Feb 2021

1. With reference to routine inspections of machinery located in remote unmanned spaces:

   (a) state FOUR precautions that should be taken to ensure the safety of personel; (4)

   (b) state FOUR notices that should be posted at the entrance of unmanned machinery spaces; (4)

   (c) define the meaning of the term *Machinery Space*. (2)

Feb 2021

2. With reference to the engine room log book:

   (a) state THREE reasons for keeping such a log book; (6)

   (b) state EACH of the following:

      (i) the person responsible for its compilation; (1)

      (ii) the interval at which it should be written up and signed; (1)

      (iii) the procedure to be followed if a correction of entry is required; (1)

      (iv) the purpose of recording a general abstract for main and auxiliary engines. (1)

Feb 2021

3. With reference to the engine log books, explain the reasons for recording EACH of the following, stating a possible cause should the readings be outside the normal parameters:

   (a) LO Sump level; (4)

   (b) cooling water inlet temperature; (3)

   (c) inlet manifold air pressure; (3)

Feb 2021

4. Describe, with the aid of a sketch, a single stage static Oily Water Separator designed to meet MARPOL Annex I requirements. (10)

Feb 2021

5. (a) With reference to sewage treatment systems, explain EACH of the following terms:

(i) aerobic; (2)

(ii) anaerobic. (2)

(b) Sketch a Biological Sewage Treatment Plant, labelling the MAIN compartments and indicating the direction of flow through the plant. (6)

Feb 2021

6. (a) Sketch a thermostatically controlled expansion valve for a vapour compression refrigeration system, labelling all components. (5)

(b) Describe the operation of the valve sketched in part (a). (5)

Feb 2021

7. (a) Describe, with the aid of a sketch, the operation of the silver ion method of water sterilisation. (6)

(b) Describe how Ultra Violet Light can be used to kill bacteria in potable water. (2)

(c) Explain the disadvantages of using Ultra Violet Light as a method of sterilisation, stating how this may be overcome. (2)

Feb 2021

8. (a) Describe, with the aid of a sketch, the method of attachment of a Bilge Keel to a vessel's hull, explaining the reason for the longitudinal position of the bilge keel, relative to the hull. (7)

(b) State the advantages and disadvantages of fitting a bilge keel compared with other methods of stabilisation. (3)

29 January 2021

9. (a) Define EACH of the following:

   (i) Flash Point; (2)

   (ii) Ignition Point (2)

   (iii) Auto Ignition Temperature. (2)

   (b) Explain the requirements for the discharge of CO_2 of a machinery space fixed firefighting installation with regard to volume and time. (4)

Feb 2021

10. (a) Explain the meaning of EACH of the following terms:

   (i) camber; (2)

   (ii) sheer. (2)

   (b) Describe how EACH of the terms explained in part (a) improve seaworthiness. (6)

Feb 2021

1. With reference to routine inspections of machinery located in remote unmanned spaces:

   (a) state FOUR precautions that should be taken to ensure the safety of personel; (4)

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   (c) define the meaning of the term *Machinery Space*. (2)

Safeguarding Personnel in Machinery Spaces:

(a) Precautions for Personnel Safety:

1. **Permit to Work System:** Implement a formal permit system for all work within the machinery space. This ensures a risk assessment is conducted, outlining procedures, ventilation requirements, and emergency protocols for specific tasks.

2. **Lockout/Tagout Procedures:** Enforce lockout/tagout procedures to isolate equipment from energy sources (electrical, mechanical, hydraulic) before any maintenance work begins. This prevents accidental startup and potential injuries.

3. **Personal Protective Equipment (PPE):** Workers must wear appropriate PPE based on the specific tasks and identified hazards. This could include safety glasses, gloves, ear protection, respirators, and fire-resistant clothing depending on the situation.

4. **Adequate Ventilation:** Maintain proper ventilation within the machinery space to remove heat, fumes, and hazardous gases. This can be achieved through natural ventilation or by using mechanical ventilation systems.

(b) Notices for Unmanned Machinery Spaces:

1. **"Unmanned Machinery Space - Entry Prohibited":** Clearly mark the entrance to indicate the space is unmanned and access is restricted.

2. **"Warning - Potential Hazards":** List potential hazards within the space, such as high temperatures, moving machinery, or flammable materials.

3. **"Emergency Contact Procedures":** Provide clear instructions on who to contact and how to raise an alarm in case of an emergency.

4. **"Ventilation Status":** Indicate the ventilation status of the space (operating, not operating, under maintenance).

(c) Definition of Machinery Space:

A machinery space is a designated compartment onboard a ship that houses the main propulsion engine(s), auxiliary engines, boilers, generators, pumps, and other essential machinery for the vessel's operation. Access

to these spaces may be restricted due to the presence of moving machinery, electrical hazards, high temperatures, or potentially hazardous atmospheres.

2021

Feb 2021

2. With reference to the engine room log book:

(a) state THREE reasons for keeping such a log book; (6)

(b) state EACH of the following:

(i) the person responsible for its compilation; (1)

(ii) the interval at which it should be written up and signed; (1)

(iii) the procedure to be followed if a correction of entry is required; (1)

(iv) the purpose of recording a general abstract for main and auxiliary engines. (1)

Engine Room Log Book: Importance and Procedures

(a) Three Reasons for Keeping an Engine Room Log Book:

1. **Monitoring and Performance Analysis:** The log book serves as a historical record of engine performance, including parameters like temperatures, pressures, running hours, and fuel consumption. This data allows engineers to:
    - Monitor trends and identify potential issues before they escalate into major problems.
    - Analyze engine performance over time and identify opportunities for efficiency improvements.
2. **Regulatory Compliance:** Many maritime regulations require the recording of specific engine room data in the log book. This includes details like fuel oil bunkering, lubricating oil changes, and machinery maintenance activities. A well-maintained log book demonstrates adherence to regulatory requirements.
3. **Communication and Handover:** The log book facilitates communication between engineers on different watches. Important information regarding equipment status, recent events, and ongoing maintenance can be documented and readily accessed by personnel taking over the next watch.

(b) Engine Room Log Book Procedures:

(i) Person Responsible: The **engineer on watch (EOOW)** is typically responsible for compiling the engine room log book.

(ii) Writing and Signing: Entries should be made **as soon as possible** after the event, observation, or action being recorded. Ideally: * Entries are made at the **end of each watch period** or as significant events occur during the watch.

(iii) Correction Procedure: Mistakes should be corrected promptly to maintain the integrity of the record. Here's how:

* **Do not erase or use white-out:** This can be seen as an attempt to tamper with the record.
* **Draw a single line through the mistake.**
* **Write the correct information neatly above the line.**
* **Initial and date the correction** next to the line to indicate who made the change and when.

(iv) Purpose of General Abstract: The general abstract for main and auxiliary engines provides a **concise summary of the engine's overall operating condition**. This includes key parameters like:

* Running hours
* Fuel consumption
* Any abnormal events or observations
* Maintenance tasks performed

This summary allows for a quick overview of the engine's performance during a specific timeframe and facilitates handover between engineers on different watches.

b 2021

Feb 2021

3. With reference to the engine log books, explain the reasons for recording EACH of the following, stating a possible cause should the readings be outside the normal parameters:

(a) LO Sump level; (4)

(b) cooling water inlet temperature; (3)

(c) inlet manifold air pressure; (3)

Engine Log Book Entries and Their Importance:

Engine log books play a vital role in monitoring engine health and identifying potential problems early on. Here's why each specific parameter is recorded and a possible cause if the readings fall outside the normal range:

(a) LO (Lubricating Oil) Sump Level:

Reason for Recording: The LO sump level is crucial for proper engine lubrication. Recording it regularly allows for:

- **Monitoring Oil Consumption:** A gradual decrease might indicate oil consumption through burning or leaks.
- **Maintaining Adequate Lubrication:** An excessively low level could lead to insufficient lubrication and potential engine damage due to friction.
- **Preventing Overfilling:** An excessively high level can cause foaming, reduced oil pressure, and potential seal damage.

Possible Cause if Outside Normal Range:

- **Low Level:** Oil leaks, worn piston rings, excessive oil burning.
- **High Level:** Overfilling during oil change, fuel dilution due to injector issues.

(b) Cooling Water Inlet Temperature:

Reason for Recording: Engine coolant temperature needs to be maintained within a specific range for optimal performance and to prevent overheating. Recording it helps to:

- **Ensure Proper Engine Cooling:** An excessively high temperature indicates insufficient cooling or potential issues with the cooling system (e.g., blocked passages, malfunctioning pump, thermostat failure).
- **Prevent Engine Damage:** Overheating can lead to warping of engine components, seized pistons, and even engine failure.

Possible Cause if Outside Normal Range:

- **High Temperature:** Low coolant level, blocked radiator or heat exchanger, faulty water pump, malfunctioning thermostat.
- **Low Temperature:** Stuck-open thermostat (rare).

(c) Inlet Manifold Air Pressure:

Reason for Recording: The air pressure entering the engine's intake manifold is essential for optimal combustion. Recording it helps to:

- **Monitor Engine Performance:** Proper air pressure ensures efficient fuel burn and engine power output.
- **Identify Airflow Issues:** Deviations from the normal range could indicate problems with the air intake system.

Possible Cause if Outside Normal Range:

- **Low Pressure:** Air leaks in the intake system, clogged air filter, malfunctioning turbocharger (if applicable).
- **High Pressure:** Restricted exhaust system (rare).

By diligently recording and monitoring these key engine parameters, engineers can identify potential problems early on, take corrective actions, and prevent major engine failures or performance issues.

2021

Feb 2021

4. Describe, with the aid of a sketch, a single stage static Oily Water Separator designed to meet MARPOL Annex I requirements. (10)

Single-Stage Static Oily Water Separator (OWS) for MARPOL Compliance

A single-stage static OWS designed to meet MARPOL Annex I requirements is a gravity-based separator that separates oil from bilge water and oily residues generated onboard a ship. Here's a breakdown of its key components and operation:

Components:

- **Coalescing Plates:** These are corrugated plates or tubes installed within the separator. Their purpose is to:
    - Increase the surface area for oil droplet contact, promoting coalescence (merging of small oil droplets into larger ones).
    - Facilitate oil droplet separation from the water due to the difference in density (oil floats on water).
- **Weir Plates:** These are strategically placed baffles that:
    - Direct the flow of bilge water upwards within the separator.
    - Help maintain a specific oil layer thickness at the top of the separator.
- **Oil Overflow Pipe:** This pipe allows the separated oil to accumulate at the top of the separator and be skimmed off periodically for proper disposal.
- **Treated Water Outlet:** This is the outlet at the bottom of the separator from where the treated bilge water (water with minimal oil content) exits the unit.
- **Level Sensors:** Sensors monitor the levels of both oil and water within the separator.

Operation:

1. **Bilge Water Inlet:** Bilge water containing oil is pumped into the separator.
2. **Gravity Separation:** Due to the difference in density, oil droplets rise to the top, while the denser water sinks towards the bottom.
3. **Coalescing Plates:** As bilge water flows through the coalescing plates, oil droplets come into contact with the increased surface area and merge into larger oil globules, accelerating separation.
4. **Weir Plates:** The weir plates ensure a specific oil layer thickness is maintained at the top and prevent oil from prematurely exiting with the treated water.
5. **Oil Skimming:** The accumulated oil layer at the top is periodically skimmed off through the overflow pipe for collection and disposal according to MARPOL regulations.
6. **Treated Water Discharge:** The treated bilge water with minimal oil content exits the separator through the treated water outlet. Level sensors monitor the water level and may trigger an alarm if it reaches a predefined limit, indicating the need for discharge or further processing.

MARPOL Compliance:

To meet MARPOL Annex I requirements, the OWS must be approved by an authorized classification society and demonstrate its ability to achieve a treated water oil content of **less than 15 parts per million (ppm)**. This ensures that the discharged bilge water meets the regulatory limit and minimizes oil pollution from ship operations.

Additional Considerations:

- **Size and Capacity:** The size and treatment capacity of the OWS will depend on the size and type of vessel.
- **Alarm Systems:** The OWS may be equipped with alarms to indicate high oil levels, low water levels, or malfunctions requiring attention.
- **Maintenance:** Regular maintenance is crucial for optimal performance. This includes cleaning the coalescing plates, checking the level sensors, and ensuring proper operation of all components.

By employing a MARPOL-compliant single-stage static OWS and maintaining it properly, ship operators can significantly reduce oily water pollution and contribute to a cleaner marine environment.

Feb 2021

5. (a) With reference to sewage treatment systems, explain EACH of the following terms:

(i) aerobic; (2)

(ii) anaerobic. (2)

(b) Sketch a Biological Sewage Treatment Plant, labelling the MAIN compartments and indicating the direction of flow through the plant. (6)

Sewage Treatment Systems: Aerobic vs. Anaerobic and Plant Processes

(a) Explaining Aerobic and Anaerobic Processes:

(i) Aerobic:

- **Definition:** Refers to a biological process that occurs in the presence of dissolved oxygen.
- **Microorganisms:** Involves the activity of **aerobic microorganisms** such as bacteria and protozoa.
- **Breakdown Process:** These microorganisms utilize oxygen to break down organic matter (waste) present in sewage into simpler compounds like water and carbon dioxide.
- **Sewage Treatment:** Aerobic processes are widely used in biological sewage treatment plants for efficient wastewater treatment.

(ii) Anaerobic:

- **Definition:** Refers to a biological process that takes place in an environment with little to no dissolved oxygen.
- **Microorganisms: Anaerobic microorganisms** such as certain bacteria and archaea are responsible for the breakdown process in this case.
- **Breakdown Process:** These microorganisms break down organic matter through a different metabolic pathway that doesn't require oxygen.
- **Sewage Treatment:** While some stages of sewage treatment may involve limited oxygen conditions, complete anaerobic treatment is less common due to its lower efficiency and generation of methane, a greenhouse gas.

(b) Biological Sewage Treatment Plant:

A biological sewage treatment plant utilizes a combination of physical and biological processes to break down and treat wastewater. Here's a breakdown of the main compartments and the flow direction:

1. **Screening and Comminution:**
    - **Function:** Large solids and debris are removed from the incoming sewage using screens or grinders (comminutors).
    - **Flow Direction:** The screened or comminuted wastewater flows onward.
2. **Primary Clarification Tank:**
    - **Function:** Allows heavier solids to settle at the bottom (sludge) for removal, while lighter organic matter and water remain in the supernatant.

- **Flow Direction:** Settled sludge is removed for further treatment, and the supernatant (partially treated wastewater) flows to the next stage.

3. **Biological Treatment (Aerobic Process):**
    - **Main Compartment:** Aeration Tank
    - **Function:** This is the heart of the aerobic treatment process.
        - Aerobic microorganisms break down organic matter in the presence of dissolved oxygen supplied through diffusers.
        - The process promotes the growth of microorganisms, which form flocs (clumps) that aid in further separation.
    - **Flow Direction:** Treated wastewater exits the aeration tank and flows onward.
4. **Secondary Clarification Tank:**
    - **Function:** Allows the formed flocs (containing microorganisms and organic matter) to settle at the bottom as secondary sludge. The remaining liquid is the treated effluent.
    - **Flow Direction:** Settled sludge may be returned to the aeration tank or undergo further processing. The treated effluent undergoes disinfection (e.g., chlorination) before discharge.

Flow Summary: Wastewater enters the plant, undergoes screening/comminution, primary clarification, biological treatment (aeration tank), secondary clarification, and disinfection before final discharge.

2021

Feb 2021

6. (a) Sketch a thermostatically controlled expansion valve for a vapour compression refrigeration system, labelling all components. (5)

(b) Describe the operation of the valve sketched in part (a). (5)

Thermostatic Expansion Valve (TXV) in Refrigeration Systems

(a) Components of a TXV:

A thermostatic expansion valve (TXV) is a key component in a vapor compression refrigeration system that regulates the flow of refrigerant into the evaporator. Here's a breakdown of its components with labels:

1. **Inlet Port:** Connects to the high-pressure side of the system, where liquid refrigerant enters the TXV.
2. **Diaphragm:** A flexible membrane separates the high-pressure side from the low-pressure side. The pressure difference acts on the diaphragm.
3. **Sensing Bulb:** Located on the outlet pipe of the evaporator. It contains a liquid or gas that expands or contracts with changes in temperature.
4. **Capillary Tube:** Connects the sensing bulb to the underside of the diaphragm. It transmits pressure changes from the sensing bulb to the diaphragm.
5. **Spring:** A pre-tensioned spring counteracts the force exerted by the diaphragm, regulating the valve opening.
6. **Valve Pin:** Controls the flow of refrigerant by opening or closing the orifice.
7. **Orifice:** A small opening that regulates the amount of refrigerant entering the evaporator.
8. **Outlet Port:** Connects to the evaporator inlet, where the controlled flow of refrigerant enters.

(b) Operation of the TXV:

The TXV operates based on the temperature of the refrigerant leaving the evaporator, also known as the **suction temperature** or **superheat**.

1. **Cooling the Evaporator:** As the refrigerant absorbs heat in the evaporator, the temperature of the refrigerant leaving the evaporator (suction temperature) rises.

2. **Sensing Bulb Response:** The sensing bulb, containing a temperature-sensitive liquid or gas, also experiences this temperature rise. This causes the liquid/gas in the bulb to expand.

3. **Pressure Transmission:** The expansion in the sensing bulb transmits pressure through the capillary tube to the underside of the diaphragm in the TXV.

4. **Diaphragm Movement:** The increased pressure from the capillary tube pushes the diaphragm upwards against the spring tension.

5. **Valve Pin Adjustment:** As the diaphragm moves up, it overcomes the spring tension and pushes the valve pin upwards. This opens the orifice, allowing more liquid refrigerant to flow into the evaporator.

6. **Temperature Regulation:** The increased flow of refrigerant helps to maintain the desired suction temperature by absorbing more heat in the evaporator.

7. **Balancing Act:** If the suction temperature continues to rise, the process repeats, allowing more refrigerant flow. Conversely, if the suction temperature falls too low due to excessive refrigerant flow, the pressure in the sensing bulb decreases, and the spring pushes the diaphragm down, closing the valve orifice and reducing refrigerant flow.

This continuous cycle ensures that the TXV maintains a relatively constant superheat (evaporator outlet temperature) by regulating the flow of refrigerant based on the temperature conditions.

021

Feb 2021

7. (a) Describe, with the aid of a sketch, the operation of the silver ion method of water sterilisation. (6)

(b) Describe how Ultra Violet Light can be used to kill bacteria in potable water. (2)

(c) Explain the disadvantages of using Ultra Violet Light as a method of sterilisation, stating how this may be overcome. (2)

Water Sterilisation Methods: Silver Ion and Ultraviolet Light

(a) Silver Ion Method:

The silver ion method is a popular technique for disinfecting water, particularly for point-of-use applications or in storage tanks. Here's how it works:

- **Silver Ions Release:** Silver ions (Ag+) are released into the water through various methods:

    - **Electrolysis:** An electric current is passed through silver electrodes, causing silver atoms to dissolve and release ions into the water.
    - **Silver-impregnated media:** Cartridges containing ceramic or other materials infused with silver slowly release silver ions as water flows through them.
- **Mechanism of Action:** Silver ions have a strong antimicrobial effect. They disrupt the cell membranes of bacteria, viruses, and other microorganisms, interfering with their vital functions and leading to their death.

- **Benefits:**

    - Effective against a broad spectrum of bacteria, viruses, and some fungi.
    - Long-lasting residual effect: Silver ions remain active in the water for some time, providing ongoing protection.
    - Generally safe for humans at recommended concentrations.
- **Limitations:**

    - Ineffective against protozoa (like Giardia) and some parasites.
    - Not as effective in turbid water as silver ions can bind to suspended particles and become less available.
    - Regular monitoring of silver ion concentration is necessary to ensure effectiveness and safety.

(b) Ultraviolet (UV) Light Sterilisation:

Ultraviolet (UV) light is another effective method for disinfecting water. Here's its operation:

- **Wavelength:** Specifically, UV light within the germicidal range (200-280 nm) is used.

- **Mechanism:** UV light disrupts the DNA and RNA of microorganisms, preventing them from reproducing and rendering them inactive.

- **Benefits:**

    - Fast and effective against a broad spectrum of bacteria, viruses, and protozoa.
    - No residual chemicals left in the water.
    - Relatively simple technology.
- **Disadvantages:**

    - Limited penetration: UV light only disinfects clear water. Turbidity, organic matter, and color can significantly reduce its effectiveness.
    - No residual effect: Microorganisms entering the treated water after disinfection are not affected.
    - Requires pre-treatment: Water may need filtration or clarification to ensure optimal UV penetration.

(c) Overcoming UV Light Limitations:

Several strategies can be employed to address the limitations of UV disinfection:

- **Pre-treatment:** Implementing filtration or clarification steps before UV treatment can significantly improve water clarity and maximize UV effectiveness.
- **Higher UV Dose:** Increasing the UV light intensity or exposure time can compensate for some turbidity issues. However, this needs to be balanced with energy consumption and potential lamp degradation.
- **Combined Treatment:** UV light can be combined with other methods like chlorination. This approach provides a broader spectrum of disinfection and can offer residual protection against post-treatment contamination.

By addressing these limitations, UV light remains a valuable tool for water disinfection, especially in applications where simple and rapid treatment is desired.

Feb 2021

8. (a) Describe, with the aid of a sketch, the method of attachment of a Bilge Keel to a vessel's hull, explaining the reason for the longitudinal position of the bilge keel, relative to the hull. (7)

(b) State the advantages and disadvantages of fitting a bilge keel compared with other methods of stabilisation. (3)

(a) Bilge Keel Attachment and Positioning:

- **Attachment Methods:** Bilge keels can be:
  - **Welded Directly:** This is a permanent method for new builds or major refits.
  - **Bolted On:** This allows for easier removal or replacement for repairs or occasional bilge keel removal needs.
  - **Adhesive Bonding (Less Common):** Advanced adhesives might be used, but welding or bolting remains more common due to strength considerations.
- **Longitudinal Positioning:** Bilge keels are positioned **longitudinally** (running along the length of the hull) on both sides of the vessel, typically just below the bilge area. This placement offers several advantages:
  - **Maximum Leverage:** The longitudinal position creates the greatest lever arm to counteract rolling motion.
  - **Minimal Draft Impact:** By positioning them near the bilge, they have minimal impact on the vessel's draft compared to other methods.
  - **Strength and Stability:** The bilge area is a naturally strong point on the hull, making it suitable for attachment and structural stability.

(b) Advantages and Disadvantages of Bilge Keels vs. Other Stabilization Methods:

Bilge Keels:

Advantages:

- **Improved Stability:** Effective in reducing rolling motion, enhancing passenger comfort and safety.
- **Minimal Draft Impact:** Compared to other methods, they have minimal impact on draft, allowing operation in shallower waters.
- **Relatively Simple Design:** Simple and cost-effective method of roll stabilization.
- **Low Maintenance:** Once installed, bilge keels require minimal maintenance.

Disadvantages:

- **Increased Drag:** Bilge keels can create some additional drag on the vessel, potentially reducing speed and fuel efficiency.
- **Performance Impact:** In some cases, they might affect maneuverability, especially at slower speeds.
- **Grounding Risk:** Bilge keels extending outwards increase the risk of grounding in shallow waters.
- **Aesthetics:** Some boat owners might find the appearance less pleasing.

Other Stabilization Methods:

- **Fin Stabilizers:** Retractable fins deployed electronically to counter rolling. More effective but complex, expensive, and require maintenance.

- **Active Stabilization Systems:** Use gyroscopes and actuators to actively counteract rolling. Excellent stabilization but the most expensive and complex option.
- **Outriggers:** Additional hulls mounted on either side, offering excellent stability but significantly increasing draft and potentially affecting performance.

The choice of stabilization method depends on factors like vessel size, intended use, sea conditions, and budget. Bilge keels offer a good balance for many recreational and small commercial vessels.

an 2021

29 January 2021

9. (a) Define EACH of the following:

(i) Flash Point; (2)

(ii) Ignition Point (2)

(iii) Auto Ignition Temperature. (2)

(b) Explain the requirements for the discharge of CO_2 of a machinery space fixed firefighting installation with regard to volume and time. (4)

(a) Engine Room Fire Main Isolation Valve

- **Need:** Isolates the fire main within the engine room in case of a fire. This allows firefighters to:
  - Maintain firefighting capabilities in other areas using water from auxiliary pumps.
  - Minimize water damage in other compartments if a fire main pipe ruptures.
- **Location:** Outside the engine room in a readily accessible and tenable position.
- **Operation:** Manually operated (handwheel or lever) to shut off water flow to the engine room section. May also have remote operation capability.

(b) Valve Type:

- **Gate Valve:** Provides positive shutoff, durability, and a relatively simple design for easy operation and maintenance.

(c) Sprinkler Head Construction

- **Frame:** Houses internal components and connects to piping.
- **Sealing Element:** Heat-sensitive element (glass bulb with liquid or bi-metallic strip) that keeps the opening sealed.
- **Deflector:** Distributes discharged water in a spray pattern.
- **Sprinkler (Optional):** May provide a pre-discharge misting effect.

I hope this summary is helpful! If you have any further questions or require explanations for different fire safety components, feel free to ask.

Feb 2021

9. (a) Explain the need for fitting, location, and operation of an engine room fire main isolation valve. (4)

(b) State the type of valve used in part (a). (1)

(c) Describe, with the aid of a sketch, the construction of a sprinkler head. (5)

Engine Room Fire Main Isolation Valve

(a) Need, Location, and Operation:

The engine room fire main isolation valve plays a crucial role in isolating the fire main within the engine room in case of a fire. Here's a breakdown of its importance:

- **Need:**
  - Fire in the engine room presents a serious threat to the entire vessel.
  - The isolation valve allows for:
    - **Maintaining firefighting capabilities:** By isolating the engine room section of the fire main, firefighters can continue using the fire main system in other parts of the ship with water from auxiliary pumps or an emergency fire pump located outside the engine room.
    - **Minimizing water damage:** If a fire main pipe ruptures due to fire damage, the isolation valve allows for quick isolation of the engine room section, preventing excessive water flooding in other compartments.
- **Location:** The isolation valve is typically located outside the engine room in a readily accessible and tenable (safe and easily reached) position. This allows firefighters to access and operate the valve safely even during a fire.
- **Operation:** The isolation valve is designed for manual operation. It has a handwheel or lever that allows personnel to quickly shut off the water flow to the engine room section of the fire main. Some may also have remote operation capability from the fire control station.

(b) Valve Type:

The engine room fire main isolation valve is typically a **gate valve**. Here's why:

- **Positive Shutoff:** Gate valves provide a positive shutoff, completely stopping water flow when closed. This is crucial for isolating the engine room section in case of a fire.
- **Durability:** Gate valves are known for their robustness and ability to withstand high pressures, making them suitable for the demands of a fire main system.
- **Relatively Simple Design:** Gate valves have a relatively simple design with a sliding wedge that blocks the flow path. This allows for easy operation and maintenance.

(c) Sprinkler Head Construction:

A sprinkler head is a heat-sensitive device installed in a sprinkler system that automatically discharges water when a fire is detected. Here's a breakdown of its key components:

- **Frame:** The frame houses all the internal components and provides a connection to the sprinkler piping.

- **Sealing Element:** A heat-sensitive element seals the opening of the sprinkler head, typically a glass bulb filled with a liquid that expands rapidly at a specific temperature. Some heads use bi-metallic strips that deform with heat.
- **Deflector:** Once the sealing element ruptures, the deflector distributes the discharged water in a spray pattern to cover the designated area.
- **Sprinkler (Optional):** Some sprinkler heads include a small sprinkler within the frame that provides a pre-discharge misting effect to potentially suppress a fire in its early stages before the full water flow activates.

Activation Process:

- In a normal state, the sealing element keeps the water supply blocked.
- When a fire raises the surrounding temperature above the designed activation temperature of the sealing element:
    - **Glass Bulb:** The liquid in the glass bulb expands rapidly, shattering the bulb.
    - **Bi-metallic Strip:** The bi-metallic strip bends due to thermal expansion, releasing the sealing mechanism.
- Water from the fire main system flows through the now open sprinkler head and is distributed by the deflector to extinguish the fire.

21

Feb 2021

10. (a) Explain the meaning of EACH of the following terms:

(i) camber; (2)

(ii) sheer. (2)

(b) Describe how EACH of the terms explained in part (a) improve seaworthiness. (6)

Ship Features and Seaworthiness:

(a) Meaning of Terms:

(i) **Camber:** Camber refers to the slight upward curvature of a ship's deck from the centerline towards the sides. Imagine a very subtle arch across the width of the deck.

(ii) **Sheer:** Sheer refers to the longitudinal curvature of a vessel's deck from bow to stern. The deck is typically higher at the bow and stern compared to the midships section. Imagine a gentle curve running along the length of the deck, with the bow and stern slightly elevated.

(b) How They Improve Seaworthiness:

Both camber and sheer contribute to a vessel's seaworthiness in several ways:

(i) Camber:

- **Improved Drainage:** The camber on the deck helps to shed water overboard more effectively. As waves wash over the deck, the curvature directs water towards the sides and drains it through scuppers (drainage holes) located along the bulwarks (vertical walls on the sides). This minimizes water accumulation on deck, reducing the risk of icing in cold conditions and improving crew footing

during rough seas.

- **Enhanced Strength:** The slight upward curvature of the deck adds some longitudinal stiffness to the structure. This can help the vessel better resist bending forces experienced in heavy seas.

(ii) Sheer:

- **Improved Buoyancy:** The higher sheer at the bow helps to increase buoyancy forward. This additional buoyancy helps the vessel to rise over waves more effectively and prevents excessive water ingress during head-on seas.

- **Reduced Wave Impact:** The sheer angle of the bow deflects waves outwards, minimizing water washing over the deck during rough conditions. This improves weather handling and keeps the deck safer for crew operations.

- **Enhanced Stability:** In some cases, a slight sheer can improve the vessel's initial stability. The wider beam at the waterline created by the sheer can help the vessel resist rolling motions caused by waves.

In conclusion, both camber and sheer are subtle design features that contribute significantly to a vessel's seaworthiness by improving drainage, enhancing buoyancy, reducing wave impact, and increasing stability. These features work together to ensure safer operation and crew well-being at sea.