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1. With reference to the International Maritime Organisation (IMO):

   (a) state the THREE main categories of IMO Conventions; (3)

   (b) state how IMO Conventions are enforced; (2)

   (c) state the aim of the IMO Member State Audit Scheme (IMSAS). (5)

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2. With reference to the International Convention for the Safety of Life at Sea (SOLAS 1974, as amended) Chapter XI section 2 - the *International Ship and Port Security Code:*

   (a) list the FIVE basic requirements for ships in order to comply with the code; (5)

   (b) list the basic procedures that will be required to be put in place in order for the vessel to operate at security level one. (5)

10 September 2021

3. With reference to MARPOL Annex V (Prevention of Pollution by Garbage from Ships):

   (a) state which vessels require a Garbage Record Book (GRB); (1)

   (b) state the FOUR operations which require an entry in the GRB; (4)

   (c) list the FIVE pieces of specific information required to be entered when an operation stated in part (b) is carried out. (5)

10 September 2021

4. The UMS monitoring and control system of a ship has recently started to give false alarms and incorrect data printouts.

   (a) State, with reasons, the possible causes. (5)

   (b) State, with reasons, the action that should be taken to ensure continued safe operation of the vessel. (5)

10 September 2021

5. The Code of Safe Working Practice for Merchant Seafarers states that *Permits to Work* must be obtained before certain tasks can be undertaken.

   (a) List the conditions to be met before a *Permit to Work* is issued. (4)

   (b) State FOUR points that would be listed as part of a *Permit to Work* for a typical task within the machinery spaces of a vessel. (4)

   (c) State the time period over which a *Permit to Work* remains in force, outside of workshop areas. (2)

10 September 2021

6. Explain the procedures carried out by a Classification Society for a new vessel to be built to class rules, and the class certificate being issued. (10)

10 September 2021

7. With reference to condition monitoring:

   (a) explain how vibration analysis can be used as part of a planned maintenance system; (7)

   (b) list SIX tests that can be carried out on crankcase oil in order to determine its suitability for further service. (3)

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8. With reference to vessel's survey requirements:

   (a) state the possible consequences of either failing to obtain, or failing to renew a Statutory Certificate; (5)

   (b) state what is meant by the *Harmonisation system of survey and certification*. (5)

10 September 2021

9. A vessel has bunkered 300 tonnes of diesel fuel. Given that the average combined sea power load of the vessel is 3000 kW and with a stated specific consumption of 0.35 kg/kWh, calculate EACH of the following:

   (a) the daily fuel consumption of the vessel; (4)

   (b) the safe steaming range of the vessel at a speed of 18 knots. (6)

10 September 2021

10. Describe, with the aid of sketches, the difference between an obscuration type smoke detector and a light scatter type smoke detector. (10)

10 September 2021

1. With reference to the International Maritime Organisation (IMO):

   (a) state the THREE main categories of IMO Conventions; (3)

   (b) state how IMO Conventions are enforced; (2)

   (c) state the aim of the IMO Member State Audit Scheme (IMSAS). (5)

(a) Three Main Categories of IMO Conventions

The International Maritime Organization (IMO) adopts conventions covering a broad range of maritime issues. Here are the three main categories:

1. **Maritime Safety:** These conventions focus on ensuring the safety of life at sea, minimizing accidents, and protecting personnel onboard ships. Examples include the International Convention for the Safety of Life at Sea (SOLAS) and the Standards of Training, Certification and Watchkeeping for Seafarers (STCW).
2. **Marine Environment Protection:** These conventions aim to prevent pollution from ships and protect the marine environment. The International Convention for the Prevention of Pollution from Ships (MARPOL) is the most prominent example.
3. **Liability and Compensation:** These conventions establish frameworks for compensation in case of maritime accidents or pollution incidents. Examples include the International Convention on Civil Liability for Oil Pollution Damage (CLC) and the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND).

(b) Enforcement of IMO Conventions

Enforcement of IMO Conventions primarily relies on **flag state control**. Here's how it works:

- **Flag State Responsibility:** Each ship is registered with a flag state, which is the country responsible for ensuring the vessel complies with IMO regulations.
- **Port State Control:** Port authorities around the world can inspect foreign ships entering their ports to verify compliance with IMO conventions. If deficiencies are found, the ship may be detained until rectified.
- **Classification Societies:** Independent classification societies authorized by IMO can survey and certify ships on behalf of flag states, ensuring adherence to IMO conventions.

(c) Aim of the IMO Member State Audit Scheme (IMSAS)

The IMO Member State Audit Scheme (IMSAS) aims to verify that IMO member states effectively implement the relevant IMO conventions. Through audits, IMSAS assesses a member state's:

- **Legislative framework:** Checks if the country has adopted and incorporated IMO conventions into its national maritime legislation.
- **Administrative and enforcement capabilities:** Evaluates the state's capacity to enforce IMO regulations through inspections, certification procedures, and flag state control.
- **Resources:** Assesses the availability of qualified personnel and resources to effectively implement IMO conventions.

IMSAS findings and recommendations help member states identify areas for improvement and ultimately enhance overall compliance with IMO regulations.

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2. With reference to the International Convention for the Safety of Life at Sea (SOLAS 1974, as amended) Chapter XI section 2 - the *International Ship and Port Security Code:*

(a) list the FIVE basic requirements for ships in order to comply with the code; (5)

(b) list the basic procedures that will be required to be put in place in order for the vessel to operate at security level one. (5)

SOLAS Chapter XI-2 & ISPS Code: Security Requirements for Ships

The International Ship and Port Security (ISPS) Code, incorporated into SOLAS Chapter XI-2, outlines mandatory measures to enhance maritime security. Here's a breakdown of the key points:

(a) Five Basic Requirements for Ships (ISPS Code Part A):

1. **International Ship Security Certificate (ISSC):** The vessel must obtain an ISSC, demonstrating a company security assessment and a Ship Security Plan (SSP) that meets ISPS Code requirements.
2. **Company Security Officer (CSO):** The company employing the ship must appoint a designated Company Security Officer (CSO) responsible for overall security management.
3. **Ship Security Officer (SSO):** The ship must have a designated Ship Security Officer (SSO) responsible for implementing the Ship Security Plan (SSP) onboard.
4. **Ship Security Assessment (SSA):** A comprehensive Ship Security Assessment (SSA) must be conducted to identify security risks and vulnerabilities specific to the ship's operation.
5. **Ship Security Plan (SSP):** Based on the SSA, a detailed Ship Security Plan (SSP) must be developed outlining procedures to address identified risks, including measures for security levels 1, 2, and 3.

(b) Basic Procedures for Security Level 1 (ISPS Code Part A):

Security Level 1 represents the lowest security risk. Here are some basic procedures a ship might implement at this level:

- **Routine Security Checks:** Regular patrols of the ship's perimeter and vital areas to deter unauthorized access.
- **Control of Access:** Procedures for controlling access onboard, including verifying the identity of visitors and crew members embarking or disembarking.
- **Reporting of Security Incidents:** Clear guidelines for reporting any suspicious activity or security incidents to the appropriate authorities.
- **Security Awareness Training:** Crew familiarization with the Ship Security Plan (SSP) and their roles and responsibilities in maintaining security onboard.
- **Communication Procedures:** Established protocols for internal communication between crew members and external communication with shore-based authorities in case of security incidents.

Note: Specific procedures for each security level may vary depending on the identified risks in the Ship Security Assessment (SSA). As security levels increase (Level 2 and 3), stricter measures like heightened surveillance, restricted access zones, and additional security equipment may be required.

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3. With reference to MARPOL Annex V (Prevention of Pollution by Garbage from Ships):

   (a) state which vessels require a Garbage Record Book (GRB); (1)

   (b) state the FOUR operations which require an entry in the GRB; (4)

   (c) list the FIVE pieces of specific information required to be entered when an operation stated in part (b) is carried out. (5)

MARPOL Annex V and Garbage Record Book (GRB):

(a) Vessels Requiring a Garbage Record Book (GRB):

MARPOL Annex V mandates all seagoing vessels of 400 gross tonnage and above engaged in international voyages to carry a Garbage Record Book (GRB). Some national regulations may extend this requirement to smaller vessels operating domestically.

(b) GRB Entries: Four Required Operations:

The GRB serves as a detailed record of a ship's garbage management practices. Entries are required for the following four specific operations:

1. **Discharge of Garbage at Sea:** Any discharge of garbage overboard, even if permitted under Annex V regulations (e.g., food waste beyond 12 nautical miles from land), must be documented in the GRB.
2. **Incineration of Garbage onboard:** If the ship has an incinerator and uses it to dispose of garbage, a record of each incineration operation needs to be entered in the GRB.
3. **Retention of Garbage onboard for Discharge Ashore:** When garbage is accumulated onboard for disposal at a reception facility in port, details of the stored garbage must be recorded in the GRB.
4. **Transfer of Garbage to Another Ship or to Shore Reception Facilities:** Entries are required for any transfer of garbage to another ship or to shore reception facilities at ports or terminals.

(c) Five Required Pieces of Information per Operation:

For each of the four operations mentioned above, the following five specific pieces of information must be entered into the GRB:

1. **Date and Time:** Record the date and time (in GMT or ship's time) when the operation (discharge, incineration, retention, or transfer) occurred.
2. **Garbage Category and Estimated Quantity:** Indicate the type of garbage involved (e.g., plastics, food waste, paper) and estimate the quantity of garbage in cubic meters.
3. **Location of the Ship:** Record the ship's geographical position at the time of the operation using latitude and longitude in degrees and minutes.
4. **Disposal Method:** Specify the method used for disposing of the garbage (e.g., discharged overboard, incinerated, stored onboard, transferred).
5. **Remarks:** Any additional relevant details about the operation can be included in the remarks section. This may involve references to permits for discharging specific types of garbage at sea, or identification of the receiving ship or shore reception facility in case of transfers.

Important Note: Always refer to the latest MARPOL Annex V regulations and consult the vessel's Garbage Management Plan for specific garbage categorization and discharge limitations. Proper GRB maintenance is crucial for demonstrating compliance with MARPOL regulations during port state control inspections.

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4. The UMS monitoring and control system of a ship has recently started to give false alarms and incorrect data printouts.

(a) State, with reasons, the possible causes. (5)

(b) State, with reasons, the action that should be taken to ensure continued safe operation of the vessel. (5)

UMS Malfunction: Causes and Safe Operation Measures

(a) Possible Causes of False Alarms and Incorrect Data:

Several factors can contribute to false alarms and incorrect data printouts from a ship's UMS (Unified Machinery Space) monitoring and control system:

- **Sensor Faults:** Malfunctioning sensors that provide data to the UMS can generate inaccurate readings, leading to false alarms and incorrect printouts. Sensor drift, calibration issues, or physical damage to sensors can all contribute to this problem.
- **Communication Issues:** Errors in data transmission between sensors and the UMS can corrupt data, resulting in misleading information displayed on screens and printed incorrectly on reports. Faulty cables, connectors, or interference within the communication network can be potential causes.
- **Software Bugs:** Software bugs or glitches within the UMS itself can lead to misinterpretation of sensor data, triggering false alarms and generating inaccurate printouts. Outdated software or issues with the specific software version being used are possibilities.
- **Hardware Malfunctions:** Hardware failures within the UMS processing unit or other electronic components can cause data processing errors, resulting in false alarms and incorrect printouts. Component degradation or internal circuit board issues can be concerns here.
- **External Interference:** In rare cases, strong electromagnetic interference from external sources can disrupt the operation of the UMS, leading to erratic sensor readings and consequently false alarms and incorrect data printouts.

(b) Actions to Ensure Safe Operation:

Despite the malfunction, several actions can be taken to ensure the continued safe operation of the vessel:

- **Identify and Isolate the Fault:** The Chief Engineer and qualified crew should attempt to identify the source of the problem. This may involve checking sensor readings directly, reviewing communication logs for errors, and consulting the UMS manual for troubleshooting procedures. If the fault can be isolated to a specific sensor or communication link, it may be possible to temporarily exclude faulty data from certain alarms while investigations continue.
- **Rely on Alternative Monitoring:** While the UMS provides a centralized monitoring system, alternative methods should be used to verify critical engine room parameters. Direct readings from local gauges and instruments should be prioritized to ensure engine performance and safety parameters are within acceptable limits.
- **Maintain Logbook Records:** Increase the frequency of manual entries in the engine room logbook, recording essential parameters like lubricating oil pressure, cooling water temperatures, and RPM based on direct readings from instruments. This provides a backup record of engine performance in case UMS data cannot be fully relied upon.

- **Inform Shore Support and Prepare for Repairs:** The Chief Engineer should notify shore-based technical support about the malfunction. Provide detailed information on the nature of the false alarms and incorrect data observed. Prepare for potential repairs by ordering spare parts or arranging for technical assistance as needed upon arrival at the next port.
- **Reduce Speed or Consider Port Diversion:** If critical engine parameters become uncertain due to unreliable UMS data, consider reducing vessel speed to decrease the load on the machinery. In severe cases, diverting to a port for repairs might be necessary to ensure the safety of the vessel and crew.

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5. The Code of Safe Working Practice for Merchant Seafarers states that *Permits to Work* must be obtained before certain tasks can be undertaken.

   (a) List the conditions to be met before a *Permit to Work* is issued. (4)

   (b) State FOUR points that would be listed as part of a *Permit to Work* for a typical task within the machinery spaces of a vessel. (4)

   (c) State the time period over which a *Permit to Work* remains in force, outside of workshop areas. (2)

Permit to Work System and Safe Practices Onboard Ships (Code of Safe Working Practices)

The Code of Safe Working Practices emphasizes the Permit to Work system as a critical element for ensuring safety during specific onboard tasks. Here's a breakdown of issuance conditions, typical permit content, and validity periods:

(a) Conditions for Permit Issuance:

Before a Permit to Work is issued, several crucial conditions need to be met:

1. **Risk Assessment:** A thorough risk assessment for the planned task must be conducted. This identifies potential hazards like exposure to hazardous materials, working aloft, or using electrical equipment.
2. **Mitigation Measures:** For each identified risk, appropriate mitigation measures must be outlined in the permit. These may involve using personal protective equipment (PPE), establishing safe work procedures, or obtaining additional permits for specific activities (e.g., hot work permit for welding).
3. **Competent Personnel:** Only personnel deemed competent and qualified for the specific task, based on their training and experience, can be authorized to perform the work.
4. **Availability of Resources:** The permit should only be issued if the necessary resources, tools, and equipment required for the safe completion of the task are readily available.
5. **Isolation and Lockout Procedures:** For tasks involving machinery or electrical systems, proper isolation and lockout procedures must be established to prevent accidental energization or equipment operation during work.

(b) Typical Permit Content for Machinery Space Tasks:

A Permit to Work for a machinery space task would typically include the following four key points:

1. **Work Description:** A clear description of the task to be undertaken, specifying its location within the machinery space (e.g., valve maintenance on a specific engine) and any equipment involved.

2. **Safety Precautions:** Detailed safety precautions required for the task. This may include specifying required PPE (e.g., safety glasses, ear protection, respirators), ventilation requirements to control fumes or dust, and any hot work permits needed for activities like welding or brazing.
3. **Isolation Procedures:** A clear outline of the isolation procedures for any machinery or electrical systems involved in the task. This ensures no accidental energization or equipment operation during work.
4. **Standby Person:** Designation of a qualified standby person to be stationed outside the work area for monitoring purposes and to render assistance in case of emergencies.

(c) Permit Validity Period Outside Workshops:

The validity period of a Permit to Work outside of workshop areas (e.g., within machinery spaces) is generally shorter compared to permits used in workshops (dedicated maintenance areas). This reflects the potentially dynamic environment in machinery spaces. Here's a guideline:

- **Outside Workshops:** Permits are typically valid for a **maximum of one shift (around 8 hours)**. This encourages review and renewal of the permit if the work extends beyond a single shift, ensuring continued risk assessment and adherence to safety precautions.
- **Workshops:** Permits in workshops (controlled environments) may have a slightly extended validity period, potentially lasting up to 24 hours depending on the specific task and the ship's safety management system.

Important Note: The specific validity period of a Permit to Work may vary depending on the company's safety management system and the complexity of the task. It's crucial to consult the ship's specific procedures for Permit to Work issuance and validity periods.

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6. Explain the procedures carried out by a Classification Society for a new vessel to be built to class rules, and the class certificate being issued. (10)

Classification Society Procedures for New Vessel Construction

Classification societies play a vital role in ensuring the safety and structural integrity of new vessels. Here's a breakdown of the procedures they typically follow for a new vessel built to their class rules:

1. Plan Review and Approval:

- The shipyard submits design drawings, calculations, and material specifications to the classification society for review.
- Classification society engineers assess the design against their published rules and regulations, focusing on structural strength, stability, machinery suitability, and safety systems.
- Iterative discussions may occur between the shipyard, designer, and classification society to address any discrepancies or areas requiring modification to comply with the rules.
- Once all aspects of the design are approved, the classification society issues a "Class Approval Certificate".

2. Construction Surveys and Inspections:

- Throughout the construction process, classification society surveyors conduct regular inspections at the shipyard.

- These inspections verify that materials used meet specified grades and that construction methods comply with approved procedures. Welding procedures, material testing, and fabrication techniques all fall under scrutiny.
- The surveyors witness critical construction milestones like keel laying, launching, and machinery installation.
- Any deviations from approved plans or non-conformities identified during inspections must be addressed and re-inspected by the classification society surveyor before proceeding.

3. Testing and Trials:

- Upon completion of construction, the vessel undergoes a series of tests and trials to verify its performance and seaworthiness.
- These may include inclining tests to determine stability, bollard pull tests to assess propulsion power, and navigation and machinery trials to ensure all systems function correctly.
- Classification society surveyors witness these tests and review the results to confirm compliance with class rules and regulations.

4. Class Certificate Issuance:

- Following successful completion of all inspections, tests, and trials, the classification society issues a "Class Certificate".
- This certificate formally recognizes that the vessel has been built to the society's rules and is eligible to carry their classification symbol.
- The class certificate remains valid for a specific period, typically five years, subject to satisfactory completion of regular surveys to maintain class status.

Additional Considerations:

- Classification societies may offer additional services during new vessel construction, such as advisory services on regulatory compliance, environmental impact assessments, and crew training programs.
- The specific procedures may vary slightly between classification societies, but the overall process of plan approval, construction surveillance, testing, and class certificate issuance remains consistent across the industry.

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7. With reference to condition monitoring:

(a) explain how vibration analysis can be used as part of a planned maintenance system; (7)

(b) list SIX tests that can be carried out on crankcase oil in order to determine its suitability for further service. (3)

Condition Monitoring Techniques

(a) Vibration Analysis in Planned Maintenance:

Vibration analysis is a valuable tool used in planned maintenance systems to monitor the health of machinery onboard a vessel or in industrial settings. Here's how it contributes to a planned maintenance approach:

- **Early Fault Detection:** Vibration analysis can detect incipient faults in rotating machinery components like bearings, gears, or shafts long before they develop into critical failures. Unusual vibration patterns can indicate wear, misalignment, or imbalance, allowing for corrective action before major breakdowns occur.
- **Improved Maintenance Scheduling:** By monitoring vibration trends over time, planned maintenance can be scheduled based on actual equipment condition rather than arbitrary time intervals. This prevents unnecessary maintenance on healthy components and prioritizes attention for equipment showing signs of deterioration.
- **Reduced Repair Costs:** Early detection of faults through vibration analysis allows for proactive maintenance interventions. This can minimize the severity of damages and reduce overall repair costs compared to letting faults progress to critical failure.
- **Enhanced Equipment Reliability:** By addressing potential problems early on, vibration analysis contributes to improved equipment reliability. This reduces the risk of unexpected machinery breakdowns and ensures operational continuity.

(b) Crankcase Oil Tests for Suitability:

Crankcase oil analysis is an essential component of planned maintenance for engines. Here are six common tests performed on crankcase oil to determine its suitability for further service:

1. **Viscosity:** This test measures the oil's resistance to flow at different temperatures. Used oil can thin out or thicken, losing its lubricating properties.
2. **Wear Metals:** The presence of increased levels of metal particles in the oil indicates wear and tear occurring within the engine. Identifying the specific metals can help pinpoint the source of the wear.
3. **Contamination:** Oil analysis checks for contaminants like water, fuel, or coolant in the oil. These contaminants can adversely affect lubrication and damage engine components.
4. **Total Base Number (TBN):** This test measures the oil's remaining alkaline reserve, which neutralizes acids produced during combustion. Depleted TBN indicates a loss of the oil's ability to neutralize acids and protect against corrosion.
5. **Oxidation:** Oil naturally oxidizes over time, thickening and losing its lubricating properties. Oil analysis tests for oxidation products to determine the oil's remaining service life.
6. **Nitration:** High nitration levels in the oil can indicate excessive combustion temperatures or incomplete combustion. This can lead to increased wear and formation of sludge in the engine.

By analyzing the results of these tests, maintenance personnel can determine if the crankcase oil is still suitable for further service or needs to be changed. This proactive approach helps maintain optimal engine performance and extend equipment life.

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8. With reference to vessel's survey requirements:

(a) state the possible consequences of either failing to obtain, or failing to renew a Statutory Certificate; (5)

(b) state what is meant by the *Harmonisation system of survey and certification*. (5)

Consequences of Failing Vessel Survey Requirements:

(a) Consequences of Failing Statutory Certificate:

Failing to obtain or renew a Statutory Certificate for a vessel can have severe consequences, impacting both safety and legal compliance. Here are some potential outcomes:

- **Detention:** Port State Control authorities may detain the vessel, preventing it from sailing until it obtains the necessary certificate. This can lead to significant delays, financial losses due to missed schedules, and reputational damage.
- **Fines:** The vessel owner or operator may face heavy fines imposed by maritime authorities for operating without a valid statutory certificate.
- **Insurance Issues:** Most marine insurance policies require vessels to maintain valid statutory certificates. Failure to do so may invalidate insurance coverage, leaving the owner liable for any accidents or incidents.
- **Safety Risks:** Operating a vessel without a valid statutory certificate indicates that it has not undergone required safety inspections. This increases the risk of accidents at sea, potentially endangering the crew, cargo, and the environment.

(b) Harmonisation System of Survey and Certification:

The Harmonisation system of survey and certification is an international effort to streamline and standardize maritime safety regulations across different countries. This system aims to:

- **Reduce Duplication:** By having standardized requirements for surveys and certificates, vessels can avoid multiple inspections when entering different ports. This saves time and costs for ship owners and operators.
- **Improve Safety:** Harmonization ensures that vessels meet a consistent level of safety standards regardless of the flag state (country of registration).
- **Facilitate International Trade:** Streamlined survey and certification procedures facilitate the movement of goods across borders without unnecessary delays due to inconsistent regulations.

The International Maritime Organization (IMO) plays a key role in promoting the Harmonisation system by developing and implementing international maritime regulations (IMRs) that are adopted by member states. Classification societies also contribute by developing class rules that often exceed minimum IMO requirements, further enhancing vessel safety.

By promoting harmonization, the maritime industry strikes a balance between regulatory efficiency and ensuring the safety of life at sea and protection of the marine environment.

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9. A vessel has bunkered 300 tonnes of diesel fuel. Given that the average combined sea power load of the vessel is 3000 kW and with a stated specific consumption of 0.35 kg/kWh, calculate EACH of the following:

(a) the daily fuel consumption of the vessel; (4)

(b) the safe steaming range of the vessel at a speed of 18 knots. (6)

Fuel Consumption and Steaming Range Calculations

We can calculate the daily fuel consumption and safe steaming range of the vessel based on the provided information.

(a) Daily Fuel Consumption:

1. **Convert kW to kWh (kilowatt-hours):** Since we're interested in daily consumption, we need to consider the total operating hours per day. A day has 24 hours, so:

   Total daily operating hours = 24 hours/day

2. **Calculate daily energy consumption:**

   Daily energy consumption (kWh) = Average combined sea power load (kW) × Daily operating hours (hours/day) Daily energy consumption = 3000 kW * 24 hours/day Daily energy consumption = 72000 kWh/day

3. **Calculate daily fuel consumption:**

   Daily fuel consumption (kg) = Daily energy consumption (kWh) × Specific consumption (kg/kWh) Daily fuel consumption = 72000 kWh/day × 0.35 kg/kWh Daily fuel consumption = 25200 kg/day

Therefore, the daily fuel consumption of the vessel is 25200 kg/day.

(b) Safe Steaming Range:

Important Note: Calculating the exact safe steaming range is complex and depends on various factors beyond just fuel consumption, such as weather conditions, sea state, and vessel efficiency at different speeds. Here, we can estimate a theoretical maximum range based on the following assumptions:

- All 300 tonnes of fuel (300,000 kg) are usable.
- There are no inefficiencies in fuel consumption.

1. **Convert tonnes of fuel to kilograms:**

   Usable fuel (kg) = Bunkered fuel (tonnes) × 1000 kg/tonne Usable fuel = 300 tonnes × 1000 kg/tonne Usable fuel = 300,000 kg

2. **Estimate safe steaming range:**

   Safe steaming range (days) = Usable fuel (kg) / Daily fuel consumption (kg/day) Safe steaming range = 300,000 kg / 25200 kg/day Safe steaming range ≈ 11.90 days (rounded to two decimal places)

Therefore, the safe steaming range of the vessel at a speed of 18 knots is approximately 11.90 days. This is a theoretical maximum, and the actual range may be lower in real-world conditions.

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10. Describe, with the aid of sketches, the difference between an obscuration type smoke detector and a light scatter type smoke detector. (10)

Both obscuration type and light scatter type smoke detectors are crucial components of fire alarm systems, but they function in slightly different ways to detect smoke particles.

1. Obscuration Type Smoke Detector:

- **Function:** This type of detector uses a light source (usually an LED) and a photoelectric sensor positioned in a chamber. In normal conditions, the light source freely reaches the sensor.
- **Smoke Detection:** When smoke enters the chamber, it obscures the light beam partially or completely. The photoelectric sensor detects this decrease in light intensity and triggers the alarm.
- **Applications:** Obscuration detectors are well-suited for detecting flaming fires that produce large, dense smoke particles. They are commonly used in residential and commercial buildings.

2. Light Scatter Type Smoke Detector:

- **Function:** This type also utilizes a light source and a photoelectric sensor. However, unlike the obscuration type, the sensor is positioned at an angle to the light source within a sealed chamber.
- **Smoke Detection:** In normal conditions, no light reaches the sensor in this configuration. When smoke particles enter the chamber, they scatter the light beam, causing some light to reach the sensor. This change in light detection triggers the alarm.
- **Applications:** Light scatter detectors are more sensitive to smaller smoke particles produced by smoldering fires, where flames may not be readily visible. They are often used in areas with potential electrical fires or slow-burning materials.

Here's a table summarizing the key differences:

Feature	Obscuration Type	Light Scatter Type
Light Source	Yes	Yes
Photoelectric Sensor	Yes	Yes
Smoke Detection Method	Obscures light beam	Scatters light beam
Ideal for Smoke Type	Large, dense smoke particles	Smaller smoke particles
Applications	Residential, Commercial	Electrical fires, Slow-burning