

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)

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2. With reference to a 440 Volt, 3-phase motor supplied with six terminal connection in the terminal box:
 - (a) sketch a Delta connection, showing the relationship between phase and line voltages; (2)
 - (b) sketch a Star connection, showing the relationship between phase and line voltages; (2)
 - (c) state the relative speed of both connections; (2)
 - (d) sketch and label the terminal link connections so the motor will run in permanent Delta mode. (4)

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3. With reference to a solid state (inverter) starter for a 3 phase induction motor:

- (a) explain the starting characteristics of this system; (4)
- (b) list the advantages and disadvantages when compared to conventional starting methods. (6)

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4. (a) State THREE reasons for the operation of a *High Pressure Cut-out* in a vapour compression refrigeration system. (3)
- (b) Describe the operation of the High Pressure Cut-Out, employed in a vapour compression refrigeration system shown in the figure. (7)

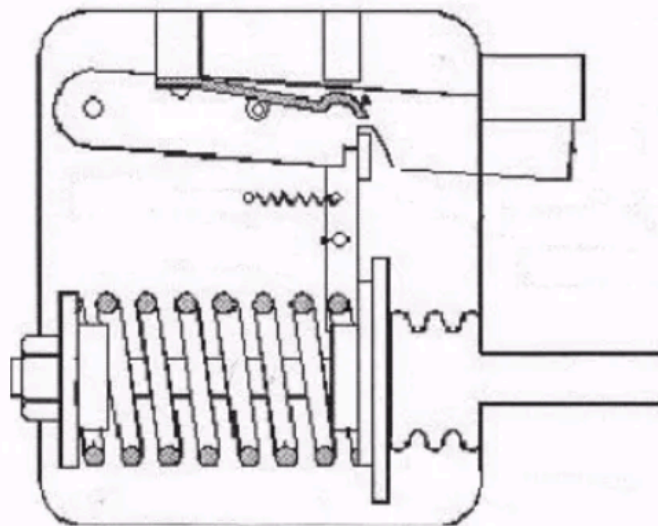


Fig Q4

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5. Describe, with the aid of a sketch, a vapour-compression refrigeration cycle, showing clearly the physical state and condition of the refrigerant in the system. (10)

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6. With reference to a reciprocating air compression:
 - (a) define the term *Volumetric Efficiency*; (4)
 - (b) explain how the operation of the suction and delivery valves affect the volumetric efficiency of the compressor. (6)

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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 tonnes that has certified lifting points, 2 at each end of the entablature, 6 m apart.

(10)

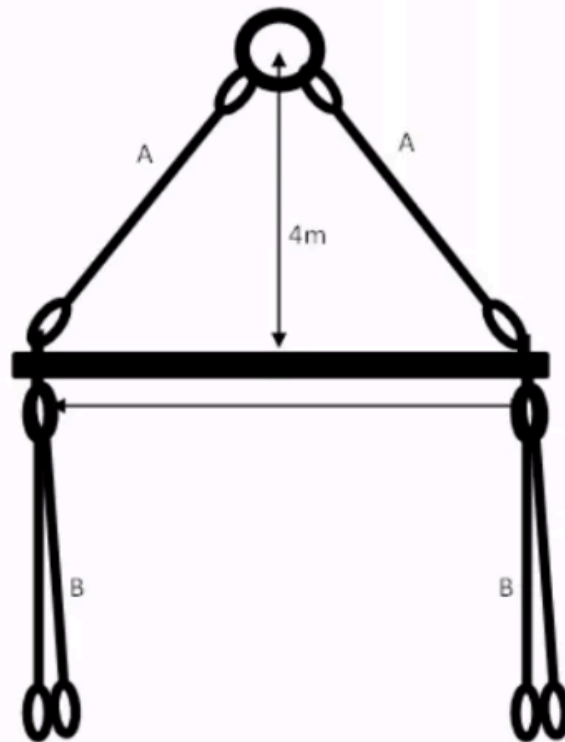


Fig Q7

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8. With reference to Open Flame Gas Installation, describe the safety requirements for the installation of EACH of the following:

(a) cylinders and attachments; (5)

(b) fittings and pipework. (5)

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9. (a) Describe, with the aid of a sketch, the securing arrangement for a pipe passing through a watertight bulkhead. (5)

(b) Sketch an arrangement for a watertight electric cable gland labelling ALL components. (5)

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10. Explain the cause and effect of vibration on a vessel.

(10)

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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.

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2. With reference to a 440 Volt, 3-phase motor supplied with six terminal connection in the terminal box:
 - (a) sketch a Delta connection, showing the relationship between phase and line voltages; (2)
 - (b) sketch a Star connection, showing the relationship between phase and line voltages; (2)
 - (c) state the relative speed of both connections; (2)
 - (d) sketch and label the terminal link connections so the motor will run in permanent Delta mode. (4)

440V, 3-Phase Motor with Six Terminals: Connection Modes

Here's a breakdown of Delta and Star connections for your 440V, 3-phase motor with six terminals, referencing the relationship between voltages and speed, and explaining how to configure it for permanent Delta mode.

(a) Delta Connection:

- **Description:** In a delta connection, the three motor windings are connected end-to-end, forming a triangular loop. Each winding connects between two line terminals.
- **Voltage Relationship:**
 - Line Voltage (VL): This is the voltage measured between any two of the three lines feeding the motor (VAB, VBC, VCA). In your case, the line voltage is 440V.
 - Phase Voltage (VP): This is the voltage measured across each individual winding (between any line terminal and the connection point of the other two windings). In a delta connection, the phase voltage is equal to the line voltage ($V_p = V_L = 440V$). This is because the line voltage is applied directly across each winding.

(b) Star Connection:

- **Description:** In a star connection, the three motor windings are connected at one end (usually internally within the motor), forming a star shape. The other ends of the windings are connected to the three line terminals. This creates a neutral point at the center of the star.
- **Voltage Relationship:**

- Line Voltage (VL): Same as delta connection ($V_L = 440V$).
- Phase Voltage (VP): This is the voltage measured between any line terminal and the neutral point. The phase voltage in a star connection is calculated by dividing the line voltage by the square root of 3 ($V_p = V_L / \sqrt{3}$). For a 440V line voltage, the phase voltage is approximately 254V ($V_p \approx 440V / \sqrt{3}$). This is because the windings are connected in series, and the voltage is divided across them.

(c) Relative Speed:

- **Starting Torque:** Delta connections generally offer a higher starting torque compared to star connections for the same motor. This is because the full line voltage is applied directly across each motor winding phase in delta.
- **Running Speed:** The running speed of the motor remains approximately the same in both delta and star connections, assuming the motor is designed for both configurations. This is because the fundamental synchronous speed of the motor is determined by the number of poles and the line frequency. The connection method primarily affects the starting torque and current.

(d) Permanent Delta Connection:

Since your motor has six terminals (likely three for each winding - U1, U2, V1, V2, W1, W2), configuring it for permanent delta doesn't require any jumpers or links. Here's why:

- In a delta connection, each winding connects between two line terminals.
- With six terminals, you already have three individual connection points for each winding.

Therefore, **leave all six terminals unconnected**. The internal configuration of the motor windings will handle the delta connection without any additional modifications.

Important Note: Always refer to the motor's manufacturer's manual or data plate for specific connection instructions. Modifying motor connections without proper knowledge can damage the motor or pose safety risks. Consult a qualified electrician if you're unsure about the connection process.

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3. With reference to a solid state (inverter) starter for a 3 phase induction motor:

- (a) explain the starting characteristics of this system; (4)
- (b) list the advantages and disadvantages when compared to conventional starting methods. (6)

Solid-State (Inverter) Starter for 3-Phase Induction Motor

A solid-state starter, also known as a soft starter or inverter starter, utilizes power electronics to control the starting and operation of a 3-phase AC induction motor. Here's a breakdown of its starting characteristics, advantages, and disadvantages compared to conventional methods.

(a) Starting Characteristics:

Solid-state starters offer a significant improvement over traditional methods like direct-on-line (DOL) starting by providing a "soft start" for the motor. This translates to several key advantages:

- **Controlled Voltage and Frequency Ramp:** Unlike DOL, which applies full voltage abruptly, a solid-state starter gradually increases both the voltage and frequency applied to the motor during startup. This controlled ramp offers several benefits:
 - **Reduced Inrush Current:** The gradual voltage increase limits the initial surge of current drawn by the motor during starting. This reduces stress on the electrical system and minimizes potential voltage dips on the power line.
 - **Limited Torque Control (Optional):** Some solid-state starters offer the ability to control the starting torque delivered to the motor. This can be beneficial in applications where excessive torque during startup might cause issues with the driven load.
- **Smooth Acceleration:** The controlled voltage and frequency increase result in a smoother acceleration of the motor. This minimizes mechanical stress on the motor's bearings, shaft, and couplings, potentially leading to longer motor life.

(b) Advantages compared to Conventional Methods (DOL Start):

- **Reduced Stress on Electrical System:** The lower inrush current during starting helps protect electrical components like transformers and cables from wear and tear.
- **Improved Power Quality:** By limiting the inrush current, inverter starters can minimize voltage dips on the power line, improving overall power quality for other equipment connected to the system.
- **Reduced Mechanical Stress:** The smooth acceleration minimizes mechanical stress on the motor and driven equipment, potentially leading to longer lifespans.
- **Limited Torque Control (in some models):** The ability to control starting torque can be beneficial in applications such as conveyors or pumps where high starting torque might cause problems with the driven load.

(c) Disadvantages compared to Conventional Methods (DOL Start):

- **Higher Initial Cost:** Inverter starters typically have a higher initial cost compared to a simple DOL starter due to the more complex power electronics involved.
- **Increased Complexity:** The inverter starter requires additional control circuitry and components, introducing a potential single point of failure compared to a simple contactor-based DOL starter.
- **Potential for Harmonic Distortion:** Depending on the design of the inverter starter, the switching of the power electronics can introduce harmonic distortion into the power supply. This might require additional filtering to meet power quality standards in some cases.

In conclusion, solid-state starters offer significant advantages over conventional DOL starts for 3-phase induction motors. However, their higher cost and increased complexity need to be considered when making a selection for a specific application.

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4. (a) State THREE reasons for the operation of a *High Pressure Cut-out* in a vapour compression refrigeration system. (3)
- (b) Describe the operation of the High Pressure Cut-Out, employed in a vapour compression refrigeration system shown in the figure. (7)

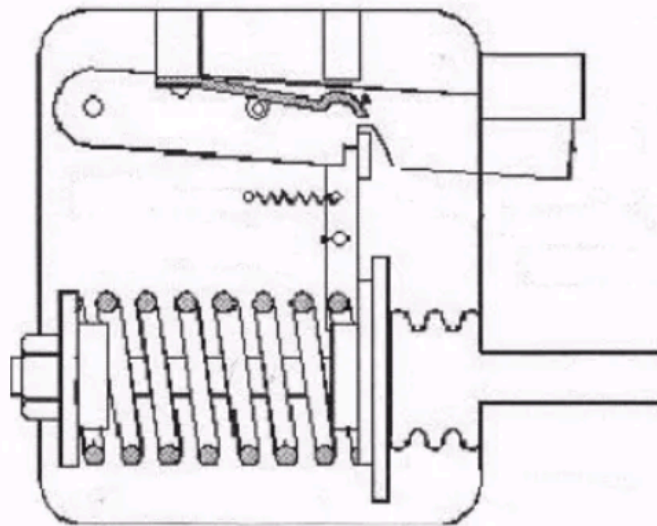


Fig Q4

*(a) Three reasons for the operation of a High-Pressure Cut-Out in a vapor compression refrigeration system are:

1. **Prevents System Damage:** The primary function of a high-pressure cut-out switch is to protect the refrigeration system from excessive pressure building up on the high-pressure side (condenser side) of the system. This pressure can rise due to various reasons such as:
 - **Condenser Failure:** Malfunctioning condenser fan or clogged condenser coils can impede proper heat rejection, leading to pressure rise.
 - **System Blockage:** Blockages in the system, such as a clogged filter or restricted capillary tube, can also cause pressure to rise on the discharge side.
 - **Loss of Refrigerant:** A refrigerant leak can lead to a decrease in refrigerant volume within the system. The remaining refrigerant will circulate but reach a higher pressure to compensate for the missing refrigerant, tripping the cut-out.
2. **Protects Compressor:** High pressure can put excessive strain on the compressor, potentially leading to motor overload, overheating, and compressor failure. The high-pressure cut-out helps safeguard the compressor by stopping its operation before such critical conditions occur.
3. **Safety Measure:** Refrigerant leaks, especially when dealing with older refrigerants, can pose environmental and safety hazards. A high-pressure cut-out can indirectly contribute to safety by stopping the system if a pressure rise indicates a potential leak.

(b) Describing the operation of the High-Pressure Cut-Out based on the image is not possible

The image you sent is a black and white drawing of a mechanical device, and it doesn't provide enough detail to identify specific components or mechanisms to explain the operation of the high-pressure cut-out.

However, in general, a high-pressure cut-out typically consists of a pressure sensor and a switch. The pressure sensor monitors the pressure on the discharge side of the compressor. If the pressure exceeds the set limit for the specific system, the pressure sensor triggers the switch, which interrupts power to the compressor motor, stopping its operation.

When the pressure falls below the reset point (which is usually slightly lower than the cut-out pressure), the switch automatically resets, and the compressor can restart. Some cut-out switches are manual reset, requiring a technician to physically reset the switch after the pressure issue is resolved.

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5. Describe, with the aid of a sketch, a vapour-compression refrigeration cycle, showing clearly the physical state and condition of the refrigerant in the system. (10)

Nov 2018 23rd

The Vapor-Compression Refrigeration Cycle: Following the Refrigerant's Journey

The vapor-compression refrigeration cycle utilizes a circulating refrigerant to absorb heat from a low-temperature area (e.g., a refrigerator compartment) and reject it to a high-temperature area (e.g., the surrounding environment). Here's a breakdown of the cycle, highlighting the refrigerant's state and condition at each stage:

1. Evaporator (Low-Pressure, Low-Temperature):

- **State: Saturated Vapor (low pressure, low temperature)**
- **Condition:** The refrigerant enters the evaporator as a low-pressure, low-temperature vapor.
- **Process:** It absorbs heat from the warm environment inside the refrigerator compartment, causing the refrigerant to evaporate (change from a liquid to a vapor) and its temperature to decrease further.

2. Suction Line:

- **State: Saturated Vapor (low pressure, low temperature)**
- **Condition:** The low-pressure, low-temperature refrigerant vapor travels through the suction line towards the compressor.

3. Compressor:

- **State: Superheated Vapor (increased pressure, slightly increased temperature)**
- **Condition:** The compressor increases the pressure of the refrigerant vapor. This compression work also causes the temperature of the vapor to rise slightly (becomes superheated vapor).

4. Discharge Line:

- **State: Superheated Vapor (high pressure, moderate temperature)**

- **Condition:** The high-pressure, moderately hot refrigerant vapor travels through the discharge line towards the condenser.

5. Condenser (High-Pressure, High-Temperature):

- **State: Saturated Liquid (high pressure, high temperature)**
- **Condition:** The hot, high-pressure refrigerant vapor enters the condenser. Here, it rejects heat to the surrounding environment (typically air or water) through the condenser coils. As it loses heat, the vapor condenses (changes from a vapor to a liquid) and its temperature decreases.

6. Liquid Line:

- **State: Subcooled Liquid (high pressure, slightly lower temperature)**
- **Condition:** The high-pressure refrigerant, now in a liquid state, exits the condenser. It may pass through an additional heat exchanger (depending on the system design) to further reduce its temperature (becomes subcooled liquid). This subcooling improves efficiency by ensuring the refrigerant enters the evaporator as a cooler liquid.

7. Expansion Device (Capillary Tube or Thermostatic Expansion Valve):

- **State: Flash Gas & Saturated Liquid (reduced pressure, lower temperature)**
- **Condition:** The high-pressure liquid refrigerant passes through an expansion device (either a capillary tube or a thermostatic expansion valve). This device restricts the flow of the refrigerant, causing a sudden pressure drop. The pressure drop results in a partial flashing of the liquid into a low-pressure, low-temperature vapor-liquid mixture.

8. Return Line:

- **State: Two-Phase Mixture (liquid & vapor, low pressure, low temperature)**
- **Condition:** The mixture of liquid and low-pressure vapor travels through the return line back to the evaporator.

The cycle then repeats:

The chilled liquid and vapor mixture from the return line reaches the evaporator, where the refrigerant absorbs heat again, and the cycle continues. By continuously circulating through these stages, the refrigerant acts as a heat transfer medium, removing heat from the low-temperature area and releasing it to the high-temperature area, achieving the desired cooling effect.

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6. With reference to a reciprocating air compression:

- (a) define the term *Volumetric Efficiency*; (4)
- (b) explain how the operation of the suction and delivery valves affect the volumetric efficiency of the compressor. (6)

Reciprocating Air Compressor: Volumetric Efficiency and Valve Effects

(a) Volumetric Efficiency:

Volumetric efficiency (VE) in a reciprocating air compressor is a dimensionless parameter that compares the actual volume of air drawn into the cylinder during the intake stroke with the theoretical displacement volume of the piston.

Here's the formula for volumetric efficiency:

$$VE = (\text{Actual Air Intake Volume}) / (\text{Theoretical Piston Displacement Volume})$$

A perfect compressor with no leakage or losses would have a VE of 1 (100%). In reality, however, there are always some losses, resulting in a VE value less than 1.

(b) How Suction and Delivery Valves Affect Volumetric Efficiency:

The operation of suction and delivery valves significantly impacts the volumetric efficiency of a reciprocating air compressor. Here's how:

Suction Valve:

- **Opening Time:** The suction valve needs to open promptly at the beginning of the intake stroke to allow air to flow into the cylinder. A delayed opening reduces the time available for air intake, lowering VE.
- **Valve Design:** The design of the suction valve should minimize flow resistance. A restrictive valve opening creates a pressure drop across the valve, hindering air intake and reducing VE.
- **Leakage:** A leaky suction valve allows air to escape back out of the cylinder during the intake stroke, further reducing the actual air intake volume and lowering VE.

Delivery Valve:

- **Closing Time:** The delivery valve needs to close promptly at the end of the compression stroke to prevent compressed air from flowing back into the cylinder. A delayed closure allows some compressed air to leak back, reducing the final pressure and VE.
- **Valve Design:** Similar to the suction valve, the delivery valve needs to be designed for minimal flow resistance. Excessive resistance during the discharge stroke can lead to some compressed air remaining in the cylinder, reducing the effective volume available for the next intake stroke and lowering VE.
- **Leakage:** A leaky delivery valve allows compressed air to escape back into the cylinder during the intake stroke, reducing the pressure differential for air intake and lowering VE.

Summary:

Well-designed and properly functioning suction and delivery valves are crucial for maximizing volumetric efficiency. Early opening and prompt closing of valves, combined with minimal flow resistance and leak-proof operation, ensure the compressor takes in the maximum possible air volume during the intake stroke and efficiently discharges the compressed air during the compression stroke. This translates to a higher volumetric efficiency and better overall compressor performance.

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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 tonnes that has certified lifting points, 2 at each end of the entablature, 6 m apart.

(10)

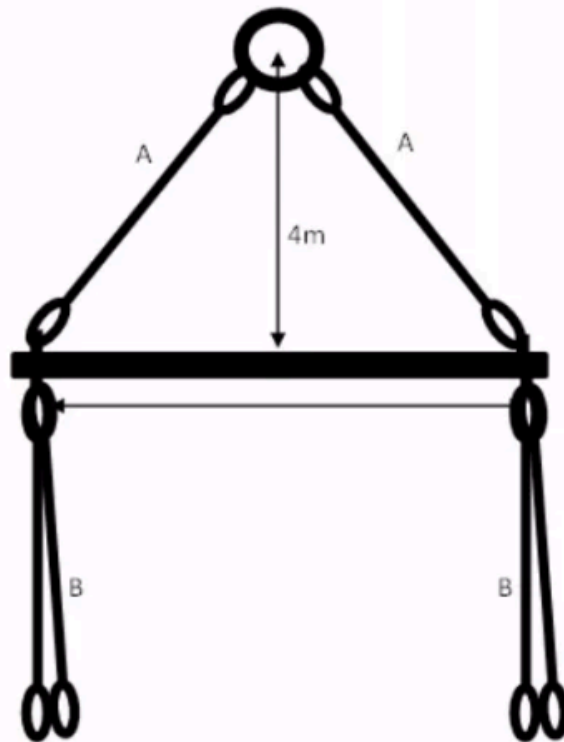


Fig Q7

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.

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8. With reference to Open Flame Gas Installation, describe the safety requirements for the installation of EACH of the following:

- (a) cylinders and attachments; (5)
- (b) fittings and pipework. (5)

Open Flame Gas Installation Safety Requirements:

Here's a breakdown of the safety requirements for open flame gas installations, focusing on cylinders and attachments, fittings, and pipework:

(a) Cylinders and Attachments:

- **Cylinder Storage:**
 - Secure cylinders upright in a well-ventilated location away from sources of heat or ignition.
 - Use designated cylinder racks or stands to prevent tipping or rolling.
 - Store flammable gas cylinders separately from oxidizing gas cylinders (e.g., oxygen) with a minimum safe distance depending on regulations.
 - Keep cylinder caps or valve protection guards in place when not in use.
- **Cylinder Valves:**
 - Open and close valves slowly to prevent pressure surges.
 - Never use tools or excessive force to open or close a cylinder valve.
 - Ensure cylinder valves are fully closed when not in use.
 - Leak test cylinder valves and connections with an approved leak detection solution (soap and water) before use.
- **Pressure Relief Devices:**
 - All gas cylinders must have a pressure relief valve to prevent overpressurization.
 - Never tamper with or remove the pressure relief device from a cylinder.
- **Cylinder Attachments:**
 - Use only pressure regulators designed for the specific gas and pressure rating of the cylinder.
 - Ensure proper connections between the cylinder valve outlet and the pressure regulator inlet, using compatible threads and gaskets.
 - Tighten connections securely with appropriate wrenches, avoiding over-tightening.
- **Flashback Arrestors:** (Highly Recommended)
 - Install flashback arrestors in the gas line near the burner to prevent flames from traveling back into the cylinder.

(b) Fittings and Pipework:

- **Pipe Material:**
 - Use only pipe materials approved for the specific gas being used (e.g., steel, copper, approved flexible hoses).
 - Avoid using incompatible materials that could react with the gas or cause leaks.
- **Pipe Sizing:**
 - Use pipes with sufficient diameter to handle the required gas flow without excessive pressure drop.
 - Consult gas pressure tables and manufacturer recommendations for appropriate pipe sizes.
- **Fittings:**
 - Use only pressure-rated fittings designed for the specific gas and pressure being used.
 - Ensure proper thread engagement and use leak-proof jointing compounds where applicable.
 - Avoid using damaged or worn-out fittings.

- **Pipework Installation:**
 - Install pipes securely using brackets or clamps to prevent movement or vibration.
 - Avoid sharp bends or kinks in the pipework that could restrict gas flow or create weak points.
 - Route pipes away from sources of heat, electrical wiring, or sharp objects that could damage them.
- **Leak Testing:**
 - After installation and periodically thereafter, conduct a leak test on the entire gas system using an approved leak detection solution.
 - Tighten any loose connections or replace faulty components as needed.

Additional Safety Measures:

- **Post clear signage:** Display warning signs indicating the type of gas used and safety precautions in the vicinity of the installation.
- **Training:** Ensure personnel operating the gas equipment are properly trained in safe handling, leak detection, and emergency procedures.
- **Ventilation:** Maintain adequate ventilation in the area where the open flame gas installation is located to prevent gas build-up.
- **Emergency Shut-off Valve:** Consider installing an easily accessible emergency shut-off valve to isolate the gas supply in case of an emergency.

By following these safety requirements and best practices, you can minimize the risk of accidents and ensure a safe open flame gas installation. It's crucial to consult the relevant national regulations and manufacturer's instructions for specific requirements and additional safety considerations.

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9. (a) Describe, with the aid of a sketch, the securing arrangement for a pipe passing through a watertight bulkhead. (5)
- (b) Sketch an arrangement for a watertight electric cable gland labelling ALL components. (5)

Securing Arrangements for Penetrations in a Watertight Structure

Here's a breakdown of securing arrangements for two common penetrations in a watertight structure:

(a) Pipe Passing Through a Watertight Bulkhead:

To maintain watertight integrity, a pipe passing through a watertight bulkhead requires a special securing arrangement. Here's a typical setup:

1. **Watertight Bulkhead Flange:** A flange is welded or bolted to the bulkhead on either side of the opening. This flange has a machined surface to create a tight seal with the pipe penetration system.

2. **Pipe Penetration Plate:** This plate, often made of steel, is sandwiched between the two bulkhead flanges. It has a central hole sized to accommodate the pipe with some clearance.
3. **Packing Material:** A compressible packing material, like a braided flax or synthetic fiber gasket, is placed in the annular space between the pipe and the penetration plate hole. This packing material is compressed to create a watertight seal around the pipe.
4. **Gland Flange and Follower:** A gland flange with a follower ring is bolted onto one side of the bulkhead flange. The follower ring applies pressure to the packing material, compressing it against the pipe and the penetration plate.
5. **Studs and Nuts:** Studs or bolts secure the gland flange and follower ring to the bulkhead flange, creating the clamping force on the packing material.

Benefits:

- Simple and reliable design.
- Easy to disassemble for pipe maintenance or replacement.

Limitations:

- Requires space on both sides of the bulkhead for flange installation.
- May require retightening of the gland bolts over time as the packing material compresses.

(b) Watertight Electric Cable Gland:

A watertight electric cable gland provides a sealed passage for an electrical cable through a watertight structure like a bulkhead or deck. Here are the key components:

1. **Body:** The main body of the gland is typically made of brass or nickel-plated brass for corrosion resistance. It houses the sealing mechanism and provides a threaded connection for mounting to the bulkhead.
2. **Cable Entry Port:** This sized opening allows the electrical cable to pass through the gland.
3. **Grommet:** A rubber or elastomeric grommet with a central hole sized for the specific cable diameter is inserted into the cable entry port. The grommet creates a tight seal around the cable jacket, preventing water ingress.
4. **Clamping Ring:** A threaded clamping ring is screwed onto the body, compressing the grommet and the cable against the cable entry port, creating a watertight seal.
5. **Locknut:** A locknut is tightened against the body to secure the clamping ring and maintain the compression on the grommet and cable.
6. **Terminal Chamber:** The body may have an internal chamber to accommodate electrical cable terminations (e.g., lugs, crimps) for connecting the cable to other electrical components.

Benefits:

- Compact design, suitable for limited space applications.
- Easy to install and maintain.
- Various sizes and types available for different cable diameters and environmental conditions.

Limitations:

- Limited reusability depending on the type of grommet used.
- May not be suitable for very large cables.

Choosing the right securing arrangement depends on several factors, including the size and type of pipe or cable, the pressure rating required, and the available space. Always consult with the manufacturer's recommendations and relevant regulations for proper installation and use.

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10. Explain the cause and effect of vibration on a vessel.

(10)

Vibration in Ships: Causes, Effects, and Concerns

Vibration is a frequent occurrence in ships, caused by various internal and external factors. While some levels of vibration are inevitable, excessive vibration can have detrimental effects on the vessel, crew, and cargo.

Causes of Vibration:

- **Machinery:** The primary source of vibration on most vessels is the operation of engines, generators, and other onboard machinery. The rotating parts of these machines can generate unbalanced forces that transmit vibrations through the hull structure.
- **Propeller Forces:** The rotation of the propeller can create fluctuating forces on the shaft and hull, leading to vibrations. These forces can vary depending on factors like propeller design, rotation speed, and interaction with the water flow.
- **Wave Action:** Waves can excite vibrations in the hull structure as the vessel encounters varying buoyancy forces along its length. The wave encounter frequency can resonate with the ship's natural frequencies, amplifying vibrations.
- **Slamming:** In rough seas, the violent impact of the bow against waves (pounding) can generate shockwaves that travel through the hull, causing short-term but intense vibrations.
- **Cargo Shifting:** Improperly secured cargo can shift or roll during voyages, creating unbalanced forces that lead to vibrations.

Effects of Vibration:

- **Structural Fatigue:** Excessive vibration can cause metal fatigue in the hull structure over time. This can lead to cracks, weakening of critical components, and potential safety hazards.
- **Noise and Discomfort:** Vibrations can transmit as noise and discomfort for crew and passengers. This can lead to fatigue, reduced efficiency, and even seasickness.
- **Equipment Damage:** Delicate onboard equipment can be damaged by excessive vibration, leading to malfunctions and costly repairs.
- **Reduced Efficiency:** Vibrations can increase resistance on moving parts within the vessel, leading to reduced overall efficiency and increased fuel consumption.

Concerns and Mitigation Strategies:

- **Safety:** Fatigue cracks caused by vibration can pose a serious safety risk if they occur in critical structural components. Regular inspections and maintenance are crucial to detect and address vibration-related issues.

- **Comfort:** Excessive vibration can significantly impact the comfort and well-being of crew and passengers. Ship designers and operators strive to minimize vibration levels through careful machinery selection, mounting techniques, and hull design to improve habitability.
- **Efficiency:** Reducing vibration not only improves comfort but also contributes to better fuel efficiency. Modern vessels often employ vibration dampening technologies like active vibration control systems to mitigate these issues.

Overall, understanding the causes and effects of vibration is crucial for ensuring the safe, comfortable, and efficient operation of a vessel. By implementing proper mitigation strategies, ship designers and operators can minimize vibration and its negative consequences.