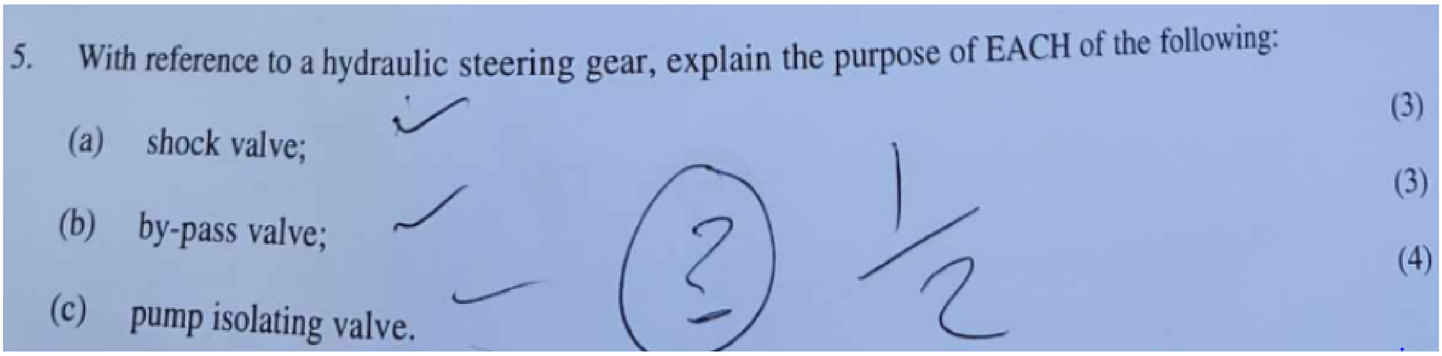
Aug 2023



5. With reference to a hydraulic steering gear, explain the purpose of EACH of the following:

(a) shock valve; (3)

(b) by-pass valve; (3)

(c) pump isolating valve. (4)

Hydraulic Steering Gear Components:

(a) Shock Valve:

The shock valve in a hydraulic steering gear acts as a safety mechanism to protect the system from sudden pressure surges.

- **Function:**
  - When the rudder encounters a large external force (e.g., heavy seas), the pressure within the hydraulic system can spike rapidly.
  - The shock valve is designed to open briefly under such high pressure.
  - This bypasses some of the hydraulic fluid, relieving the pressure surge and preventing damage to components like cylinders, pipes, or the pump itself.
- **Reset:**
  - The shock valve typically resets automatically once the pressure falls below a certain threshold.
  - This allows the steering gear to function normally again.

(b) By-pass Valve:

The by-pass valve in a hydraulic steering gear serves two primary purposes:

1. **Emergency Steering:**
   - In some steering gear designs, a by-pass valve can be used for emergency steering.
   - When activated, it allows fluid to bypass a specific cylinder or bank of cylinders, allowing the remaining cylinders to continue operating.
   - This enables a degree of steering control even if one or more cylinders are malfunctioning.
2. **System Start-up:**
   - The by-pass valve may also be used during system start-up.
   - It allows the pump to circulate fluid and build pressure without initially loading the steering cylinders.
   - Once the system reaches operating pressure, the by-pass valve closes, and the steering gear becomes fully operational.

(c) Pump Isolating Valve:

The pump isolating valve serves for isolation and maintenance purposes:

- **Function:**
  - It allows the complete isolation of the hydraulic pump from the rest of the steering gear system.
  - This can be done by closing the valve, essentially stopping fluid flow between the pump and the rest of the circuit.

- **Benefits:**
  - This isolation capability facilitates maintenance on the pump itself without affecting other components of the steering gear.
  - Additionally, it allows for repairs or replacements on the pump lines without draining the entire hydraulic system.
  - In some instances, the isolating valve might also be used during emergency situations to prevent further fluid loss from a damaged pump.

Nov 2018 9th

Nov 2018 9th

5. Describe, with the aid of a sketch, the operation of a Hydraulic Telemotor system. (10)

nov 2018 2nd

Nov 2018 2nd

5. Describe, with the aid of a sketch, the operation of a Hydraulic Telemotor system. (10)

A hydraulic telemotor system is a mechanism used to remotely control the steering of a vessel or other large machinery using hydraulic principles. Here's a breakdown of its operation:

Components:

- **Bridge Transmitter:** Located on the bridge (control room), this unit typically includes a steering wheel connected to a rack and pinion mechanism.
- **Hydraulic Lines:** These are high-pressure hoses that connect the transmitter and receiver.
- **Receiver:** Located near the steering gear, this unit translates the hydraulic signal from the transmitter into mechanical movement.

Operation:

1. **Steering Wheel Movement:** When the helmsman turns the steering wheel on the bridge, the rack and pinion mechanism in the transmitter translates this rotational movement into linear displacement.
2. **Hydraulic Fluid Movement:** This linear displacement of the rack and pinion in the transmitter forces hydraulic fluid from a reservoir into one side of a cylinder within the transmitter. Simultaneously, the fluid on the opposite side of the cylinder is displaced.
3. **Pressure Transmission:** The movement of the hydraulic fluid creates a pressure difference across the transmitter cylinder. This pressure difference is transmitted through the hydraulic lines to the receiver.
4. **Receiver Movement:** The pressure difference in the receiver acts on two pistons or rams within the receiver unit. This pressure differential causes the rams to move in opposite directions.
5. **Steering Gear Control:** The movement of the rams in the receiver is then connected (through linkages) to the steering gear of the vessel, causing it to turn accordingly.

Benefits of Hydraulic Telemotor Systems:

- **Remote Control:** Enables precise steering control from the bridge, which can be far from the actual steering gear location.
- **Amplified Force:** Hydraulics can amplify the force exerted by the helmsman on the steering wheel, making it easier to steer large vessels.
- **Redundancy:** Often used as a backup system in case of electrical or mechanical steering failure.

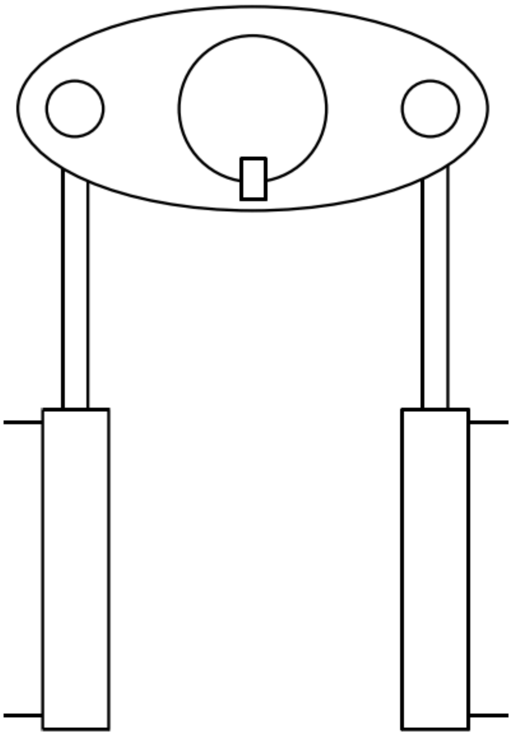
Limitations:

- **Complexity:** Compared to simpler mechanical steering systems, hydraulic telemotor systems involve more components and require regular maintenance.
- **Leakage Risk:** Leaks in the hydraulic lines can compromise system performance and potentially lead to environmental concerns.
- **Slower Response:** There can be a slight time delay between the movement of the steering wheel and the response of the steering gear compared to some other systems.

Overall, hydraulic telemotor systems offer a reliable and effective way to remotely control the steering of large machinery using hydraulic principles.

Sept 2021

5. Using the Worksheet Q5, sketch the hydraulic system for the two ram steering gear shown. The system should be capable of ensuring that steerage may be maintained should hydraulic pipe failure occur at any point. (10)



Two-Ram Steering Gear with Redundancy:

This system utilizes two separate hydraulic circuits, each powering one of the two rams (cylinders) that control the rudder. Key features of this design for redundancy include:

- **Dual Pumps and Reservoirs:** The system incorporates two separate hydraulic pumps and reservoirs. Each pump and reservoir supplies fluid to its respective steering ram, creating independent circuits.
- **Directional Control Valves:** Two directional control valves, one for each circuit, control the flow of hydraulic fluid to each ram. These valves are typically solenoid-operated, receiving electrical signals to direct fluid flow.
- **Isolation Valves:** Isolation valves are strategically placed in each circuit, typically located near the reservoirs or pumps. These valves can be manually closed to isolate a specific circuit in case of a failure.
- **Priority Valve (Optional):** An optional priority valve can be incorporated to prioritize one circuit over the other in case of a pressure drop in one system. This ensures that at least one steering ram remains operational.

Operation:

During normal operation, both hydraulic circuits function simultaneously. When the directional control valves are actuated, they direct hydraulic fluid flow to either side of their respective rams, causing the rams to extend or retract, turning the rudder accordingly.

Maintaining Steerage During Hydraulic Pipe Failure:

If a hydraulic pipe failure occurs in one circuit, the isolation valve in that circuit can be manually closed to isolate the leak. The remaining operational circuit can then continue to provide hydraulic power to its corresponding ram, allowing the rudder to be controlled with reduced steering capability.

Benefits of Redundant System:

- **Improved Reliability:** The dual-circuit design offers a higher level of reliability compared to a single-circuit system. Even with a pipe failure, steerage can potentially be maintained.
- **Enhanced Safety:** Redundancy helps ensure better maneuverability and control of the vessel in case of a hydraulic system malfunction, reducing the risk of accidents.

Limitations:

- **Increased Complexity:** Redundant systems involve more components, leading to increased complexity and potentially higher maintenance costs.
- **Weight and Space:** The additional pumps, reservoirs, and valves add weight and require more space for installation.

In conclusion, a two-ram steering gear with a redundant hydraulic system provides a reliable solution for steering control while offering a safety measure in case of hydraulic pipe failure.

May 28th 2021

May 28th 2021

5. List ALL the necessary checks of the steering gear before a vessel leaves port. (10)

sept 2020

Sept 2020

5. Describe ALL the necessary checks of the steering gear before a vessel leaves port. (10)

Question 5. Candidates lose marks by not mentioning alarms, emergency power supply and not actually inspecting the gear.

Here are all the necessary checks of the steering gear before a vessel leaves port:

Pre-departure Checks:

These checks ensure the steering gear is operational and can respond reliably during the voyage:

- **Visual Inspection:** Perform a thorough visual inspection of all steering gear components, including:
  - Rams (cylinders) and linkages: Look for any signs of damage, leaks, or loose connections.
  - Pumps and motors: Check for leaks, unusual noises, or excessive vibrations.
  - Reservoirs: Verify proper fluid level and cleanliness of the hydraulic fluid.
  - Pipes and hoses: Inspect for wear, cracks, or damage that could lead to leaks.
- **Operational Testing:** Conduct a full operational test of the steering gear:
  - Rudder movement:** Test the ability to move the rudder through its full range of motion in both directions.
  - Response time:** Check the system's response time between initiating a turn and the rudder movement. This should be within specified limits.
  - Dead spots (optional): In some systems, check for any dead spots where the rudder doesn't respond immediately to steering wheel input.
- **Alarm Systems:** Verify that all steering gear alarms (e.g., low oil pressure, high oil temperature) are functioning correctly.
- **Communication Checks:** Ensure proper communication between the bridge and the steering gear compartment. This could involve testing phone lines, intercoms, or dedicated control systems.
- **Emergency Steering:** If applicable, test the emergency steering system to ensure its functionality in case of a primary steering gear failure.

Documentation:

- Record all the pre-departure checks in the steering gear logbook, noting any discrepancies or observations.

Additional Considerations:

- **Consult Manuals:** Refer to the specific steering gear manufacturer's manuals and the vessel's operating procedures for detailed pre-departure check procedures.
- **Crew Training:** Ensure the crew is familiar with the steering gear system, including normal operation, troubleshooting procedures, and emergency steering gear operation.

By performing these comprehensive checks before departure, the crew can ensure the steering gear is functioning properly and the vessel can be maneuvered safely during the voyage.

Feb 2021

5. (a) State the rudder movement required by SOLAS II-I, Reg 29. (5)

(b) Explain how it is ensured that the maximum movement stated in part (a) is not exceeded in an electro-hydraulic, ram type steering gear. (2)

(c) Explain how the steering gear system is protected from damage should the maximum movement be exceeded. (3)

SOLAS II-1, Reg 29 and Rudder Movement

(a) Rudder Movement Required by SOLAS II-1, Reg 29:

SOLAS (International Convention for the Safety of Life at Sea) Reg. II-1/29 specifies the minimum rudder movement capability for steering gears on board ships. It states that the main steering gear must be capable of putting the rudder over from:

- **35 degrees on one side to 35 degrees on the other side** with the ship at its deepest seagoing draught (fully loaded) and running ahead at maximum ahead service speed.

OR

- **15 degrees on one side to 15 degrees on the other side** with the ship at its deepest seagoing draught and running ahead at one half of the maximum ahead service speed or 7 knots, whichever is
- pen_spark
- greater.

(b) Ensuring Maximum Movement in Electro-Hydraulic Ram Steering Gear:

In an electro-hydraulic ram type steering gear, several features work together to ensure the maximum rudder angle (as specified in SOLAS) is not exceeded:

- **Limiting Stops:** Mechanical stops are typically installed on the rudder stock or within the ram itself. These stops physically prevent the rudder from exceeding its designed maximum angle in either direction.
- **Position Feedback System:** The system incorporates a position sensor (e.g., rotary encoder) mounted on the rudder stock. This sensor continuously transmits the actual rudder angle to the control system.
- **Control System Logic:** The control system (computer or electronic controller) receives the rudder angle feedback. It compares this feedback with the commanded rudder angle from the bridge. If the commanded angle exceeds the maximum limit, the control system stops or limits the flow of hydraulic fluid to the rams, preventing further movement beyond the safe limit.
- **Hydraulic Relief Valves:** In some systems, pressure relief valves might be incorporated in the hydraulic lines. These valves bypass excess pressure if the force required to move the rudder exceeds a certain limit, preventing damage to the rams or other components.

(c) Protecting the Steering Gear from Damage if Maximum Movement is Exceeded:

Several mechanisms protect the steering gear system from damage if the maximum rudder angle is unintentionally exceeded:

- **Limiting Stops:** The mechanical stops on the rudder stock or ram act as the primary safeguard. They prevent physical overtravel, protecting the rams and linkages from excessive stress.
- **Hydraulic Relief Valves:** As mentioned earlier, relief valves can protect the system by bypassing excess pressure if the force required to move the rudder becomes too high. This prevents damage to pumps, motors, and other hydraulic components.
- **Control System Shut-off:** In some cases, the control system might be programmed to shut down or limit power to the rams if the maximum angle is exceeded. This prevents further movement and allows for troubleshooting the cause of the issue.

These features work together to prevent excessive rudder movement and protect the steering gear from damage in case of accidental over-command or external factors like heavy seas.

Sources

info

1. tc.canada.ca/en/marine-transportation/marine-safety/11-steering-gear
2. www.imorules.com/GUID-CF547534-23B3-4162-8415-6C806370E406.html

Nov 2021

Nov 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)

Question 5. Most, not all, make a reasonable sketch but few can then relate the sketch, or use it, to show the need for spherical bearings.

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) to control the movement of the rudder. Here's a breakdown of a typical arrangement, including fittings:

- **Rams:** The two rams are typically positioned symmetrically on either side of the vessel's centerline, often mounted on the hull structure. They consist of a cylinder body, piston rod, and end fittings.
- **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. The tiller can be a forged or fabricated steel structure designed to handle the forces exerted by the rams.
- **Ram End Fittings:** The piston rods of the rams connect to the tiller using suitable fittings. These fittings can vary depending on the design but typically involve:
  - **Clevises:** U-shaped yokes with a pin connecting them to the tiller. The clevis allows 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:** In some cases, trunnion mounts might be used, where the piston rod is supported on a fixed pin on the tiller, allowing for some rotational movement.
- **Tie Bar (Optional):** In some configurations, a tie bar may connect the two piston rods at their ends to ensure they move in unison and distribute the load evenly across the rudder stock.

(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:** Spherical bearings can automatically adjust to slight variations in alignment between the ram and the tiller, ensuring smooth and efficient force transfer.
- **Reduced Friction:** These 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:** Spherical bearings 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.

Nov 2020

Nov 2020

5. Describe, with the aid of a block diagram, the operation of an automatic steering system, including auto-pilot and valve operated steering gear. (10)

Question 5. Very poor. Many do not understand the term 'block diagram', many simply sketch and describe a steering gear. Of those that try to describe the basics of control, they appear to believe that the rudder angle is fed back to the auto-pilot – i.e that the rudder has a set angle required to maintain the vessel on course rather than the rudder moving from centre to return the vessel to the set course. Rudder feedback is used to limit the rate of change of course but none mention this. Several make no attempt.

5. Describe, with the aid of a block diagram, the control of an automatic steering system, including auto-pilot and valve operated steering gear. (10)

Block Diagram of an Automatic Steering System with Auto-Pilot and Valve Operated Steering Gear

An automatic steering system, also known as autopilot, utilizes various components to maintain a set course for a vessel. Here's a block diagram outlining its operation:

Blocks:

1. **Course Reference System (CRS):**
    - This block provides a reference for the desired course. It can be a:
        - **Gyrocompass:** Senses the vessel's heading based on Earth's rotation.
        - **GPS (Global Positioning System):** Provides highly accurate position information.
        - **Combination of both:** For enhanced accuracy and redundancy.
2. **Course Setter:**
    - This allows the operator to input the desired course (heading) for the autopilot to follow.
3. **Heading Sensor:**
    - Senses the vessel's actual heading information. This can be:
        - **Gyrocompass output** (if separate from CRS).
        - **GPS derived heading:** Utilizing position data and course over ground (COG).
4. **Autopilot Controller:**
    - This is the "brain" of the system. It compares the desired course (from CRS and Course Setter) with the actual heading (from Heading Sensor).
    - Based on the difference (course error), the controller calculates the necessary rudder adjustments to minimize the error and maintain the desired course.
    - Common control algorithms used include Proportional-Integral-Derivative (PID) control.
5. **Rudder Command Signal:**
    - The autopilot controller generates a control signal based on the calculated rudder adjustment. This signal can be:
        - **Electrical signal:** Sent to a servo motor driving a valve.
        - **Hydraulic signal:** Controls a pilot valve in a hydraulic system.
6. **Valve Operated Steering Gear:**
    - This block translates the control signal from the autopilot into physical movement of the rudder. It can be:
        - **Electro-hydraulic system:** An electric motor drives a pump that pressurizes hydraulic fluid. A servo valve, controlled by the autopilot's signal, directs the fluid flow to rams that move the rudder.
        - **Electro-pneumatic system:** A solenoid valve, controlled by the autopilot's electrical signal, directs compressed air to actuators that move the rudder.
7. **Feedback Loop:**

  - The actual rudder position (often sensed by a rudder angle sensor) can be fed back to the autopilot controller. This feedback helps to ensure accurate and precise rudder adjustments.

Overall Operation:

1. The operator sets the desired course using the Course Setter.
2. The CRS and Heading Sensor provide continuous information about the desired and actual headings, respectively.
3. The autopilot controller compares these headings and calculates the course error.
4. Based on the error, the controller generates a rudder command signal.
5. The valve-operated steering gear translates this signal into rudder movement.
6. (Optional) The actual rudder position is fed back to the controller for improved accuracy.

This continuous cycle of comparison, calculation, and adjustment allows the autopilot to maintain the set course automatically, reducing workload for the crew and improving navigational efficiency.

May 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.

Nov 2023

5. With reference to steering gears, explain the meaning of EACH of the following:

(a) 100% redundancy; (5)

(b) single failure criteria. (5)

Oct 2020

Oct 2020

5. With reference to steering gears, explain the meaning of EACH of the following:

(a) 100% redundancy; (5)

(b) single failure criteria. (5)

Redundancy and Single Failure Criteria in Steering Gears

(a) 100% Redundancy:

In the context of steering gears, 100% redundancy refers to a system design where complete steering functionality can be maintained even if a single component within a primary system fails. This essentially means having a complete backup system capable of taking over when the main system experiences an issue.

Here are some ways 100% redundancy can be achieved in steering gears:

- **Dual Electro-Hydraulic Systems:** Two independent electro-hydraulic circuits power separate rams, each capable of moving the rudder alone. If one circuit fails, the other can still steer the vessel.
- **Dual Pumps and Reservoirs:** Two separate pumps and reservoirs supply hydraulic fluid to the steering rams, ensuring continued operation even if one pump or reservoir fails.
- **Dual Telemotor Systems:** Two independent electronic control systems operate separate hydraulic valves. If one telemotor system fails, the other can still control the steering gear.

(b) Single Failure Criteria:

The single failure criteria is a principle applied in designing safety-critical systems, including steering gears. It states that the system should be designed to remain operational even if a single component failure occurs. This ensures the vessel retains some degree of maneuverability and avoids a complete loss of steering control.

Here's how the single failure criteria relates to 100% redundancy:

- A system designed with 100% redundancy inherently fulfills the single failure criteria. With a complete backup system, a single component failure within the primary system doesn't render the entire steering gear inoperable.
- When designing a steering gear, engineers consider various potential failure points (pumps, valves, pipes) and incorporate redundancy measures to ensure continued operation despite any single failure.

The single failure criteria plays a crucial role in ensuring the safety of the vessel and its crew. By designing steering gears to meet this criteria, the risk of losing steering control due to a single component failure is significantly reduced.

Sept (18th) 2020

5. Sketch a valve operated, rotary vane steering gear, showing the hydraulic system from the directional valve to the rotary vane unit. (10)

Valve Operated Rotary Vane Steering Gear: Hydraulic System Breakdown

A valve-operated rotary vane steering gear utilizes hydraulics to translate control signals from a bridge system into rudder movement. Here's a breakdown of the hydraulic system, focusing on the path from the directional control valve to the rotary vane unit:

Components:

- **Directional Control Valve:** This valve is located near the bridge control system and receives electrical or mechanical control signals. It acts as a "gatekeeper" for hydraulic fluid flow.
- **Hydraulic Pump:** This pump, typically driven 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.
- **Pipelines:** High-pressure hoses or steel pipes connect the various components and carry the pressurized fluid.

Operation:

1. **Directional Control Valve Movement:** When the helmsman on the bridge operates the steering wheel or controls, this action sends a signal (electrical or mechanical) to the directional control valve.
2. **Valve Port Movement:** Based on the received signal, the directional control valve spool or poppet moves within the valve body. This movement opens specific ports within the valve, directing the flow of hydraulic fluid.
3. **High-Pressure Fluid Path:** With the valve positioned correctly, high-pressure fluid from the pump is directed to one side of the rotary vane unit's chamber.
4. **Low-Pressure Fluid Path:** Simultaneously, the valve also opens a passage for the hydraulic fluid on the opposite side of the rotary vane unit to return to the reservoir. This creates a pressure differential across the unit.
5. **Rotary Vane Movement:** The pressure difference within the rotary vane unit acts on a set of vanes housed within a cylindrical rotor. This pressure pushes the vanes, causing the rotor to rotate in a specific direction.
6. **Rudder Movement:** The rotating shaft of the rotor is typically connected to the rudder stock through a reduction gear mechanism. This translates the rotary motion of the vane unit into the desired angular movement of the rudder.

Additional Considerations:

- **Pressure Relief Valve (Optional):** A pressure relief valve might be incorporated within the system to protect against excessive pressure buildup in case of malfunctions.
- **Pilot-operated Valves:** In some designs, pilot-operated directional control valves might be used. These valves utilize a smaller, separate hydraulic circuit to control the main valve spool, offering more precise control over fluid flow.

Overall, the valve-operated rotary vane steering gear utilizes a directional control valve to direct pressurized hydraulic fluid, creating a pressure differential within the rotary vane unit. This differential drives the rotation of the vanes, ultimately resulting in the desired movement of the rudder.

April 2021

April 2021

5. With reference to a hydraulic steering gear, describe TWO methods that may be used to prevent the idle pump from motoring. (10)

Here are two methods used to prevent the idle pump from motoring in a hydraulic steering gear system:

1. Pressure Relief Valve:

- **Function:** A pressure relief valve is a mechanical safety device installed within the hydraulic circuit. It remains closed when the system pressure is below a preset threshold.
- **Operation:** As the hydraulic pump continuously pressurizes the fluid, the pressure builds up in the system. Once the pressure reaches the relief valve's setting, the valve opens.
- **Preventing Idle Pump Motoring:** When the steering gear is not in operation, and the rudder isn't being moved, the pressure in the system remains low. The pressure relief valve stays closed, allowing fluid to return to the reservoir through the bypass passage within the valve. This prevents the pump from unnecessarily churning fluid and wasting energy.
- **Benefits:** Simple and reliable method, easy to integrate into existing systems.
- **Drawbacks:** May lead to slight pressure fluctuations as the valve opens and closes, potentially affecting steering responsiveness.

2. Load Sensing Pump:

- **Function:** A load sensing pump is a more advanced type of hydraulic pump that adjusts its output flow based on the system's actual demand.
- **Operation:** The pump continuously monitors the system pressure through a sensor. When the pressure rises due to a demand for hydraulic power (e.g., moving the rudder), the pump automatically increases its flow rate to meet that demand.

- **Preventing Idle Pump Motoring:** When there's no demand for hydraulic power (rudder not moving), the system pressure remains low. The load sensing pump detects this low pressure and automatically reduces its flow to a minimum, or even stops completely in some designs. This eliminates unnecessary churning of fluid by the pump during idle periods.
- **Benefits:** More efficient operation, reduces energy consumption and heat generation in the system.
- **Drawbacks:** More complex and expensive compared to pressure relief valves. May require additional sensors and control systems.

Choosing the Right Method:

The selection between a pressure relief valve and a load sensing pump depends on several factors, including:

- **System Complexity:** For simpler systems, a pressure relief valve might be sufficient.
- **Performance Requirements:** If precise control and energy efficiency are crucial, a load sensing pump could be a better choice.
- **Cost Considerations:** Pressure relief valves are generally less expensive than load sensing pumps.

By implementing one of these methods, the hydraulic system ensures that the pump doesn't waste energy by motoring when the steering gear is not in use.

Feb 19th 2021

Feb 19th 2021

5. With reference to a hydraulic steering gear:

(a) state the purpose of the hunting gear; (2)

(b) explain, with the aid of sketches, the action of the hunting gear. (8)

Hunting Gear in Hydraulic Steering Gear

(a) Purpose of Hunting Gear:

In a hydraulic steering gear system, the hunting gear acts as a feedback mechanism that ensures the rudder reaches the desired angle and maintains its position accurately. It essentially bridges the gap between the command given from the bridge and the actual movement of the rudder.

(b) Action of the Hunting Gear:

Here's a breakdown of how the hunting gear functions:

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 directional control valve directs pressurized hydraulic fluid to one side of the steering gear rams, causing them to extend or retract.

3. **Rudder Movement:** As the rams move, they push or pull on the rudder stock, turning the rudder in the desired direction.
4. **Hunting Gear Connection:** The hunting gear is typically linked mechanically to the rudder stock on one end and to the control system (via linkages or a telemotor receiver) on the other end.
5. **Feedback Loop:** As the rudder reaches the commanded angle, the movement is sensed by the hunting gear through its connection to the rudder stock.
6. **Adjusting Hydraulic Flow:** The hunting gear then transmits a signal (mechanical or hydraulic) back to the control system or the directional control valve. This signal indicates that the desired rudder angle has been achieved.
7. **Stopping Fluid Flow:** Based on the hunting gear's feedback, the control system or valve might:
    - Stop the flow of hydraulic fluid to the rams, preventing further movement.
    - Adjust the flow to maintain the rudder at the desired position against external forces (waves, wind).

Benefits of Hunting Gear:

- **Accurate Rudder Positioning:** Hunting gear ensures the rudder reaches the exact angle commanded from the bridge, improving steering precision.
- **Maintaining Rudder Position:** It helps the system compensate for external forces that might try to deflect the rudder from its set position.
- **Reduced Operator Input:** By automatically adjusting for minor deviations, hunting gear reduces the need for constant adjustments by the helmsman.

Overall, the hunting gear plays a crucial role in a hydraulic steering gear system by providing a feedback loop that ensures precise and stable control of the rudder.

July 2021

July 2021

5. Sketch a valve operated, rotary vane steering gear, showing the hydraulic system from the directional valve to the rotary vane unit. (10)

In a valve-operated rotary vane steering gear, the hydraulic system translates electrical or mechanical control signals from the bridge into precise rudder movements. Here's a breakdown of the hydraulic system's operation from the directional control valve to the rotary vane unit:

Components:

- **Directional Control Valve:** Located near the bridge control system, this valve receives electrical or mechanical signals and acts as a gatekeeper for pressurized hydraulic fluid flow.
- **Hydraulic Pump:** Driven by an electric motor or diesel engine, this pump pressurizes the hydraulic fluid within the system.
- **Reservoir:** This tank stores the hydraulic fluid and maintains its proper level.
- **Pipelines:** High-pressure hoses or steel pipes connect the various components and carry the pressurized fluid.

- **Rotary Vane Unit:** This is the core component responsible for converting hydraulic pressure into rotary motion to turn the rudder.

Operation:

1. **Directional Control Valve Movement:** The helmsman's actions on the bridge (turning the steering wheel or using controls) send a signal to the directional control valve.
2. **Valve Spool/Poppet Movement:** Based on the received signal, the valve's internal spool or poppet moves within the valve body. This movement opens specific ports to direct hydraulic fluid flow.
3. **High-Pressure Fluid Path:** With the valve positioned correctly, pressurized fluid from the pump is directed to one side of the rotary vane unit's chamber.
4. **Low-Pressure Fluid Path:** Simultaneously, the valve also opens a passage for the hydraulic fluid on the opposite side of the rotary vane unit to return to the reservoir. This creates a crucial pressure differential across the unit.
5. **Rotary Vane Movement:** The pressure difference acts upon a set of vanes housed within a cylindrical rotor inside the rotary vane unit. The higher pressure pushes against these vanes, causing the rotor to rotate in a specific direction.
6. **Rudder Movement:** The rotating shaft of the rotor is typically connected to the rudder stock through a reduction gear mechanism. This translates the rotary motion of the vane unit into the desired angular movement of the rudder.

Additional Considerations:

- **Pressure Relief Valve (Optional):** A pressure relief valve might be incorporated to protect the system against excessive pressure buildup due to malfunctions.
- **Pilot-operated Valves:** In some designs, pilot-operated directional control valves might be used. These valves utilize a smaller, separate hydraulic circuit to control the main valve spool, offering more precise control over fluid flow.

Overall, the valve-operated rotary vane steering gear utilizes a directional control valve to direct pressurized hydraulic fluid, creating a pressure differential within the rotary vane unit. This differential drives the rotation of the vanes, ultimately resulting in the desired movement of the rudder.

May 2024

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

March 19th 2021

March 19th 2021

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

Two-Ram Type Steering Gear with Hydraulic Circuit Breakdown

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

Main Components:

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

Hydraulic Circuit Operation:

1. **Command Signal:** The helmsman on the bridge operates the steering wheel or controls, sending a signal (electrical or mechanical) to the directional control valve.
2. **Valve Movement:** Based on the signal, the spool or poppet within the directional control valve moves, opening specific ports.
3. **High-Pressure Fluid Flow:** Depending on the desired rudder movement (turn left or right), the valve directs pressurized fluid from the pump to one side of the designated ram's cylinder.
4. **Low-Pressure Fluid Path:** Simultaneously, the valve opens a passage for the hydraulic fluid on the opposite side of the ram to return to the reservoir. This creates a pressure differential across the ram's piston.
5. **Ram Extension/Retraction:** The pressure difference acts on the piston within the ram's cylinder. The high-pressure side pushes the piston rod in the desired direction, either extending or retracting the ram.
6. **Rudder Movement:** The connecting end fitting of the ram's piston rod is attached to the tiller. As the ram extends or retracts, it pushes or pulls on the tiller, causing the rudder stock to rotate and turn the rudder in the desired direction.
7. **Opposite Ram Action:** When turning the rudder, the other ram receives fluid flow to the opposite side of its cylinder, causing its piston rod to move in the opposite direction. This ensures balanced force application on the tiller and minimizes twisting of the rudder stock.
8. **Centering the Rudder:** When the helmsman centers the steering wheel, the directional control valve directs fluid flow to neither side of the rams, or allows fluid flow equally on both sides. This holds the pistons in their centered positions, keeping the rudder centered.

Additional Components (Optional):

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

- **Filters:** Hydraulic fluid filters are essential to remove contaminants from the fluid, protecting pumps, valves, and other components from wear and tear.

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

March 26th 2021

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.