

March 2024

2. Describe, with the aid of a sketch, a constant pressure hydraulic power system for a vessel's Anchor Windlass, showing safety features and labelling ALL components of the system.

(10)

Constant Pressure Hydraulic Power System for Anchor Windlass

A constant pressure hydraulic power system provides a reliable and powerful solution for operating a vessel's anchor windlass. Here's a breakdown of its components, operation, and safety features:

Components:

1. **Reservoir:** This tank stores the hydraulic fluid (usually oil) and maintains its level. It may also incorporate a breather filter to allow air exchange and prevent contamination.
2. **Pump:** A positive displacement pump (e.g., gear pump, vane pump) is the heart of the system. It continuously draws fluid from the reservoir and pressurizes it. Electric motors, diesel engines, or even a shaft from the main engine can drive the pump.
3. **Pressure Relief Valve:** This safety valve protects the system from excessive pressure build-up. It bypasses excess fluid back to the reservoir if the pressure exceeds a set limit.
4. **Filter:** A hydraulic filter removes contaminants from the fluid to prevent wear and tear on system components.
5. **Directional Control Valve:** This valve controls the direction of the fluid flow, directing it to the appropriate actuator (e.g., hydraulic motor) based on operator commands (usually through levers or buttons). It can be a solenoid-operated valve for precise control.
6. **Hydraulic Motor:** This motor converts the pressurized hydraulic fluid into rotary motion to drive the windlass. Different motor types (e.g., radial piston, axial piston) can be chosen based on torque and speed requirements.
7. **Piping and Hoses:** These connect the components, carrying the pressurized fluid throughout the system. They are designed for high pressure and chosen for compatibility with the hydraulic fluid.
8. **Actuator (Optional):** In some systems, an additional actuator (e.g., hydraulic cylinder) might be used for functions like raising/lowering the anchor chain gypsy or deploying an anchor brake.

Operation:

1. **Power Source:** The pump is activated by its designated power source (electric motor, diesel engine, etc.).
2. **Fluid Flow:** The pump continuously draws fluid from the reservoir and pressurizes it.
3. **Pressure Relief Valve:** The pressure relief valve ensures the system pressure stays within safe limits by bypassing excess fluid back to the reservoir if needed.
4. **Filter:** The fluid passes through a filter to remove contaminants before reaching the control valve.

5. **Directional Control Valve:** The operator controls the directional control valve, directing pressurized fluid to specific ports on the valve.
6. **Hydraulic Motor:** Based on the valve position, the pressurized fluid flows to the hydraulic motor, causing it to rotate in a specific direction (hoisting or lowering the anchor).
7. **Anchor Windlass:** The rotating shaft of the hydraulic motor drives the windlass gears, raising or lowering the anchor chain.

Safety Features:

- **Pressure Relief Valve:** As mentioned earlier, this valve prevents overpressure and protects the system from damage.
- **Check Valves (Optional):** In some systems, check valves can be placed strategically to prevent unintended flow reversal or pressure loss in specific situations.
- **Low-Level Sensor (Optional):** This sensor can be used to warn of low fluid levels in the reservoir, preventing pump damage due to cavitation.
- **Fluid Selection:** Choosing the appropriate hydraulic fluid with proper viscosity and fire resistance is crucial for safe operation.
- **Regular Maintenance:** Regular inspection, maintenance, and replacement of filters and worn components ensure system reliability and safety.

Benefits of Constant Pressure System:

- **Reliable Power:** The constant pressure ensures consistent power delivery for anchor handling operations.
- **Precise Control:** Directional control valves offer precise control over the windlass operation.
- **Scalability:** The system can be sized based on the specific windlass requirements and anchor size of the vessel.
- **Efficiency:** Modern hydraulic components offer good efficiency in converting engine power to usable work at the windlass.

In conclusion, a constant pressure hydraulic power system provides a robust and efficient solution for operating a vessel's anchor windlass. By incorporating safety features and proper maintenance, this system ensures safe and reliable anchor handling operations.

Nov 2023

Nov 2023

2. Describe, with the aid of a sketch, a hydraulic rack and pinion starting system, labelling the MAIN components. (10)

A hydraulic rack and pinion starting system offers an alternative to traditional electric starter motors for large internal combustion engines, particularly in heavy machinery and industrial applications. Here's a breakdown of its main components and operation:

Main Components:

1. **Hydraulic Pump:** This is the heart of the system. It can be driven by an electric motor, a dedicated diesel engine, or even connected to the host machine's hydraulic system if available. The pump takes fluid from the reservoir and pressurizes it.
2. **Reservoir:** This tank stores the hydraulic fluid (usually oil) and maintains its level. It may also incorporate a breather filter to allow air exchange and prevent contamination.
3. **Directional Control Valve (Start Valve):** This valve controls the flow of pressurized fluid and directs it to the starter motor based on operator input (usually a start button or control system). It can be a solenoid-operated valve for precise control.
4. **Hydraulic Accumulator (Optional):** This component acts as a pressure accumulator and stores pressurized hydraulic fluid. It can provide a surge of high-pressure fluid during starting, especially beneficial for cold starts or large engines.
5. **Pressure Relief Valve:** This safety valve protects the system from excessive pressure build-up. It bypasses excess fluid back to the reservoir if the pressure exceeds a set limit.
6. **Hydraulic Starter Motor:** This is a specialized motor designed for high torque output using pressurized hydraulic fluid. It often uses a rack and pinion mechanism for gear reduction and increased torque output.
 - **Rack:** A linear gear that translates the hydraulic force into a linear motion.
 - **Pinion:** A circular gear that meshes with the rack and converts the linear motion into rotary motion to crank the engine.
7. **Engagement Mechanism:** This mechanism ensures proper engagement of the pinion gear with the engine's flywheel ring gear during starting. It might involve a spring-loaded mechanism or a solenoid for automatic engagement/disengagement.

Operation:

1. **Engine Stopped:** The hydraulic pump is inactive, and the system is pressurized (either by the running engine's hydraulic system or a dedicated pump if separate).
2. **Start Command:** When the operator presses the start button, the directional control valve opens.
3. **Pressurized Fluid Flow:** Pressurized fluid from the reservoir (or accumulator) flows to the hydraulic starter motor.
4. **Engagement:** The engagement mechanism ensures proper meshing of the pinion gear with the engine's flywheel ring gear.
5. **Engine Cranking:** The pressurized fluid acting on the rack and pinion mechanism within the starter motor generates high torque, which is used to crank the engine's flywheel and initiate combustion.
6. **Engine Starts:** Once the engine reaches sufficient speed, the operator releases the start button, and the directional control valve closes.
7. **Disengagement:** The engagement mechanism automatically disengages the pinion gear from the flywheel ring gear to prevent unnecessary wear and tear.

Benefits of Hydraulic Rack and Pinion Starting System:

- **High Starting Torque:** The system provides exceptional cranking power for large engines, even in cold weather conditions.
- **Reduced Electrical Load:** Compared to electric starters, this system puts less strain on the electrical system, which can be beneficial for applications with limited battery capacity.

- **Durability:** Hydraulic components are generally robust and can withstand high loads, offering a longer lifespan compared to electric starters in demanding applications.
- **Scalability:** The system can be adapted to various engine sizes by selecting appropriate pump and starter motor capacities.

In conclusion, the hydraulic rack and pinion starting system offers a reliable and powerful solution for starting large internal combustion engines, particularly in heavy machinery and industrial settings.

June 2023

June 2023

2. (a) Explain why a hydraulic actuator is preferred for a vessel's stabiliser over an electrical actuator. (5)
- (b) Sketch a hydraulic circuit for a single stabiliser, suitable for a constant pressure system. (5)

Hydraulic Actuators for Vessel Stabilizers

(a) Advantages of Hydraulic Actuators:

Several factors make hydraulic actuators a preferred choice for vessel stabilizers compared to electrical actuators:

- **High Power Density:** Hydraulic systems can generate significantly higher force and torque compared to electrical actuators of similar size and weight. This is crucial for stabilizers that need to counteract large wave forces acting on the vessel.
- **Fast Response:** Hydraulic systems offer faster response times due to the inherent properties of fluids. This allows the stabilizer fins to react quickly to wave motions and provide more effective stabilization.
- **Load Handling:** Hydraulic systems excel at handling high dynamic loads experienced by stabilizers in rough seas. They can absorb shock loads and provide smoother operation compared to electric motors, which can stall under extreme loads.
- **Simplicity and Reliability:** Hydraulic systems are generally simpler in design compared to complex electric motors with gear reduction units. This translates to potentially higher reliability and easier maintenance at sea.
- **Environmental Resistance:** Hydraulic components can be chosen for their resistance to the harsh marine environment, including salt spray and corrosion.

Electrical actuators may be suitable for smaller vessels or applications requiring lower power. However, for most practical applications on larger vessels, the advantages of high power

density, fast response, and load handling make hydraulic actuators the preferred choice for vessel stabilizers.

(b) Hydraulic Circuit for a Single Stabilizer (Constant Pressure System):

In a constant pressure hydraulic system for a vessel stabilizer, the following key components are involved:

1. **Reservoir:** Stores the hydraulic fluid and maintains its level.
2. **Pump:** Continuously pressurizes the fluid in the system (driven by an electric motor or diesel engine).
3. **Pressure Relief Valve:** Protects the system from overpressure by bypassing excess fluid back to the reservoir.
4. **Filter:** Removes contaminants from the fluid to protect system components.
5. **Solenoid-operated Directional Control Valve:** This valve controls the flow and direction of pressurized fluid based on electrical signals from the stabilizer control system. It has multiple positions:
 - **Center:** Neutral position, no fluid flow to the actuator.
 - **Port 1:** Directs fluid to extend the actuator rod, pushing the stabilizer fin down.
 - **Port 2:** Directs fluid to retract the actuator rod, pulling the stabilizer fin up.
6. **Hydraulic Cylinder (Double-acting):** This actuator converts pressurized fluid into linear motion to position the stabilizer fin. It has a piston rod connected to the fin linkage.
7. **Position Sensor:** Provides feedback on the current position of the stabilizer fin to the control system.

Operation:

1. **Control System Input:** The vessel's stabilization control system analyzes sensor data (roll angle, wave motion) and sends electrical signals to the directional control valve.
2. **Valve Actuation:** Based on the electrical signal, the valve directs pressurized fluid to either Port 1 (fin down) or Port 2 (fin up) of the actuator.
3. **Actuator Movement:** The pressurized fluid extends or retracts the actuator rod, respectively pushing the stabilizer fin down or pulling it up.
4. **Fin Positioning:** The movement of the fin counteracts the roll motion of the vessel, providing stabilization.
5. **Position Feedback:** The position sensor continuously monitors the fin's position and sends feedback to the control system.
6. **Control Loop:** The control system adjusts the valve position based on the sensor feedback, maintaining the desired fin position and vessel stability.

This is a simplified representation. Additional components like check valves or accumulators might be incorporated for specific system requirements.

June 2021

1. Explain the operation of the hydraulic system shown in figure. (10)

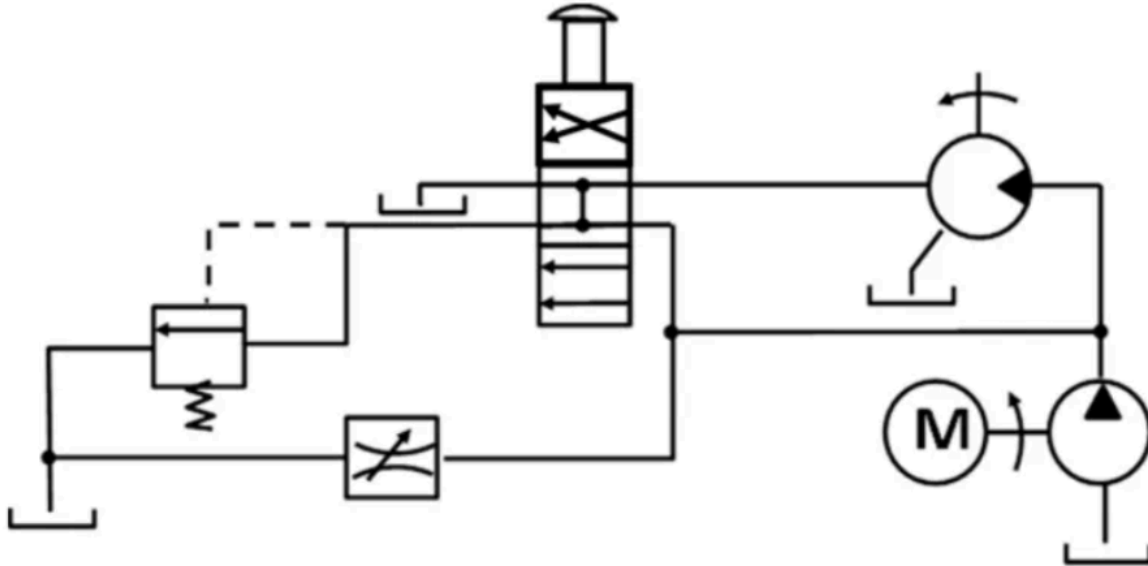
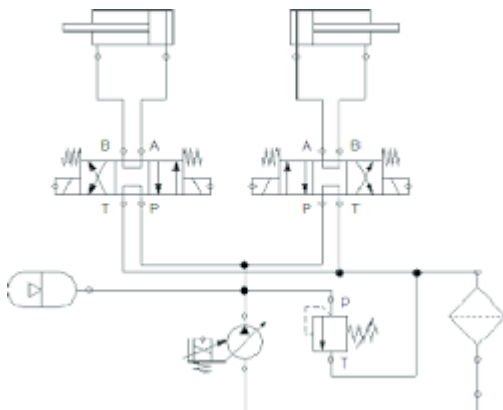


Fig Q1

It appears to be a hydraulic circuit for a single stabilizer fin on a vessel, likely part of a constant pressure system. Here's a breakdown of the components and their operation:



[Opens in a new window](#)

www.researchgate.net

Hydraulic circuit for stabiliser fin

pen_spark

Components:

1. **Reservoir:** Stores the hydraulic fluid and maintains its level.
2. **Pump:** Continuously pressurizes the fluid in the system (not shown in this diagram but assumed to be present).

3. **Pressure Relief Valve:** Protects the system from overpressure by bypassing excess fluid back to the reservoir (not shown in this diagram but assumed to be present in a constant pressure system).
4. **Filter:** Removes contaminants from the fluid before it reaches the control valve (not shown in this diagram but recommended for system protection).
5. **Solenoid-Operated Directional Control Valve (4/3 Position, Open Center):** This valve controls the flow and direction of pressurized fluid based on electrical signals from the stabilizer control system. It has multiple positions:
 - **Center:** Neutral position, fluid flows freely back to the reservoir from both pump outlet and actuator (open center).
 - **Port A:** Directs fluid from the pump to the "extend" port of the actuator, pushing the stabilizer fin down.
 - **Port B:** Directs fluid from the pump to the "retract" port of the actuator, pulling the stabilizer fin up.
 - **Relief:** In case of excessive pressure, the valve may have a built-in relief function to bypass fluid back to the reservoir (depending on specific valve design).
6. **Hydraulic Cylinder (Double-acting):** This actuator converts pressurized fluid into linear motion to position the stabilizer fin. It has a piston rod connected to the fin linkage.
7. **Position Sensor (not shown):** This sensor (usually linear position transducer) would be mounted on the actuator to provide feedback on the current position of the stabilizer fin to the control system.

Operation:

1. **Control System Input:** The vessel's stabilization control system analyzes sensor data (roll angle, wave motion) and sends electrical signals to the directional control valve.
2. **Valve Actuation:** Based on the electrical signal, the valve moves to the desired position (Port A, Port B, or Center).
 - **Center:** In neutral position, fluid flows freely back to the reservoir from both the pump and the actuator (assuming an open-center valve). The stabilizer fin remains in its current position due to external forces (e.g., spring centering or wave action).
 - **Port A:** When energized, the valve directs pressurized fluid from the pump (not shown) to the "extend" port of the actuator.
 - **Port B:** When energized, the valve directs pressurized fluid from the pump (not shown) to the "retract" port of the actuator.
3. **Actuator Movement:**
 - **Extending the Fin (Port A):** Pressurized fluid entering the "extend" port extends the actuator rod, pushing the stabilizer fin down (counteracting roll in one direction).
 - **Retracting the Fin (Port B):** Pressurized fluid entering the "retract" port extends the other side of the actuator rod, pulling the stabilizer fin up (counteracting roll in the other direction).
4. **Position Feedback (not shown):** In real systems, a position sensor would continuously monitor the actuator rod movement (fin position) and send feedback signals to the control system.
5. **Control Loop:** The control system adjusts the valve position based on the sensor feedback (if applicable) and other sensor data (roll angle, wave motion) to maintain the desired fin position and vessel stability.

Additional Notes:

- This diagram depicts a basic open-center directional control valve. Other valve types with different flow paths might be used in real systems.
- A well-designed system would likely incorporate a filter to remove contaminants from the fluid before it reaches the valve for better protection of components.
- The pressure relief valve, though not shown explicitly in this diagram, is a crucial safety feature in a constant pressure system to prevent overpressure situations.

I hope this explanation clarifies the operation of the hydraulic circuit for the stabilizer fin.

Sept 2021

Sept 2021

1. (a) Explain why a hydraulic actuator is preferred for a vessel's stabiliser over an electrical actuator. (5)
- (b) Sketch a hydraulic circuit for a single stabiliser, suitable for a constant pressure system. (5)

(a) Advantages of Hydraulic Actuators:

- **High Power Density:** Hydraulic systems can generate significantly higher force and torque compared to electrical actuators of similar size and weight. This is essential for stabilizers that need to counteract large wave forces acting on the vessel.
- **Fast Response:** Hydraulic systems offer faster response times due to the inherent properties of fluids. This allows the stabilizer fins to react quickly to wave motions and provide more effective stabilization.
- **Load Handling:** Hydraulic systems excel at handling high dynamic loads experienced by stabilizers in rough seas. They can absorb shock loads and provide smoother operation compared to electric motors, which can stall under extreme loads.
- **Simplicity and Reliability:** Hydraulic systems are generally simpler in design compared to complex electric motors with gear reduction units. This translates to potentially higher reliability and easier maintenance at sea.
- **Environmental Resistance:** Hydraulic components can be chosen for their resistance to the harsh marine environment, including salt spray and corrosion.

(b) Hydraulic Circuit for a Single Stabilizer (Constant Pressure System):

Components:

1. **Reservoir:** Stores the hydraulic fluid and maintains its level.
2. **Pump:** Continuously pressurizes the fluid in the system (driven by an electric motor or diesel engine).
3. **Pressure Relief Valve:** Protects the system from overpressure by bypassing excess fluid back to the reservoir (not shown in all diagrams).
4. **Filter:** Removes contaminants from the fluid to protect system components (recommended but not always shown).
5. **Solenoid-operated Directional Control Valve (4/3 Position, Open Center):** This valve controls the flow and direction of pressurized fluid based on electrical signals from the stabilizer control system. It has multiple positions:
 - **Center:** Neutral position, fluid flows freely back to the reservoir from both pump outlet and actuator (open center).

- **Port A:** Directs fluid to extend the actuator rod, pushing the stabilizer fin down.
 - **Port B:** Directs fluid to retract the actuator rod, pulling the stabilizer fin up.
 - **Relief:** In case of excessive pressure, the valve may have a built-in relief function to bypass fluid back to the reservoir (depending on specific valve design).
6. **Hydraulic Cylinder (Double-acting):** This actuator converts pressurized fluid into linear motion to position the stabilizer fin. It has a piston rod connected to the fin linkage.
 7. **Position Sensor (not always shown):** This sensor (usually linear position transducer) would be mounted on the actuator to provide feedback on the current position of the stabilizer fin to the control system.

Operation:

1. **Control System Input:** The vessel's stabilization control system analyzes sensor data (roll angle, wave motion) and sends electrical signals to the directional control valve.
2. **Valve Actuation:** Based on the electrical signal, the valve moves to the desired position (Port A, Port B, or Center).
 - **Center:** In neutral position, fluid flows freely back to the reservoir from both the pump and the actuator (assuming an open-center valve). The stabilizer fin remains in its current position due to external forces (e.g., spring centering or wave action).
 - **Port A:** When energized, the valve directs pressurized fluid from the pump (not shown) to the "extend" port of the actuator.
 - **Port B:** When energized, the valve directs pressurized fluid from the pump (not shown) to the "retract" port of the actuator.
3. **Actuator Movement:**
 - **Extending the Fin (Port A):** Pressurized fluid entering the "extend" port extends the actuator rod, pushing the stabilizer fin down (counteracting roll in one direction).
 - **Retracting the Fin (Port B):** Pressurized fluid entering the "retract" port extends the other side of the actuator rod, pulling the stabilizer fin up (counteracting roll in the other direction).
4. **Position Feedback (not shown):** In real systems, a position sensor would continuously monitor the actuator rod movement (fin position) and send feedback signals to the control system.
5. **Control Loop:** The control system adjusts the valve position based on the sensor feedback (if applicable) and other sensor data (roll angle, wave motion) to maintain the desired fin position and vessel stability.

Additional Notes:

- This diagram depicts a basic open-center directional control valve. Other valve types with different flow paths might be used in real systems.
- A well-designed system would likely incorporate a filter to remove contaminants from the fluid before it reaches the valve for better protection of components.

I hope this comprehensive explanation clarifies the advantages of hydraulic actuators and the operation of a hydraulic circuit for a vessel stabilizer!

Sept 2021

2. Sketch a hydraulic system for adjusting the angle of fin stabilisers, labelling ALL parts. (10)

Hydraulic System for Adjusting Fin Stabilizer Angle (Constant Pressure System)

This system utilizes pressurized hydraulic fluid to precisely control the position (angle) of fin stabilizers on a vessel, counteracting roll and improving stability. Here's a breakdown of the key components and their operation:

Components:

1. **Reservoir:** This tank stores the hydraulic fluid (usually oil) and maintains its level. It may incorporate a breather filter to allow air exchange and prevent contamination.
2. **Pump:** A positive displacement pump (e.g., gear pump, vane pump) is the heart of the system. Driven by an electric motor or diesel engine, it continuously draws fluid from the reservoir and pressurizes it.
3. **Pressure Relief Valve:** This safety valve protects the system from excessive pressure build-up. It bypasses excess fluid back to the reservoir if the pressure exceeds a set limit.
4. **Filter:** A hydraulic filter removes contaminants from the fluid before it reaches the control valve, protecting system components from wear and tear.
5. **Solenoid-Operated Directional Control Valve (4/3 Position, Closed Center):** This valve plays a crucial role in controlling the flow and direction of pressurized fluid based on electrical signals from the stabilizer control system. It has multiple positions:
 - **Center:** Neutral position, fluid flow is blocked within the valve, and the actuator holds its position (closed center).
 - **Port A:** Directs fluid to extend the actuator rod, pushing the stabilizer fin down (counteracting roll in one direction).
 - **Port B:** Directs fluid to retract the actuator rod, pulling the stabilizer fin up (counteracting roll in the other direction).
 - **Relief:** In case of excessive pressure, the valve may have a built-in relief function to bypass fluid back to the reservoir (depending on specific valve design).
6. **Hydraulic Cylinder (Double-acting):** This actuator converts pressurized fluid into linear motion to adjust the angle of the stabilizer fin. It has a piston rod connected to a linkage mechanism that controls the fin's position.
7. **Position Sensor (Linear Transducer):** Mounted on the actuator, this sensor provides continuous feedback on the current position (angle) of the stabilizer fin to the control system. This is crucial for precise control.

Operation:

1. **Control System Input:** The vessel's stabilization control system analyzes sensor data (roll angle, wave motion, desired fin position) and sends electrical signals to the directional control valve.
2. **Valve Actuation:** Based on the electrical signal:

- **Center:** In neutral position, the valve blocks the flow of fluid, and the actuator holds the stabilizer fin in its current position (due to internal pressure or external forces like springs).
 - **Port A:** When energized, the valve directs pressurized fluid from the pump (not shown) to the "extend" port of the actuator.
 - **Port B:** When energized, the valve directs pressurized fluid from the pump (not shown) to the "retract" port of the actuator.
3. **Actuator Movement:**
- **Extending the Actuator (Port A):** Pressurized fluid entering the "extend" port extends the actuator rod, which through the linkage mechanism, pushes the stabilizer fin down to a specific angle.
 - **Retracting the Actuator (Port B):** Pressurized fluid entering the "retract" port extends the other side of the actuator rod, pulling the linkage and stabilizer fin up to a specific angle.
4. **Position Feedback:** The position sensor continuously monitors the actuator rod movement (fin angle) and sends feedback signals to the control system.
5. **Control Loop:** The control system compares the desired fin position with the actual position feedback from the sensor. It then adjusts the directional control valve position (Port A, Port B, or Center) to maintain the precise fin angle required for optimal stabilization.

Additional Notes:

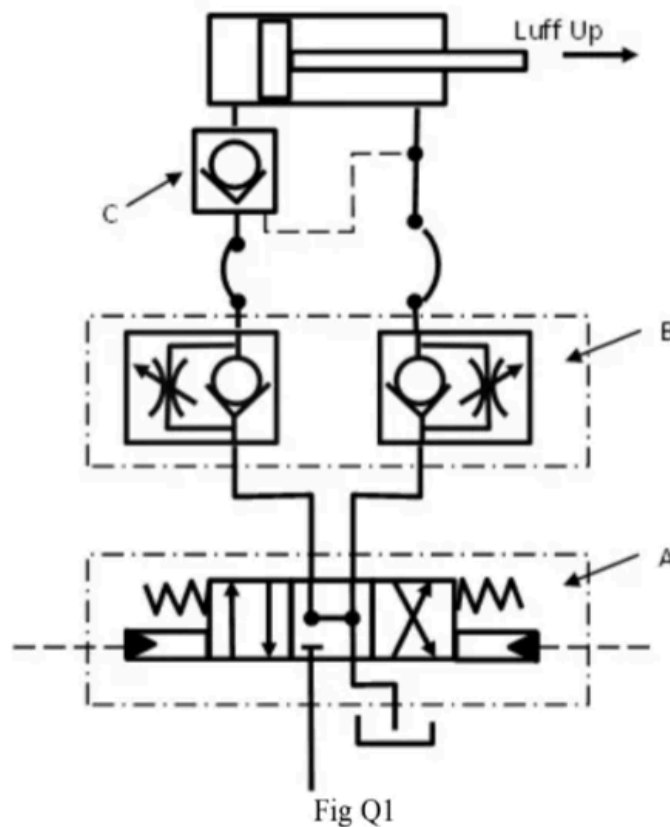
- This is a simplified representation. Real systems might incorporate additional valves (e.g., check valves for specific functions) or accumulators for improved response during peak loads.
- A closed-center directional control valve is commonly used in stabilizer fin systems to prevent actuator drift due to leakage when in the neutral position.
- The control system plays a crucial role by processing sensor data and issuing commands to the valve for precise and dynamic fin positioning based on sea conditions.

This hydraulic system offers several advantages:

- **High Power and Control:** Hydraulics provide the necessary force to adjust the fins effectively and counter roll even in rough seas.
- **Precise Positioning:** The closed-center valve and position feedback ensure accurate control of the fin angle for optimal stabilization.
- **Fast Response:** Hydraulic systems react quickly to wave motions, allowing for timely adjustments of the fins.
- **Durability:** Hydraulic components can withstand the harsh marine environment and demanding operation.

April 2021

1. The operating hydraulic circuit for a luffing cylinder for a deck crane is shown in the figure. Explain the purpose and describe the operation of EACH item A, B and C. (10)



Item A: Solenoid-Operated Directional Control Valve

- **Purpose:** This valve controls the flow and direction of pressurized hydraulic fluid to the luffing cylinder, ultimately raising or lowering the boom of the deck crane.
- **Operation:** The valve is likely a 4/3 position, solenoid-operated directional control valve. It has multiple spool positions that can be controlled by electrical signals from the crane operator's controls. Here's a breakdown of possible positions:
 - **Center:** Neutral position, fluid flow is blocked within the valve. The luffing cylinder holds its position (usually due to internal pressure).
 - **Port 1:** Directs pressurized fluid from the pump (not shown in the diagram) to the "extend" port of the luffing cylinder. This extends the cylinder rod, causing the boom to raise.
 - **Port 2:** Directs pressurized fluid from the pump (not shown) to the "retract" port of the luffing cylinder. This retracts the cylinder rod, causing the boom to lower.
 - **Relief:** The valve might have a built-in pressure relief function (depending on the specific design) to bypass excess fluid back to the reservoir in case of pressure surges.

Item B: Luffing Cylinder (Double-Acting)

- **Purpose:** This hydraulic actuator converts pressurized fluid into linear motion to raise or lower the crane's boom.

- **Operation:** The cylinder has a piston rod connected to the crane's boom lifting mechanism. By controlling the direction of pressurized fluid flow using the directional control valve (Item A), the cylinder rod can be extended or retracted:
 - **Boom Up (Port 1 Energized):** When Port 1 of the directional control valve is energized, pressurized fluid flows into the "extend" port of the cylinder. This extends the piston rod, pushing the boom upwards through the lifting mechanism.
 - **Boom Down (Port 2 Energized):** When Port 2 of the directional control valve is energized, pressurized fluid flows into the "retract" port of the cylinder. This retracts the piston rod, pulling the boom downwards through the lifting mechanism.

Item C: Pressure Relief Valve

- **Purpose:** This safety valve protects the hydraulic system from excessive pressure build-up.
- **Operation:** The pressure relief valve is usually set to a specific pressure threshold. If the system pressure exceeds this limit (due to pump malfunction or other factors), the valve opens and bypasses excess fluid back to the reservoir, preventing damage to components.

Overall System Operation:

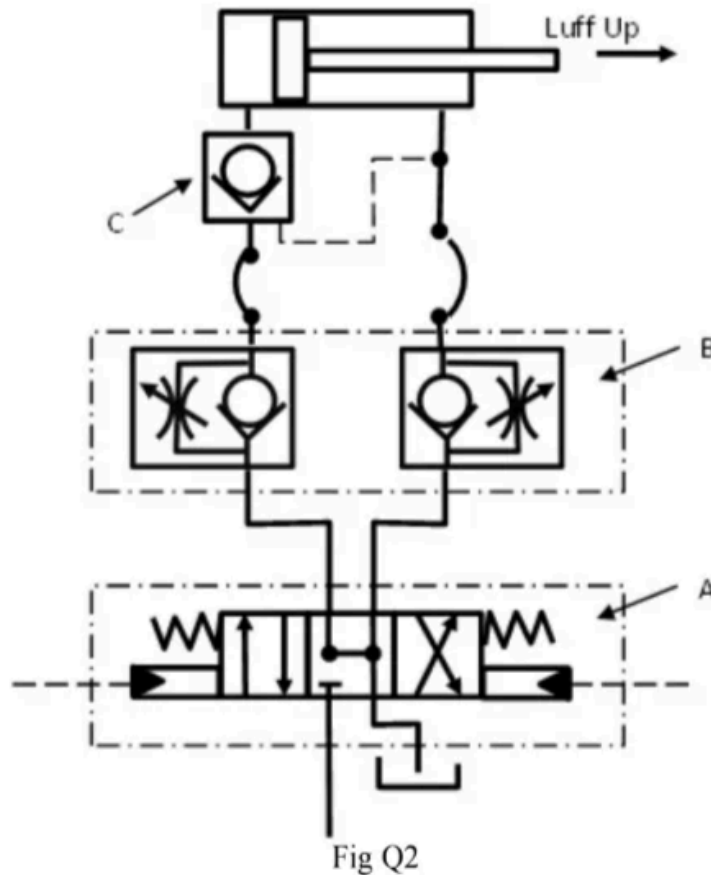
The crane operator controls the boom movement (up or down) through a control panel that sends electrical signals to the solenoid-operated directional control valve (Item A). The valve then directs pressurized fluid to the appropriate port of the luffing cylinder (Item B), causing the piston rod to extend or retract. This extension or retraction translates to boom movement through the crane's lifting mechanism. The pressure relief valve (Item C) acts as a safety measure to safeguard the system in case of pressure spikes.

Note:

- This is a simplified explanation based on the limited information in the black and white diagram. Real systems might incorporate additional valves for specific functions (e.g., check valves for holding pressure) or other components depending on the crane's design and complexity.

June 2020

2. The operating hydraulic circuit for a luffing cylinder for a deck crane is shown in the figure. Explain the purpose and describe the operation of EACH item A, B and C. (10)



Nov 2018

Nov 2018

2. With reference to a crane operated by a constant pressure hydraulic system incorporating unidirectional, fixed displacement pumps that run continuously, explain EACH of the following:
- (a) the purpose of the accumulator; (2)
 - (b) how the hydraulic pressure is regulated; (2)
 - (c) how the speed and direction of the hoist motor is varied; (3)
 - (d) how the torque available from the hoist motor can be varied. (3)

Hydraulic Crane System with Unidirectional Pumps:

Here's an explanation of each aspect of the constant pressure hydraulic system you described, incorporating unidirectional, fixed displacement pumps:

(a) Purpose of the Accumulator:

In a constant pressure system with fixed displacement pumps that run continuously, an accumulator plays a crucial role in:

- **Peak Flow Demands:** The accumulator acts as a reservoir for pressurized hydraulic fluid. During moments when the crane requires a sudden surge of flow for operations like lifting heavy loads or rapid lowering, the accumulator can supplement the pump's output and provide the necessary extra fluid. This helps maintain consistent system pressure and prevents performance dips during peak demands.
- **Smoothing Pressure Fluctuations:** Even with continuous pump operation, there can be minor fluctuations in pressure due to pump inefficiencies or varying flow demands. The accumulator helps absorb these pressure fluctuations, providing a steadier flow of pressurized fluid to the crane's actuators (hoist motor, luffing cylinder, etc.).

(b) How Hydraulic Pressure is Regulated:

A constant pressure system maintains a set pressure level throughout the circuit. Here's how it's achieved:

- **Pressure Relief Valve:** This valve is set to a specific pressure threshold. If the system pressure exceeds this limit due to pump output, the pressure relief valve opens and diverts excess fluid back to the reservoir. This bypass mechanism ensures the pressure doesn't climb above the safe operating limit.
- **Pump Unloading Valve (Optional):** Some systems might incorporate an additional pump unloading valve. This valve can be controlled by the system pressure. When the pressure reaches the desired level, the valve unloads the pump by diverting its output back to the reservoir. This prevents unnecessary energy consumption when the system doesn't require full pump capacity.

(c) How Speed and Direction of the Hoist Motor are Varied:

The speed and direction of the hoist motor (responsible for raising and lowering loads) are typically controlled using a **solenoid-operated directional control valve**. This valve has multiple positions that can be activated by electrical signals from the crane operator's controls. Here's how it works:

- **Center:** Neutral position, fluid flow is blocked within the valve. The hoist motor remains stationary.
- **Port 1:** Directs pressurized fluid to one side of the hoist motor, causing it to rotate in a specific direction (raising the load).
- **Port 2:** Directs pressurized fluid to the opposite side of the hoist motor, causing it to rotate in the opposite direction (lowering the load).
- **Relief:** The valve might have a built-in pressure relief function to bypass excess pressure if needed.

By controlling the direction of fluid flow using the solenoid valve, the operator can change the rotation direction of the hoist motor, achieving raising or lowering of the load. The speed of the motor is primarily controlled by the flow rate of the pressurized fluid. A higher flow rate translates to a faster motor speed (faster lifting or lowering). This flow rate can be indirectly controlled by adjusting the engine speed of the prime mover driving the pump (assuming a variable-speed engine is used).

In some systems, additional components like flow control valves might be introduced to offer more precise control over the flow rate and, consequently, the hoist motor speed.

(d) How Torque Available from the Hoist Motor is Varied:

The torque available from the hoist motor is primarily determined by the system pressure and the displacement of the motor itself. In this constant pressure system:

- **System Pressure:** Since the pressure is maintained at a constant level by the pressure relief valve, it cannot be directly adjusted to vary torque.
- **Hoist Motor Displacement:** The displacement of the hoist motor is a fixed design parameter. A larger displacement motor can inherently generate higher torque compared to a smaller one at the same pressure.

Therefore, in this specific system configuration, the torque available from the hoist motor is limited and cannot be easily varied during operation.

However, some crane designs might incorporate additional features to achieve variable torque, such as:

- **Multiple Speed Motors:** Using a multi-speed hoist motor with different displacement settings allows for selecting a gear that offers the desired torque for the specific load.
- **Variable Displacement Pump (if not a fixed displacement pump):** If the system utilizes a variable displacement pump, the pump output (flow rate and pressure) can be adjusted, indirectly affecting the torque available at the hoist motor.

It's important to note that the specific methods for controlling speed, direction, and torque can vary depending on the crane's design and the manufacturer's chosen control system.

March 2020

March 2020

1. (a) Sketch the hydraulic symbol for a directional control valve. (3)
(b) Describe the operation of EACH of the following hydraulic valves:
 - (i) directional control valve; (2)
 - (ii) speed control valve; (2)
 - (iii) brake valve. (3)

You've provided a great explanation of hydraulic valve symbols and operations! Here's a summary of the key points:

(a) Directional Control Valve Symbol:

The symbol for a directional control valve resembles a rectangular box with lines representing ports and a spool or slider inside. Here's a breakdown:

- **Rectangle:** Represents the valve body.
- **Lines:** Each line signifies a port on the valve (usually labeled P for Pump, T for Tank, A and B for actuator lines). The number of lines depends on the valve's functionality (e.g., 4/2 valve has 4 lines, 4/3 valve has 5 lines).
- **Spool/Slider:** This internal element controls the flow paths within the valve by directing fluid based on its position. The symbol may depict different spool positions (center, extend, retract) with varying line connections.

Here are some variations of directional control valve symbols:

- **4/2 Solenoid-Operated Valve:** This common valve has 4 ports and 2 spool positions (center, either extend or retract). It's often used with a solenoid to control the spool position electrically.
- **4/3 Center-Closed Valve:** This valve has 4 ports and 3 spool positions (center blocking flow, extend, retract). It maintains the actuator's position when in the center.

(b) Operation of Hydraulic Valves:

(i) Directional Control Valve:

As mentioned, a directional control valve manages the flow and direction of pressurized fluid. Here's its operation:

- **Center Position:** In this neutral position, the spool blocks the flow paths between ports, typically holding the actuator in its current position (depending on the valve type).
- **Extend Position:** When actuated (electrically or manually), the spool connects the pump line (P) to the "extend" port of the actuator (usually port A), allowing pressurized fluid to flow and extend the actuator rod.
- **Retract Position:** In this position, the spool connects the pump line (P) to the "retract" port of the actuator (usually port B), allowing pressurized fluid to flow and retract the actuator rod.

(ii) Speed Control Valve:

A speed control valve regulates the flow rate of pressurized fluid within a circuit. Here are two common types:

- **Pressure Compensated Flow Control Valve:** This valve maintains a constant flow rate regardless of pressure changes. It achieves this by adjusting an internal bypass based on system pressure.
- **Throttle Valve:** This valve has an adjustable opening that restricts the flow of fluid. Adjusting the opening allows for regulating the flow rate and consequently the speed of an actuator.

(iii) Brake Valve:

A brake valve controls the engagement and disengagement of a hydraulic braking system. Here are two common types:

- **On/Off Brake Valve:** This two-position valve allows for either applying the brake (blocking fluid flow) or releasing the brake (allowing fluid flow to engage a spring-loaded brake mechanism).
- **Proportional Brake Valve:** This valve offers more precise control by regulating the pressure applied to the brake. A higher pressure translates to a stronger braking force.

March 2021

1. With reference to a crane operated by a constant pressure hydraulic system incorporating unidirectional, fixed displacement pumps that run continuously, explain EACH of the following:
 - (a) the purpose of the accumulator; (2)
 - (b) how the hydraulic pressure is regulated; (2)
 - (c) how the speed and direction of the hoist motor is varied; (3)
 - (d) how the torque available from the hoist motor can be varied. (3)

Hydraulic Crane System with Unidirectional Pumps:

Here's a breakdown of the functionalities you requested in a constant pressure system with fixed displacement pumps:

(a) Purpose of the Accumulator:

In this system, the accumulator serves two crucial purposes:

- **Peak Flow Demands:** With fixed displacement pumps continuously running, the accumulator acts as a reservoir for pressurized hydraulic fluid. During moments when the crane requires a sudden surge of flow for lifting heavy loads or rapid lowering, the accumulator can supplement the pump's output and provide the extra fluid needed. This helps maintain consistent system pressure and prevents performance dips during peak demands.
- **Smoothing Pressure Fluctuations:** Even with continuous pump operation, there can be minor fluctuations in pressure due to pump inefficiencies or varying flow demands. The accumulator helps absorb these pressure fluctuations by acting as a buffer. It provides a steadier flow of pressurized fluid to the crane's actuators (hoist motor, luffing cylinder, etc.).

(b) How Hydraulic Pressure is Regulated:

A constant pressure system maintains a set pressure level throughout the circuit. Here's how it's achieved:

- **Pressure Relief Valve:** This safety valve is the primary pressure regulation mechanism. It's set to a specific pressure threshold. If the system pressure exceeds this limit due to pump output, the pressure relief valve opens and diverts excess fluid back to the reservoir. This bypass mechanism ensures the pressure doesn't climb above the safe operating limit.
- **Pump Unloading Valve (Optional):** Some systems might incorporate an additional pump unloading valve. This valve can be controlled by the system pressure. When the pressure reaches the desired level, the valve unloads the pump by diverting its output back to the reservoir. This prevents unnecessary energy consumption when the system doesn't require full pump capacity.

(c) How Speed and Direction of the Hoist Motor are Varied:

The speed and direction of the hoist motor (responsible for raising and lowering loads) are typically controlled using a **solenoid-operated directional control valve**. This valve has multiple positions that can be activated by electrical signals from the crane operator's controls. Here's how it works:

- **Center:** Neutral position, fluid flow is blocked within the valve. The hoist motor remains stationary.
- **Port 1:** Directs pressurized fluid to one side of the hoist motor, causing it to rotate in a specific direction (raising the load).
- **Port 2:** Directs pressurized fluid to the opposite side of the hoist motor, causing it to rotate in the opposite direction (lowering the load).
- **Relief:** The valve might have a built-in pressure relief function to bypass excess pressure if needed.

By controlling the direction of fluid flow using the solenoid valve, the operator can change the rotation direction of the hoist motor, achieving raising or lowering of the load. The speed of the motor is primarily controlled by the flow rate of the pressurized fluid. A higher flow rate translates to a faster motor speed (faster lifting or lowering). This flow rate can be indirectly controlled by adjusting the engine speed of the prime mover driving the pump (assuming a variable-speed engine is used).

In some systems, additional components like flow control valves might be introduced to offer more precise control over the flow rate and, consequently, the hoist motor speed.

(d) How Torque Available from the Hoist Motor Can be Varied:

The torque available from the hoist motor is primarily determined by the system pressure and the displacement of the motor itself. In this constant pressure system:

- **System Pressure:** Since the pressure is maintained at a constant level by the pressure relief valve, it cannot be directly adjusted to vary torque.
- **Hoist Motor Displacement:** The displacement of the hoist motor is a fixed design parameter. A larger displacement motor can inherently generate higher torque compared to a smaller one at the same pressure.

Therefore, in this specific system configuration, the torque available from the hoist motor is limited and cannot be easily varied during operation.

However, some crane designs might incorporate additional features to achieve variable torque, such as:

- **Multiple Speed Motors:** Using a multi-speed hoist motor with different displacement settings allows for selecting a gear that offers the desired torque for the specific load.
- **Variable Displacement Pump (if not a fixed displacement pump):** If the system utilizes a variable displacement pump, the pump output (flow rate and pressure) can be adjusted, indirectly affecting the torque available at the hoist motor.

It's important to note that the specific methods for controlling speed, direction, and torque can vary depending on the crane's design and the manufacturer's chosen control system.

May 2021 14th

May 2021 14th

1. Describe, with the aid of a sketch, a constant pressure hydraulic power system for a vessel's Anchor Windlass, showing safety features and labelling ALL components of the system.

(10)

This system utilizes pressurized hydraulic fluid to efficiently operate a vessel's anchor windlass for raising and lowering the anchor. Here's a breakdown of the components and their functions:

Components:

1. **Reservoir:** This tank stores the hydraulic fluid (usually oil) and maintains its level. It may incorporate a breather filter to allow air exchange and prevent contamination.
2. **Electric Motor:** This motor drives the hydraulic pump.
3. **Fixed Displacement Pump:** This positive displacement pump continuously draws fluid from the reservoir and pressurizes it. The pump displacement (fixed volume per revolution) determines the system pressure.
4. **Pressure Relief Valve:** This safety valve protects the system from excessive pressure build-up. It bypasses excess fluid back to the reservoir if the pressure exceeds a set limit.
5. **Filter:** A hydraulic filter removes contaminants from the fluid before it reaches the control valve, protecting system components from wear and tear.
6. **Solenoid-Operated Directional Control Valve (4/3 Position, Center-Closed):** This valve controls the flow and direction of pressurized fluid based on electrical signals from the windlass control panel. It has multiple positions:
 - **Center:** Neutral position, fluid flow is blocked within the valve (closed-center), holding the anchor windlass in position (due to internal pressure or external braking).
 - **Port A:** Directs fluid to extend the windlass motor cylinder, raising the anchor.
 - **Port B:** Directs fluid to retract the windlass motor cylinder, lowering the anchor.
 - **Relief:** In case of excessive pressure, the valve may have a built-in relief function to bypass fluid back to the reservoir (depending on specific valve design).
7. **Windlass Motor Cylinder (Double-Acting):** This hydraulic actuator converts pressurized fluid into linear motion to operate the anchor windlass. It has a piston rod connected to the windlass mechanism, raising or lowering the anchor based on fluid flow direction.
8. **Pressure Gauge:** Provides a visual indication of the system pressure to the operator.
9. **Level Gauge (on Reservoir):** Allows monitoring of the hydraulic fluid level in the reservoir for proper system operation.
10. **Check Valve (Optional):** This one-way valve can be placed strategically in the system to prevent flow reversal in specific situations (e.g., preventing anchor drift due to pressure loss).

Safety Features:

- **Pressure Relief Valve:** Protects the system from overpressure.
- **Solenoid-Operated Directional Control Valve (Center-Closed):** Holds the anchor windlass in position when in neutral, preventing accidental movement.

- **Check Valve (Optional):** Prevents unintended anchor drift due to pressure loss.
- **Low-Fluid Level Shutdown (Optional):** System can be designed to automatically shut down in case of insufficient fluid level in the reservoir.

Labeled Diagram:

Note: This is a simplified representation. Real systems might incorporate additional valves for specific functions (e.g., pressure control valves, sequence valves) or other components depending on the windlass design and complexity.

Nov 2020

Nov 2020

2. Describe, with the aid of a sketch, a hydraulic rack and pinion starting system, labelling the MAIN components. (10)

Question 2. Some sketch a standard hydraulic system for e.g. a steering gear. Some give no description. Some show a hydraulic motor.

A hydraulic rack and pinion starting system utilizes pressurized hydraulic fluid to crank a vehicle's engine instead of a traditional electric starter motor. Here's a breakdown of the main components:

1. Hydraulic Pump:

- This positive displacement pump is driven by the vehicle's engine (usually via belt or shaft from the crankshaft) and generates pressurized hydraulic fluid.

2. Hydraulic Reservoir:

- This tank stores the hydraulic fluid and maintains its level. It may incorporate a filter and breather to prevent contamination.

3. Pressure Relief Valve:

- This safety valve protects the system from excessive pressure build-up. It bypasses excess fluid back to the reservoir if the pressure exceeds a set limit.

4. Solenoid-Operated Directional Control Valve:

- This valve controls the flow and direction of pressurized fluid based on electrical signals from the driver's ignition switch. It typically has two main positions:
 - **Neutral:** Blocks fluid flow to the starting motor, keeping the engine stopped.
 - **Start:** Directs pressurized fluid to the hydraulic starting motor.

5. Hydraulic Starting Motor (Rack and Pinion Design):

- This is the core component that replaces the traditional electric starter motor. It consists of a housing containing a hydraulic cylinder with a piston connected to a rack. The rack meshes with a pinion gear that engages with the engine's flywheel (ring gear).
 - When the directional control valve sends pressurized fluid to the cylinder, the piston extends, pushing the rack and pinion gear. This pinion gear rotates the engine's flywheel, cranking the engine for starting.

- Once the engine starts and reaches a certain speed, an overrunning clutch mechanism within the starting motor disengages the pinion gear from the flywheel to prevent over-cranking.

6. Check Valve (Optional):

- This one-way valve can be used in some systems to prevent fluid backflow when the engine starts and the hydraulic starting motor disengages.

Benefits of Hydraulic Rack and Pinion Starting System:

- **Higher Torque:** Compared to electric starters, hydraulic systems can generate significantly higher torque, making them suitable for starting large diesel engines used in heavy-duty vehicles or machinery.
- **Reduced Strain:** The hydraulic system takes the load off the electrical system, which can be beneficial in applications where electrical power is limited.
- **Durability:** Hydraulic components are often known for their durability in harsh operating environments.

Drawbacks:

- **Complexity:** Compared to electric starters, hydraulic systems are more complex and require additional maintenance.
- **Size and Weight:** Hydraulic components can be larger and heavier than electric starters, adding weight to the vehicle.
- **Cold Weather Performance:** Hydraulic fluid viscosity can increase in cold weather, potentially affecting starting performance.

Nov 2018 23rd

Nov 2018 23rd

2. Describe, with the aid of a sketch, a constant pressure hydraulic power system for a vessel's Anchor Windlass, showing safety features and labelling ALL components of the system.

(10)

Constant Pressure Hydraulic System for Anchor Windlass (Labeled Diagram)

This system utilizes pressurized hydraulic fluid to efficiently operate a vessel's anchor windlass for raising and lowering the anchor. Here's a breakdown of the components and their functions:

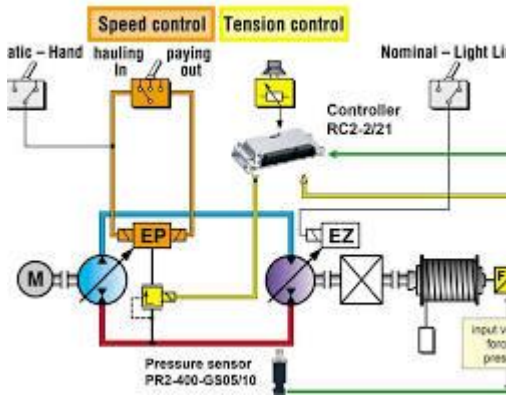
Components:

1. **Reservoir:** This tank stores the hydraulic fluid (usually oil) and maintains its level. It may incorporate a breather filter to allow air exchange and prevent contamination.
2. **pen_spark**
3. **Electric Motor:** This motor drives the hydraulic pump.
4. **Fixed Displacement Pump:** This positive displacement pump continuously draws fluid from the reservoir and pressurizes it. The pump displacement (fixed volume per revolution) determines the system pressure.
5. **Pressure Relief Valve:** This safety valve protects the system from excessive pressure build-up. It bypasses excess fluid back to the reservoir if the pressure exceeds a set limit.
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7. **Solenoid-Operated Directional Control Valve (4/3 Position, Center-Closed):** This valve controls the flow and direction of pressurized fluid based on electrical signals from the windlass control panel. It has multiple positions:
 - **Center:** Neutral position, fluid flow is blocked within the valve (closed-center), holding the anchor windlass in position (due to internal pressure or external braking).
 - **Port A:** Directs fluid to extend the windlass motor cylinder, raising the anchor.
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 - **Relief:** In case of excessive pressure, the valve may have a built-in relief function to bypass fluid back to the reservoir (depending on specific valve design).
8. **Windlass Motor Cylinder (Double-Acting):** This hydraulic actuator converts pressurized fluid into linear motion to operate the anchor windlass. It has a piston rod connected to the windlass mechanism, raising or lowering the anchor based on fluid flow direction.
9. **Pressure Gauge:** Provides a visual indication of the system pressure to the operator.
10. **Level Gauge (on Reservoir):** Allows monitoring of the hydraulic fluid level in the reservoir for proper system operation.
11. **Check Valve (Optional):** This one-way valve can be placed strategically in the system to prevent flow reversal in specific situations (e.g., preventing anchor drift due to pressure loss).

Safety Features:

- **Pressure Relief Valve:** Protects the system from overpressure.
- **Solenoid-Operated Directional Control Valve (Center-Closed):** Holds the anchor windlass in position when in neutral, preventing accidental movement.
- **Check Valve (Optional):** Prevents unintended anchor drift due to pressure loss.
- **Low-Fluid Level Shutdown (Optional):** System can be designed to automatically shut down in case of insufficient fluid level in the reservoir.

Labeled Diagram:



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Constant Pressure Hydraulic System for Anchor Windlass

Note: This is a simplified representation. Real systems might incorporate additional valves for specific functions (e.g., pressure control valves, sequence valves) or other components depending on the windlass design and complexity.

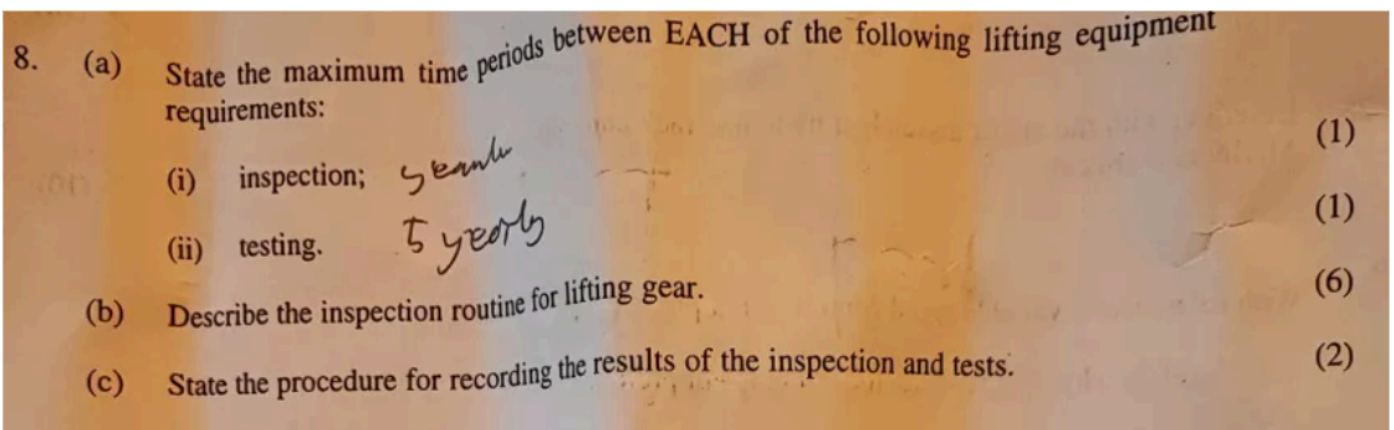
March 2020

March 2020

7. (a) State the maximum time periods between EACH of the following lifting equipment requirements:
- (i) inspection; (1)
 - (ii) testing. (1)
- (b) Describe the inspection routine for lifting gear. (6)
- (c) State the procedure for recording the results of the inspection and tests. (2)

Nov 2023

Nov 2023



Here's a breakdown of the maximum time periods between lifting equipment requirements:

(a) Inspection and Testing Intervals:

The specific intervals for inspection and testing of lifting equipment can vary depending on the regulations in your region. Here's a general guideline based on some common standards:

- **Inspection:** Inspections are typically required **more frequently** than testing. Common intervals for thorough inspections range from:
 - **Daily:** This is often recommended for frequently used equipment or equipment subjected to harsh conditions.
 - **Weekly or Monthly:** This is a common frequency for many lifting equipment types.
 - **Six Months:** This might be applicable for specific equipment with lower usage or less critical applications.
- **Testing:** Testing is usually performed **less frequently** than inspections. Common intervals for thorough examinations and load testing may include:
 - **Every 12 Months:** This is a common standard for many lifting equipment types.
 - **Every 6 Months:** This might be required for lifting equipment used to lift people or for critical applications.

It's crucial to consult the relevant regulations and manufacturer's recommendations for the specific equipment you're using to determine the exact required inspection and testing intervals.

(b) Lifting Gear Inspection Routine:

A thorough inspection of lifting gear should typically include the following steps:

1. **Visual Inspection:** Carefully examine all components of the lifting equipment for any signs of damage, wear and tear, corrosion, cracks, or deformation. This includes checking:
 - Chains, slings, and ropes for broken links, excessive wear, or deterioration.
 - Hooks and shackles for cracks, distortion, or missing safety pins.
 - Lifting beams and other structural components for bends, cracks, or loose connections.
 - Labels and markings for legibility and compliance with regulations.
 - Any safety devices like overload protection systems for proper operation.

2. **Operational Checks:** Verify the functionality of all moving parts, ensuring smooth operation and proper engagement of mechanisms. This might involve:
 - Testing the operation of brakes and locking mechanisms.
 - Checking the functionality of winches or hoists.
 - Verifying the smooth operation of sheaves and rollers.
3. **Documentation Review:** Ensure all relevant documentation is present and up-to-date, including:
 - Inspection reports from previous inspections.
 - Manufacturer's certificates and user manuals.
 - Proof load test certificates if applicable.

(c) Recording Inspection and Test Results:

The results of inspections and tests of lifting equipment should be documented and kept readily available for future reference. This documentation typically includes:

- **Equipment Identification:** Unique identifier of the lifting equipment.
- **Date of Inspection/Test:** Record the date the inspection or test was carried out.
- **Inspector/Tester Information:** Details of the qualified inspector or testing personnel.
- **Detailed Findings:** A detailed record of all observations made during the inspection, including any defects or issues identified.
- **Test Results:** If a load test was performed, record the test results and confirm compliance with lifting capacity.
- **Actions Taken:** Record any actions taken following the inspection or test, such as repairs, replacements, or taking the equipment out of service.

The specific format for recording inspection and test results may vary depending on your organization's procedures and regulations. It's important to maintain a clear and organized system for documenting these critical records.

April 2021

April 2021

7. (a) A crane is being fitted to deploy and recover a load from a vessel. With reference to the present regulations, state the standards that the crane must comply with before being used on board. (7)
- (b) State the information entered on a Proof Load Test certificate. (3)

Crane Regulations and Proof Load Test Certificates

(a) Crane Standards for Vessel Use:

Before a crane can be used to deploy and recover a load from a vessel, it must comply with several international and national regulations. Here are some key standards to consider:

- **International Maritime Organization (IMO):**
 - **Code of Safe Practice for Ships in Cargo Handling (CSS Code):** This code outlines various safety requirements for cargo handling operations, including the use of cranes onboard ships. It addresses aspects like crane design, stability considerations, operator training, and safe working practices.
 - **Safe Work at Height (SWAH) Code:** This code provides recommendations for working at heights onboard ships, including safe access and egress for crane operators when using elevated cabs.
- **International Organization for Standardization (ISO):**
 - **ISO 4878 - Cranes - Principles of design and verification:** This standard establishes general principles for the design and verification of cranes, including structural strength, stability, and fatigue considerations.
 - **ISO 14439 - Cranes - Lifting performance - Part 1: General:** This standard specifies requirements for the determination of lifting performance of cranes, including proof load testing and load charts.
- **National Regulations:** In addition to international standards, many countries have their own national regulations governing the use of cranes onboard vessels. These regulations may adopt or modify international standards and may include additional requirements specific to the country's maritime industry.

It's crucial to consult the relevant classification society (e.g., American Bureau of Shipping (ABS), Lloyd's Register) and the national maritime authority for the specific regulations applicable to your location and the type of vessel the crane will be used on.

(b) Information on a Proof Load Test Certificate:

A Proof Load Test Certificate documents the results of a load test performed on a crane to verify its lifting capacity and structural integrity. Here's some of the information typically included on a Proof Load Test Certificate:

- **Crane Identification:** This includes details like the crane manufacturer, model number, and serial number.
- **Test Date and Location:** Date and location where the proof load test was conducted.
- **Test Authority:** Information about the accredited testing company or organization that performed the test.
- **Test Conditions:** This may include details like ambient temperature, wind speed, and any special test configurations used.
- **Test Loads:** The certificate will specify the test loads applied to the crane during the test, typically expressed as a percentage of the crane's rated lifting capacity (e.g., 110% of SWL).
- **Test Results:** The certificate will record the outcome of the test, confirming whether the crane passed or failed the test with respect to its rated capacity.
- **Inspector's Signature:** The certificate will be signed by a qualified inspector who witnessed the test and reviewed the results.

The specific format and content of a Proof Load Test Certificate may vary depending on the testing company and the regulations they follow. Always ensure the certificate is issued by a reputable testing organization and meets the requirements of the relevant classification society and national maritime authority.

Nov 2020

Nov 2020

8. The lifting arrangement shown in the figure, has two slings, A, with a SWL of 5 tonnes, four slings, B, with a SWL of 2.5 tonnes with a ring and beam each of which have a SWL of 12 tonnes .
Explain the suitability or otherwise of this arrangement for lifting a generator engine, including flywheel, weighing 8.5 tonnes that has certified lifting points, 2 at each end of the entablature, 6 m apart.

(10)

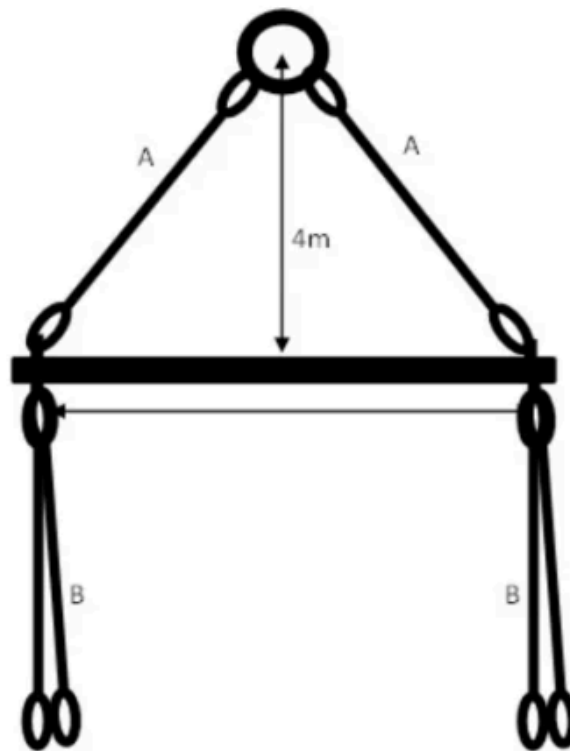


Fig Q8

Question 8. Well answered by those who have an understanding of basic triangle of forces. Many ignore the effect of the flywheel on load distribution.

Based on the information provided and the image of the lifting arrangement, the lifting arrangement **might be suitable** for lifting the 8.5-tonne generator engine, but a more detailed analysis is needed to confirm. Here's a breakdown of the factors to consider:

Available Lifting Capacity:

- Total capacity of slings A: 2 slings * 5 tonnes/sling = 10 tonnes
- Total capacity of slings B: 4 slings * 2.5 tonnes/sling = 10 tonnes
- Minimum capacity of ring and beam (whichever is lower): 12 tonnes

At first glance, it appears there's sufficient capacity:

- Minimum sling capacity (A or B) + ring/beam capacity = 10 tonnes + 12 tonnes = 22 tonnes
- This is greater than the weight of the engine (8.5 tonnes).

However, we need to consider additional factors:

- **Derating factor (if applicable):** Some slings might have a derating factor applied depending on the lifting angle. This reduces their safe working load (SWL) at angles other than vertical. Check the sling specifications for any derating factors.
- **Weight distribution:** Since there are slings at both ends (6 meters apart) with a spreader beam, the weight distribution might not be perfectly equal. This can affect the loading on each sling. A proper sling angle calculator should be used to determine the exact load on each sling considering the spreader beam configuration and lifting angle.
- **Lifting point limitations:** The certified lifting points on the engine might have a lower capacity than the slings or ring/beam. Verify the lifting capacity specified by the engine manufacturer for the designated lifting points.

Based on these considerations:

- If there's no derating factor for the slings at the intended lift angle,
- The weight is evenly distributed between the slings due to the spreader beam, and
- The engine's lifting points can handle the load,

then the lifting arrangement appears suitable.

Recommendations:

- Consult a qualified lifting professional to assess the specific lifting arrangement and ensure it complies with relevant regulations.
- Use a sling angle calculator to determine the exact load on each sling based on the spreader beam configuration and lifting angle. Refer to the image you sent for the spreader beam configuration details.
- Verify the lifting capacity of the engine's certified lifting points as specified by the manufacturer.
- Never exceed the SWL of any lifting component in the arrangement.

Additional Considerations:

- **Spreader Beam:** Ensure the spreader beam used has a sufficient capacity and is suitable for the lifting points on the engine. The spreader beam in the image appears to be a double beam spreader beam, which can help with equal distribution of the load between the slings.
- **Rigging:** Double-check all rigging components (shackles, hooks, etc.) for compatibility and adequate capacity.
- **Inspection:** Before lifting, ensure all slings, spreader beam, and other lifting equipment are thoroughly inspected for any signs of damage or wear and tear.

By carefully considering these factors and consulting with a lifting professional, you can ensure the safe and successful lifting of the generator engine.

Nov 2018

7. The lifting arrangement shown in the figure, has two slings, A, with a SWL of 5 tonnes, four slings, B, with a SWL of 2.5 tonnes with a ring and beam each of which have a SWL of 12 tonnes .

Explain the suitability or otherwise of this arrangement for lifting a generator engine, including flywheel, weighing 8.5 tonnes that has certified lifting points, 2 at each end of the entablature, 6 m apart.

(10)

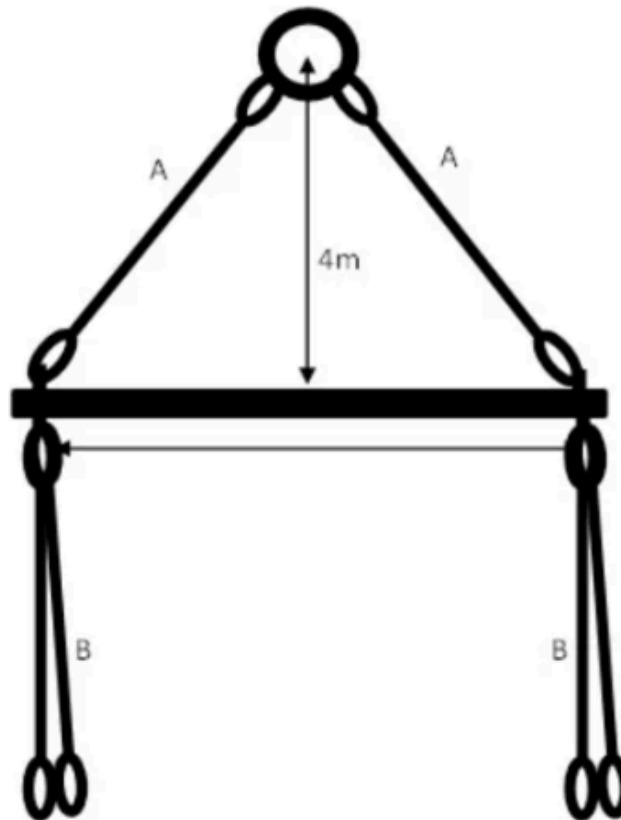


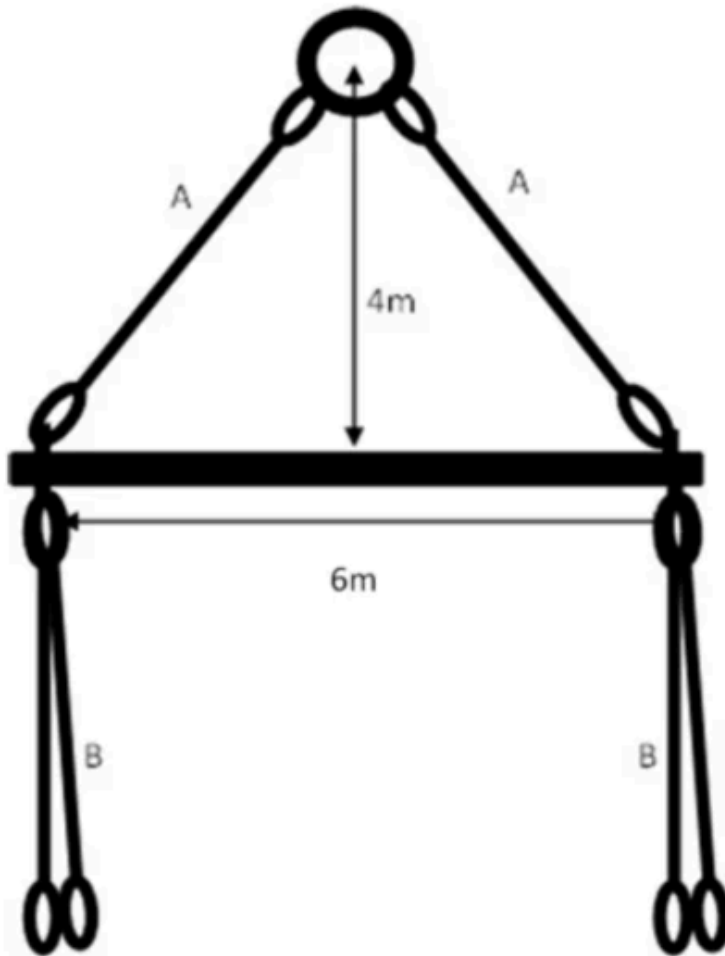
Fig Q7

Sept 2021

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(10)



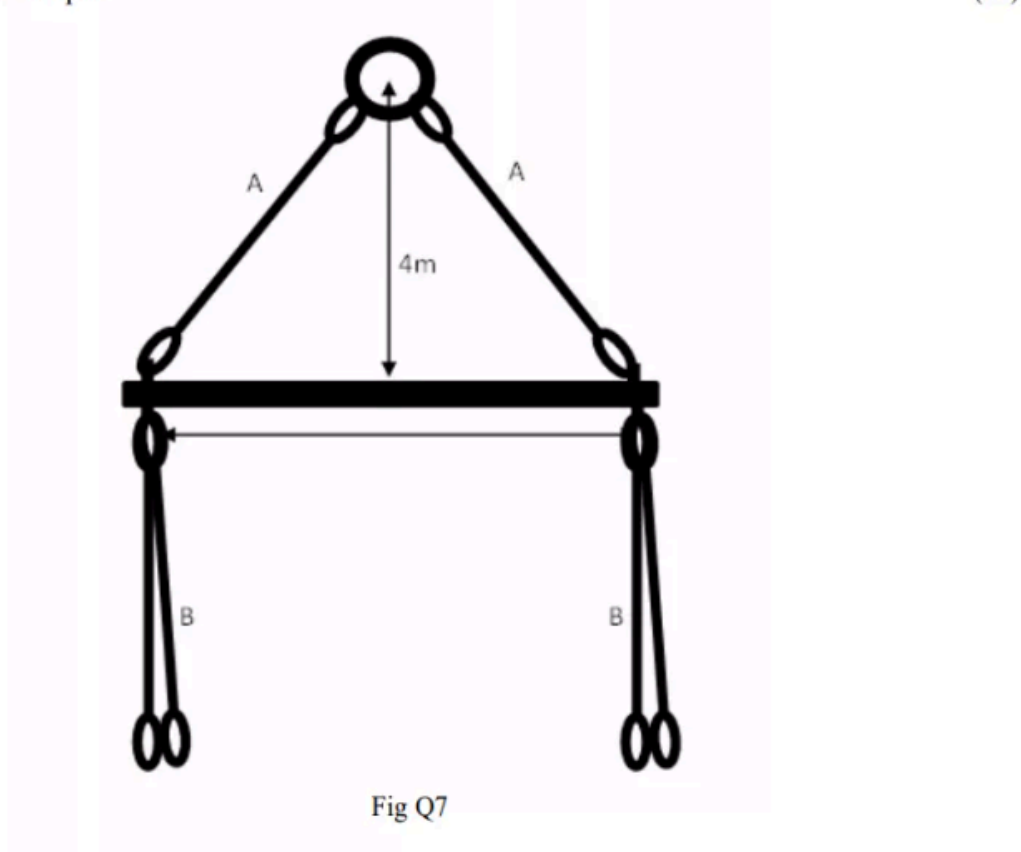
May 2021

May 2021 14th

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Explain the suitability or otherwise of this arrangement for lifting a generator engine, including flywheel, weighing 8 tonnes that has certified lifting points, 2 at each end of the entablature, 6 m apart.

(10)



Nov 2018 3rd

Nov 2018 23rd

7. (a) A crane is being fitted to deploy and recover a load from a vessel. With reference to the present regulations, state the standards that the crane must comply with before being used on board. (7)
- (b) State the information entered on a Proof Load Test certificate. (3)

Crane Regulations and Proof Load Test Certificates for Vessel Use

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 - **Code of Safe Practice for Ships in Cargo Handling (CSS Code):** This code outlines various safety requirements for cargo handling operations, including the use of cranes

onboard ships. It addresses aspects like crane design, stability considerations, operator training, and safe working practices.

- **Safe Work at Height (SWAH) Code:** This code provides recommendations for working at heights onboard ships, including safe access and egress for crane operators when using elevated cabs.
- **International Organization for Standardization (ISO):**
 - **ISO 4878 - Cranes - Principles of design and verification:** This standard establishes general principles for the design and verification of cranes, including structural strength, stability, and fatigue considerations.
 - **ISO 14439 - Cranes - Lifting performance - Part 1: General:** This standard specifies requirements for the determination of lifting performance of cranes, including proof load testing and load charts.
- **National Regulations:** In addition to international standards, many countries have their own national regulations governing the use of cranes onboard vessels. These regulations may adopt or modify international standards and may include additional requirements specific to the country's maritime industry.

It's crucial to consult the relevant classification society (e.g., American Bureau of Shipping (ABS), Lloyd's Register) and the national maritime authority for the specific regulations applicable to your location and the type of vessel the crane will be used on.

(b) Information on a Proof Load Test Certificate:

A Proof Load Test Certificate documents the results of a load test performed on a crane to verify its lifting capacity and structural integrity. Here's some of the information typically included on a Proof Load Test Certificate:

- **Crane Identification:** This includes details like the crane manufacturer, model number, and serial number.
- **Test Date and Location:** Date and location where the proof load test was conducted.
- **Test Authority:** Information about the accredited testing company or organization that performed the test.
- **Test Conditions:** This may include details like ambient temperature, wind speed, and any special test configurations used.
- **Test Loads:** The certificate will specify the test loads applied to the crane during the test, typically expressed as a percentage of the crane's rated lifting capacity (e.g., 110% of SWL).
- **Test Results:** The certificate will record the outcome of the test, confirming whether the crane passed or failed the test with respect to its rated capacity.
- **Inspector's Signature:** The certificate will be signed by a qualified inspector who witnessed the test and reviewed the results.

The specific format and content of a Proof Load Test Certificate may vary depending on the testing company and the regulations they follow. Always ensure the certificate is issued by a reputable testing organization and meets the requirements of the relevant classification society and national maritime authority.