AUXILIARY EQUIPMENT PART II

Attempt ALL questions
Marks for each part question are shown in brackets

1. With reference to a pressure compensated variable displacement, swash plate pump, explain FOUR different possible causes of reduction in performance.

   Note: The filter has been cleaned, the system is in good condition and there are no visual signs. (10)

2. (a) Sketch the hydraulic symbol for a 4:3 directional control valve. (3)

   (b) Describe the operation of EACH of the following hydraulic valves:

   (i) directional control valve; (2)

   (ii) speed control valve; (2)

   (iii) brake valve. (3)

3. With reference to storage batteries, explain EACH of the following:

   (a) the term UPS; (3)

   (b) the operation of an inverter, stating why it may be required; (4)

   (c) the term 150 Ah. (3)

4. With reference to a.c. 3 phase motors:

   (a) explain the meaning of the term soft starter; (4)

   (b) describe, with the aid of a diagram, the operation of a solid state soft starter. (6)

5. (a) Explain EACH of the following terms with reference to refrigeration gases:

   (i) the Green House Effect; (3)

   (ii) ozone depletion. (3)

   (b) Describe the effect of undercharge in a refrigeration system. (4)

6. Describe, with the aid of a sketch, how the relative humidity may be controlled in an Air Conditioning System. (10)

7. (a) State the maximum time periods between EACH of the following lifting equipment requirements:

   (i) thorough examination and inspection; (1)

   (ii) testing. (1)

   (b) Describe the inspection routine for lifting gear. (6)

   (c) State the procedure for recording the results of the inspection and tests. (2)

8. With reference to the storage of volatile fuels, describe the construction and placement requirements of the storage tanks for aviation fuel, including tank ventilation. (10)

9. (a) State the purpose of the collision bulkhead and the regulations appertaining to its dimensions and position. (4)

   (b) Explain the difference between A, B and C class bulkheads. (6)

10. (a) Explain what is meant by the term *pounding* as applied to a vessel being driven hard in a seaway. (3)

    (b) Explain how *panting* may often occur at the same time as pounding in heavy seas. (3)

    (c) Describe how the hull is strengthened to resist *panting* and *pounding*. (4)

1. With reference to a pressure compensated variable displacement, swash plate pump, explain FOUR different possible causes of reduction in performance.

Note: The filter has been cleaned, the system is in good condition and there are no visual signs. (10)

this one is testing knowledge of **hydraulic pump performance losses** (specifically in a pressure compensated variable displacement swash plate pump). Since the system is noted as being clean and with no obvious defects, the answer should focus on **internal/mechanical and fluid issues**.

Q1: With reference to a pressure compensated variable displacement swash plate pump, explain FOUR possible causes of reduction in performance.

1. **Internal leakage (wear of pistons, barrel, or slipper pads):**
   - Over time, wear between the piston shoes, cylinder barrel, or swash plate causes increased **internal leakage**.
   - This results in reduced volumetric efficiency and loss of delivered flow/pressure.
2. **Faulty or maladjusted pressure compensator valve:**
   - The compensator controls pump displacement in response to system demand.
   - If worn, sticking, or incorrectly set, the pump may prematurely destroke, reducing flow and pressure.
3. **Cavitation or aeration in the pump inlet:**
   - Even with clean filters, restricted suction lines, low fluid level, or entrained air can cause cavitation.
   - This reduces efficiency, damages components, and leads to performance drop.
4. **Excessive clearances due to thermal expansion or wear:**
   - Clearances between moving parts (swash plate, pistons, valve plate) may increase due to wear or overheating.
   - This increases leakage and reduces the effective output of the pump.

✅ **Other acceptable causes (depending on examiner expectations):**

- Worn or damaged swash plate control mechanism (reduced angle = reduced stroke length).

- Fluid degradation (loss of viscosity reduces volumetric and mechanical efficiency).
- Spring fatigue in the control system (affecting displacement control response).

📌 **Examiner's key points expected:**

- Internal leakage due to wear.
- Compensator/control malfunction.
- Cavitation/aeration issues.
- Excessive wear/clearances reducing displacement efficiency.

2. (a) Sketch the hydraulic symbol for a 4:3 directional control valve. (3)

(b) Describe the operation of EACH of the following hydraulic valves:

(i) directional control valve; (2)

(ii) speed control valve; (2)

(iii) brake valve. (3)

Q2(a) – Sketch the hydraulic symbol for a 4/3 directional control valve (3 marks)

- **4/3 valve** means **4 ports** (usually: P = pressure, T = tank/return, A & B = actuator ports) and **3 positions**.
- Middle position: can be **open centre, closed centre, tandem centre, or float centre** depending on the system.
- Symbol: three adjacent squares (showing the 3 positions), each square showing internal flow paths. Arrows indicate direction of flow.

👉 Since I can't sketch directly here in text, the **exam answer** should be drawn like this:

- **Box 1 (left):** P connected to A, B connected to T (actuator extends).
- **Box 2 (centre):** All ports blocked (closed centre).
- **Box 3 (right):** P connected to B, A connected to T (actuator retracts).

That's the **standard 4/3 DCV symbol**.

Q2(b) – Describe the operation of EACH of the following valves

(i) Directional control valve (DCV) (2 marks)

- Controls the **direction of flow** of hydraulic fluid to actuators (cylinders or motors).
- Determines whether the actuator extends, retracts, or holds position by opening and closing specific flow paths.

(ii) Speed control valve (2 marks)

- A flow control valve that **regulates the rate of flow** to an actuator.
- By restricting flow, it controls the **speed of a hydraulic motor or cylinder** without changing pump output.
- Often combined with a check valve to allow free flow in the reverse direction.

(iii) Brake valve (3 marks)

- Prevents uncontrolled movement of actuators (e.g., a winch or hoist under load).
- Works as a **counterbalance valve**, holding load until sufficient pilot pressure is applied to release it.
- Provides **safety against load dropping** if supply pressure fails.

3. With reference to storage batteries, explain EACH of the following:

(a) the term UPS; (3)

(b) the operation of an inverter, stating why it may be required; (4)

(c) the term 150 Ah. (3)

Q3(a) – the term UPS (3 marks)

- **UPS = Uninterruptible Power Supply**.
- A device/system that provides **instantaneous backup electrical power** from batteries when the main power supply fails.
- Ensures critical equipment (computers, control systems, alarms, navigation, medical gear, etc.) continues running without interruption.

✅ **Key points for marks:** definition, role, and example use.

Q3(b) – operation of an inverter, stating why it may be required (4 marks)

- An **inverter converts DC (direct current)** from a storage battery into **AC (alternating current)** at the required voltage and frequency.
- It works by **switching DC rapidly** through electronic circuits (semiconductors/transistors), creating an AC output waveform.
- **Why required:**
  - Most shipboard/industrial systems and domestic appliances run on AC.
  - Batteries store energy in DC, so an inverter is essential to power AC loads.

✅ **Key points:** function, principle of conversion, and practical need.

Q3(c) – the term 150 Ah (3 marks)

- **Ah = Ampere-hour**: a measure of **battery capacity**.
- A 150 Ah battery can deliver **150 amps for 1 hour**, or **15 amps for 10 hours**, before being fully discharged (under standard test conditions).
- It indicates how long a battery can supply current before needing recharge.

✅ **Key points:** definition of Ah, meaning of 150, and practical interpretation.

4. With reference to a.c. 3 phase motors:

(a) explain the meaning of the term soft starter; (4)

(b) describe, with the aid of a diagram, the operation of a solid state soft starter. (6)

Q4(a) – Explain the meaning of the term soft starter (4 marks)

- A **soft starter** is an electronic device used to **gradually ramp up the voltage and current** supplied to a 3-phase induction motor during start-up.
- This reduces **inrush current** and **mechanical stress** on the motor and driven equipment.
- It provides a **smooth acceleration**, preventing sudden torque shocks to the shaft, couplings, and driven machinery.
- After start-up, the motor runs at full voltage as normal.

✅ **Marking points:**

- Reduces inrush current
- Provides gradual/smooth acceleration
- Minimises mechanical/electrical stress
- Used during motor start only

Q4(b) – Describe, with the aid of a diagram, the operation of a solid-state soft starter (6 marks)

Operation:

- A solid-state soft starter uses **thyristors (SCRs)** or **triacs** connected in anti-parallel on each phase of the motor supply line.
- At start-up, the firing angle of the SCRs is gradually changed to allow an **increasing portion of the AC waveform** to pass through, effectively ramping up the voltage supplied to the motor.
- As voltage rises, motor torque increases gradually until the motor reaches full speed.
- Once full speed is achieved, the SCRs are bypassed by contactors to reduce heat losses.
- Some advanced soft starters also provide **controlled stop** (gradual voltage reduction to stop pumps, avoiding water hammer).

Simple diagram (conceptual description since I can't sketch here):

- 3-phase AC supply → 3 pairs of anti-parallel SCRs (one pair per phase) → Motor.
- Control unit adjusts SCR firing angle to ramp voltage.
- Optional bypass contactor in parallel to SCRs for running condition.

✅ **Marking points:**

- Use of SCRs/triacs in each phase
- Gradual increase in voltage by phase angle control
- Smooth motor acceleration
- Reduction of current surges
- Bypass contactor use
- Optional soft stop

5. (a) Explain EACH of the following terms with reference to refrigeration gases:

(i) the Green House Effect; (3)

(ii) ozone depletion. (3)

(b) Describe the effect of undercharge in a refrigeration system. (4)

Q5(a)(i) – The Greenhouse Effect (3 marks)

- The **greenhouse effect** refers to the trapping of heat in the Earth's atmosphere by certain gases (CO_2, CH_4, and some refrigeration gases such as HFCs).
- Refrigerant gases with **high Global Warming Potential (GWP)**, when released, absorb infrared radiation and prevent heat from escaping into space.
- This leads to a gradual rise in global temperatures and contributes to **climate change**.

✅ Key points:

- Caused by gases absorbing heat radiation.
- Refrigerants like HFCs contribute significantly due to high GWP.
- Results in global warming.

Q5(a)(ii) – Ozone Depletion (3 marks)

- Ozone depletion is the **thinning of the stratospheric ozone layer**, which protects the Earth from harmful ultraviolet (UV) radiation.
- Certain refrigerants, particularly **CFCs and HCFCs**, release chlorine (Cl) or bromine (Br) atoms in the stratosphere.
- These atoms **catalytically destroy ozone molecules** ($O_3 \rightarrow O_2$), reducing protection against UV rays.
- This increases risks of skin cancer, cataracts, and damage to marine ecosystems.

✅ Key points:

- Caused by chlorine/bromine from refrigerant breakdown.
- Destroys ozone molecules.
- Leads to more UV reaching the Earth.

Q5(b) – Effect of undercharge in a refrigeration system (4 marks)

- Undercharging means the refrigerant quantity in the system is **too low**.
- Main effects:
    1. **Reduced cooling capacity** – insufficient refrigerant flow reduces heat transfer.
    2. **Evaporator superheating** – not enough liquid refrigerant, so more vapor overheating occurs.
    3. **Compressor overheating** – due to lack of cooling and lubrication from refrigerant return.
    4. **Possible air ingress** – leading to higher discharge pressures and inefficiency.

✅ Key points for marks:

- Reduced system efficiency / poor cooling.
- High superheat.
- Compressor overheating.
- Risk of damage due to inadequate lubrication.

6. Describe, with the aid of a sketch, how the relative humidity may be controlled in an Air Conditioning System. (10)

Explanation

Relative humidity (RH) is the ratio of the actual water vapour present in the air to the maximum possible water vapour the air can hold at a given temperature. To control RH, air-conditioning systems **cool, dehumidify, reheat, or humidify the air**.

Methods of Control

1. **Dehumidification (RH reduction):**
    - Warm, moist air is passed over a **cooling coil (evaporator)**.
    - The coil temperature is below the dew point, causing **condensation of moisture**.
    - This lowers the absolute and relative humidity.
2. **Humidification (RH increase):**

  - When the air is too dry, a **humidifier** (steam injection or water spray chamber) adds moisture to the air stream.
  - This increases the relative humidity to the desired level.

3. **Reheating:**
  - After dehumidification, the air is often **too cold**.
  - A reheater coil (electric or hot water/steam coil) is used to bring the temperature back up while maintaining lower RH.

4. **Automatic Controls:**
  - **Humidistats** are used to sense and regulate the humidity levels.
  - They control humidifiers, dehumidifiers, and reheaters to maintain comfortable indoor conditions (usually 40–60% RH).

Sketch (simple line diagram)

A basic diagram should include:

- **Air inlet** (warm, moist air).
- **Cooling coil/evaporator** (for dehumidification).
- **Condensate drain** (to remove condensed water).
- **Reheater coil** (for reheating after dehumidification).
- **Humidifier (spray or steam)** for adding moisture.
- **Air outlet** (conditioned air to the space).
- Direction of air flow shown with arrows.

Answer Structure (10 marks)

- **Definition of RH and importance** (2 marks).
- **Dehumidification process** (3 marks).
- **Humidification process** (2 marks).
- **Reheating and controls (humidistat use)** (2 marks).

- **Clear sketch showing components and airflow** (1 mark).

7. (a) State the maximum time periods between EACH of the following lifting equipment requirements:

(i) thorough examination and inspection; (1)

(ii) testing. (1)

(b) Describe the inspection routine for lifting gear. (6)

(c) State the procedure for recording the results of the inspection and tests. (2)

(a) Maximum time periods

(i) **Thorough examination and inspection:**

- Every **12 months** (for lifting appliances such as cranes, derricks, winches, etc.).
- For lifting gear/accessories (slings, shackles, chains) → every **6 months**.

(ii) **Testing:**

- After initial installation and before being put into service.
- **Every 5 years** thereafter for lifting appliances (proof load test).
- Also required after **major repair, modification, or accident**.

(b) Inspection routine for lifting gear (6 marks)

1. **Visual inspection** for deformation, cracks, excessive wear, distortion.
2. **Check pins, shackles, and hooks** for correct operation, absence of cracks, secure safety catches.
3. **Examine wire ropes/chains** for broken wires, corrosion, elongation, or kinks.
4. **Lubrication condition** – ensure proper lubrication of moving parts.
5. **Identification marks** (safe working load (SWL), certificates, colour coding).
6. **Check for corrosion and deterioration** due to environment (especially saltwater exposure).

(c) Procedure for recording results (2 marks)

- Results of **thorough examinations, inspections, and tests** must be **entered into the Register of Lifting Appliances and Gear (Form 99 or equivalent log book)**.
- Records must be **signed and certified by a competent person/surveyor**, retained onboard, and made available for inspection by flag state or port authorities.

✅ **Marking breakdown suggestion**

- (a) 2 marks → correct periodicity.
- (b) 6 marks → routine checks.
- (c) 2 marks → proper recording procedure.

8. With reference to the storage of volatile fuels, describe the construction and placement requirements of the storage tanks for aviation fuel, including tank ventilation. (10)

Construction requirements

1. **Material** – Tanks constructed of steel, suitably coated internally to resist corrosion and contamination.
2. **Double bottom/Double wall tanks** – Provides extra protection against leakage and reduces risk of fire spread.
3. **Structural strength** – Tanks must be designed to withstand internal pressure variations and external stresses.
4. **Smooth internal surfaces** – Avoids accumulation of sludge, facilitates cleaning, prevents pockets of vapour.
5. **Fittings** – Tanks must be provided with flame arrestors, level gauges, remote sounding arrangements, and isolating valves.

Placement requirements

1. **Location** –
    - Aviation fuel tanks must be placed in **safe, well-ventilated compartments**, segregated from machinery spaces.
    - Located away from heat sources, electrical equipment, or accommodation spaces.
    - Protected from collision damage (e.g., wing tanks or cofferdams between fuel tanks and engine room bulkheads).

2. **Drainage and coaming** – Fuel storage areas must have spill containment (drip trays, coamings) to prevent spread.

3. **Segregation** – Dedicated pipelines and pumps for aviation fuel only (to prevent contamination).

Tank ventilation requirements

1. **Vent outlets** – Led to open deck in a safe position, well away from accommodation, air intakes, or ignition sources.

2. **Vent design** – Fitted with **flame arrestors** to prevent ignition from outside sources.

3. **Breathing arrangements** – Tanks must be designed to breathe under normal atmospheric conditions, preventing vacuum or overpressure.

4. **High-level alarms** – Overfill alarms and gauging devices required to prevent spillage during bunkering.

5. **Ventilation capacity** – Sufficient to disperse flammable vapours, with vent piping designed to avoid accumulation of liquid fuel.

✅ **Summary for 10 marks**

- **Construction (4 marks):** steel, double wall, strength, smooth surface, fittings.
- **Placement (3 marks):** safe location, segregation, protection, drainage.
- **Ventilation (3 marks):** safe outlet, flame arrestors, alarms, breathing system.

9. (a) State the purpose of the collision bulkhead and the regulations appertaining to its dimensions and position. (4)

(b) Explain the difference between A, B and C class bulkheads. (6)

(a) Collision bulkhead – purpose, dimensions, and position (4 marks)

Purpose:

- To prevent flooding of the vessel in case of a collision at the bow.
- Forms a watertight barrier between the forepeak and the rest of the ship.
- Limits the spread of water ingress, enhancing survivability.

Regulations (SOLAS):

1. **Position –** Must be located not less than **5% of the vessel's length from the forward perpendicular**, and not more than **8% of the vessel's length** (or 10 m, whichever is greater).

2. **Height** – Must extend up to the freeboard deck.

3. **Openings** – No doors, manholes, or ventilation ducts are permitted below the bulkhead deck (to maintain watertight integrity).

4. **Pipelines** – Any necessary piping through the bulkhead must have valves fitted directly on the bulkhead and operable from above the freeboard deck.

(b) Differences between A, B, and C class bulkheads (6 marks)

A-Class Bulkheads:

- Constructed of steel or equivalent material.
- Prevent passage of smoke and flame for **at least 1 hour**.
- Insulated to restrict temperature rise (max 139°C average, 180°C at any point) on unexposed side for 60 minutes.
- Found between machinery spaces and accommodation, main vertical divisions, etc.

B-Class Bulkheads:

- Constructed of non-combustible materials.
- Prevent passage of flame for **at least 30 minutes**.
- Limited insulation – temperature rise on the unexposed side restricted for 30 minutes.
- Used in accommodation spaces, cabins, and corridors.

C-Class Bulkheads:

- Constructed of non-combustible materials.
- **No requirement** for insulation against heat transfer.
- Do not prevent passage of heat, only restrict flame spread to some extent.
- Used where lesser fire protection is acceptable (e.g., between certain accommodation spaces).

10. (a) Explain what is meant by the term *pounding* as applied to a vessel being driven hard in a seaway. (3)

(b) Explain how *panting* may often occur at the same time as pounding in heavy seas. (3)

(c) Describe how the hull is strengthened to resist *panting* and *pounding*. (4)

(a) Pounding (3 marks)

- **Definition:** Pounding occurs when the vessel's bow lifts clear of the water in heavy seas and then falls violently back onto the water surface.
- **Effect:** This causes **slamming loads** on the bottom plating forward, creating shock stresses on the structure.
- **Consequence:** May lead to cracking of plating, loosening of rivets/welds, and damage to forepeak structure.

(b) Panting (3 marks)

- **Definition:** Panting is the in-and-out movement (flexing) of the shell plating at the bow due to fluctuating water pressure as the ship pitches in a seaway.
- **Relation to pounding:** Panting often occurs simultaneously with pounding because both are most severe in heavy head seas, especially in the forward part of the vessel.
- **Effect:** Causes cyclic stresses that may weaken plating and framing if not reinforced.

(c) Strengthening against panting and pounding (4 marks)

To resist panting:

- Panting beams fitted across the bow region.
- Stringers and panting frames provided in forepeak and near collision bulkhead.
- Additional intercostal stiffening on deck and shell plating at the bow.

To resist pounding:

- Heavier bottom shell plating in forepart.
- Closely spaced floors, double bottom structure strengthened.

- Extra longitudinals and deep floors fitted in forward bottom region.