device protecting a critical circuit, then that circuit will also trip to protect the entire system.

Benefits:

- Maintains power supply to critical equipment during minor faults or overloads on non-critical circuits.
- Minimizes disruption to essential functions of the vessel.
- Protects critical equipment from damage caused by excessive current flow.

(b) Circuits Not Suitable for Preferential Trip (3 Examples):

While preferential trip offers advantages, some circuits cannot be included in this strategy due to safety or operational considerations. Here are three examples:

1. **Emergency Lighting Circuits:** These circuits are crucial for maintaining visibility and safe evacuation during emergencies. They should not be connected to a preferential trip system and should trip immediately on any fault to ensure uninterrupted operation.

2. **Fire Detection and Alarm Systems:** Early detection and notification of a fire is critical for crew safety. Fire alarm circuits should not be connected to a preferential trip and should trip immediately on any fault to ensure uninterrupted operation.
3. **Bilge Pump Circuits:** Continuous operation of bilge pumps might be essential to prevent flooding. These circuits should not be connected to a preferential trip and should ideally have their own dedicated power source to ensure uninterrupted operation.

Overall:

Preferential trip systems provide a valuable strategy for maintaining power supply to critical equipment during electrical faults. However, careful consideration is needed when assigning circuits to this system, and critical safety or operational functions should not be compromised by relying on preferential trip behavior.

2021

May 2021

9. (a) Describe, with the aid of a sketch, a cartridge type fuse. (7)

(b) State why a fuse used in a motor circuit differs from a fuse used in a lighting circuit. (3)

Question 9. Many descriptions are superficial, basically just describing a fuse wire.

(a) Cartridge Fuse Description

A cartridge fuse is a cylindrical safety device used in electrical circuits to protect against overcurrent conditions. Here's a breakdown of its key features:

- **Construction:** It typically consists of a **glass or ceramic tube** enclosing a thin metal **filament** or **strip**. The fuse element melts or breaks when the current flowing through it exceeds a designated safe limit.
- **Contact Points:** The fuse has metal caps or terminals at each end for secure connection within the fuse holder on the circuit.
- **Ratings:** Cartridge fuses are available in various amperage ratings, each designed to interrupt a specific level of overcurrent. The rating is typically printed on the fuse body.
- **Operation:** During normal operation, the current flows through the fuse element without issue. However, if the current exceeds the fuse rating due to an overload or short circuit, the element heats up rapidly. This heat generation causes the element to melt or break, interrupting the current flow and protecting the circuit from damage.

(b) Differences in Fuses for Motor vs. Lighting Circuits

While both motor and lighting circuits use fuses for overcurrent protection, there are some key differences in the type of fuses employed:

Motor Circuit Fuses:

- **Slow-Blow Fuses:** Motor circuits require **slow-blow fuses**. These fuses are designed to tolerate brief surges in current that occur during motor startup. The element heats up slightly during the inrush current but doesn't melt as it's a temporary surge. It only melts if the overload persists for a longer duration.

- **Reason:** Motors draw a high initial current (inrush current) when they start due to overcoming the inertia of the motor and overcoming friction. A fast-blow fuse would unnecessarily trip during this normal starting surge, interrupting the motor operation.

Lighting Circuit Fuses:

- **Fast-Blow Fuses:** Lighting circuits typically use **fast-blow fuses**. These fuses are designed to interrupt the circuit quickly for any overcurrent condition.
- **Reason:** Lighting circuits are generally less susceptible to temporary current surges. A fast-blow fuse ensures rapid tripping in case of a short circuit or overload, minimizing damage to wiring and lighting fixtures.

Additional Considerations:

- **Fuse Rating:** Motor circuit fuses will have a higher amperage rating compared to lighting circuit fuses to accommodate the motor's starting current and running load.
- **Application Specific Fuses:** In some cases, specialized motor fuses might be used that offer additional features like time-delay characteristics or current limiting capabilities to provide optimal protection for specific motor types and applications.

Choosing the right type and rating of fuse for the specific circuit is crucial for effective protection and safe operation of electrical equipment.

y 2021

May 2021

10. Describe TWO methods for detecting earth faults within a distribution system. (10)

Question 10. Many struggle with a method other than lamps. The few that do give a valid second method do not say what is being measured to give the earth indication.

Two Methods for Detecting Earth Faults in a Distribution System:

Earth faults occur when a live conductor comes into unintentional contact with the earth (ground). Early detection and isolation of earth faults are crucial to minimize safety risks, equipment damage, and service interruptions. Here are two common methods for detecting earth faults in a distribution system:

1. Residual Current Devices (RCDs):

- **Principle:** RCDs compare the current flowing in the live conductor to the current returning in the neutral conductor. In a healthy system, these currents should be equal.
- **Operation:** An RCD continuously monitors the difference between the phase and neutral currents. If a fault to earth occurs, some current will leak to ground, causing an imbalance

between the phase and neutral currents. When the difference exceeds a preset threshold, the RCD trips, disconnecting the circuit.

Types of RCDs:

- **AC RCDs:** These are the most common type and detect AC earth fault currents.
- **High-Frequency AC RCDs:** These RCDs are specifically designed to detect pulsating or high-frequency AC earth fault currents, which can occur with switch-mode power supplies or variable speed drives.
- **DC RCDs:** These are used in DC power systems to detect earth faults involving the DC conductors.

Advantages of RCDs:

- **Fast Detection:** RCDs offer very fast fault detection times, which helps minimize damage and potential fire hazards.
- **High Sensitivity:** RCDs can be set to detect even small earth fault currents, providing good protection for personnel safety.
- **Ease of Use:** RCDs are relatively simple devices to install and maintain.

2. Earth Fault Impedance Relay:

- **Principle:** This method uses an injection technique to detect earth faults. A small, controlled AC current is deliberately injected into the system's neutral conductor at a specific frequency. The earth fault impedance, which is the opposition to current flow between the faulty phase and earth, is then measured.
- **Operation:** The earth fault impedance relay continuously monitors the injected current and the resulting voltage on the neutral conductor. In a healthy system, the earth fault impedance will be very high. However, if a fault to earth occurs, the earth fault impedance will decrease significantly. When the measured impedance falls below a preset threshold, the relay trips, indicating an earth fault and isolating the faulty section.

Advantages of Earth Fault Impedance Relay:

- **Selectivity:** Earth fault impedance relays can be set to discriminate between faults on different sections of the feeder, allowing for targeted isolation of the fault location.
- **Adaptability:** These relays can be used in various distribution system configurations with different grounding arrangements.

Choosing the Right Method:

The choice between RCDs and earth fault impedance relays depends on several factors, including:

- **System size and complexity:** For smaller distribution systems, RCDs might be sufficient. For larger and more complex systems, earth fault impedance relays might offer better fault location selectivity.
- **Fault current levels:** RCDs are most effective for low earth fault currents. For high earth fault currents, earth fault impedance relays might be a better option.
- **Cost considerations:** RCDs are generally simpler and less expensive than earth fault impedance relays.

Consulting with a qualified electrical engineer is recommended to determine the most suitable earth fault detection method for your specific distribution system requirements.