# Oct 2018

1. With reference to noise levels in ships:

(a) describe the recommended maximum periods of time for personnel employed on watchkeeping duties within enclosed machinery spaces; (6)

(b) explain why these recommendations have been made; (2)

(c) state the permitted noise level at which hearing protection is:

(i) recommended; (1)

(ii) mandatory. (1)

# Oct 2018

2. Describe the responsibilities of the off-going duty engineer with respect to EACH of the following:

(a) fuel service tanks; (2)

(b) oily water separator; (2)

(c) potable water tanks; (2)

(d) machinery space defect book; (2)

(e) main engine sump level. (2)

# Oct 2018

3. (a) Explain what is meant by the term *Machinery Abstract.* (4)

(b) List SIX items which would be recorded in a typical Machinery Abstract. (6)

## Oct 2018

4. With reference to Oily Water Separators and the pumping of bilges, explain the purpose of EACH of the following:

(a) a bilge holding tank; (2)

(b) an oil drain tank; (2)

(c) an oil content discharge monitor; (2)

(d) a vacuum breaker; (2)

(e) an oil detection probe. (2)

## Oct 2018

5. Describe the operation of a Biological Sewage Treatment Plant. (10)

## Oct 2018

6. With reference to Marine Air Conditioning Systems, explain EACH of the following expressions:

(a) wet bulb temperature (2)

(b) dry bulb temperature; (2)

(c) comfort zone; (2)

(d) psychrometric chart; (2)

(e) relative humidity. (2)

## Oct 2018

7. (a) Describe, with the aid of a sketch, a reverse osmosis plant, from feed water inlet, to product tank, labelling ALL components and showing the position in the system of the monitoring instruments. (7)

(b) Describe the feed water pre-treatment process before the water enters the spirally wound membrane modules. (3)

Oct 2018

8. Explain, with the aid of a sketch, the hydrodynamic operation of an *Active Fin Stabilizer*. (10)

Oct 2018

9. Describe, with the aid of a sketch, a multiple bottle $CO_2$ gas system suitable for the protection of machinery spaces. (10)

Oct 2018

10. (a) With reference to ship construction, define a bulkhead. (2)

(b) State the functions of bulkheads. (8)

Oct 2018

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# Noise Levels and Hearing Protection on Ships:

**(a) Recommended Watchkeeping Duration in Machinery Spaces:**

Due to the high noise levels in enclosed machinery spaces, exposure limits are recommended to protect crew hearing. Specific durations may vary depending on regulations and flag state, but here's a general guideline:

- **Continuous Exposure:** It's generally recommended to minimize continuous exposure to noise levels exceeding 85 decibels (dB(A)) within enclosed machinery spaces.
- **Maximum Exposure Periods:** For higher noise levels, exposure times should be limited. For example, some regulations might recommend a maximum of 4 hours at 88 dB(A), 2 hours at 91 dB(A), and so on, with mandatory breaks in quieter areas.

**(b) Rationale for Recommended Exposure Limits:**

These recommendations are made to prevent Noise-Induced Hearing Loss (NIHL), a permanent condition caused by prolonged exposure to loud noises. NIHL can lead to:

- **Hearing Threshold Shifts:** Difficulty hearing faint sounds or conversations.
- **Tinnitus:** A ringing or buzzing sensation in the ears.
- **Hyperacusis:** Increased sensitivity to certain sounds, causing discomfort.

NIHL can significantly impact a seafarer's ability to perform their duties safely and effectively. Hearing is crucial for situational awareness, communication, and following instructions during emergencies.

**(c) Permitted Noise Levels for Hearing Protection:**

Hearing protection is essential in noisy environments to minimize the risk of NIHL. Here's a breakdown of when it's recommended and mandatory:

**(i) Recommended Use:**

- **80 dB(A) and Above:** Hearing protection is recommended even at moderate noise levels of 80 dB(A) and above as a preventative measure to minimize long-term hearing damage from continuous exposure.

**(ii) Mandatory Use:**

- **85 dB(A) and Above:** Wearing hearing protection becomes mandatory for most regulations and flag states when noise levels reach or exceed 85 dB(A) for a sustained period. This ensures adequate protection for crew members working in these environments.

It's important to note that these are general guidelines. Always refer to the specific regulations and recommendations set by the maritime authority or flag state governing the vessel's operation.

# Oct 2018

2. Describe the responsibilities of the off-going duty engineer with respect to EACH of the following:

(a) fuel service tanks; (2)

(b) oily water separator; (2)

(c) potable water tanks; (2)

(d) machinery space defect book; (2)

(e) main engine sump level. (2)

## Off-Going Duty Engineer Responsibilities:

The off-going duty engineer has several handover responsibilities to ensure a smooth transition for the oncoming watch engineer. Here's a breakdown of their duties regarding the specific points mentioned:

**(a) Fuel Service Tanks:**

- **Level Gauges:** The off-going engineer should verify fuel levels in all designated service tanks using level gauges or sounding methods. This information should be communicated to the oncoming engineer during handover.
- **Quality:** If there are any concerns about fuel quality (e.g., contamination, unusual appearance), the off-going engineer should report them and ensure appropriate actions are documented.

**(b) Oily Water Separator (OWS):**

- **Operational Status:** The off-going engineer should confirm the OWS is functioning correctly and report any malfunctions or alarms encountered during their watch.
- **Bilge Alarm:** They should ensure the bilge alarm system is functional and no abnormal bilge water accumulation has occurred.
- **Record Keeping:** Any entries related to OWS operation, bilge water discharge, or alarm activations should be documented in the engine room log book before handover.

**(c) Potable Water Tanks:**

- **Water Levels:** The off-going engineer should check the water levels in all potable water tanks and report any significant changes or concerns about water availability.
- **Quality:** If there are any doubts about the quality of potable water (e.g., taste, odor, discoloration), they should be reported, and further testing might be necessary.

**(d) Machinery Space Defect Book:**

- **New Defects:** The off-going engineer should record any new machinery defects identified during their watch in the designated defect book. This includes a detailed description of the problem, its location, and any troubleshooting steps taken.
- **Outstanding Defects:** They should highlight any existing machinery defects that remain unaddressed and require further attention from the oncoming engineer or maintenance personnel.

**(e) Main Engine Sump Level:**

- **Level Check:** The off-going engineer should verify the main engine sump level using the dipstick or sight gauge. This reading should be communicated to the oncoming engineer during handover.
- **Abnormal Levels:** If the sump level is outside the normal operating range (too high or too low), they should report it and ensure the cause is investigated before the oncoming engineer assumes watch.

Oct 2018

3. (a) Explain what is meant by the term *Machinery Abstract*. (4)

(b) List SIX items which would be recorded in a typical Machinery Abstract. (6)

## Machinery Abstract Explained:

A Machinery Abstract is a concise document summarizing the essential information about a ship's main propulsion and auxiliary machinery systems. It serves as a quick reference guide for crew members, surveyors, and other personnel who need to understand the vessel's propulsion plant and other important machinery onboard.

Here are some key points about a Machinery Abstract:

- **Content:** It typically includes technical specifications, drawings, diagrams, and performance data for the main engines, generators, pumps, compressors, boilers, and other significant onboard machinery.
- **Purpose:** The Machinery Abstract helps with:
  - **Operational Efficiency:** Providing essential information for optimal machinery operation.
  - **Maintenance and Repair:** Facilitating troubleshooting, maintenance procedures, and repair activities.
  - **Regulatory Compliance:** Meeting regulatory requirements for ship surveying and certification.

## Typical Items Recorded in a Machinery Abstract:

1. **Engine Details:** This section would include information about the main propulsion engine(s), such as type (e.g., diesel, gas turbine), manufacturer, model, power output, rated speed, fuel consumption data, and lubrication oil specifications.

2. **Generator Details:** Similar to engine details, this section would list information about the ship's generator sets, including type, manufacturer, model, power output, and auxiliary engine data if applicable.

3. **Auxiliary Machinery:** This section would detail other important machinery onboard, such as pumps (bilge pumps, cooling water pumps, fire pumps), compressors (air compressors, refrigeration compressors), and boilers (if applicable). Information would include type, capacity, and operational parameters.

4. **Piping Systems:** The Machinery Abstract might include diagrams or descriptions of the main piping systems onboard, such as fuel oil piping, lubrication oil piping, cooling water piping, and compressed air piping.

5. **Control Systems:** In some cases, the abstract might include a brief overview of the machinery control systems, specifying whether manual or automated control is used and highlighting any important control features.

6. **Alarm Systems:** The Machinery Abstract may list the main alarms associated with the machinery plant, including a description of the alarm condition each one triggers. This information helps crew members understand and respond to alarm situations effectively.

**Note:** The specific content of a Machinery Abstract may vary depending on the size and complexity of the vessel and the regulatory requirements of the flag state.

Oct 2018

4. With reference to Oily Water Separators and the pumping of bilges, explain the purpose of EACH of the following:

   (a) a bilge holding tank; (2)

   (b) an oil drain tank; (2)

   (c) an oil content discharge monitor; (2)

   (d) a vacuum breaker; (2)

   (e) an oil detection probe. (2)

# Bilge Systems and Oily Water Separators: Key Components Explained

**(a) Bilge Holding Tank:**

The bilge holding tank serves as a temporary storage tank for bilge water collected from various compartments within the vessel. Bilge water is a mixture of water that accumulates in the lowest bilge areas of the ship and may contain oil, grease, and other contaminants.

- **Why it's important:**
  - The bilge holding tank allows for the controlled collection and processing of bilge water. This prevents the direct discharge of untreated bilge water overboard, minimizing oil pollution.
  - It provides a buffer between bilge pumping operations and OWS processing. Bilge water can be pumped into the holding tank and then transferred to the OWS at a controlled rate for efficient oil-water separation.

**(b) Oil Drain Tank:**

The oil drain tank is a smaller tank used to collect oil drained from various machinery and equipment onboard the ship. This includes used lubricating oil from engines, gearboxes, and hydraulic systems.

- **Why it's important:**
  - The oil drain tank provides a dedicated space to collect used oil for proper disposal or recycling ashore. This prevents mixing used oil with bilge water in the holding tank, simplifying the separation and handling process.

- It allows for the controlled transfer of used oil for shore-based treatment or re-refining, promoting environmentally responsible practices.

**(c) Oil Content Discharge Monitor (OCM):**

An oil content discharge monitor (OCM) is a crucial instrument installed on the overboard discharge line of an OWS.

- **Purpose:**
    - The OCM continuously monitors the oil content in the treated bilge water before it is discharged overboard. It ensures the oil concentration in the discharged water complies with MARPOL regulations (typically less than 15 ppm).
    - If the OCM detects an oil content exceeding the limit, it can automatically trigger an alarm and prevent the overboard discharge of non-compliant bilge water.

**(d) Vacuum Breaker:**

A vacuum breaker is a safety device installed on the bilge piping system.

- **Function:**
    - It prevents the creation of a vacuum within the bilge piping system. A vacuum could potentially cause seawater to be siphoned back into the bilge tanks, contaminating the bilge water with clean seawater.
    - The vacuum breaker allows air to enter the piping system when a vacuum occurs, preventing backflow and maintaining proper system operation.

**(e) Oil Detection Probe:**

An oil detection probe is a sensor used within the bilge system or the OWS itself.

- **Purpose:**
    - The probe detects the presence and level of oil in the bilge water or treated water within the separator.
    - This information can be used for various purposes, such as:
        - Triggering alarms if excessive oil is detected in the bilge water.
        - Controlling the pumping rate to the OWS to optimize separation efficiency.
        - Monitoring the oil-water interface level within the OWS.

By understanding the purpose of these components, crew members can ensure efficient bilge water management and proper operation of the Oily Water Separator system, minimizing the risk of oil pollution and complying with international regulations.

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Oct 2018

5. Describe the operation of a Biological Sewage Treatment Plant. (10)

# Biological Sewage Treatment Plant: A Step-by-Step Breakdown

A biological sewage treatment plant utilizes a three-stage process to efficiently break down and treat wastewater:

**1. Primary Treatment (Physical Separation):**

This stage focuses on removing large solids and suspended materials through physical processes.

- **Screening:** Large objects like rags, plastics, and debris are removed using screens with varying bar spacing. Imagine a colander catching large food scraps while letting the water flow through.
- **Comminution:** Remaining solids are shredded or ground into smaller particles using grinders (comminutors). Think of a food processor breaking down large chunks into smaller pieces for easier handling.
- **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 (partially treated wastewater). The supernatant looks like murky water after some larger particles have settled out.
- **Sludge Removal:** Settled primary sludge is periodically removed for further treatment or disposal. Think of scooping out the settled material at the bottom of a pond.

**2. Secondary Treatment (Biological Treatment):**

This is the heart of the process, where microorganisms become the workhorses for wastewater treatment.

- **Aeration Tank:** The primary-treated wastewater enters the aeration tank, a large tank teeming with life (microorganisms).
  - **Air is continuously bubbled** through diffusers at the bottom. This ensures a constant supply of dissolved oxygen, crucial for the survival and activity of **aerobic bacteria**. Think of an air pump keeping an aquarium oxygenated.
  - These bacteria feed on the organic matter in the wastewater, breaking it down into simpler compounds like carbon dioxide and water. The process is similar to natural biodegradation in well-oxygenated environments.
  - The breakdown process promotes the growth of microorganisms, which form **flocs** (clumps) that contain both bacteria and organic matter. These flocs are essential for efficient separation in the next stage. Imagine tiny organisms attaching themselves to food particles, forming larger clumps that will settle more easily.
  - **Mixing:** The air bubbles also play a role in efficiently mixing the wastewater. This ensures all parts come into contact with the microorganisms for optimal treatment.

**3. Secondary Clarification:**

Here, the wastewater separates from the biological treatment products.

- **Secondary Clarifier Tank:** The treated wastewater from the aeration tank flows into a secondary clarifier tank.
  - The formed flocs (containing microorganisms and organic matter) settle at the bottom as **secondary sludge**. The remaining liquid is the **treated effluent**, which looks significantly clearer than the influent (untreated sewage).
  - Settled sludge may be returned to the aeration tank to maintain the population of microorganisms or undergo further processing.

**4. Disinfection (Optional):**

In some cases, an additional disinfection step ensures minimal risk of pathogens in the discharged water.

- **Disinfection Process:** The treated effluent may undergo disinfection before discharge overboard. This is done to further reduce or eliminate any remaining harmful bacteria and viruses.
  - Common disinfection methods include:

- **Chlorination:** Calcium hypochlorite (bleach powder) is added, releasing chlorine that inactivates pathogens.
- **Ultraviolet (UV) Radiation:** UV light is used to kill or inactivate microorganisms.

**5. Discharge:**

- **Treated Effluent:** The disinfected wastewater (effluent) undergoes final quality checks and is then discharged overboard, meeting the required environmental standards set by regulations.

**Key Points:**

- Each stage plays a crucial role in achieving efficient wastewater treatment.
- The biological treatment stage depends heavily on the activity of aerobic microorganisms, which require oxygen for their breakdown process.
- The formation of flocs in the aeration tank is what allows for efficient separation of treated wastewater from the remaining organic matter.
- Disinfection is an optional step that ensures the treated effluent meets environmental regulations and minimizes the risk of spreading pathogens.

018 2018

## Oct 2018

6. With reference to Marine Air Conditioning Systems, explain EACH of the following expressions:

(a) wet bulb temperature (2)

(b) dry bulb temperature; (2)

(c) comfort zone; (2)

(d) psychrometric chart; (2)

(e) relative humidity. (2)

In the context of Marine Air Conditioning Systems, these terms are all related to understanding air properties and creating a comfortable environment:

(a) **Wet Bulb Temperature (WBT):** This is the temperature measured by a thermometer wrapped in a wet cloth with air flowing over it. As the water evaporates, it cools the thermometer. The wet bulb temperature represents the **lowest temperature achievable by evaporative cooling** under the existing air conditions. Marine air conditioning systems often use wet bulb temperature as a reference point for dehumidification needs.

(b) **Dry Bulb Temperature (DBT):** This is the **actual air temperature** measured by a standard thermometer. It represents the sensible heat content of the air, independent of moisture content. Both dry bulb and wet bulb temperatures are used to characterize the air conditions and determine the cooling and dehumidification requirements of a marine air conditioning system.

(c) **Comfort Zone:** This is the range of **dry bulb and wet bulb temperatures considered comfortable for most people**. The specific comfort zone can vary slightly depending on individual preferences and activity levels. Marine air conditioning systems aim to maintain the cabin air within this comfort zone for optimal passenger and crew well-being.

(d) **Psychrometric Chart:** This is a graphical representation of the **relationship between dry bulb temperature, wet bulb temperature, relative humidity, and enthalpy (total heat content) of air**. Psychrometric charts are valuable tools for HVAC (Heating, Ventilation, and Air Conditioning) engineers to design and operate air conditioning systems effectively. They allow visualization of the cooling and dehumidification processes and selection of appropriate equipment settings to achieve desired comfort conditions.

(e) **Relative Humidity (RH):** This is a measure of the **amount of water vapor present in the air compared to the maximum amount the air can hold at a specific temperature**. Expressed as a percentage, relative humidity affects how comfortable people feel. High relative humidity makes the air feel muggy and can impede evaporative cooling mechanisms of the human body. Marine air conditioning systems often control dehumidification to maintain a comfortable relative humidity level within the cabin.

Oct 2018

7. (a) Describe, with the aid of a sketch, a reverse osmosis plant, from feed water inlet, to product tank, labelling ALL components and showing the position in the system of the monitoring instruments. (7)

(b) Describe the feed water pre-treatment process before the water enters the spirally wound membrane modules. (3)

# Reverse Osmosis Plant: Feedwater to Product Tank

A reverse osmosis (RO) plant consists of several stages working together to purify water. Here's a breakdown from feed water inlet to product tank, including monitoring instruments:

**Components and Monitoring:**

1. **Feed Water Inlet:** Raw water enters the plant, often from a well, seawater source, or municipal supply.
2. **Pre-treatment (with Monitoring Instruments):** This stage removes impurities that could damage the RO membrane. Depending on the feed water quality, it may involve:
    - **Multimedia Filter:** Removes suspended particles like sand, silt, and debris.
        - **Monitoring:** Pressure gauges monitor filter performance.
    - **Activated Carbon Filter:** Absorbs chlorine, organic contaminants, and taste/odor causing substances.
        - **Monitoring:** Pressure gauges monitor filter performance.
    - **Antiscalant Dosing System:** Chemicals are added to prevent scaling on the membrane.
        - **Monitoring:** Conductivity meters monitor antiscalant concentration in the feed water.
    - **Coagulation/Flocculation (Optional):** This step removes smaller particles and organic matter (if needed).
        - **Monitoring:** pH meters monitor the optimal coagulation process.
3. **High-Pressure Pump:** This pump increases the pressure of the pre-treated water to overcome the osmotic pressure and drive water through the membrane.
    - **Monitoring:** Pressure gauges and flow meters monitor pump performance and feed water pressure.
4. **Spiral Wound Membrane Modules:** These house the semi-permeable membranes that allow water molecules to pass through while rejecting contaminants. The system typically uses multiple membrane modules arranged in series or parallel for increased efficiency.
    - **Monitoring:** Conductivity meters monitor permeate (product water) quality, indicating its purity. Pressure gauges monitor pressure across the membrane modules.
5. **Permeate Tank:** The filtered, low-salinity water (permeate) is collected and stored in this pressurized tank.
    - **Monitoring:** Level sensors and pressure gauges monitor the permeate water level and pressure in the tank.

6. **Brine Reject Stream:** The concentrated brine solution containing the rejected salts and impurities is discharged from the system. The discharge location depends on regulations and may involve further treatment.
   - **Monitoring:** Conductivity meters or salinity sensors monitor the concentration of the reject stream.

# Feedwater Pre-treatment Process

Pre-treatment is crucial for protecting the RO membrane and ensuring efficient operation. Here's a closer look:

1. **Coarse Filtration:** Water passes through a series of graded layers of filter media (sand, gravel, etc.) that trap suspended particles like dirt, silt, and organic matter.
   - **Benefit:** Protects the membrane from physical damage caused by large particles.
2. **Activated Carbon Filtration:** Water flows through activated carbon, a highly adsorbent material that removes chlorine, taste/odor causing compounds, and some organic contaminants.
   - **Benefit:** Prevents chlorine from damaging the membrane and improves permeate quality.
3. **Antiscalant Dosing:** Chemicals are added to the pre-treated water to prevent scaling on the membrane from minerals like calcium and magnesium. These antiscalants bind to the minerals, keeping them in solution and preventing them from precipitating on the membrane surface.
   - **Benefit:** Extends membrane life and maintains RO system efficiency.
4. **Coagulation/Flocculation (Optional):** This step is used if the seawater has high levels of turbidity or organic matter. It involves adding coagulant chemicals that cause suspended particles to clump together (flocculate) and then settle out or get removed by subsequent filtration.
   - **Benefit:** Removes smaller particles and organic matter that could foul the membrane.

The specific pre-treatment steps and chemicals used will depend on the quality of the feed water entering the plant.

018

Oct 2018

8. Explain, with the aid of a sketch, the hydrodynamic operation of an *Active Fin Stabilizer*. (10)

# Active Fin Stabilizer: Hydrodynamic Operation

Active fin stabilizers are a type of roll stabilization system that utilizes retractable fins and a control system to counteract a ship's rolling motion. Unlike bilge keels (passive stabilizers), active fins are electronically controlled to generate a dynamic opposing force, providing a more responsive and effective roll reduction. Here's a breakdown of their hydrodynamic operation:

**Components:**

- **Retractable Fins:** These are typically hydrofoil-shaped fins mounted on either side of the vessel, usually near the midship section (middle of the ship). They can retract into recesses in the hull when not in use to minimize drag.
- **Hydraulic Actuators:** Powerful hydraulic rams or cylinders are connected to each fin, allowing for precise control of the fin angle (angle of attack) relative to the water flow.
- **Control System:** This system plays a crucial role in the stabilization process, including:
   - **Roll Sensors:** Gyroscopes or accelerometers continuously monitor the ship's rolling motion and its direction.

- **Control Unit:** This unit processes the sensor data and calculates the required fin angle adjustment to counteract the roll.

**Operation:**

1. **Roll Detection:** The roll sensors constantly monitor the ship's rolling motion, measuring the angle and direction of the roll.
2. **Control System Response:** The control unit receives the sensor data and determines the necessary fin movement to counter the roll. It calculates the ideal fin angle and transmits this information to the hydraulic actuators.
3. **Fin Adjustment:** Based on the control unit's output, the hydraulic actuators on each side extend the fins and adjust their angle of attack relative to the oncoming water flow.

- **Starboard Roll:** If the ship rolls to starboard (right), the control unit commands the starboard fin to increase its angle of attack (tilt outwards) and the portside fin to decrease its angle of attack (tilt inwards). As the ship moves forward, the angled fins generate lift (similar to an airplane wing) that acts against the roll motion.

  - **Starboard Fin:** The increased angle of attack on the starboard fin creates a strong lift force directed upwards, counteracting the roll and pushing the starboard side down.
  - **Portside Fin:** The decreased angle of attack on the portside fin reduces or creates a downward lift force, further assisting in bringing the ship back to level.
- **Portside Roll:** Conversely, if the ship rolls to port, the fin angles are adjusted oppositely to generate a counteracting lift force that rights the ship.

**Hydrodynamic Principles:**

The effectiveness of active fin stabilizers relies on several key hydrodynamic principles:

- **Lift Force:** As water flows past the angled fins, it creates lift, similar to the way an airplane wing generates lift. The angle of attack determines the magnitude of the lift force.
- **Opposing Force:** By adjusting the fin angles, the system creates a lift force that opposes the rolling motion of the ship. This counteracting force helps to dampen the roll and bring the vessel back to a level position.
- **Faster Response:** Compared to passive systems, active fin stabilizers can react much faster to changes in roll angle due to the electronic control system and rapid fin adjustments.

**Benefits:**

- **Highly Effective:** Active fin stabilizers can achieve significant roll reductions, often exceeding 80% depending on sea conditions.
- **Fast Response Time:** The system can react quickly to changing roll motions due to the real-time sensor data and rapid fin adjustments.
- **Retractable Fins:** When not in use, the fins can be retracted to minimize drag and improve fuel efficiency.
- **Scalability:** The system can be adapted to different vessel sizes and roll reduction requirements by adjusting fin size, actuator power, and control algorithms.

**Drawbacks:**

- **Complexity:** Active fin stabilizers are more complex than passive systems due to the additional fins, actuators, sensors, and control units. This complexity increases installation and maintenance costs.
- **Power Consumption:** The hydraulic pumps and control systems require power to operate, adding to the overall energy consumption of the vessel.

- **Maintenance Needs:** The hydraulic actuators and moving parts require regular maintenance to ensure proper operation.

Overall, active fin stabilizers are a powerful tool for significantly reducing a ship's rolling motion, enhancing passenger comfort, and improving operational efficiency. However, their complexity, energy consumption, and maintenance needs need to be considered when compared to simpler passive stabilization methods.

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Oct 2018

9. Describe, with the aid of a sketch, a multiple bottle $CO_2$ gas system suitable for the protection of machinery spaces. (10)

# Multiple Bottle CO2 Gas System for Machinery Spaces

A multiple bottle CO2 gas system is a fire suppression system that utilizes carbon dioxide (CO2) gas flooding to extinguish fires within enclosed machinery spaces on marine vessels. Here's a breakdown of its components and operation:

**Components:**

- **CO2 Storage Bank:** This consists of multiple high-pressure CO2 cylinders manifolded together to provide a sufficient volume of CO2 gas for extinguishing a fire in the machinery space.
- **Pilot Cylinders:** Separate, smaller cylinders containing CO2 gas used to initiate the release of the main CO2 bank.
- **Control Panel:** The control panel houses the system's activation mechanisms, pressure gauges, and alarms. It might have manual release levers and may also be integrated with the ship's fire alarm system.
- **Release Solenoid Valves:** Solenoid valves control the flow of CO2 gas from the pilot cylinders to the main CO2 bank.
- **Distribution Piping:** A network of pipes carries the CO2 gas from the CO2 bank throughout the machinery space, with discharge nozzles strategically placed for optimal distribution.
- **Pressure Relief Valves:** Safety valves installed on the CO2 bank and piping to prevent excessive pressure buildup in case of malfunctions.

**Operation:**

1. **Fire Detection:** A fire within the machinery space is detected by a fire alarm system (heat detectors, smoke detectors, etc.).
2. **Alarm Activation:** The fire alarm triggers an audible and visual alarm on the control panel and throughout the vessel.
3. **Manual or Automatic Activation:** The CO2 system can be activated manually using a lever on the control panel or automatically through the fire alarm system (depending on the system configuration).
4. **Pilot Cylinder Release:** Once activated, the control panel energizes the solenoid valves, allowing the CO2 gas from the pilot cylinders to flow.
5. **Main CO2 Bank Release:** The pressurized CO2 gas from the pilot cylinders triggers the release mechanism of the main CO2 bank, typically a pneumatic or hydraulic actuator.
6. **CO2 Flooding:** The CO2 gas from the main bank is rapidly discharged into the machinery space through the distribution piping and discharge nozzles.

7. **Fire Extinguishment:** The CO2 gas displaces oxygen within the space, creating an oxygen-deficient environment that suffocates the fire.

**Advantages:**

- **Rapid Fire Extinguishment:** CO2 gas flooding can extinguish fires quickly and effectively.
- **Clean Extinguishing Agent:** CO2 leaves no residue after discharge, minimizing cleanup efforts.
- **Penetrates Enclosed Areas:** CO2 gas can penetrate enclosed spaces and reach hidden pockets of fire.

**Disadvantages:**

- **Oxygen Depletion Hazard:** CO2 flooding can displace oxygen, posing a risk of suffocation to personnel trapped within the machinery space during discharge. Evacuation procedures are crucial before system activation.
- **Temperature Extremes:** CO2 gas discharge can cause a rapid temperature drop, potentially causing damage to some machinery components.
- **Limited Visibility:** CO2 gas flooding can significantly reduce visibility within the machinery space, hindering firefighting efforts after the initial fire suppression.

**Suitability:**

Multiple bottle CO2 gas systems are suitable for protecting machinery spaces on marine vessels due to their rapid fire extinguishing capabilities. However, proper training, procedures, and safety precautions are essential to ensure the safe and effective use of these systems. Alternative fire suppression systems, like water mist systems, might be used in some cases where CO2 poses a risk to personnel or equipment.

2018

Oct 2018

10. (a) With reference to ship construction, define a bulkhead. (2)

(b) State the functions of bulkheads. (8)

# Bulkheads in Ship Construction:

**(a) Definition:**

A bulkhead in ship construction is a vertical wall-like structure that extends from the bottom of the vessel (usually the keel) up to the deck(s) above. These walls subdivide the ship's interior into separate compartments. Bulkheads can be made of various materials, typically steel plates welded together to form a strong and watertight barrier.

**(b) Functions of Bulkheads:**

Bulkheads serve several critical purposes in a ship:

1. **Compartimentolization and Damage Control:** The primary function of bulkheads is to subdivide the ship's interior into watertight compartments. This compartmentalization plays a vital role in damage control. If the ship's hull is punctured in one compartment due to a collision or grounding, the water ingress will be contained within that specific compartment. By limiting flooding to a confined space, the

bulkheads help prevent the entire ship from sinking and improve the vessel's survivability.

2. **Maintaining Buoyancy and Stability:** By restricting floodwater to a specific compartment, bulkheads help the ship maintain overall buoyancy and stability. Uncontrolled flooding throughout the vessel could compromise its ability to stay afloat and upright. The contained water in a damaged compartment can be pumped out to restore buoyancy and improve vessel stability.

3. **Structural Support:** Bulkheads also contribute to the overall structural strength of the ship. They help the hull resist bending forces experienced during rough seas and can add longitudinal stiffness to the vessel.

4. **Functional Separation:** In some cases, bulkheads can be used to separate different functional areas of the ship. For example, a fire-resistant bulkhead might separate the engine room from accommodation areas to contain a potential fire.