

March 2020

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- (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)

March 2020

2. With reference to induction motor starters:
 - (a) state when a STAR/DELTA starter may be required; (2)
 - (b) describe the operation of a STAR/DELTA starter; (5)
 - (c) explain why the motor configuration is changed from STAR to DELTA. (3)

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3. Explain what happens to the output voltage of an a.c. generator from sudden application of a large load to a steady state condition. (10)

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4. State THREE different methods used to detect a refrigerant gas leak, explaining EACH method. (10)

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- (b) Describe the faults which lead to TWO of the reasons for the stoppage, listed in part (a) (6)

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6. Explain the maintenance and inspection that should be carried out on SCUBA cylinders. (10)

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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)

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8. (a) State THREE dangers arising from the use of LPG open flame appliances. (3)
- (b) Describe the requirements for a *Gas Detector* suitable for a LPG installation. (7)

March 2020

9. With reference to longitudinal stresses in a vessel's hull:
- (a) state the cause of the stress; (3)
 - (b) state the areas where the stress is a maximum; (3)
 - (c) describe the structure that resists the stress. (4)

March 2020

10. With reference to transverse stresses in a vessel's hull:
- (a) state the cause of the stress when the vessel is:
 - (i) floating in still water; (1)
 - (ii) being acted on by waves; (2)
 - (iii) drydocked. (1)
 - (b) state the areas where the stress is a maximum when the vessel is:
 - (i) floating in still water; (1)
 - (ii) drydocked; (1)
 - (c) describe the structure that resists the stress. (4)

March 2020

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 - (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 2020

2. With reference to induction motor starters:

- (a) state when a STAR/DELTA starter may be required; (2)
- (b) describe the operation of a STAR/DELTA starter; (5)
- (c) explain why the motor configuration is changed from STAR to DELTA. (3)

Induction Motor Star-Delta Starters

Star-delta starters are a type of reduced voltage starter commonly used with three-phase induction motors. Here's a breakdown of their application, operation, and the reason for switching configurations:

(a) When is a Star-Delta Starter Required?

Star-delta starters are particularly beneficial in situations where:

- **The motor has a high starting current:** Induction motors draw a significant surge of current when starting, which can overload the power supply and cause voltage dips. A star-delta starter helps to reduce this starting current.
- **The application doesn't require high starting torque:** While star-delta starters reduce starting current, they also decrease the starting torque compared to a direct online connection. So, they are suitable for applications where the motor doesn't need to overcome a high initial load to get going.

- **Cost-effective solution:** Compared to more sophisticated soft starters, star-delta starters are a relatively inexpensive way to manage high starting currents.

(b) Operation of a Star-Delta Starter:

A star-delta starter has two main components:

1. **Contactors:** These are electromagnetic switches that connect or disconnect the motor windings from the power supply. There are typically three contactors, one for each phase, in both the star and delta configurations.
2. **Timer:** This device controls the switching sequence between star and delta connections.

Here's the typical operation sequence:

1. **Start:** When the motor is turned on, the star contactor energizes, connecting the motor windings in a star configuration.
2. **Reduced Starting Current:** The star connection reduces the voltage applied to each motor winding (by a factor of $1/\sqrt{3}$) and consequently reduces the starting current drawn from the supply.
3. **Acceleration:** The motor accelerates with the reduced voltage. The timer is set for a predetermined time based on the motor's characteristics.
4. **Delta Connection:** After the timer elapses, the star contactor de-energizes, and the delta contactor energizes. This connects the motor windings in a delta configuration, applying the full line voltage to each winding.
5. **Running:** The motor operates at its normal speed and torque in the delta connection.

(c) Why Change from Star to Delta?

There are two main reasons for switching the motor configuration from star to delta:

- **Reduced Starting Current:** The primary objective is to limit the high inrush current during motor startup. By initially connecting the windings in a star configuration, the starting current is significantly reduced, protecting the electrical supply from overload.
- **Improved Efficiency at Running Speed:** Once the motor has accelerated and overcome the initial load, the delta connection provides the full line voltage to each winding. This allows the motor to operate at its designed efficiency and full torque capability.

In essence, a star-delta starter offers a balance between protecting the power supply during startup and allowing the motor to run efficiently at its normal operating speed.

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3. Explain what happens to the output voltage of an a.c. generator from sudden application of a large load to a steady state condition. (10)

When a large load is suddenly applied to an AC generator in a steady-state condition, the output voltage will initially experience a **dip** followed by a potential **stabilization or slight increase**. Here's a breakdown of the process:

1. **Sudden Load Increase:** When a large load is suddenly applied to the generator, it demands more electrical power.

2. **Generator's Inertia:** The rotating parts of the generator (rotor) have inertia and resist any sudden change in speed.
3. **Torque Imbalance:** The increased load demand creates a temporary torque imbalance between the driving torque (engine) and the load torque (electrical demand).
4. **Generator Speed Drop:** Due to the inertia, the generator's speed will initially slow down slightly as it tries to deliver more power to meet the increased load demand.

Impact on Voltage:

- **Generator Voltage and Speed Relationship:** The output voltage of an AC generator is directly proportional to its speed (following Faraday's law of electromagnetic induction).
- **Voltage Dip:** As the generator's speed dips momentarily due to the torque imbalance, the output voltage will also experience a corresponding **dip**.

Response Mechanisms (Governor and Voltage Regulator):

Modern generators are equipped with control systems like governors and voltage regulators:

- **Governor:** The governor senses the decrease in speed and responds by increasing the fuel supply to the engine (prime mover). This injects more mechanical power into the generator's shaft.
- **Voltage Regulator:** The voltage regulator also detects the voltage dip and may adjust the generator's field current to maintain the output voltage within a specific range.

Voltage Recovery and Stabilization:

- **Increased Engine Torque:** As the engine's fuel supply increases, the torque delivered to the generator shaft starts to rise.
- **Speed Recovery:** With the increased torque counteracting the increased load, the generator's speed gradually recovers towards its original steady-state value.
- **Voltage Stabilization:** As the speed recovers, the output voltage also stabilizes and may even slightly increase if the voltage regulator actively adjusts the field current.

Overall:

The initial voltage dip is a transient response due to the inertia of the generator's rotating parts. The control systems work to restore the speed and voltage to their steady-state values, ensuring continued power delivery to the connected load.

Important Note:

The severity of the voltage dip depends on various factors like the generator's size, the magnitude of the sudden load increase, and the response time of the control systems. In most well-regulated systems, the voltage dip is temporary and quickly recovers within a short timeframe (milliseconds).

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4. State THREE different methods used to detect a refrigerant gas leak, explaining EACH method.

Here are three different methods used to detect a refrigerant gas leak, along with explanations for each:

1. **Electronic Leak Detector:**

- **Description:** This method utilizes a handheld electronic device that can pinpoint the location of a leak. The detector is equipped with a sensor that reacts to the presence of refrigerant.
- **Explanation:** As the detector is moved around the suspected leak area, the sensor sensitivity increases when it comes close to a leak. The device typically provides an audible or visual alert (light or bar graph) to indicate the intensity of the leak. Different types of electronic leak detectors may be sensitive to specific refrigerants or a broader range.
- **Advantages:** This method is highly sensitive, allowing for the detection of even small leaks. It's also portable and relatively easy to use, making it suitable for initial leak detection.

2. **Soapy Water Solution:**

- **Description:** This is a simple and inexpensive method that can be effective for detecting larger leaks. It involves applying a soapy water solution to the suspected leak areas.
- **Explanation:** Refrigerant gas escaping from a leak will create bubbles when it comes into contact with the soapy water. The presence and size of bubbles can indicate the location and severity of the leak.
- **Advantages:** This method is readily available and easy to implement. It's a good preliminary check for leaks, especially around fittings and connections.

3. **Ultrasonic Leak Detection:**

- **Description:** This method utilizes an ultrasonic detector that can identify the high-frequency sound emitted by escaping refrigerant gas.
- **Explanation:** The detector is equipped with a microphone that picks up the ultrasonic sound waves. These sound waves are inaudible to the human ear but can be detected by the instrument. The detector may provide an audible or visual indication of the leak's location.
- **Advantages:** Ultrasonic leak detection can be effective in noisy environments where electronic detectors might struggle with background noise. It can also be used to pinpoint leaks that may be hidden behind walls or inaccessible areas.

Important Considerations:

- The choice of leak detection method depends on the specific situation, the type of refrigerant, and the size of the suspected leak.
- For large or complex systems, it's recommended to consult a qualified technician for professional leak detection and repair.
- Always follow safety precautions when handling refrigerants. Refrigerants can be harmful if inhaled and some require specific handling procedures.

March 2020

5. (a) List FOUR reasons for a refrigeration compressor to stop unexpectedly, after running for a short period. (4)
- (b) Describe the faults which lead to TWO of the reasons for the stoppage, listed in part (a) (6)

Refrigeration Compressor Unexpected Stoppage: Reasons and Faults

(a) Four Reasons for Unexpected Compressor Stoppage:

1. Electrical Faults:

- Issues like tripped circuit breakers, blown fuses, or internal motor malfunctions can interrupt power supply to the compressor, causing it to stop unexpectedly.

2. Low Suction Pressure:

- If the pressure on the suction side of the compressor drops below a certain level, it may activate a safety mechanism to prevent damage. This could be due to factors like a refrigerant leak, clogged suction line, or malfunctioning expansion valve.

3. High Discharge Pressure:

- Conversely, excessively high pressure on the discharge side can also trigger a safety shutdown to protect the compressor. This might be caused by a dirty condenser coil, a blocked capillary tube (in some systems), or a faulty pressure relief valve.

4. Overload Protection:

- Modern compressors often have built-in overload protection that cuts off power if the motor gets too hot. This can be caused by excessive load on the compressor due to high ambient temperatures, insufficient airflow over the condenser, or internal mechanical issues.

(b) Description of Faults for Two Reasons:

1. Low Suction Pressure:

● Possible Faults:

- **Refrigerant Leak:** A leak in the refrigerant line allows the refrigerant to escape, reducing the pressure in the system and causing the compressor to shut down on low suction pressure. Identifying and repairing the leak is crucial before restarting the system.
- **Clogged Suction Line:** A blockage in the suction line due to debris or ice buildup restricts the flow of refrigerant, leading to a drop in suction pressure and compressor stoppage. The blockage needs to be located and cleared to restore proper flow.
- **Malfunctioning Expansion Valve:** A faulty expansion valve can over-expand the refrigerant, causing too much liquid refrigerant to enter the evaporator. This can lead to insufficient suction pressure and compressor shutdown. The expansion valve may need to be repaired or replaced.

2. High Discharge Pressure:

● Possible Faults:

- **Dirty Condenser Coil:** Dust, dirt, or debris accumulated on the condenser coil reduces its ability to dissipate heat effectively. This causes the discharge pressure to rise, leading to compressor shutdown on high-pressure protection. The condenser coil needs to be cleaned thoroughly to ensure proper heat rejection.
- **Blocked Capillary Tube (in some systems):** A capillary tube is a small-diameter tube used in some refrigeration systems to meter the flow of refrigerant. A blockage within the capillary tube restricts the flow of refrigerant, leading to a rise in discharge pressure and compressor shutdown. The capillary tube may need to be replaced.

Note: These are just a few examples, and the specific cause of the compressor stoppage will depend on the individual refrigeration system and its operating conditions. A qualified technician can diagnose the exact fault and recommend the appropriate repair or replacement action.

6. Explain the maintenance and inspection that should be carried out on SCUBA cylinders. (10)

SCUBA cylinders require regular maintenance and inspection to ensure diver safety. Here's a breakdown of the key procedures:

Visual Inspection (Annual):

- **Frequency:** Performed annually by a qualified technician trained in cylinder inspection.
- **Process:** The technician will thoroughly inspect the cylinder's exterior for any signs of damage, including:
 - Dents, gouges, cracks, or bulges
 - Corrosion or pitting
 - Damage to threads or valve connection points
 - Fading or peeling of paint or markings (may indicate underlying corrosion)
- **Internal Inspection (Optional):** In some cases, an internal inspection using a borescope or other specialized tools may be recommended, especially for older cylinders or those with a history of heavy use.

Hydrostatic Testing (Every 5 Years):

- **Frequency:** Required every five years by most diving regulations.
- **Process:**
 - The cylinder is emptied of any remaining air.
 - It is filled with water to a pressure exceeding its normal working pressure (typically by a factor of 1.5).
 - The cylinder is carefully examined for any signs of permanent deformation or leaks during pressurization.
 - If the cylinder passes the test, it will be stamped with the new test date.

Valve Maintenance:

- **Frequency:** Regular maintenance is recommended, typically every year or two, by a qualified technician.
- **Process:** The technician will disassemble, clean, lubricate, and inspect the valve components for wear or damage. They will also ensure proper operation and replace any worn components if necessary.

Additional Maintenance Tips:

- **Record Keeping:** Maintain a logbook to record all inspections, maintenance procedures, and test results performed on the cylinder.
- **Proper Storage:** Store cylinders in a cool, dry, and well-ventilated area away from direct sunlight and excessive heat.
- **Handling:** Always handle cylinders with care to avoid any damage. Use proper lifting techniques and avoid dropping or dragging them.
- **Diver Responsibility:** Divers should visually inspect their cylinders before each dive for any obvious signs of damage.

Importance of Maintenance:

Regular maintenance and inspection of SCUBA cylinders are critical for diver safety. These procedures help identify any potential weaknesses or damage that could lead to a catastrophic failure during a dive. By following these guidelines and using reputable dive centers that maintain their equipment properly, divers can minimize risks and ensure a safe and enjoyable diving experience.

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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)

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.

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8. (a) State THREE dangers arising from the use of LPG open flame appliances. (3)
- (b) Describe the requirements for a *Gas Detector* suitable for a LPG installation. (7)

Dangers of LPG Open Flame Appliances:

(a) Three dangers arising from the use of LPG open flame appliances include:

1. **Carbon Monoxide Poisoning:** LPG combustion produces carbon monoxide (CO), a colorless, odorless gas. Incomplete combustion due to faulty appliances, inadequate ventilation, or blocked flues can lead to CO buildup. CO poisoning can cause headaches, dizziness, nausea, and even death if not detected promptly.

2. **Fire and Explosion:** Leaked LPG gas is highly flammable and can easily ignite from sparks, flames, or pilot lights. In a confined space, a leak can create an explosive gas-air mixture, posing a significant fire and explosion risk.
3. **Burns:** Open flames from LPG appliances can cause severe burns if touched accidentally. This is especially dangerous for young children or people with limited mobility.

Requirements for an LPG Gas Detector:

(b) Here are the key requirements for a Gas Detector suitable for a LPG installation:

- **Gas Detection:** The detector should be specifically designed to detect leaks of Liquefied Petroleum Gas (LPG) commonly used in domestic and recreational applications (propane and butane).
- **Alarm Function:** Upon detecting an LPG leak, the detector should emit a loud and clear audible alarm to warn occupants of the potential danger.
- **Sensor Technology:** Most suitable detectors use electrochemical sensors that are sensitive to LPG gas. These sensors have a longer lifespan and are more reliable than older catalytic bead sensors.
- **Automatic Shut-off (Optional):** Some advanced detectors may have the capability to automatically shut off the LPG supply valve in case of a significant leak, providing an additional layer of safety.
- **Location:** Gas detectors should be installed strategically in areas where LPG appliances are located, typically near the floor level where LPG gas tends to settle due to its heavier-than-air nature.
- **Certification:** Ensure the gas detector meets relevant safety standards and is certified by a recognized testing body.
- **Regular Maintenance:** Follow the manufacturer's instructions for regular maintenance of the gas detector, including testing and cleaning to ensure its proper functionality.

By installing and maintaining suitable LPG gas detectors, occupants can be alerted to potential leaks and take timely action to minimize the risk of fires, explosions, and carbon monoxide poisoning.

March 2020

9. With reference to longitudinal stresses in a vessel's hull:
 - (a) state the cause of the stress; (3)
 - (b) state the areas where the stress is a maximum; (3)
 - (c) describe the structure that resists the stress. (4)

Longitudinal Stresses in a Ship's Hull

(a) Cause of Longitudinal Stress:

Longitudinal stress in a ship's hull arises from forces acting along the length of the vessel that tend to bend or stretch the hull. These forces can be caused by a variety of factors:

- **Vertical Bending:** The primary cause is the **distribution of weight and buoyancy** along the ship's length. The weight of the vessel and its cargo acts downwards, while the hydrostatic

pressure of the water exerts an upward buoyancy force. If these forces are not evenly distributed, they can create a bending moment that stresses the hull longitudinally.

- **Hogging and Sagging:** Depending on the distribution of weight and wave action, two main scenarios can occur:
 - **Hogging:** When the vessel is supported on either end by wave crests, with the center unsupported in a wave trough, the hull tends to bend upwards in the center, creating a hogging condition.
 - **Sagging:** Conversely, when the vessel is supported in the center by a wave crest and the ends are in wave troughs, the hull tends to bend downwards in the center, creating a sagging condition.

(b) Areas of Maximum Stress:

The areas where longitudinal stress is a maximum depend on the specific loading condition (hogging or sagging):

- **Hogging:** During hogging, the maximum stress typically occurs at the **amidships** section (middle of the vessel's length) on the **deck** due to the combined effects of weight concentration and upward bending moment.
- **Sagging:** During sagging, the maximum stress typically occurs at the **amidships** section on the **bottom** plating as the hull tends to sag downwards under the weight and the wave action creates a downward bending moment.

(c) Structures Resisting the Stress:

The primary structures that resist longitudinal stresses in a ship's hull are:

- **Double Bottom (if present):** This acts like a horizontal girder, adding vertical and longitudinal strength to the hull. It helps distribute loads more evenly and resists the bending moment.
- **Longitudinal Stiffeners:** These are vertical or horizontal beams running along the length or height of the hull. They act like internal girders, stiffening the hull and resisting bending forces. They are particularly crucial in areas where longitudinal stresses are concentrated.
- **Deck Girders:** These are horizontal beams running across the width of the vessel within the deck structure. They help distribute loads across the deck and contribute to resisting longitudinal bending moments, especially during hogging conditions.
- **Keel:** The keel acts as the main longitudinal stiffener at the bottom of the hull. It provides rigidity and strength against longitudinal bending forces.

Overall Design: The overall design and scantling (thickness) of the hull plates also play a significant role. Thicker plates and strategically placed reinforcements in high-stress areas can significantly improve the hull's resistance to longitudinal bending.

March 2020

10. With reference to transverse stresses in a vessel's hull:

(a) state the cause of the stress when the vessel is:

(i) floating in still water; (1)

(ii) being acted on by waves; (2)

(iii) drydocked. (1)

(b) state the areas where the stress is a maximum when the vessel is:

(i) floating in still water; (1)

(ii) drydocked; (1)

(c) describe the structure that resists the stress. (4)

Transverse Stresses in a Ship's Hull: Causes, Locations, and Resistance

(a) Cause of Transverse Stress:

(i) Floating in Still Water:

- **Cause:** The primary cause of transverse stress in still water is the static pressure of the water acting perpendicular to the hull.
- **Explanation:** As the vessel displaces water, the water exerts an upward buoyant force on the hull bottom. This force is counteracted by the weight of the vessel acting downwards. However, this weight distribution isn't perfectly uniform throughout the length of the vessel. Heavier machinery or cargo may be concentrated in specific areas, creating an uneven distribution of forces and leading to slight bending of the hull in a transverse direction (sideways).

(ii) Being Acted on by Waves:

- **Cause:** Waves generate dynamic forces that act on the hull, causing significant transverse stresses.
- **Explanation:** Wave action can subject the vessel to various forces, including:
 - **Wave Buoyancy:** As the wave profile passes, the hull experiences varying buoyant forces depending on its position relative to the wave crest and trough. This creates a dynamic bending moment that stresses the hull transversely.
 - **Slamming:** In rough seas, the vessel might slam against the wave crest, inducing a sudden and concentrated force that can cause high transient transverse stresses.

(iii) Drydocked:

- **Cause:** When a vessel is drydocked and supported on blocks, the water pressure that normally counteracts its weight is removed.

- **Explanation:** The hull weight is now entirely supported by the keel blocks and bilge blocks at discrete points. This concentrated support creates a significant bending moment that stresses the hull transversely, particularly between the support points.

(b) Areas of Maximum Stress:

(i) Floating in Still Water:

- **Location:** Maximum stress typically occurs at the **amidships** section (middle of the vessel's length) due to the combined effects of weight distribution and overall beam (width) of the hull.

(ii) Drydocked:

- **Location:** Maximum stress occurs at the points where the hull rests on the **support blocks**, particularly between the keel blocks and at the bilges (areas where the hull curves inward towards the bottom).

(c) Structures Resisting the Stress:

The primary structures that resist transverse stresses in a ship's hull are:

- **Double Bottom (if present):** This is a structural strengthening element involving a second inner hull bottom. It provides additional vertical strength and helps distribute loads more evenly, reducing transverse stresses.
- **Longitudinal Stiffeners:** These are vertical or horizontal beams running along the length or height of the hull. They act like internal girders, stiffening the hull and resisting bending forces.
- **Bulkheads:** These are vertical partitions dividing the hull into watertight compartments. They add rigidity to the hull and help resist transverse stresses by acting like transverse beams.
- **Deck Girders:** These are horizontal beams running across the width of the vessel within the deck structure. They help distribute loads across the deck and contribute to resisting transverse bending moments.

Overall Design: The overall design and scantling (thickness) of the hull plates also play a crucial role in resisting transverse stresses. Thicker plates and strategically placed reinforcements in high-stress areas can significantly improve the hull's strength and resistance to deformation.