Aug 2020

1. With reference to risk assessment and the Code of Safe Working Practices for Merchant Seamen:

   (a) explain the purpose of a risk assessment; (4)

   (b) state the person responsible for carrying out the risk assessment; (3)

   (c) outline what should be considered when carrying out a risk assessment. (3)

Aug 2020

2. List FIVE statutory items that the relieving officer shall be informed of by the officer in charge of the engineering watch prior to taking over the engineering watch. (10)

Aug 2020

3. With reference to maintenance and maintenance systems:

   (a) state SIX reasons for keeping records; (6)

   (b) explain the advantages of an approved maintenance system. (4)

Aug 2020

4. With reference to the use of Oily Water Bilge Separators:

   (a) state, with reasons, the type of pump which should be used; (3)

   (b) explain the effect of the bilge water feed rate on the performance; (3)

   (c) explain the purpose of EACH of the following:

      (i) a bilge holding tank; (2)

      (ii) an oil content discharge monitor. (2)

Aug 2020

5. (a) State FOUR possible contaminants that may be present in marine gas oil. (4)

   (b) Describe a means of dealing with THREE of the contaminants listed in part (a). (6)

Aug 2020

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

Aug 2020

7. With reference to refrigeration plants, describe the effects of EACH of the following, stating remedial actions to be taken in EACH case:

   (a) undercharge of refrigerant; (3)

   (b) air in the system; (3)

   (c) water or moisture in the system. (4)

Aug 2020

8. (a) State TWO methods of producing fresh water on board an ocean going vessel. (2)

   (b) State TWO methods of killing the bacteria which may be present in the water. (2)

   (c) Explain the reasons for adding hydrated lime to water produced on board an ocean going vessel. (3)

   (d) Outline the procedure to be followed before a fresh water tank is brought back into service. (3)

Aug 2020

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

Aug 2020

10. (a) State the meaning of EACH of the following terms in relation to a vessel's size:

(i) gross tonnage; (2)

(ii) net tonnage; (1)

(iii) lightweight; (2)

(iv) deadweight; (2)

(v) displacement. (2)

(b) State the relationship between Lightweight, Deadweight and Displacement. (1)

Aug 2020

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   (a) explain the purpose of a risk assessment; (4)

   (b) state the person responsible for carrying out the risk assessment; (3)

   (c) outline what should be considered when carrying out a risk assessment. (3)

Risk Assessment and Merchant Seaman Safety:

(a) Purpose of a Risk Assessment:

In the context of the Code of Safe Working Practices for Merchant Seamen, a risk assessment serves two main purposes:

1. **Proactive Safety Management:** It helps identify potential hazards associated with various tasks and activities performed on board a merchant ship. By proactively identifying risks, measures can be taken to mitigate them before an accident or injury occurs.

2. **Complying with Regulations:** The Code and other maritime safety regulations mandate conducting risk assessments. This ensures a systematic approach to safety onboard and demonstrates a commitment to crew safety.

(b) Responsibility for Risk Assessment:

The responsibility for carrying out risk assessments can vary depending on the specific task and complexity. Here's a breakdown:

- **Master/Chief Engineer:** Hold overall responsibility for shipboard safety and ensuring risk assessments are conducted for all onboard activities.

- **Department Heads (Chief Engineer, Deck Officer):** Responsible for overseeing risk assessments within their departments (engine room, deck operations).

- **Individual Workers:** Have a responsibility to be aware of risks associated with their tasks and to follow established safety procedures outlined in the risk assessments.

(c) Considerations During Risk Assessment:

When conducting a risk assessment, several factors need to be considered, aligned with the Code's principles:

1. **Task Analysis:** Break down the specific task or activity into its individual steps. Identify potential hazards associated with each step.

2. **Likelihood and Severity of Harm:** For each hazard, assess the likelihood of it occurring and the potential severity of the harm it could cause (minor injury, serious injury, fatality).

3. **Existing Controls:** Evaluate existing safety measures already in place to mitigate the risks. This could include personal protective equipment (PPE), safe work practices, alarms, or engineering controls.

4. **Residual Risk:** After considering existing controls, assess the remaining level of risk. This helps determine if additional control measures are needed.

5. **Documentation and Review:** The risk assessment findings should be documented, including identified hazards, control measures, and residual risk levels. The assessment should be reviewed periodically and updated as necessary, especially after changes in equipment, procedures, or work environment.

By following these steps, a comprehensive risk assessment can be conducted, promoting a safer working environment for merchant seamen.

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2. List FIVE statutory items that the relieving officer shall be informed of by the officer in charge of the engineering watch prior to taking over the engineering watch. (10)

Standing Orders and Special Instructions: This includes informing the relieving officer of any specific instructions or operational limitations set by the Chief Engineer or relevant authorities. These might be related to:

- Engine operation parameters (e.g., speed restrictions, load limitations).
- Equipment usage restrictions due to maintenance or repairs.
- Fuel changeover procedures or any specific fuel quality concerns.

Condition of Machinery and Ongoing Maintenance: The relieving officer should be informed about the current state of the main and auxiliary machinery. This includes:

- Any ongoing maintenance tasks or equipment malfunctions.
- Abnormal readings or alarm activations encountered during the previous watch.
- The overall operational status of critical systems.

Fuel Oil and Lubricating Oil Levels and Quality: Information about fuel and oil levels in service tanks should be communicated. This includes:

- Availability of fuel for continued operation.
- Any concerns about fuel quality (e.g., contamination) requiring further monitoring.
- Levels and condition of lubricating oil in designated sumps.

Fresh Water and Ballast Water Levels: The relieving officer should be informed about the status of water tanks:

- Levels of potable water available for crew consumption.
- Ballast water tank levels and any recent discharge or pumping operations.

Overall Watchkeeping Duties and Handover of Documentation: The off-going engineer should ensure the relieving officer is familiar with their watchkeeping duties and responsibilities. This might involve:

- Handover of any relevant logbooks, checklists, or operational manuals.
- Briefing on alarm systems and emergency procedures.
- Highlighting any specific communication protocols or reporting requirements.

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3. With reference to maintenance and maintenance systems:

(a) state SIX reasons for keeping records; (6)

(b) explain the advantages of an approved maintenance system. (4)

Importance of Records and Approved Maintenance Systems:

(a) Six Reasons for Keeping Maintenance Records:

1. **Trending and Analysis:** Maintenance records provide historical data on equipment performance, repairs, and replacements. Analyzing trends in these records allows for:
    - Identifying early signs of equipment degradation.
    - Predicting potential failures before they occur.
    - Optimizing maintenance schedules based on actual equipment needs.
2. **Decision-Making:** Records provide a basis for informed decision-making regarding maintenance strategies 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 needs.
3. **Regulatory Compliance:** Many maritime regulations require documented maintenance plans and records. These records demonstrate adherence to:
    - Safety standards for machinery operation.
    - Environmental regulations regarding waste disposal and pollution prevention (e.g., used oil management).
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 and maintenance procedures.
    - Documentation of best practices for future reference.
5. **Warranty Claims:** Detailed maintenance records can be crucial when making warranty claims on equipment repairs or replacements. They demonstrate that proper maintenance procedures were

followed, potentially strengthening a claim.

6. **Traceability and Accountability:** Records provide a documented history of maintenance actions taken. This allows for:
    - Identifying who performed specific maintenance tasks.
    - Tracing the use of spare parts and materials.
    - Ensuring accountability for equipment care and adherence to maintenance schedules.

(b) Advantages of an Approved Maintenance System (AMS):

An approved maintenance system offers several advantages over informal or ad-hoc maintenance practices:

- **Structured Approach:** An AMS provides a structured framework for planning, scheduling, and executing maintenance tasks. This ensures a systematic and comprehensive approach to equipment upkeep.
- **Improved Reliability:** By following a documented AMS, the likelihood of equipment failures is reduced. Regular inspections, preventive maintenance, and timely replacement of worn-out parts promote reliable equipment operation.
- **Reduced Costs:** An AMS can help optimize maintenance costs through:
    - Prioritizing tasks based on criticality and avoiding unnecessary maintenance.
    - Extending equipment lifespan with preventative measures.
    - Streamlining maintenance processes and improving efficiency.
- **Enhanced Safety:** A well-maintained AMS contributes to a safer working environment by:
    - Identifying potential safety hazards before they lead to accidents.
    - Ensuring equipment is operating within safe parameters.
    - Promoting a culture of preventative maintenance that prioritizes safety.
- **Regulatory Compliance:** Approved AMS often align with relevant maritime regulations and best practices. This simplifies compliance efforts and ensures adherence to safety and environmental standards.

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4. With reference to the use of Oily Water Bilge Separators:

(a) state, with reasons, the type of pump which should be used; (3)

(b) explain the effect of the bilge water feed rate on the performance; (3)

(c) explain the purpose of EACH of the following:

(i) a bilge holding tank; (2)

(ii) an oil content discharge monitor. (2)

Oily Water Bilge Separators: Pumps, Feed Rate, and Key Components

(a) Pump Type for Bilge Water with OWS:

- **Positive Displacement Pump (Recommended):**
  - Delivers a consistent flow rate regardless of discharge pressure. This consistent flow is crucial for optimal OWS operation.
  - Can handle viscous fluids and solids present in bilge water more effectively compared to centrifugal pumps.

Reasons for Choosing a Positive Displacement Pump:

- **Consistent Flow:** Ensures the OWS can process bilge water at the designed rate for efficient oil-water separation.
- **Handles Challenges:** Can effectively handle the presence of viscous fluids or solids in bilge water, which can clog centrifugal pumps.

(b) Effect of Bilge Water Feed Rate on OWS Performance:

- **Excessive Feed Rate:**
  - If bilge water is pumped to the OWS at a rate exceeding its designed capacity, it can overwhelm the separator. This can lead to:
    - Incomplete oil separation, resulting in oily water being discharged overboard, exceeding regulatory limits.
    - Reduced efficiency of the separation process, allowing emulsified oil (oil droplets suspended in water) to pass through the separator.
- **Maintaining Designed Feed Rate:** By using a positive displacement pump and controlling the pumping rate, the bilge water can be processed by the OWS effectively, ensuring proper oil-water separation and compliant overboard discharge.

(c) Purpose of Key Oily Water Separator Components:

(i) Bilge Holding Tank:

- **Purpose:** Provides temporary storage for bilge water collected from various compartments within the vessel.
- **Benefits:**
  - Prevents direct discharge of untreated bilge water overboard, minimizing oil pollution.
  - Acts as a buffer between bilge pumping operations and OWS processing, allowing controlled transfer of bilge water at a suitable rate for the separator.

(ii) Oil Content Discharge Monitor (OCM):

- **Function:** Continuously monitors the oil content in the treated bilge water before it is discharged overboard.
- **Importance:**
  - Ensures the oil concentration in the discharged water complies with MARPOL regulations (typically less than 15 ppm).
  - Triggers an alarm and prevents overboard discharge if oil content exceeds the limit, protecting the marine environment.

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5. (a) State FOUR possible contaminants that may be present in marine gas oil. (4)

(b) Describe a means of dealing with THREE of the contaminants listed in part (a). (6)

Marine Gas Oil Contaminants and Treatment Methods:

(a) Four Possible Contaminants in Marine Gas Oil:

1. **Water:** Even small amounts of water can create a breeding ground for microbes and accelerate corrosion within the fuel system.

2. **Sediments:** Dirt, rust, and other debris entering the fuel during bunkering or storage can clog filters and injectors, impacting engine performance.

3. **Asphaltenes:** These are complex hydrocarbon molecules that can precipitate from the fuel, especially during cold conditions, leading to sludge formation and filter blockage.

4. **Microbes (Bacteria and Fungi):** In the presence of water and warm temperatures, microbes can multiply in fuel, forming biofilms and slimes that clog filters and reduce fuel quality.

(b) Dealing with Contaminants:

1. Water:

- **Settling Tanks:** Allowing fuel to settle in designated tanks can separate water from the oil due to their differing densities. The water can then be drained from the bottom of the tank.
- **Centrifugation:** Fuel can be passed through a centrifuge that separates water from the oil based on their different weights at high rotational speeds.
- **Desiccants:** Moisture-absorbing materials like silica gel can be used in fuel storage tanks to remove trace amounts of water from the air and prevent condensation.

2. Sediments:

- **Primary Filters:** Coarse filters at the bunkering point and tank inlets can trap larger particles of dirt and debris before they enter the fuel system.
- **Secondary Filters:** Finer filters located throughout the fuel system remove any remaining sediment particles before they reach the engine. These filters require regular cleaning or replacement based on maintenance schedules and operational conditions.
- **Tank Cleaning:** Periodic cleaning of fuel storage tanks removes accumulated sludge and sediment deposits that could re-enter the fuel system.

3. Asphaltenes:

- **Fuel Heating:** Heating fuel storage tanks during cold weather can help keep asphaltenes in solution and prevent them from precipitating. However, this requires careful temperature control to avoid exceeding safety limits.

- **Fuel Additives:** Specific additives can be used to modify the properties of asphaltenes, preventing them from agglomerating and forming sludge. The selection of appropriate additives depends on the specific type of fuel and operating conditions.
- **Centrifugation:** As mentioned for water removal, centrifugation can also be effective in separating asphaltene particles from the fuel oil.

By employing these methods, the presence of contaminants in marine gas oil can be minimized, preventing equipment damage and ensuring optimal engine performance. It's important to note that the specific treatment methods chosen will depend on the severity of contamination, type of contaminant, and the onboard equipment available.

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6. 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.

Aug 2020

7. With reference to refrigeration plants, describe the effects of EACH of the following, stating remedial actions to be taken in EACH case:

(a) undercharge of refrigerant; (3)

(b) air in the system; (3)

(c) water or moisture in the system. (4)

Refrigeration Plant Issues and Solutions

(a) Undercharge of Refrigerant:

- **Effect:**
    - **Reduced System Capacity:** An undercharged system doesn't have enough refrigerant to absorb heat efficiently. This leads to a decrease in the cooling capacity of the refrigeration plant. The desired temperature in the chilled space may not be achieved.
    - **Increased Compressor Workload:** The compressor has to work harder to circulate the limited refrigerant available. This can lead to higher energy consumption and potential compressor overheating.
    - **Suction Line Icing:** In severe cases, the reduced pressure in the suction line due to low refrigerant can cause moisture in the air to freeze, forming ice on the suction line.
- **Remedial Actions:**
    - **Leak Detection and Repair:** The first step is to identify and repair any leaks in the system that may be causing the undercharge.
    - **Refrigerant Charging:** A qualified technician should safely evacuate any non-condensable gases and properly recharge the system with the correct amount and type of refrigerant according to the manufacturer's specifications.
    - **System Monitoring:** Monitor system pressures and temperatures after recharging to ensure proper operation.

(b) Air in the System:

- **Effect:**
    - **Reduced System Efficiency:** Air acts as a non-condensable gas in the system. It occupies space that should be filled with refrigerant, reducing the system's capacity to absorb heat. This can lead to similar issues as an undercharge, such as reduced cooling capacity and increased compressor workload.
    - **System Noises:** Air in the system can cause unusual noises during operation due to turbulence and circulation of the non-condensable gas.
    - **Oil Circulation Issues:** Air can interfere with the proper circulation of lubricating oil for the compressor, potentially leading to wear and tear.
- **Remedial Actions:**

- **System Evacuation:** A qualified technician should use a vacuum pump to evacuate the air from the system. This is typically done during system commissioning or after repairs that may have introduced air.
- **Leak Detection and Repair:** Identify and repair any leaks that may be allowing air to enter the system.
- **Leak Testing:** After evacuation, perform a leak test to ensure the system remains sealed and air-free.

(c) Water or Moisture in the System:

- **Effect:**
  - **System Acidification:** Water can react with the refrigerant and lubricant oil to form acidic byproducts. These acids can corrode system components and shorten their lifespan.
  - **Ice Buildup:** Moisture can freeze in various parts of the system, particularly the expansion valve and evaporator coil, restricting refrigerant flow and reducing cooling capacity.
  - **System Blockage:** Ice formation can potentially block components like the expansion valve, leading to complete system failure.
- **Remedial Actions:**
  - **Moisture Removal:** A qualified technician can use specialized equipment to remove moisture from the system through a process called dehydration. This may involve evacuation, purging with dry air or nitrogen, and the use of desiccants.
  - **Leak Detection and Repair:** Identify and repair any leaks that may be allowing moisture to enter the system. Common sources include leaks around connections or faulty seals.
  - **System Inspection:** Inspect components like the receiver and sight glass for signs of water contamination.
  - **Preventative Maintenance:** Regular system maintenance, including filter changes and oil analysis, can help prevent moisture ingress and system contamination.

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8. (a) State TWO methods of producing fresh water on board an ocean going vessel. (2)

(b) State TWO methods of killing the bacteria which may be present in the water. (2)

(c) Explain the reasons for adding hydrated lime to water produced on board an ocean going vessel. (3)

(d) Outline the procedure to be followed before a fresh water tank is brought back into service. (3)

Fresh Water Production and Disinfection on Ocean Vessels:

Fresh Water Production:

1. **Reverse Osmosis (RO):** This is a widely used method where seawater is forced through a semi-permeable membrane, allowing water molecules to pass through while rejecting dissolved salts and impurities. RO systems require pre-treatment to protect the membranes and produce high-quality drinking water.

2. **Distillation:** This traditional method boils seawater to produce steam, which is then condensed into pure water. While effective, distillation is energy-intensive and requires regular cleaning of the evaporator units due to scale buildup.

Killing Bacteria:

1. **Chlorination:** Low levels of chlorine are often added to the produced freshwater to kill bacteria. Continuous or shock chlorination methods can be employed. However, careful monitoring is necessary to avoid excessive chlorine levels, which can affect taste and potentially create harmful byproducts.

2. **Ultraviolet (UV) Light:** UV disinfection disrupts the DNA of bacteria, rendering them inactive. This method is quick, effective, and doesn't leave any residual chemicals in the water. However, UV light only penetrates clear water, so pre-filtration or proper maintenance to minimize turbidity is crucial.

Hydrated Lime Addition:

Hydrated lime (calcium hydroxide) is commonly added to water produced on board ships for several reasons:

- **pH Adjustment:** Fresh water produced by RO or distillation tends to be slightly acidic due to dissolved carbon dioxide. Lime increases the pH level to a slightly alkaline range (around 7.0-8.5) for several benefits:
    - Improves taste
    - Reduces pipe corrosion
    - Provides a slight residual disinfection effect
- **Precipitation of Metals:** Lime can help precipitate out some dissolved metals like iron and manganese, which can improve water quality and aesthetics.

Fresh Water Tank Re-commissioning:

Before bringing a freshwater tank back into service after cleaning or repairs, a specific procedure is followed to ensure the safety of the water:

1. **Physical Cleaning:** The tank is thoroughly cleaned to remove any debris, rust, or scale buildup. This might involve mechanical cleaning, high-pressure washing, and disinfection with a suitable solution.
2. **Disinfection:** The tank is then disinfected using a method like chlorine or a chlorine dioxide solution. The specific concentration and contact time will depend on regulations and the chosen disinfectant.
3. **Neutralization:** After disinfection, the chlorine residual needs to be neutralized with a dechlorination agent like sodium thiosulfate to ensure acceptable taste and prevent pipe corrosion.
4. **Flushing and Testing:** The tank is flushed thoroughly with clean water to remove any residual disinfectant or cleaning chemicals. Water samples are then taken for microbiological testing to ensure the absence of harmful bacteria before the tank is released for use.

These steps ensure that the freshwater tank is clean, free of harmful bacteria, and ready to provide safe drinking water for the crew and passengers.

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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 CO_2 gas system is a fire suppression system that utilizes carbon dioxide (CO_2) 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.

2020

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10. (a) State the meaning of EACH of the following terms in relation to a vessel's size:

(i) gross tonnage; (2)

(ii) net tonnage; (1)

(iii) lightweight; (2)

(iv) deadweight; (2)

(v) displacement. (2)

(b) State the relationship between Lightweight, Deadweight and Displacement. (1)

Vessel Size Terminology:

(a) Here's a breakdown of the terms related to a vessel's size:

(i) **Gross Tonnage (GT):** This is a dimensionless unit that represents the total enclosed volume of a vessel. It's calculated based on a formula that considers the volume of all permanent enclosed spaces of the ship in cubic feet, divided by 100. While not a measure of weight, it provides a general indication of a vessel's overall size.

(ii) **Net Tonnage (NT):** This is another dimensionless unit derived from the gross tonnage. It represents the usable cargo space within the vessel, after accounting for areas dedicated to crew accommodation, machinery spaces, navigation, and propulsion. A larger difference between GT and NT indicates a higher proportion of space dedicated to cargo.

(iii) **Lightweight (LW):** This refers to the weight of the vessel itself, excluding cargo, fuel, passengers, crew, and any stores or provisions onboard. It includes the weight of the hull, superstructure, machinery, equipment, and permanent fixtures.

(iv) **Deadweight (DWT):** This is the weight carrying capacity of a vessel. It's calculated by subtracting the lightweight from the displacement. In simpler terms, it's the maximum weight of cargo, fuel, passengers, crew, and stores that a vessel can safely carry.

(v) **Displacement (DIS):** This refers to the total weight of water displaced by the vessel when floating at a specific trim and draft. In simpler terms, it's the weight of water the vessel pushes aside to float. Displacement is equal to the total weight of the vessel (lightweight) plus the weight of everything onboard (cargo, fuel, passengers, crew, and stores).

(b) Relationship Between Lightweight, Deadweight, and Displacement:

These terms are interrelated and form a critical equation for understanding a vessel's weight and carrying capacity:

Displacement (DIS) = Lightweight (LW) + Deadweight (DWT)

- **Displacement:** Represents the total weight of the vessel and everything onboard.
- **Lightweight:** The weight of the empty vessel itself.
- **Deadweight:** The maximum weight the vessel can carry (cargo, fuel, etc.).

Knowing a vessel's displacement and lightweight allows you to calculate its deadweight capacity. This information is crucial for loading cargo safely and ensuring the vessel remains within its operational limits.