June 2021

1. Explain EACH of the following:

   (a) Merchant Shipping Notices; (4)

   (b) Marine Guidance Notes; (3)

   (c) Marine Information Notes. (3)

June 2021

2. List TEN common log entries, excluding machinery temperatures, pressures and other parameters. (10)

June 2021

3. (a) State THREE advantages of using condition monitoring as part of a planned maintenance system. (3)

   (b) State THREE examples of criteria that could be used as a basis for condition based maintenance. (3)

   (c) State FOUR reasons for keeping records of operating criteria and planned maintenance carried out. (4)

June 2021

4. With reference to Annex 1 of the MARPOL convention, state EACH of the following:

   (a) the appropriate system to be fitted on a vessel 400GRT or above; (4)

   (b) the documentation required, explaining why it is required; (2)

   (c) the information to be recorded when pumping bilges overboard through an oil water separator. (4)

June 2021

5. List FIVE precautions to be observed before taking on bunkers, stating a reason for EACH precaution. (10)

June 2021

6. (a) State the THREE main stages of a Biological Sewage Treatment Plant. (3)

(b) Describe the operation of a Biological Sewage Treatment Plant, explaining the process carried out in EACH of the stages stated in part (a). (7)

June 2021

7. (a) State THREE functions of air conditioning. (3)

(b) With referance to air conditioning, explain EACH of the following:

(i) absolute humidity; (2)

(ii) relative humidity; (2)

(iii) dew point. (3)

June 2021

8. Describe, with the aid of a sketch, the construction of a spirally wound membrane suitable for use in a Reverse Osmosis water making plant, identifying ALL component parts. (10)

June 2021

9. Describe, with the aid of a sketch, the construction and operation of a *thermistor* type rate of rise heat detector. (10)

June 2021

10. With reference to a vessel's structure, explain the meaning of EACH of the following terms:

(a) beam; (2)

(b) frame; (2)

(c) girder; (2)

(d) beam knee; (2)

(e) stringer. (2)

June 2021

1. Explain EACH of the following:

(a) Merchant Shipping Notices; (4)

(b) Marine Guidance Notes; (3)

(c) Marine Information Notes. (3)

These terms refer to different categories of information distributed by maritime authorities, typically the UK Maritime and Coastguard Agency (MCA), to provide guidance and regulations for the shipping industry. Here's a breakdown of each:

(a) Merchant Shipping Notices (MSNs):

- **Function:** MSNs are legally binding documents that convey mandatory information related to UK merchant shipping legislation.
- **Content:** They typically contain details of new or revised Statutory Instruments (SIs) that regulate various aspects of ship operation, safety, pollution prevention, and crew welfare.
- **Target Audience:** Primarily aimed at ship owners, operators, and masters of merchant vessels.

- **Compliance:** Following the regulations outlined in MSNs is mandatory for all ships operating under the UK flag or within UK territorial waters.

(b) Marine Guidance Notes (MGNs):

- **Function:** MGNs offer non-mandatory advice and best practices to the shipping industry on various topics related to safety, pollution prevention, and efficient ship operation.
- **Content:** They provide detailed guidance on interpreting regulations outlined in MSNs and SIs, recommend safe working practices, and offer advice on how to comply with international maritime regulations (e.g., IMO regulations).
- **Target Audience:** Similar to MSNs, MGNs are primarily directed towards ship owners, operators, and masters. However, they may also be useful for crew members, naval architects, and maritime training institutions.
- **Compliance:** While not mandatory, following the recommendations in MGNs demonstrates a commitment to best practices and can be used as evidence of due diligence in case of an incident.

(c) Marine Information Notes (MINs):

- **Function:** MINs provide short-term, time-sensitive information relevant to the shipping industry.
- **Content:** They might contain details on upcoming regulatory changes, announcements of training courses, information on new safety equipment, or temporary notices related to navigational hazards or port restrictions.
- **Target Audience:** Similar to MSNs and MGNs, MINs are directed towards ship owners, operators, and masters. However, specific information may be relevant to certain crew members or departments onboard.
- **Action:** The information in MINs typically requires some form of action from the recipient, such as attending a training course, updating navigational charts, or implementing new safety procedures. Due to their time-sensitive nature, MINs usually have a cancellation date specified.

June 2021

2. List TEN common log entries, excluding machinery temperatures, pressures and other parameters. (10)

Here are ten common log entries, excluding machinery parameters:

1. **Commencement/Relief of Watch:** "0800hrs: Relieved OOW [Name] on watch. All navigation lights functioning normally. Course [Course in degrees] at [Speed] knots. ETA [Estimated Time of Arrival] for [Port name] unchanged."
2. **Course Alteration:** "1200hrs: Altered course to [New course in degrees] due to [Reason, e.g., approaching traffic, waypoint on route]."
3. **Weather Observation:** "1600hrs: Weather observation: Wind [Direction] [Force on Beaufort scale], visibility [Nautical miles], Sea state [Sea state description]."
4. **Navigation Mark Sighted:** "1800hrs: Sighted [Navigation mark name] abeam to starboard at [Distance] nautical miles."
5. **Cargo Operation Update:** "0000hrs (Next day): Cargo hold No. [Number] hatch closed. Secured for sea."
6. **Safety Drill:** "0900hrs: Abandon ship drill conducted. All crew members mustered at lifeboat stations within [Time] minutes."

7. **Medical Treatment:** "1400hrs: Crew member [Name] reported feeling unwell. Treated for [Minor illness] with [Medication]."
8. **Equipment Malfunction:** "1000hrs: Auto-pilot malfunction detected. Switched to manual steering."
9. **Wildlife Sighting:** "1500hrs: Observed pod of dolphins [Number] off the port bow at approximately [Distance] nautical miles."
10. **Communication Received:** "2000hrs: Received navigational warning regarding [Navigation hazard, e.g., debris field] at position [Coordinates]."

Here are ten common log entries, excluding machinery parameters:

1. **Commencement/Relief of Watch:** "0800hrs: Relieved [Name of Engineer] on watch. All auxiliary machinery running normally. Sea state [Sea state description]."
2. **Commencing/Completing Maintenance:** "1000hrs: Commenced routine maintenance on main engine air filters. Completed at 1100hrs."
3. **Cargo Operation Update:** "1400hrs: Cargo hold No. 2 discharging operations commenced."
4. **Safety Drill:** "1500hrs: Fire drill conducted. All crew members mustered at designated stations within [Time] minutes."
5. **Medical Treatment:** "1600hrs: Crew member [Name] reported feeling unwell. Treated for [Minor illness] with [Medication]."
6. **Equipment Malfunction:** "1800hrs: Auxiliary generator [Number] alarm activated for [Reason, e.g., low oil pressure]. Switched to standby generator."
7. **Navigation Mark Sighted:** "2000hrs: Sighted lighthouse [Name] on bearing [Direction] at approximately [Distance] nautical miles."
8. **Course Alteration:** "0000hrs (Next day): Altered course to [New course in degrees] to avoid approaching traffic."
9. **Weather Observation:** "0400hrs: Weather observation: Wind [Direction] [Force on Beaufort scale], visibility [Nautical miles], Sea state [Sea state description]."
10. **Communication Received:** "0600hrs: Received weather warning regarding [Navigation hazard, e.g., storm] approaching from [Direction] at an estimated distance of [Distance] nautical miles."

June 2021

3. (a) State THREE advantages of using condition monitoring as part of a planned maintenance system. (3)

(b) State THREE examples of criteria that could be used as a basis for condition based maintenance. (3)

(c) State FOUR reasons for keeping records of operating criteria and planned maintenance carried out. (4)

(a) Advantages of Condition Monitoring in Planned Maintenance:

1. **Predictive Maintenance:** Condition monitoring allows for a shift from reactive maintenance (fixing problems after breakdowns) to predictive maintenance. By monitoring equipment health in real-time, potential issues can be identified and addressed before they lead to failures. This minimizes downtime, maintenance costs, and the risk of catastrophic equipment failures.

2. **Optimized Maintenance Schedules:** Condition monitoring data provides valuable insights into equipment health, allowing for more targeted maintenance schedules. Tasks can be prioritized based on actual sensor readings and performance indicators instead of relying solely on arbitrary time intervals. This optimizes resource allocation and ensures maintenance is performed when truly necessary.

3. **Improved Equipment Lifespan:** Early detection and correction of minor problems through condition monitoring prevent them from escalating into major issues. This proactive approach promotes better equipment health and extends the operational lifespan of machinery.

(b) Criteria for Condition-Based Maintenance:

1. **Vibration Analysis:** Excessive vibration often indicates developing problems like bearing wear, rotor imbalance, or misalignment. Monitoring vibration levels and trends can trigger maintenance actions before breakdowns occur.

2. **Oil Analysis:** Periodic oil sampling and analysis can reveal signs of wear and tear within machinery. The presence of metal particles, excessive water content, or abnormal viscosity can indicate potential issues requiring investigation.

3. **Temperature Monitoring:** Deviations from normal operating temperatures can point towards malfunctions. Engine coolant temperature, bearing temperatures, or electrical component temperatures can be monitored to identify potential problems like overheating, blocked cooling passages, or increased friction.

(c) Reasons for Keeping Records of Operating Criteria and Maintenance:

1. **Trending and Analysis:** Maintaining historical records of operating data and maintenance performed allows for trend analysis. By studying past trends in vibration data, oil analysis results, or fuel consumption figures, engineers can identify potential issues early on and develop preventive maintenance strategies.

2. **Decision-Making:** Records provide a data-driven basis for informed decision-making regarding future maintenance needs and resource allocation. This includes:

    - Evaluating the cost-effectiveness of different maintenance approaches.
    - Prioritizing maintenance tasks based on urgency and potential impact.
    - Budgeting for future maintenance requirements based on past trends.
3. **Regulatory Compliance:** Many maritime regulations require documented maintenance plans and records. These records demonstrate adherence to:

    - Safety standards for machinery operation and equipment performance.
    - Environmental regulations regarding waste disposal and pollution prevention (e.g., used oil management practices).
4. **Knowledge Transfer:** Well-maintained records facilitate knowledge transfer between engineers and maintenance personnel. They provide:

    - Information on past repairs and solutions for recurring problems.
    - Training opportunities for new crew members on equipment history, maintenance procedures, and interpreting condition monitoring data.

- Documentation of best practices for future reference, ensuring continuity and improved maintenance practices across personnel changes.

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June 2021

4. With reference to Annex 1 of the MARPOL convention, state EACH of the following:

(a) the appropriate system to be fitted on a vessel 400GRT or above; (4)

(b) the documentation required, explaining why it is required; (2)

(c) the information to be recorded when pumping bilges overboard through an oil water separator. (4)

MARPOL Annex I and Bilge Water Management

(a) Required System for Vessels 400 GRT or Above:

According to MARPOL Annex I, vessels of 400 gross tonnage (GRT) and above must be equipped with an **Oily Water Separator (OWS)**. This is a treatment system designed to separate oil from bilge water and oily residues generated onboard the ship. The OWS removes oil contaminants from the bilge water, allowing the treated water to be discharged overboard within the regulatory limits set by MARPOL.

(b) Required Documentation: Oil Record Book (ORB)

Every vessel required to have an OWS must also maintain an **Oil Record Book (ORB)**. This is an official document mandated by MARPOL and serves as a record-keeping system for all operations involving oily mixtures onboard.

Reasons for Requiring an ORB:

- **Transparency:** The ORB acts as a transparent record, allowing authorities to verify compliance with MARPOL regulations regarding oily waste management.
- **Monitoring:** Regular entries in the ORB enable crew members to monitor oil discharges and identify any potential issues with the OWS or bilge water handling procedures.
- **Evidence:** The ORB can serve as evidence in case of any investigations or disputes related to oily waste management practices onboard.

(c) Information Recorded During Bilge Overboard Discharge with OWS:

When pumping bilge water overboard through an OWS, the following information must be recorded in the Oil Record Book:

- **Date and Time:** The date and time when bilge water pumping and overboard discharge commenced and finished.
- **Position of the Ship:** The geographical position of the ship (latitude and longitude) at the time of discharge.
- **Quantity Discharged:** The estimated or measured quantity of bilge water discharged overboard.
- **Operational Condition:** The operational condition of the vessel at the time of discharge (e.g., en route, maneuvering, at anchor).

- **Condition of the OWS:** A brief notation regarding the operational status of the OWS before and after discharge. This may include readings from the Oil Content Monitor (OCM) or any observations about the separator's performance.

By maintaining accurate and detailed records in the ORB, ship operators can demonstrate responsible bilge water management practices and ensure compliance with MARPOL regulations.

June 2021

5. List FIVE precautions to be observed before taking on bunkers, stating a reason for EACH precaution. (10)

Here are five precautions to be observed before taking on bunkers, along with the reason for each precaution:

1. **Review Bunker Delivery Note (BDN) and Analyze Fuel Certificate:**
- **Reason:** This ensures the fuel being delivered matches the specifications ordered (e.g., grade, sulfur content, viscosity). Mismatched fuel can have detrimental effects on engine performance and compliance with emission regulations.
2. **Physically Inspect Bunkering Manifolds and Hoses:**
- **Reason:** To identify any visible leaks, damage, or worn-out components. Using faulty hoses or connections increases the risk of spills during bunkering.
3. **Verify Vessel's Bunkering Tanks Capacity and Ullage:**
- **Reason:** Prevents overfilling of tanks, which can lead to overflows and environmental pollution. Ullage refers to the empty space remaining in a tank, ensuring sufficient capacity for the planned bunker quantity.
4. **Double-Check Bunkering Procedures and Communication Protocols:**
- **Reason:** Clear communication between vessel crew and bunker supplier personnel minimizes misunderstandings and ensures a smooth, safe bunkering operation. This includes confirming hose connections, agreed flow rates, and emergency shutdown procedures.
5. **Ensure All Necessary Personnel are Briefed and PPE is Worn:**
- **Reason:** Proper briefing on safety protocols and usage of Personal Protective Equipment (PPE) like gloves, safety glasses, and respirators protects personnel from potential hazards during bunkering, such as fuel spills or exposure to fumes.

June 2021

6. (a) State the THREE main stages of a Biological Sewage Treatment Plant. (3)

(b) Describe the operation of a Biological Sewage Treatment Plant, explaining the process carried out in EACH of the stages stated in part (a). (7)

Biological Sewage Treatment Plant: Stages and Processes

(a) Three Main Stages:

A Biological Sewage Treatment Plant utilizes a three-stage process for efficient wastewater treatment:

1. **Primary Treatment (Physical Separation)**
2. **Secondary Treatment (Biological Treatment)**
3. **Tertiary Treatment (Disinfection)** (Optional)

(b) Description of Each Stage:

(1) Primary Treatment (Physical Separation):

- **Function:** Removes large solids and suspended materials from the incoming sewage through physical processes.
- **Process:**
    - **Screening:** Large objects like rags, plastics, and debris are removed using screens with varying bar spacing.
    - **Comminution:** Remaining solids are shredded or ground into smaller particles using grinders (comminutors) to facilitate further processing.
    - **Settling:** The screened/comminuted wastewater flows into a primary clarifier tank. Here, heavier solids settle at the bottom due to gravity (forming primary sludge), while lighter organic matter and water remain in the supernatant. The supernatant then moves on to the next stage.
    - **Sludge Removal:** Settled primary sludge is periodically removed for further treatment or disposal.

(2) Secondary Treatment (Biological Treatment):

- **Function:** Employs aerobic microorganisms to break down organic matter remaining in the wastewater.
- **Process:**
    - **Aeration Tank:** The primary-treated wastewater enters the aeration tank, where:
        - **Air is continuously bubbled** through diffusers, maintaining a dissolved oxygen supply.
        - **Aerobic bacteria** present in abundance feed on the organic matter, breaking it down into simpler compounds.
        - The process promotes the growth of microorganisms, which form flocs (clumps) that aid in separation.
    - **Mixing:** The air bubbles also help mix the wastewater, ensuring all parts come into contact with the microorganisms for optimal treatment.

(3) Tertiary Treatment (Disinfection) (Optional):

- **Function:** Reduces or eliminates harmful bacteria and viruses present in the treated wastewater before discharge. (Not all plants have this stage)
- **Process:**
    - **Disinfection Methods:**
        - **Chlorination:** Calcium hypochlorite (bleach powder) is commonly used, releasing chlorine that inactivates pathogens.
        - **Ultraviolet (UV) Radiation:** Another method utilizes UV light to kill or inactivate microorganisms.
    - **Effluent Discharge:** The disinfected wastewater (effluent) undergoes final quality checks and is then discharged overboard, meeting the required environmental standards.

June 2021

7. (a) State THREE functions of air conditioning. (3)

(b) With referance to air conditioning, explain EACH of the following:

(i) absolute humidity; (2)

(ii) relative humidity; (2)

(iii) dew point. (3)

Air Conditioning and Humidity

(a) Three Functions of Air Conditioning:

Air conditioning systems provide comfort and improve indoor air quality by performing three main functions:

1. **Temperature Control:** Air conditioners remove heat from the indoor air, lowering the temperature to a desired level set by the user. This creates a cooler and more comfortable environment.

2. **Humidity Control:** Many air conditioning systems also control humidity by removing moisture from the air during the cooling process. This dehumidification helps prevent excessive moisture buildup, which can lead to sweating, discomfort, and mold growth.

3. **Air Circulation:** Air conditioners circulate air throughout the room, ensuring even distribution of cool air and preventing hot and cold spots. This promotes a more comfortable and consistent temperature within the space.

(b) Air Conditioning and Humidity Concepts:

(i) Absolute Humidity:

- **Definition:** Absolute humidity refers to the **total amount of water vapor present in a given volume of air**, regardless of temperature.
- **Units:** It is typically measured in grams of water vapor per cubic meter of air (g/m^3) or grains of water vapor per pound of dry air (gr/lb).
- **Air Conditioning:** Air conditioners don't directly control absolute humidity. However, by lowering the air temperature, they can affect how much moisture the air can hold (explained in relative humidity).

(ii) Relative Humidity:

- **Definition:** Relative humidity (RH) is a measure of how much **moisture the air currently holds compared to its maximum capacity** at a specific temperature.
- **Units:** It is expressed as a percentage (%).
- **Air Conditioning:** Air conditioning reduces air temperature. Colder air has a lower capacity to hold moisture. As the air cools in an air conditioner, the relative humidity increases. If the RH becomes too high, the air feels muggy and uncomfortable. To address this, some air conditioning systems have

dehumidification features that further reduce moisture content and maintain a comfortable relative humidity level.

(iii) Dew Point:

- **Definition:** Dew point is the temperature at which the air becomes saturated with moisture (100% relative humidity). If the air temperature cools down to the dew point, water vapor condenses into visible water droplets, forming dew or fog.
- **Air Conditioning:** Air conditioners lower the air temperature. As the air cools down, it approaches its dew point. By monitoring the dew point, air conditioning systems can regulate dehumidification to prevent condensation on surfaces within the conditioned space. This helps prevent moisture damage and mold growth.

In summary:

- Absolute humidity indicates the total moisture content in the air.
- Relative humidity indicates how close the air is to saturation at a given temperature.
- Dew point is the temperature at which condensation occurs.

Air conditioners influence both relative humidity and dew point by manipulating air temperature. This allows them to create a comfortable and controlled environment.

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June 2021

8. Describe, with the aid of a sketch, the construction of a spirally wound membrane suitable for use in a Reverse Osmosis water making plant, identifying ALL component parts. (10)

Anatomy of a Spiral Wound Membrane for Reverse Osmosis

A spiral wound membrane is the heart of a reverse osmosis (RO) system, responsible for separating pure water from dissolved contaminants. Here's a breakdown of its construction:

Components:

1. **Permeate Spacer (Permeator):** This is a mesh-like structure placed on the feed water side of the membrane. Its function is multifold:
    - **Create a channel:** It creates a defined channel for the feed water to flow along the membrane surface.
    - **Promote turbulence:** The mesh disrupts the formation of a stagnant layer of concentrated brine solution next to the membrane, improving mass transfer and efficiency.
    - **Support the membrane:** It provides structural support to the thin membrane layer, preventing collapsing under pressure.
2. **Feed Channel (Feed Spacer):** This is another spacer located between the permeate spacer and the membrane. It helps maintain a consistent distance between the membrane and the permeate spacer, ensuring proper flow and preventing the membrane from collapsing.
3. **Semi-permeable Membrane:** This is the core of the assembly, typically made from a thin layer of polyamide (e.g., Nylon-6) or other selective polymers. It has a microporous structure that allows water molecules to pass through while rejecting most dissolved ions and larger molecules.

4. **Backing Material:** This non-permeable layer supports the thin membrane film from the high-pressure feed water on the other side. It's typically made from a strong and chemically resistant material like polyester or polysulfone.

5. **Feed Spacer Carrier:** This is a perforated tube that houses the permeate spacer and feed channel. It allows the feed water to flow into the permeate spacer channel and provides structural support for the entire assembly.

6. **Brine Channel Collector:** This is a channel on the other side of the membrane where the concentrated brine solution (reject stream) containing the filtered-out contaminants accumulates.

Construction Process:

1. The permeate spacer and feed channel are often pre-assembled.
2. The flat sheet membrane is then laminated onto the backing material.
3. The entire assembly is then wrapped around a perforated central core, forming a spiral configuration. This maximizes the membrane surface area within the pressure vessel housing the modules.
4. The edges of the membrane are sealed to prevent leakage.

Benefits of Spiral Wound Design:

- High packing density: The spiral design allows for a large membrane surface area within a compact module, maximizing water production capacity.
- Efficient flow: The spacers promote even flow distribution across the membrane surface, improving mass transfer and system performance.
- Cost-effective: The modular design allows for easy replacement of individual modules if needed.

Overall, the spiral wound membrane's construction combines selective permeability with efficient flow dynamics, making it a key component for reverse osmosis water purification.

e 2021

June 2021

9. Describe, with the aid of a sketch, the construction and operation of a *thermistor* type rate of rise heat detector. (10)

Thermistor Rate of Rise Heat Detector: Construction and Operation

A thermistor type rate of rise heat detector utilizes the **temperature-dependent resistance** of a thermistor (Thermally Sensitive Resistor) to detect rapid increases in temperature, indicating a potential fire. Here's a breakdown of its construction and operation:

Construction:

- **Thermistor:** The core component is a thermistor, a small, bead-shaped semiconductor device with a high resistance that decreases significantly as the temperature rises.
- **Circuit Board:** The thermistor is integrated into an electronic circuit board.
- **Voltage Source:** The circuit is powered by a constant voltage source, typically a battery.
- **Comparator:** The circuit includes a comparator, an electronic component that compares two voltage inputs.

- **Fixed Resistor:** A fixed resistor with a known resistance value is also part of the circuit, creating a voltage divider with the thermistor.
- **Alarm Mechanism:** The circuit is connected to an alarm mechanism, such as a buzzer or flashing light.

Operation:

1. **Normal Conditions:** When the ambient temperature is stable, the thermistor's resistance remains high. This results in a specific voltage drop across the thermistor in the voltage divider circuit. This voltage is fed to one input of the comparator.
2. **Temperature Rise:** If a fire starts, the temperature surrounding the detector increases rapidly.
3. **Thermistor Resistance Decrease:** As the temperature rises, the thermistor's resistance decreases significantly. This alters the voltage drop across the thermistor in the voltage divider circuit.
4. **Comparator Trigger:** The voltage change at the thermistor is compared to a fixed reference voltage (set by the comparator) at the other input. When the temperature rise is rapid enough to cause the voltage drop across the thermistor to fall below the reference voltage, the comparator triggers.
5. **Alarm Activation:** The comparator's output signal activates the alarm mechanism, typically a loud buzzer or flashing light, alerting occupants to a potential fire.

Key Points:

- **Rate of Rise Detection:** These detectors are designed to be more sensitive to rapid temperature increases rather than absolute temperature. This helps to distinguish between a gradual rise in ambient temperature (e.g., due to heating system) and a sudden increase indicative of a fire.
- **Sensitivity Adjustment:** Some detectors offer sensitivity adjustments to match the specific environment.
- **Simple Design:** Compared to more complex fire detection systems, thermistor rate of rise detectors are relatively simple and cost-effective.

Limitations:

- **Limited Area Coverage:** These detectors typically have a limited detection range. Multiple detectors are needed to cover a large area effectively.
- **Susceptibility to Dust:** Dust buildup on the thermistor can affect its sensitivity and require regular cleaning.
- **False Alarms:** Sudden, non-fire-related temperature changes (e.g., steam release) might trigger false alarms.

Thermistor rate of rise heat detectors offer a reliable and cost-effective solution for early fire detection in various applications, particularly in residential and commercial buildings. Their focus on rapid temperature rise helps to minimize false alarms due to gradual temperature changes. However, proper placement, regular maintenance, and potential limitations should be considered for optimal fire safety.

June 2021

10. With reference to a vessel's structure, explain the meaning of EACH of the following terms:

(a) beam; (2)

(b) frame; (2)

(c) girder; (2)

(d) beam knee; (2)

(e) stringer. (2)

Ship's Structural Components:

Here's a breakdown of the key structural components of a vessel:

(a) **Beam:** The beam refers to a horizontal transverse structural member that supports the decks and bulkheads. It spans across the width of the vessel, providing lateral strength and rigidity to the hull. Beams are typically made of steel and can be various shapes depending on the vessel's size and design.

(b) **Frame:** Frames are vertical members that run transversely (across the width) of the vessel, forming the ribs of the hull. They are connected to the keel and the deck beams, providing longitudinal strength and shaping the vessel's hull. Frames are typically made of steel profiles like flanged plates or angles.

(c) **Girder:** A girder is a longitudinal (fore-and-aft) structural member that provides increased strength and stiffness in areas of high stress concentration. Girders can be located at the deck level (deck girders), along the bottom of the vessel (keel girder), or vertically (bulkhead stiffeners). They are often larger and more robust than regular beams or frames.

(d) **Beam Knee:** A beam knee is a bracket-shaped reinforcement used at the connection point between a beam and a frame. It provides additional support and distributes the load more evenly between the two members. Beam knees are particularly important in areas where the beams experience high bending forces.

(e) **Stringer:** Stringers are longitudinal structural members attached to the side shell plating (the outer hull plating) of the vessel. They can be located on the inside or outside of the plating and help to reinforce it against longitudinal bending and buckling forces. Stringers can be made from various materials like steel bars, sections, or extruded profiles.