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1. With reference to the International Safety Management Code (I.S.M.):

   (a) state the THREE main objectives of the I.S.M. code; (6)

   (b) describe the role of the *designated person ashore (d.p.a.)*. (4)

16 November 2018

2. With reference to the MARPOL Convention Annex I:

   (a) list SIX circumstances under which an entry must be made in the Oil Record Book; (6)

   (b) detail the specific entries that must be made in the Oil Record Book following a routine overboard discharge of machinery space bilge water. (4)

16 November 2018

3. As required by the STCW Convention:

   (a) state THREE actions that the Officer in charge of an Engineering Watch undertakes when assisting maintenance, repair or emergency activities; (6)

   (b) state TWO circumstances under which the Officer in charge of the Engineering Watch shall notify the Chief Engineer Officer without delay. (4)

16 November 2018

4. (a) State the main purposes of the International Labour Organisation (ILO). (4)

   (b) List SIX areas where the MLC Convention applies to workers at sea. (6)

16 November 2018

5. (a) List FOUR examples of materials on board a vessel for which a Material Safety Data Sheet (MSDS) should be supplied. (4)

   (b) List SIX items of information that could be obtained from a MSDS. (6)

16 November 2018

6. With reference to a vessel's maintenance:

   (a) list FOUR reasons why it is desirable for machinery to be covered by a planned maintenance system; (4)

   (b) state FOUR reasons why unscheduled maintenance may need to be performed; (4)

   (c) state ONE example of acceptable unscheduled maintenance. (2)

16 November 2018

7. With reference to the classification survey of a vessel in dry dock:

   (a) list EIGHT separate items of the hull and associated equipment that would be examined by the surveyor; (4)

   (b) describe TWO ways in which the thickness of a steel hull may be determined. (6)

16 November 2018

8. (a) Describe the basic construction and operation of a Vertical Ship Lift. (6)

   (b) List TWO advantages and TWO disadvantages of a Vertical Ship Lift. (4)

16 November 2018

9. (a) A vessel has two main engines each with a working sump lubricating oil capacity of 750 litres and an average daily consumption each of 3.5 litres at full power.

Calculate the safe reserve lubricating oil requirements for a voyage of 2500 miles at a speed of 18 knots. (6)

(b) State TWO factors that will need to be taken into consideration when calculating the fresh water requirements for an extended voyage. (4)

16 November 2018

10. With reference to the use of a CO_2 flooding system:

(a) list the precautions that should be taken before releasing CO_2 into the machinery spaces of a vessel; (4)

(b) state the length of time that should be allowed to elapse before re-entry into the machinery spaces can be considered, following release of CO_2; (2)

(c) state the precautions that should be taken before the machinery space can be safely re-entered, following release of CO_2. (4)

16 November 2018

1. With reference to the International Safety Management Code (I.S.M.):

   (a) state the THREE main objectives of the I.S.M. code; (6)

   (b) describe the role of the *designated person ashore (d.p.a.)*. (4)

(a) Three Main Objectives of the ISM Code

The International Safety Management (ISM) Code outlines a mandatory framework for shipboard safety management. Here are its three main objectives:

1. **Ensure Safety at Sea:** The ISM Code aims to prevent accidents, minimize injury or loss of life at sea, and safeguard the environment. It achieves this by promoting a culture of safety onboard vessels and encouraging continuous improvement in safety management practices.
2. **Prevent Pollution:** The code emphasizes preventing pollution from ship operations, including oil spills, sewage discharge, and garbage disposal. This aligns with protecting the marine environment and reducing the ecological impact of shipping activities.
3. **Enhance Compliance with Regulations:** The ISM Code promotes adherence to international maritime safety and pollution prevention regulations, including SOLAS, MARPOL, and STCW. It establishes a systematic approach for managing safety risks and ensuring compliance with these vital regulations.

(b) Role of the Designated Person Ashore (DPA)

The Designated Person Ashore (DPA) plays a critical role in implementing the ISM Code and ensuring a safe and environmentally responsible ship operation. Here's a breakdown of their key responsibilities:

- **Maintaining the Link Between Shore and Ship:** The DPA acts as the primary point of contact for the crew onboard regarding safety and environmental issues. They facilitate communication between the vessel's personnel and shore-based management.
- **Monitoring Safety and Pollution Prevention:** The DPA monitors the implementation of the company's Safety Management System (SMS) onboard the vessel. They review reports, audits, and corrective actions related to safety and pollution prevention, ensuring effectiveness.
- **Providing Resources and Support:** The DPA is responsible for ensuring adequate resources, including personnel, training, and equipment, are available onboard to maintain safety and prevent pollution. They also support the crew in resolving safety issues and addressing any deficiencies.
- **Verifying Compliance with the ISM Code:** The DPA conducts internal audits and reviews to verify the company's continued compliance with the ISM Code requirements. They identify any areas for improvement and report them to the shore-based management.
- **Emergency Response:** In case of an emergency at sea, the DPA plays a crucial role in coordinating the company's response efforts. They provide support and resources to the vessel's crew during critical situations.

By fulfilling these responsibilities, the DPA serves as a vital link in the safety management chain, ensuring a strong connection between shore-based management and the crew onboard, ultimately contributing to a safer and more environmentally responsible maritime industry.

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2. With reference to the MARPOL Convention Annex I:

   (a) list SIX circumstances under which an entry must be made in the Oil Record Book; (6)

   (b) detail the specific entries that must be made in the Oil Record Book following a routine overboard discharge of machinery space bilge water. (4)

(a) Six Circumstances for Oil Record Book Entries:

MARPOL Annex I mandates entries in the Oil Record Book (ORB) under various operational scenarios to maintain a clear record of oil-related activities onboard a ship. Here are six key circumstances:

1. **Loading of Oil Cargo:** Details such as the type of oil loaded, quantity loaded, and tank(s) used for storage must be recorded.
2. **Transfer of Oil Cargo:** Entries are required for oil transfers between tanks onboard the ship, including quantities transferred and tanks involved.
3. **Discharge of Oil Residues:** Any discharge of oily residues or bilge water mixtures must be recorded, specifying the quantity discharged, method of discharge (e.g., shore reception facility, incinerator), and the reason for discharge.
4. **Machinery Space Operations:** Entries are required for various machinery space operations, including lube oil transfers, filter cleaning, and any accidental or operational discharges of oil.
5. **Bunkering:** Records of bunkering operations must include the type of fuel oil received, quantity bunkered, and tank(s) used for storage.
6. **Retention of Oily Mixtures on Board:** If oily bilge water or other mixtures are retained onboard for further treatment or disposal ashore, a record must be maintained in the ORB, specifying the quantity retained and the tank(s) used for storage.

(b) Entries for Routine Overboard Discharge of Bilge Water:

Following a routine overboard discharge of machinery space bilge water permitted under MARPOL Annex I (meeting the specified oil content limits), the following specific entries must be made in the Oil Record Book Part I (Machinery Space Operations):

- **Date and Time:** Record the date and time (in GMT or ship's time) when the bilge water discharge commenced and finished.
- **Position of the Ship:** Include the ship's geographical position at the time of discharge using latitude and longitude in degrees and minutes.
- **Quantity Discharged:** Record the estimated or measured quantity of bilge water discharged overboard in cubic meters.
- **Oil Content:** Indicate that the bilge water discharge met the MARPOL Annex I requirements for oil content (typically less than 15 ppm). If a bilge water separator is used, the record may include a reference to the separator model and its MARPOL certificate.
- **Method of Discharge:** Specify the method used for discharging the bilge water overboard (e.g., gravity discharge, pump discharge).
- **Reason for Discharge:** Indicate that the discharge was a routine operation and the bilge water met the regulatory oil content limits.
- **Signature:** The officer in charge of the operation and the master of the ship must sign the respective sections in the ORB.

Important Note: It's crucial to consult the specific requirements of MARPOL Annex I and the vessel's SOPEP for detailed guidance on bilge water management and overboard discharge limitations. Bilge water discharge restrictions may apply in certain areas or special areas designated by the IMO.

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3. As required by the STCW Convention:

(a) state THREE actions that the Officer in charge of an Engineering Watch undertakes when assisting maintenance, repair or emergency activities; (6)

(b) state TWO circumstances under which the Officer in charge of the Engineering Watch shall notify the Chief Engineer Officer without delay. (4)

STCW and the Officer In Charge of an Engineering Watch (OICEW)

(a) Actions of OICEW During Maintenance, Repair, or Emergencies (STCW):

The STCW Convention emphasizes the responsibilities of the Officer In Charge of an Engineering Watch (OICEW) during maintenance, repair, or emergency activities onboard a vessel. Here are three key actions an OICEW undertakes:

1. **Risk Assessment and Supervision:** The OICEW should participate in a risk assessment before any maintenance, repair, or emergency operation begins. This involves identifying potential hazards and ensuring appropriate safety precautions are implemented. They also supervise the work to ensure adherence to safe working practices and procedures.
2. **Communication and Coordination:** The OICEW plays a crucial role in communication and coordination during such activities. They must keep the Chief Engineer Officer informed of the ongoing work, any identified risks, and ensure clear communication between personnel involved.
3. **Monitoring and Watchkeeping:** While maintenance or repairs are ongoing, the OICEW maintains overall watchkeeping duties within the engine room. This includes monitoring critical machinery parameters, alarms, and ensuring the safe operation of remaining equipment.

(b) Circumstances for OICEW to Notify Chief Engineer Officer (STCW):

The OICEW is obligated to notify the Chief Engineer Officer without delay under two specific circumstances:

1. **Equipment Malfunction or Breakdown:** If the OICEW encounters a significant equipment malfunction or breakdown that could potentially affect the propulsion or safety of the vessel, immediate notification to the Chief Engineer is crucial. This allows for a prompt and coordinated response to address the issue and ensure the safe operation of the ship.
2. **Safety Concerns:** If the OICEW has any safety concerns regarding the ongoing maintenance, repair, or emergency activities, they must notify the Chief Engineer Officer without delay. This could involve concerns about inadequate safety precautions, the competence of personnel involved, or any other factor that could potentially compromise safety.

By fulfilling these responsibilities, the OICEW plays a vital role in ensuring safe and efficient machinery space operations during maintenance, repair, and emergency situations.

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4. (a) State the main purposes of the International Labour Organisation (ILO). (4)

(b) List SIX areas where the MLC Convention applies to workers at sea. (6)

International Labour Organisation (ILO) and the Maritime Labour Convention (MLC)

(a) Main Purposes of the International Labour Organisation (ILO):

The International Labour Organisation (ILO) is a specialized agency of the United Nations dedicated to promoting decent work conditions across the globe. Here are its main purposes:

1. **Setting International Labour Standards:** The ILO develops and maintains a set of international labour standards through conventions and recommendations. These standards address various workplace issues like minimum wages, working hours, occupational safety and health, and social security.
2. **Promoting Decent Work:** The ILO promotes the concept of "decent work" encompassing opportunities for productive and well-rewarded employment in conditions of safety, equity, security, and human dignity.
3. **Technical Cooperation and Assistance:** The ILO provides technical cooperation and assistance to member states (countries) to help them implement international labour standards and improve national labour laws and practices.
4. **Protecting Workers' Rights:** The ILO advocates for the protection of workers' fundamental rights, including freedom of association, the right to collective bargaining, and the elimination of forced labour and child labour.

(b) Six Areas Where the MLC Convention Applies to Workers at Sea:

The Maritime Labour Convention (MLC), adopted by the ILO, establishes minimum working standards for seafarers worldwide. Here are six key areas where the MLC applies to seafarers:

1. **Minimum Requirements for Seafarers to Work on a Ship:** The MLC defines the minimum competency standards, medical fitness requirements, and certification needs for seafarers to work onboard vessels.
2. **Conditions of Employment:** The MLC sets out regulations concerning seafarers' employment contracts, wages, working hours, paid leave, repatriation in case of termination of employment, and dispute settlement mechanisms.
3. **Accommodation, Recreational Facilities, Food and Catering:** The MLC establishes minimum standards for seafarers' accommodation onboard ships, including size, amenities, and sanitation requirements. It also addresses recreational facilities, food quality, and catering services.
4. **Occupational Safety and Health Protection:** The MLC focuses on protecting seafarers' health and safety at work. It covers areas like accident prevention, safe work practices, medical care onboard, and protection against occupational hazards.
5. **Welfare:** The MLC recognizes the specific challenges of seafaring and emphasizes the importance of seafarers' welfare. It promotes access to communication facilities, recreational activities, and religious observances while at sea.

6. **Social Security Protection:** The MLC encourages member states to ensure seafarers have access to adequate social security protection covering unemployment, sickness, injury, disability, old age, and maternity leave.

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5. (a) List FOUR examples of materials on board a vessel for which a Material Safety Data Sheet (MSDS) should be supplied. (4)

(b) List SIX items of information that could be obtained from a MSDS. (6)

Material Safety Data Sheets (MSDS) Onboard Vessels

(a) Four Examples of Materials Requiring MSDS:

Vessels carry various materials, and some pose potential safety hazards. Here are four examples where an MSDS should be readily available:

1. **Flammable Liquids:** Fuels like diesel, gasoline, and lubricating oils are essential for ship operation. However, they are flammable and can release hazardous vapors. An MSDS provides information on safe handling, storage, and firefighting procedures for these liquids.
2. **Cleaning Chemicals:** A variety of cleaning chemicals are used for maintenance and sanitation purposes onboard. These chemicals can be corrosive, toxic, or irritating. An MSDS outlines proper personal protective equipment (PPE) requirements and safe handling practices for these chemicals.
3. **Compressed Gases:** Vessels may use compressed gases like oxygen for breathing apparatus, inert gases for fire prevention, or refrigerant gases in air conditioning systems. An MSDS details the hazards associated with pressurized gases, appropriate handling procedures, and potential health risks in case of leakage.
4. **Paints and Solvents:** Paints and solvents used for maintenance and corrosion protection can be flammable and contain harmful chemicals. An MSDS provides information on proper ventilation requirements during application, safe storage practices, and disposal procedures for paint thinner and used paint cans.

(b) Six Key Details Found in an MSDS:

An MSDS is a vital document for understanding the properties and hazards of various materials onboard. Here are six key pieces of information obtainable from an MSDS:

1. **Material Identification:** The MSDS clearly identifies the material by name and chemical formula and may include trade names or synonyms used for the material.
2. **Hazardous Ingredients:** The MSDS lists the hazardous ingredients present in the material and their respective concentrations. This information helps identify potential health risks associated with exposure.
3. **Physical and Chemical Properties:** The MSDS details physical properties like boiling point, flash point, flammability limits, and chemical properties like acidity or alkalinity of the material.
4. **Health Hazards:** The MSDS describes the potential health hazards associated with exposure to the material, including symptoms of inhalation, skin contact, or ingestion. It may also recommend first aid procedures in case of accidents.

5. **Fire Fighting Measures:** The MSDS provides information on suitable firefighting techniques for the material, including recommended extinguishing agents and precautions to be taken during firefighting operations.
6. **Handling and Storage:** The MSDS outlines safe handling procedures for the material, including the use of appropriate PPE, ventilation requirements, and proper storage conditions to minimize the risk of accidents or spills.

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6. With reference to a vessel's maintenance:

(a) list FOUR reasons why it is desirable for machinery to be covered by a planned maintenance system; (4)

(b) state FOUR reasons why unscheduled maintenance may need to be performed; (4)

(c) state ONE example of acceptable unscheduled maintenance. (2)

Planned vs. Unscheduled Maintenance on a Vessel

(a) Benefits of Planned Maintenance for Machinery:

A planned maintenance system (PMS) offers several advantages for vessel machinery:

1. **Prevents Unexpected Breakdowns:** By proactively scheduling maintenance based on manufacturer recommendations and condition monitoring, a PMS helps prevent unexpected equipment failures at sea. This reduces the risk of accidents, delays, and loss of revenue.
2. **Optimizes Equipment Lifespan:** Regular maintenance tasks like lubrication, filter changes, and adjustments minimize wear and tear on machinery components. This extends the equipment's useful life and reduces the need for costly replacements.
3. **Reduces Repair Costs:** Early detection of potential issues through condition monitoring allows for timely corrective action. Addressing minor problems before they escalate into major failures keeps repair costs under control.
4. **Improves Operational Efficiency:** Well-maintained machinery operates more efficiently, consuming less fuel and performing at optimal levels. This translates to cost savings on fuel and enhances overall vessel performance.

(b) Reasons for Unscheduled Maintenance:

While a PMS minimizes unscheduled maintenance, certain situations may necessitate immediate attention:

1. **Sudden Equipment Failure:** Despite precautions, components can fail unexpectedly due to manufacturing defects, material fatigue, or external factors like excessive loads. Unscheduled maintenance becomes necessary to restore functionality.
2. **Accidental Damage:** Collisions, groundings, or exposure to harsh weather conditions can damage machinery requiring immediate repair to ensure vessel safety and seaworthiness.
3. **Unexpected Wear and Tear:** Operating conditions may be more severe than anticipated, leading to accelerated wear and tear on components. Unscheduled maintenance becomes necessary to address excessive wear before complete failure.

4. **Safety System Activation:** Safety systems like alarms and shutdowns may trigger due to abnormal operating parameters. Unscheduled maintenance is required to diagnose the cause of the activation and ensure continued safe operation.

(c) Example of Acceptable Unscheduled Maintenance:

One example of acceptable unscheduled maintenance could be replacing a blown fuse on a critical electrical circuit. This minor repair can be performed relatively quickly and does not require extensive disassembly of machinery. However, the incident should be investigated to determine the cause of the fuse blowing to prevent future occurrences.

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7. With reference to the classification survey of a vessel in dry dock:

   (a) list EIGHT separate items of the hull and associated equipment that would be examined by the surveyor; (4)

   (b) describe TWO ways in which the thickness of a steel hull may be determined. (6)

Dry Docking Plans and Pre-Docking Conditions

(a) Six Items of Information from a Docking Plan:

A well-prepared docking plan provides crucial details for a successful dry-docking operation. Here are six key pieces of information you can typically find:

1. **Vessel Characteristics:** Dimensions (length, breadth, draft), weight, and center of gravity of the vessel. This data is vital for calculating block placement and ensuring proper support during dry-docking.
2. **Docking Block Arrangement:** The specific type, size, and precise placement of docking blocks used to support the vessel in the dry dock. This ensures even weight distribution and minimizes stress on the hull structure.
3. **Sea Chest and Valve Locations:** The location of all sea chests (openings for water intake/outflow) and associated valves is identified. This information is essential for divers to blank off these openings and prevent water ingress during flooding.
4. **Planned Maintenance and Repairs:** The docking plan outlines the specific maintenance and repair tasks scheduled for the dry-docking period. This helps coordinate workforces and allocate resources efficiently.
5. **Stability Calculations and Ballast Distribution:** The plan may include stability calculations to determine optimal ballast water distribution within the vessel during dry-docking. This maintains vessel stability and prevents tipping while out of the water.
6. **Waste Management Plan:** The plan may outline procedures for handling and disposing of waste generated during maintenance activities, such as paint scrapings, sandblasting debris, and oily wastes. This ensures compliance with environmental regulations.

(b) Four Conditions to be Met Before Dry-Docking:

Several crucial conditions must be met before a vessel can be safely dry-docked:

1. **Classification Society Approval:** Classification societies conduct surveys to ensure vessels meet safety and regulatory standards. Their approval is often required before dry-docking, particularly for extensive repairs or modifications.
2. **Docking Facility Suitability:** The chosen dry dock facility must be suitable for the size and weight of the vessel. Factors like dock dimensions, lifting capacity, and available services (e.g., cranes, waste disposal) need to be considered.
3. **Weather Conditions:** Favorable weather conditions are essential for safe dry-docking operations. High winds, waves, or storms can pose significant risks during the lifting and positioning of the vessel.
4. **Pre-Docking Preparations:** The vessel itself needs to be prepared for dry-docking. This includes removing loose equipment, hazardous materials, double-bottom tank sounding and valve checks, sea chest blanking, and a pre-docking meeting for clear communication between all parties involved.

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8. (a) Describe the basic construction and operation of a Vertical Ship Lift. (6)

(b) List TWO advantages and TWO disadvantages of a Vertical Ship Lift. (4)

Vertical Ship Lifts: Elevating Vessels Efficiently

(a) Construction and Operation:

A Vertical Ship Lift is a massive mechanical device used to raise and lower vessels between bodies of water with different elevations. Here's a breakdown of its construction and operation:

- **Structure:** A vertical ship lift consists of a large platform strong enough to support the weight of a vessel. The platform is suspended from a sturdy gantry frame equipped with powerful winch systems. These winches utilize wire ropes or hydraulic rams for precise vertical movement of the platform.
- **Operation:** The process of raising or lowering a vessel involves several steps:
    1. **Vessel Positioning:** The vessel carefully navigates into a receiving basin located at the lower end of the lift. Guides and mooring lines ensure proper alignment with the platform.
    2. **Platform Submersion:** The platform descends until it is completely submerged, allowing the vessel to sail onto it. Water tightness between the basin and the platform is maintained during this stage.
    3. **Lifting and Lowering:** Once the vessel is secured on the platform, the winches are activated, raising the platform with the vessel to the desired upper water level. The reverse process is used for lowering a vessel.
    4. **Exiting the Lift:** Upon reaching the upper level, the platform is positioned over the exit canal. The vessel sails off the platform and continues its journey on the higher water body.

(b) Advantages and Disadvantages of Vertical Ship Lifts:

Vertical ship lifts offer some distinct advantages:

- **Faster Transit:** Compared to traditional canal locks, vertical ship lifts can raise or lower vessels much faster, reducing transit time and increasing efficiency on waterways with significant elevation differences.
- **Overcoming Large Elevation Changes:** Vertical ship lifts can effectively handle larger elevation changes between water bodies compared to multi-stage canal lock systems.

However, there are also some limitations to consider:

- **High Construction and Maintenance Costs:** Building and maintaining a large and powerful vertical ship lift can be significantly more expensive than canal lock systems.
- **Limited Vessel Capacity:** The platform size of a vertical ship lift restricts the maximum size of vessels it can accommodate, whereas canals can theoretically handle a wider range of vessel sizes.

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9. (a) A vessel has two main engines each with a working sump lubricating oil capacity of 750 litres and an average daily consumption each of 3.5 litres at full power.

Calculate the safe reserve lubricating oil requirements for a voyage of 2500 miles at a speed of 18 knots. (6)

(b) State TWO factors that will need to be taken into consideration when calculating the fresh water requirements for an extended voyage. (4)

Safe Reserve Lubricating Oil and Fresh Water Requirements

(a) Safe Reserve Lubricating Oil:

While the provided information allows us to calculate the total engine sump capacity and daily oil consumption, determining a specific "safe reserve" requires additional considerations. Here's what we can calculate and the missing factors:

1. **Total Engine Sump Capacity:**

Total engine sump capacity = Engine sump capacity per engine (litres) × Number of engines Total engine sump capacity = 750 litres/engine × 2 engines Total engine sump capacity = 1500 litres

2. **Daily Oil Consumption for Both Engines at Full Power:**

Daily oil consumption (litres/day) = Daily consumption per engine (litres/day) × Number of engines Daily oil consumption = 3.5 litres/day/engine × 2 engines Daily oil consumption = 7 litres/day

Missing Information for Safe Reserve:

- **Engine Efficiency at Cruising Speed (18 knots):** Engines likely operate at lower power (and therefore lower oil consumption) than full power during cruising speed. Knowing efficiency at 18 knots is crucial for accurately estimating oil consumption during the voyage.
- **Desired Safe Reserve Level:** This depends on company policies, risk tolerance, and the availability of replenishment opportunities during the voyage.

Therefore, without knowing engine efficiency at 18 knots and the desired safe reserve level, we cannot calculate a specific safe reserve lubricating oil requirement for this voyage.

(b) Fresh Water Requirements for an Extended Voyage:

Two prominent factors significantly influence fresh water requirements for an extended voyage:

1. **Number of People on Board (Crew and Passengers):** The more people onboard, the greater the demand for fresh water for drinking, washing, sanitation, and cooking.

2. **Duration of the Voyage:** Extended voyages obviously necessitate more fresh water to sustain those onboard for the entire duration. Here, the voyage length is 2500 miles, but the total time depends on the vessel's average speed (not given).

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10. With reference to the use of a CO_2 flooding system:

(a) list the precautions that should be taken before releasing CO_2 into the machinery spaces of a vessel; (4)

(b) state the length of time that should be allowed to elapse before re-entry into the machinery spaces can be considered, following release of CO_2; (2)

(c) state the precautions that should be taken before the machinery space can be safely re-entered, following release of CO_2. (4)

CO2 Flooding System Precautions and Re-entry on Vessels

(a) Precautions Before Releasing CO2 into Machinery Spaces:

- **Personnel Evacuation:** All personnel must be evacuated from the machinery space and surrounding areas at risk of CO2 exposure.
- **Ventilation Shutdown:** All ventilation systems in the machinery space and potentially affected areas must be shut down to prevent CO2 from spreading.
- **Electrical Isolation:** All electrical equipment in the machinery space should be isolated to prevent sparking and potential reignition.
- **Confirmation of Fire Extinguishment:** Ensure the fire is extinguished before flooding the space with CO2. Flooding an active fire can be hazardous.
- **System Activation:** Only activate the CO2 flooding system after all precautions are verified and personnel are clear.

(b) Time Allowed Before Re-Entry:

Re-entry should not be considered until a safe oxygen level is confirmed within the machinery space. This typically takes **several hours**, depending on the size of the space and ventilation capabilities.

(c) Precautions Before Re-Entry After CO2 Release:

- **Oxygen Level Testing:** Before re-entry, qualified personnel must use appropriate gas detectors to verify safe oxygen levels (typically around 20.9% by volume).
- **Ventilation Activation:** Once safe oxygen levels are confirmed, activate ventilation systems to purge the remaining CO2 from the space.
- **Continuous Monitoring:** During ventilation and re-entry, personnel should continuously monitor oxygen levels and wear appropriate respiratory protection until the space is completely clear of CO2.
- **Visual Inspection:** A thorough visual inspection for remaining smoldering fire or hot spots is crucial before declaring the space safe for normal operations.

Remember: CO_2 displacement can be fatal. Following these safety measures is essential to prevent personnel injury or loss of life during CO_2 flooding system operation and subsequent re-entry into the machinery space.