1. Outline the procedures and arrangements to be put into place before a permit to work is issued for entry into a confined space. (10)

33

1. Outline the procedures and arrangements to be put into place before a permit to work is issued for entry into a confined space. (10 marks)

Before a **Permit to Work (PTW)** for confined space entry is issued, a number of safety precautions and arrangements must be completed to ensure that the atmosphere is safe and that adequate rescue facilities are available.

---

1. Risk Assessment

- A suitable and sufficient **risk assessment** must be carried out.
- Hazards should be identified, such as:
  - Oxygen deficiency or enrichment,
  - Toxic gases,
  - Flammable atmospheres,
  - Engulfment hazards,
  - Mechanical or electrical hazards,
  - Heat stress.

---

2. Isolate the Space

The space must be isolated from all possible sources of danger by:

- Closing and securing valves,
- Blanking or disconnecting pipelines,
- Isolating pumps and machinery,
- Locking and tagging electrical supplies,
- Applying lock-out/tag-out procedures.

---

3. Empty and Clean the Space

- Drain, pump out, or remove residues.
- Remove sludge, scale, oil, cargo residues, or other contaminants.
- Wash or clean the space if necessary.

4. Ventilate the Space

- Thoroughly ventilate the compartment using natural or mechanical ventilation.
- Continue ventilation until atmospheric tests indicate safe conditions.
- Ventilation should be maintained during entry where required.

---

5. Atmosphere Testing

A competent person should test the atmosphere for:

(a) Oxygen Content

- Oxygen concentration should normally be approximately **21% by volume**.

(b) Flammable Vapours

- The atmosphere should be below the permitted percentage of the **Lower Explosive Limit (LEL)**.

(c) Toxic Gases

Examples include:

- Hydrogen sulphide (H_2S),
- Carbon monoxide (CO),
- Hydrocarbon vapours.

Tests should be carried out:

- At the top,
- Middle,
- Bottom of the space,
  because gases may stratify.

---

6. Issue the Permit to Work

The permit should specify:

- The exact location of the space,
- Work to be carried out,
- Time limits of validity,
- Test results,
- Precautions to be observed,
- Names of personnel authorised to enter,
- Signature of the responsible officer.

---

7. Brief Personnel

- All persons involved should be informed of:
  - The hazards,
  - Emergency procedures,
  - Means of communication,
  - The limitations of the permit.

---

8. Appoint a Responsible Attendant

- A competent person should remain **outside the confined space at all times**.
- The attendant should:
  - Maintain communication,
  - Keep a record of personnel inside,
  - Raise the alarm if necessary.
- The attendant must not enter the space to attempt rescue unless properly equipped and relieved.

---

9. Provide Rescue Equipment

Suitable rescue equipment should be available at the entrance, including:

- Safety harnesses and lifelines,
- Rescue lines,
- Self-contained breathing apparatus (SCBA),
- Stretcher,
- Resuscitation equipment,
- Portable lighting where necessary.

A rescue plan should be established before entry.

---

10. Personal Protective Equipment (PPE)

Personnel entering the space should be provided with appropriate PPE, such as:

- Safety helmet,
- Protective clothing,
- Gloves,
- Safety footwear,
- Portable gas detector,
- Approved lighting,
- Respiratory protection if required.

Exam-Style Answer

Before a confined space permit is issued, a risk assessment must be completed and the space isolated from all hazards using lock-out/tag-out procedures. The space should be emptied, cleaned, and thoroughly ventilated. Atmospheric testing must confirm safe oxygen levels, absence of flammable gases, and acceptable concentrations of toxic gases. A permit to work detailing the precautions and personnel involved should then be issued. Personnel must be briefed, a responsible attendant stationed outside the space, rescue equipment prepared, and appropriate PPE provided before entry is permitted.

Key Points Examiners Look For

✓ Risk assessment completed
✓ Isolation and lock-out/tag-out
✓ Cleaning and ventilation of the space
✓ Atmospheric testing (O_2, flammable, toxic gases)
✓ Permit to work issued and signed
✓ Personnel briefed
✓ Attendant at the entrance
✓ Rescue arrangements in place
✓ SCBA and resuscitation equipment available
✓ Appropriate PPE provided

2. State the responsibility of the watchkeeping engineer officer with respect to EACH of the following:

(a) discovering a fire in the machinery space; 39 (6) ✓

(b) electrocution of another person. 43 (4)

2. State the responsibility of the watchkeeping engineer officer with respect to EACH of the following:

(a) Discovering a fire in the machinery space. (6 marks)

If the watchkeeping engineer discovers a fire in the machinery space, they should take the following actions:

1. Raise the Alarm Immediately

- Activate the fire alarm.
- Inform the bridge and Chief Engineer of the location and nature of the fire.

2. Assess the Fire

- Identify, if possible:
  - The source of the fire,
  - The type and extent of the fire,
  - Whether it can be tackled safely with portable equipment.

3. Stop the Fuel Supply

- Shut off the fuel supply to the affected equipment if it is safe to do so.
- Operate remote quick-closing valves if necessary.

4. Attack the Fire if Safe

- Use the appropriate portable extinguisher:
  - CO_2 for electrical fires,
  - Foam or dry powder for oil fires.
- Only attempt this if personal safety is not endangered.

5. Isolate Ventilation and Machinery

- Stop ventilation fans serving the affected space.
- Close fire dampers and skylights.
- Stop machinery contributing to the fire where appropriate.

6. Prepare for Fixed Fire-Fighting Systems

- Muster the fire party and report conditions to the Master and Chief Engineer.
- If the fire cannot be controlled, evacuate personnel and prepare the machinery space for the release of the fixed CO_2 smothering system in accordance with emergency procedures.

Exam-Style Answer

On discovering a machinery space fire, the watchkeeping engineer should immediately raise the alarm and notify the bridge and Chief Engineer. The source and extent of the fire should be assessed, fuel supplies isolated, and the fire attacked with suitable portable extinguishers if it is safe to do so. Ventilation and machinery should be stopped as necessary, fire dampers closed, and preparations made for the use of the fixed fire-extinguishing system if the fire cannot be controlled.

(b) Electrocution of another person. (4 marks)

If another person suffers an electric shock, the watchkeeping engineer should:

1. Isolate the Electrical Supply

- Switch off the power supply immediately.
- If this is not possible, use a dry insulating object to separate the casualty from the live conductor.

Do not touch the casualty directly while they are still in contact with the electrical source.

2. Raise the Alarm and Call for Assistance

- Inform the bridge and request medical assistance.
- Summon trained first-aiders.

3. Assess the Casualty

- Check:
  - Response,
  - Airway,
  - Breathing,
  - Circulation.

4. Administer First Aid

- If the casualty is not breathing and has no pulse, commence **CPR** immediately.
- Treat burns as appropriate.
- Keep the casualty warm and under observation until medical assistance is available.

Exam-Style Answer

In the event of electrocution, the watchkeeping engineer must first isolate the electrical supply or free the casualty using insulating materials without endangering themselves. The alarm should be raised and medical assistance requested. The casualty's airway, breathing, and circulation should be assessed, CPR commenced if necessary, and burns treated while awaiting further medical attention.

Quick Revision Summary

Situation	Immediate Actions
Machinery space fire	Raise alarm, inform bridge/Chief Engineer, isolate fuel and ventilation, fight fire if safe, prepare fixed CO_2 system

Electrocution	Isolate power, avoid direct contact, call for help, assess ABC, commence CPR if required

3. With reference to the bunkering of fuel:

(a) explain what is meant by a *Shipboard Oil Pollution Emergency* Plan (SOPEP); (1)

(b) state the FOUR requirements of a *Shipboard Oil Pollution Emergency Plan* (SOPEP); (4)

(c) state the immediate action to be taken should an oil spill occur. (5)

3. With reference to the bunkering of fuel:

(a) Explain what is meant by a Shipboard Oil Pollution Emergency Plan (SOPEP). (1 mark)

> A **Shipboard Oil Pollution Emergency Plan (SOPEP)** is a ship-specific plan that provides procedures and guidance to be followed by the crew in the event of an actual or probable oil pollution incident, in order to minimise pollution and comply with MARPOL requirements.

It is required under **MARPOL Annex I** for ships of **400 GT and above**, and for all oil tankers of **150 GT and above**.

(b) State the FOUR requirements of a Shipboard Oil Pollution Emergency Plan (SOPEP). (4 marks)

According to MARPOL Annex I, a SOPEP should contain the following four main sections:

1. Procedures for Reporting Oil Pollution Incidents

- Guidance on how to make reports in the event of an oil spill.
- Includes the format and information required under IMO reporting procedures.

2. List of Authorities and Persons to be Contacted

- Details of coastal state authorities.
- Contact details for port authorities, owners, managers, and other relevant organisations.

3. Immediate Action to Reduce or Control the Discharge

- Procedures to be followed by the Master and crew to minimise or stop the oil spill.
- Includes operational measures and shipboard response actions.

4. Procedures and Point of Contact for Co-ordinating Shipboard Action

- Details of who is responsible for implementing the plan.
- Guidance for co-ordinating actions between the ship and shore authorities.

Exam-Style Answer

The SOPEP should include:

1. Procedures for reporting oil pollution incidents.
2. A list of authorities and persons to be contacted.
3. Immediate actions to control or minimise the discharge.
4. Procedures and contact details for co-ordinating shipboard response with shore authorities.

(c) State the immediate action to be taken should an oil spill occur. (5 marks)

If an oil spill occurs during bunkering, the watchkeeping engineer should take the following immediate actions:

1. Stop the Transfer of Oil

- Order **"STOP BUNKERING"** immediately.
- Stop transfer pumps and close bunker valves.

2. Raise the Alarm

- Inform:
  - The Master,
  - Chief Engineer,
  - Officer of the Watch,
  - Terminal or bunker barge personnel.

3. Prevent Further Escape of Oil

- Close scuppers and save-alls.
- Plug deck drains.
- Isolate the source of the leak or overflow.

4. Contain the Spill

- Deploy SOPEP equipment such as:
  - Absorbent pads,

- Absorbent granules,
- Portable booms,
- Drain covers.

5. Report the Incident

- Notify the appropriate authorities in accordance with the SOPEP procedures.
- Record the incident and actions taken.

6. Clean Up and Monitor

- Recover spilled oil safely.
- Dispose of contaminated materials correctly.
- Continue monitoring to prevent further pollution.

Exam-Style Answer

In the event of an oil spill, bunkering should be stopped immediately by stopping pumps and closing valves. The alarm should be raised and the Master, Chief Engineer, and terminal informed. Scuppers and drains should be sealed to prevent oil entering the sea, and SOPEP equipment used to contain the spill. The incident should then be reported in accordance with the SOPEP, and clean-up operations commenced.

Quick Revision Summary

Part	Key Points
(a) SOPEP	Shipboard plan for responding to actual or probable oil pollution incidents
(b) Four Requirements	Reporting procedures; contact list; actions to control discharge; coordination procedures
(c) Immediate Actions	Stop bunkering; raise alarm; contain spill; use SOPEP equipment; report and clean up

4. (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)

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

Marine Gas Oil (MGO) may become contaminated during storage, transfer, or service. Four possible contaminants are:

1. Water

- May enter through condensation, leaking tank boundaries, faulty vents, or during bunkering.

2. Solid Particles (Dirt, Rust and Sediment)

- Can originate from storage tanks, pipelines, bunker barges, corrosion products, or poor housekeeping.

3. Microbiological Contamination (Diesel Bug)

- Bacteria, fungi, and yeasts can grow at the fuel/water interface.

4. Lubricating Oil or Other Oil Contamination

- Contamination from incorrect bunkering, cross-connections, or mixing with other petroleum products.

Other acceptable answers include:

- Salt water,
- Catalyst fines,
- Sludge,
- Asphaltenes,
- Chemical contaminants.

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

1. Water

Means of Dealing With It

- Allow the fuel to settle in storage or settling tanks.
- Drain water regularly from tank drain points.
- Pass the fuel through a **centrifugal purifier or separator** to remove water before use.

Explanation

Water separates from the fuel due to its higher density and can be removed by settling and centrifugal separation.

---

2. Solid Particles (Dirt/Rust)

Means of Dealing With Them

- Use **duplex filters and strainers** in the fuel system.
- Clean tanks periodically to remove accumulated sediment.
- Employ centrifugal separators to remove fine solids.

Explanation

Filtration and separation prevent abrasive particles from reaching fuel pumps and injectors.

---

3. Microbiological Contamination (Diesel Bug)

Means of Dealing With It

- Remove free water from tanks, as microorganisms require water to survive.
- Dose the fuel with an approved **biocide**.
- Clean and disinfect contaminated tanks if infestation is severe.

Explanation

Eliminating water and treating with biocide destroys the microorganisms and prevents further growth.

Exam-Style Answer

(a)

Four contaminants that may be present in marine gas oil are:

- Water,
- Dirt/rust/sediment,
- Microbiological contamination (diesel bug),
- Lubricating oil or other oil contamination.

(b)

Water may be removed by settling, draining, and centrifugal purification. Solid contaminants may be removed by filters, strainers, and separators. Microbiological contamination may be controlled by removing water, treating the fuel with biocide, and cleaning the tanks.

Quick Revision Table

Contaminant	Possible Source	Method of Removal/Treatment
Water	Condensation, leaks	Settling, draining, purifier
Dirt/Rust	Corroded tanks, bunkering	Filters, strainers, separators
Diesel Bug	Fuel/water interface	Biocide, tank cleaning, water removal
Oil Contamination	Cross-contamination	Identify source, isolate and clean system

5. With reference to sewage systems:

(a) state the ventilation arrangements for collection, storage and treatment tanks; (5)

(b) describe the personal hygiene requirements for those undertaking maintenance. (5)

5. With reference to sewage systems:

(a) State the ventilation arrangements for collection, storage and treatment tanks. (5 marks)

Collection, storage, and sewage treatment tanks require effective ventilation to prevent the accumulation of toxic, flammable, and foul-smelling gases.

1. Ventilation to Open Deck

- Tanks should be fitted with **vent pipes leading directly to the open atmosphere**.
- Vent outlets should discharge in a safe location away from accommodation spaces and air intakes.

2. Independent Venting

- Each sewage tank should have its **own dedicated vent line** or an approved venting arrangement.
- Cross-connections with other tank vent systems should be avoided.

3. Adequate Vent Size

- Vent pipes should be of sufficient diameter to:
  - Prevent pressure build-up during filling,
  - Prevent vacuum formation during emptying,
  - Allow adequate airflow for biological processes.

4. Flame Screens and Weather Protection

- Vent terminals should be fitted with:
  - Weather protection,
  - Insect screens where appropriate,
  - Flame screens if required by design.

5. Ventilation for Treatment Tanks

- Aerobic sewage treatment plants require a continuous supply of air.
- Air blowers or compressors are used to provide oxygen for the microorganisms responsible for sewage treatment.

Importance of Ventilation

Proper ventilation prevents the accumulation of dangerous gases such as:

- **Hydrogen sulphide (H_2S)**,
- **Methane (CH_4)**,
- **Carbon dioxide (CO_2)**,
- Ammonia (NH_3).

Exam-Style Answer

> Collection, storage, and treatment tanks should be fitted with adequately sized vent pipes leading to the open deck and away from accommodation and air intakes. Vent systems should prevent pressure or vacuum formation and should generally be independent of other systems. Vent terminals should be protected against weather and insects, and aerobic treatment plants should have continuous air supplied by blowers to support the treatment process.

(b) Describe the personal hygiene requirements for those undertaking maintenance. (5 marks)

Personnel carrying out maintenance on sewage systems are at risk from infection and contamination and must observe strict personal hygiene.

1. Wear Appropriate PPE

Personnel should wear:

- Waterproof gloves,
- Coveralls or protective clothing,
- Rubber boots,
- Eye and face protection,
- Respiratory protection where necessary.

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2. Avoid Direct Contact

- Avoid contact with sewage and contaminated surfaces.
- Cover cuts, abrasions, and broken skin with waterproof dressings before commencing work.

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3. Wash Thoroughly After Work

- Hands and exposed skin should be washed thoroughly with soap and clean water after completing the task.
- Particular attention should be paid before eating, drinking, or smoking.

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4. Prohibit Eating, Drinking, and Smoking

- Eating, drinking, chewing gum, and smoking should not take place during maintenance work.
- This prevents accidental ingestion of contaminants.

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5. Clean and Disinfect Equipment and Clothing

- Reusable PPE and tools should be cleaned and disinfected after use.
- Contaminated clothing should be removed and laundered appropriately.

Additional Precautions

- Personnel should be aware of the risk of diseases such as **hepatitis, gastroenteritis, and leptospirosis**.

- Vaccinations recommended by company medical guidance should be kept up to date.
- Any illness following exposure should be reported promptly.

Exam-Style Answer

Personnel undertaking sewage system maintenance should wear suitable PPE, including gloves, boots, and protective clothing, and avoid direct contact with sewage. Cuts should be covered with waterproof dressings. Eating, drinking, and smoking should be prohibited during the work. After completion, hands and exposed skin should be washed thoroughly, and contaminated equipment and clothing cleaned and disinfected before reuse.

Quick Revision Summary

Part	Key Points
Ventilation Arrangements	Open deck venting, independent vents, adequate sizing, protected vent heads, air supply to aerobic plants
Personal Hygiene	PPE, cover cuts, no eating/drinking/smoking, wash thoroughly, disinfect clothing and equipment

6. (a) With reference to Air Conditioning, define EACH of the following terms:

(i) *humidity;* (3)

(ii) *relative humidity.* (3)

(b) Describe TWO ways of controlling relative humidity. (4)

6. (a) With reference to Air Conditioning, define EACH of the following terms:

(i) Humidity (3 marks)

Humidity is the amount of water vapour present in the air.

More precisely, it is the **mass of water vapour contained in a given mass of dry air**, usually expressed in kilograms of water vapour per kilogram of dry air.

Example

- Warm tropical air generally contains more moisture than cold air.
- Therefore, it has a higher humidity.

(ii) Relative Humidity (3 marks)

Relative Humidity (RH) is the ratio of the actual amount of water vapour present in the air to the maximum amount of water vapour that the air could hold at the same temperature and pressure, expressed as a percentage.

$$\text{RH} = \frac{\text{Actual moisture content}}{\text{Saturated moisture content at the same temperature}} \times 100$$

$$RH = \frac{\text{Actual moisture content}}{\text{Saturated moisture content at the same temperature}} \times 100$$

Example

- If the air contains half the moisture it could hold at that temperature:

$$RH = 50\%$$

Significance

- At **100% RH**, the air is saturated and cannot hold any more moisture without condensation occurring.

(b) Describe TWO ways of controlling relative humidity. (4 marks)

1. Cooling and Dehumidification

Method

- Air is passed over a **cooling coil** whose temperature is below the dew point of the air.
- Moisture condenses on the coil surface and is drained away.

Result

- The moisture content of the air decreases.
- Relative humidity is reduced.

Used In

- Marine air-conditioning plants.
- Refrigerated spaces.

2. Humidification

Method

- Moisture is added to the air by:
  - Steam injection,
  - Water spray humidifiers,
  - Evaporative humidifiers.

Result

- The moisture content of the air increases.
- Relative humidity rises to the desired value.

Used In

- Accommodation air-conditioning systems in dry climates.
- Spaces requiring controlled humidity.

Other Acceptable Answers

Examiners may also accept:

- **Reheating** air after dehumidification to achieve the required RH and temperature.
- **Mixing fresh air with return air** to adjust moisture levels.

Exam-Style Answer

(a)

Humidity is the amount of water vapour present in the air.
Relative humidity is the percentage ratio of the actual water vapour present to the maximum amount the air can hold at the same temperature and pressure.

(b)

Relative humidity may be controlled by passing air over cooling coils below the dew point to condense and remove moisture, thereby reducing RH. It may also be controlled by adding moisture using steam injection or humidifiers to increase RH to the desired level.

Quick Revision Summary

Term/Method	Definition
Humidity	Amount of water vapour in the air
Relative Humidity	Actual moisture ÷ maximum possible moisture × 100%
Reduce RH	Cooling/dehumidification using cooling coils
Increase RH	Humidification using steam or water sprays

With reference to reverse osmosis plants:

(a) describe the sea water pre-treatment process before the water enters the membrane modules; (6)

(b) describe how the purity of the permeate is measured; (3)

(c) state the limits of impurity in the permeate when produced to World Health Organisation Standards. (1)

With reference to reverse osmosis plants:

(a) Describe the sea water pre-treatment process before the water enters the membrane modules. (6 marks)

Before seawater enters the reverse osmosis (RO) membrane modules, it undergoes several stages of **pre-treatment** to remove contaminants and prevent damage or fouling of the membranes.

1. Sea Water Intake

- Seawater is drawn from the sea through the ship's sea suction.
- The intake is usually fitted with coarse strainers to prevent large debris entering the system.

---

2. Coarse Filtration

- The seawater passes through a **coarse strainer**.
- This removes large suspended matter such as:
  - Seaweed,
  - Shell fragments,
  - Sand particles,
  - Marine organisms.

---

3. Fine Filtration (Cartridge Filters)

- The water then passes through **fine cartridge filters** (typically 5–20 μm).
- These remove smaller suspended solids that could block the membranes.

---

4. Chemical Treatment (Anti-scalant)

- An **anti-scalant chemical** may be injected into the feed water.
- This prevents precipitation of salts such as:
  - Calcium carbonate,
  - Calcium sulphate,
  - Magnesium compounds,
    which could form scale on the membrane surfaces.

---

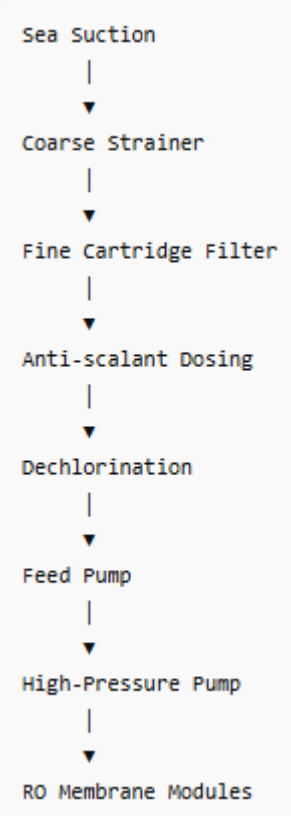
5. Chlorination and Dechlorination

- Chlorine may be used initially to control biological growth.
- However, because chlorine damages most RO membranes, it must be removed before the water reaches the membranes, commonly by:
  - Activated carbon filtration, or
  - Sodium bisulphite dosing.

---

6. Feed Pump and High-Pressure Pump

- The treated seawater enters the feed pump and then the **high-pressure pump**.
- The pressure is raised sufficiently (typically **55–70 bar**) to overcome the natural osmotic pressure before entering the membrane modules.



(b) Describe how the purity of the permeate is measured. (2 marks)

The purity of the permeate is normally measured using a:

Salinometer (conductivity meter).

Operation

- The instrument measures the **electrical conductivity** of the permeate.
- Dissolved salts increase conductivity.
- The lower the conductivity, the purer the water.

The reading may be displayed as:

- Conductivity (µS/cm), or
- Total Dissolved Solids (TDS) in mg/L (ppm).

Many systems incorporate an automatic dump valve that rejects permeate if its salinity exceeds the preset limit.

(c) State the limits of impurity in the permeate when produced to World Health Organisation Standards. (1 mark)

According to **World Health Organisation (WHO) standards**:

> The total dissolved solids (TDS) content of potable water should not exceed approximately **1,000 mg/L (1,000 ppm).**

Many marine reverse osmosis plants are designed to produce water with a much lower TDS, often **below 500 ppm**.

Exam-Style Answer

(a)

> Seawater is taken through the sea suction and passed through coarse strainers and fine cartridge filters to remove suspended matter. Anti-scalant chemicals may be added to prevent scale formation, and any chlorine present is removed before the water reaches the membranes. The feed water is then pressurised by a high-pressure pump and delivered to the reverse osmosis membrane modules.

(b)

> The purity of the permeate is measured using a salinometer or conductivity meter, which measures the electrical conductivity of the product water and indicates its dissolved salt content.

(c)

> Potable water produced to WHO standards should contain no more than **1,000 ppm (1,000 mg/L) total dissolved solids**.

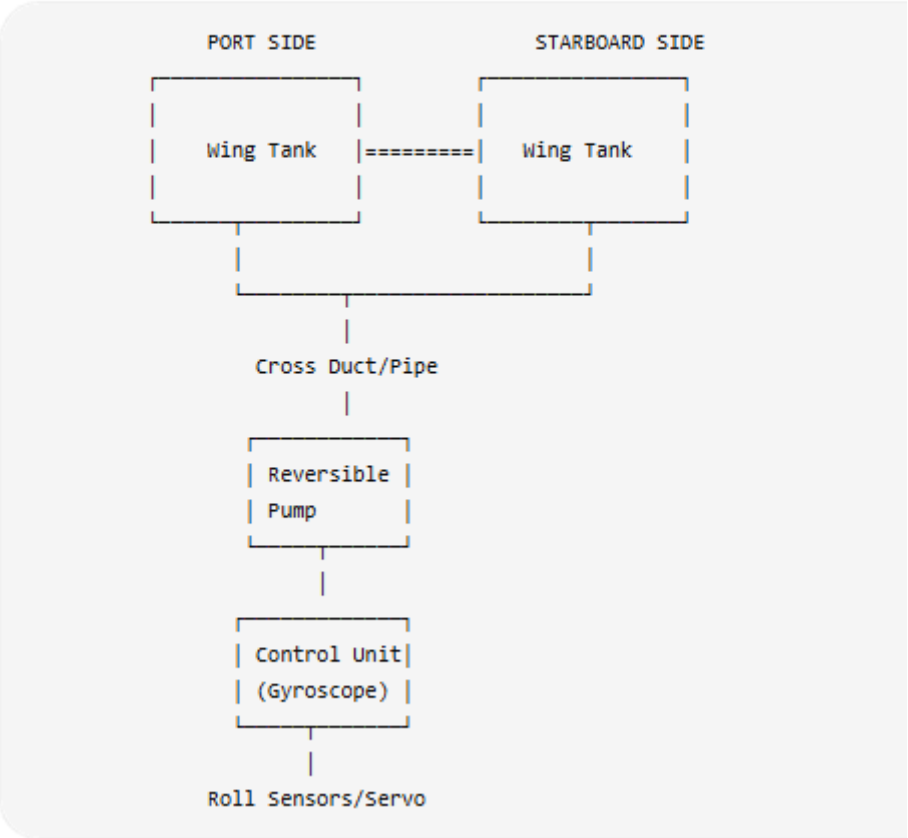
8. Describe, with the aid of a sketch, the construction and operation of an *Active Controlled Tank* roll damping system. (10) 3

8. Describe, with the aid of a sketch, the construction and operation of an Active Controlled Tank roll damping system. (10 marks)

An **Active Controlled Tank (ACT) roll damping system** is an anti-roll system that reduces the rolling motion of a vessel by transferring water between tanks on opposite sides of the ship. The movement of water is

automatically controlled so that the generated moment opposes the vessel's roll.

Sketch of an Active Controlled Tank System



Construction

The system consists of:

1. Wing Tanks

- Two partially filled tanks located high in the vessel, one on the **port side** and one on the **starboard side**.

2. Cross-Connection Duct

- A large pipe connecting the two tanks.
- Allows water to be transferred from one tank to the other.

3. Reversible Pump

- Transfers water rapidly between the tanks.
- May be electrically or hydraulically driven.

4. Control Valves

- Regulate the flow of water.
- Operate automatically under the command of the control system.

5. Gyroscope/Roll Sensor

- Detects the direction, amplitude, and rate of roll of the vessel.

6. Automatic Control Unit

- Processes the sensor signals.
- Commands the pump and valves to transfer water appropriately.

Operation

Vessel Rolling to Port

Roll to Port

PORT STARBOARD

↓ ↑

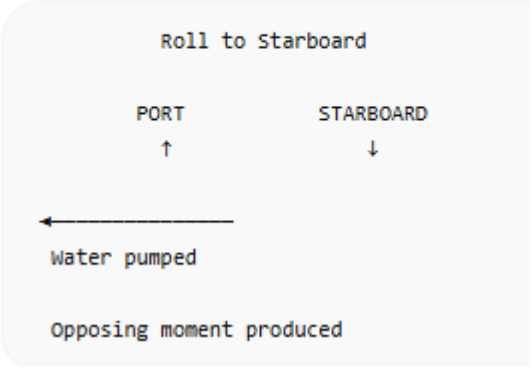
Water pumped

——————————▶

Opposing moment produced

- The gyroscope detects that the vessel is rolling to port.
- The control unit starts the pump.
- Water is transferred towards the **starboard tank**.
- The movement of water creates a moment opposing the roll.
- This reduces the rolling amplitude.

Vessel Rolling to Starboard



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)

9. (a) Define EACH of the following:

(i) Flash Point (2 marks)

Flash Point is the **lowest temperature at which a liquid gives off sufficient vapour to form an ignitable mixture with air that will flash when an external source of ignition is applied, but will not continue to burn once the ignition source is removed.**

Example

- Marine Gas Oil has a minimum flash point of **60°C** under SOLAS requirements.

(ii) Ignition Point (Fire Point) (2 marks)

Ignition Point (Fire Point) is the **lowest temperature at which the vapours from a substance, once ignited, will continue to burn for a specified period (usually at least 5 seconds) after the ignition source has been removed.**

Difference from Flash Point

- **Flash Point:** Burns momentarily.
- **Ignition (Fire) Point:** Continues to burn after ignition.

(iii) Auto-Ignition Temperature (2 marks)

> **Auto-Ignition Temperature** is the **lowest temperature at which a substance will ignite spontaneously in air without the application of an external flame, spark, or other ignition source.**

Example

- Fuel oil leaking onto a hot exhaust manifold may ignite if the surface temperature exceeds the fuel's auto-ignition temperature.

Exam-Style Definitions

> **Flash Point:** The lowest temperature at which a liquid produces enough vapour to ignite momentarily when an external ignition source is applied.
>
> **Ignition Point (Fire Point):** The lowest temperature at which vapours continue to burn after the ignition source has been removed.
>
> **Auto-Ignition Temperature:** The lowest temperature at which a substance ignites spontaneously without an external ignition source.

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

Under **SOLAS requirements**, the fixed CO_2 fire-extinguishing installation for machinery spaces must be capable of providing sufficient CO_2 to rapidly extinguish a fire.

Volume Requirement

The quantity of CO_2 carried must be sufficient to give a free gas volume equal to at least:

> **40% of the gross volume of the largest machinery space protected**, excluding the volume of the casing above the level at which the horizontal area of the casing is 40% or less of the machinery space area.

However:

- The quantity provided need not exceed that required for **35% of the gross volume of the largest machinery space**, including the casing.

Minimum Capacity

The system must not contain less than:

> **30% of the gross volume of the largest machinery space protected.**

Time Requirement

The piping and controls must be arranged so that:

> **85% of the required quantity of CO_2 can be discharged into the machinery space within 2 minutes.**

This ensures that the oxygen concentration is reduced quickly enough to extinguish the fire and prevent re-ignition.

Exam-Style Answer

(a)

> **Flash Point:** The lowest temperature at which vapours from a liquid ignite momentarily when an external ignition source is applied.
>
> **Ignition Point:** The lowest temperature at which the vapours continue to burn after the ignition source is removed.
>
> **Auto-Ignition Temperature:** The lowest temperature at which a substance ignites without an external source of ignition.

(b)

> A machinery space fixed CO_2 installation must contain sufficient CO_2 to provide a free gas volume of at least **40% of the gross volume of the largest machinery space protected**, subject to the SOLAS limits of **35% including the casing and not less than 30%**. The system must be capable of discharging **85% of the required quantity within 2 minutes**.

Quick Revision Table

Term	Definition
Flash Point	Vapour ignites briefly with an external flame
Ignition (Fire) Point	Vapour continues to burn after ignition source is removed
Auto-Ignition Temperature	Ignites without any external ignition source
CO_2 Requirement	40% of machinery space volume (SOLAS limits apply)
Discharge Time	85% of CO_2 discharged within 2 minutes

Opposing moment produced

- The sensor detects starboard roll.
- The pump reverses.
- Water is transferred to the **port tank**.
- The resulting moment opposes the roll and damps the motion.

Principle of Operation

> The system works by transferring water so that the movement of the liquid mass produces a counteracting heeling moment opposite to the ship's rolling motion.

The timing of the transfer is critical:

- Water must move at the correct phase of the roll cycle.
- The automatic control system ensures that the counter-moment is produced at the optimum time.

Advantages

- Effective reduction of rolling motion.

- Improves passenger comfort.
- Reduces cargo movement and cargo damage.
- Can operate at low speeds and when the vessel is stationary.
- No external projections below the hull.

Disadvantages

- Occupies valuable tank space.
- Increased complexity and maintenance.
- Requires electrical power and control systems.
- Less effective at very high ship speeds compared with fin stabilisers.

Exam-Style Answer

An Active Controlled Tank roll damping system consists of two partially filled wing tanks connected by a cross-duct containing a reversible pump and control valves. A gyroscope detects the ship's rolling motion and sends signals to an automatic controller. As the vessel rolls, water is transferred to the opposite tank at the correct point in the roll cycle, producing a moment that opposes the roll and reduces its amplitude. The system improves stability and passenger comfort and is particularly useful because it remains effective even when the vessel is operating at low speed or is stationary.

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)

9. (a) Define EACH of the following:

(i) Flash Point (2 marks)

Flash Point is the **lowest temperature at which a liquid gives off sufficient vapour to form an ignitable mixture with air that will flash when an external source of ignition is applied, but will not continue to burn once the ignition source is removed.**

Example

- Marine Gas Oil has a minimum flash point of **60°C** under SOLAS requirements.

(ii) Ignition Point (Fire Point) (2 marks)

Ignition Point (Fire Point) is the **lowest temperature at which the vapours from a substance, once ignited, will continue to burn for a specified period (usually at least 5 seconds) after the ignition source has been removed.**

Difference from Flash Point

- **Flash Point:** Burns momentarily.
- **Ignition (Fire) Point:** Continues to burn after ignition.

(iii) Auto-Ignition Temperature (2 marks)

Auto-Ignition Temperature is the **lowest temperature at which a substance will ignite spontaneously in air without the application of an external flame, spark, or other ignition source.**

Example

- Fuel oil leaking onto a hot exhaust manifold may ignite if the surface temperature exceeds the fuel's auto-ignition temperature.

Exam-Style Definitions

Flash Point: The lowest temperature at which a liquid produces enough vapour to ignite momentarily when an external ignition source is applied.

Ignition Point (Fire Point): The lowest temperature at which vapours continue to burn after the ignition source has been removed.

Auto-Ignition Temperature: The lowest temperature at which a substance ignites spontaneously without an external ignition source.

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

Under **SOLAS requirements**, the fixed CO_2 fire-extinguishing installation for machinery spaces must be capable of providing sufficient CO_2 to rapidly extinguish a fire.

Volume Requirement

The quantity of CO_2 carried must be sufficient to give a free gas volume equal to at least:

> **40% of the gross volume of the largest machinery space protected**, excluding the volume of the casing above the level at which the horizontal area of the casing is 40% or less of the machinery space area.

However:

- The quantity provided need not exceed that required for **35% of the gross volume of the largest machinery space**, including the casing.

Minimum Capacity

The system must not contain less than:

> **30% of the gross volume of the largest machinery space protected.**

Time Requirement

The piping and controls must be arranged so that:

> **85% of the required quantity of CO_2 can be discharged into the machinery space within 2 minutes.**

This ensures that the oxygen concentration is reduced quickly enough to extinguish the fire and prevent re-ignition.

Exam-Style Answer

(a)

Flash Point: The lowest temperature at which vapours from a liquid ignite momentarily when an external ignition source is applied.

Ignition Point: The lowest temperature at which the vapours continue to burn after the ignition source is removed.

Auto-Ignition Temperature: The lowest temperature at which a substance ignites without an external source of ignition.

(b)

A machinery space fixed CO_2 installation must contain sufficient CO_2 to provide a free gas volume of at least **40% of the gross volume of the largest machinery space protected**, subject to the SOLAS limits of **35% including the casing and not less than 30%**. The system must be capable of discharging **85% of the required quantity within 2 minutes**.

Quick Revision Table

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

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

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

A **bulkhead** is a vertical partition or wall built across or along a ship, extending from the bottom or deck and forming a subdivision of the vessel into separate compartments.

Bulkheads may be:

- Watertight,
- Non-watertight,
- Fire-resisting,
- Oiltight.

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

Bulkheads perform several important functions in a ship's construction:

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1. Maintain Watertight Integrity

- Watertight bulkheads restrict the spread of flooding following damage to the hull.
- They improve the vessel's ability to survive after collision or grounding.

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2. Subdivide the Ship into Compartments

- Divide the vessel into machinery spaces, cargo holds, tanks, accommodation spaces, and stores.
- Assist in the efficient organisation of the ship.

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3. Provide Structural Strength

- Bulkheads contribute to the **transverse and longitudinal strength** of the hull.
- They stiffen the ship's structure and resist deformation caused by sea loads.

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4. Limit the Spread of Fire

- Fire-resisting bulkheads restrict the spread of fire, heat, and smoke between compartments.
- They provide protection for escape routes and accommodation spaces.

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5. Form Boundaries of Tanks

- Oiltight and watertight bulkheads form the boundaries of:
    - Fuel oil tanks,
    - Ballast tanks,
    - Fresh water tanks,

- Cargo tanks.

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6. Reduce Free Surface Effects

- Longitudinal bulkheads in tanks reduce the movement of liquids.
- This improves the vessel's stability by minimising free surface effect.

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7. Support Decks and Equipment

- Bulkheads provide support for decks, platforms, ladders, piping, machinery, and fittings attached to them.

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8. Improve Damage Stability

- By limiting the extent of flooding, bulkheads help maintain buoyancy and stability after damage.
- This increases the likelihood of the vessel remaining afloat.

Exam-Style Answer

(a)

A bulkhead is a vertical partition in a ship used to divide the vessel into separate compartments. It may be watertight, oiltight, or fire-resisting.

(b)

The functions of bulkheads are to maintain watertight integrity, subdivide the ship into compartments, provide structural strength, limit the spread of fire, form tank boundaries, reduce free surface effects, support decks and equipment, and improve the ship's damage stability.

Quick Revision Summary

Function	Purpose
Watertight subdivision	Limits flooding

Compartmentation	Separates ship spaces
Structural strength	Strengthens hull
Fire protection	Restricts spread of fire
Tank boundaries	Forms tanks
Reduce free surface	Improves stability
Support structure	Supports decks/equipment
Damage stability	Helps vessel survive damage