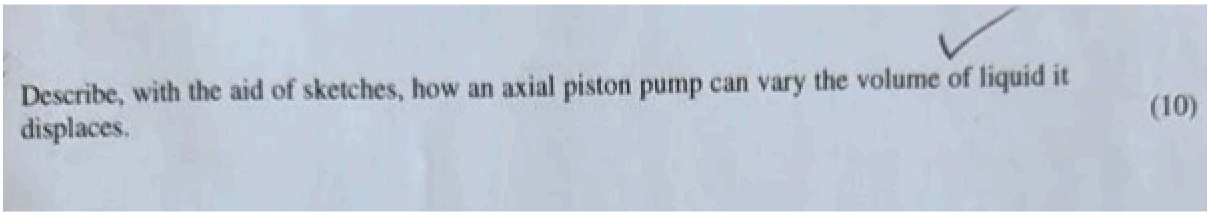


Describe, with the aid of sketches, how an axial piston pump can vary the volume of liquid it displaces. (10)

Describe, with the aid of sketches, how an axial piston pump can vary the volume of liquid it displaces. (10 marks)

An **axial piston pump** varies its displacement by changing the **angle of the swash plate**. By altering this angle, the stroke length of the pistons changes, which changes the volume of fluid delivered during each revolution.

Construction

The main components are:

- Drive shaft
- Cylinder block (barrel)
- Pistons arranged parallel to the shaft
- Slipper pads
- Swash plate (tilting plate)
- Valve/port plate
- Servo or manual control mechanism

Principle of Operation

As the shaft rotates:

- The cylinder block rotates with the drive shaft.
- The piston slippers bear against the swash plate.
- The inclined swash plate causes the pistons to reciprocate in their bores.
- During the outward stroke, fluid is drawn into the cylinder.
- During the inward stroke, fluid is discharged to the system.

The amount of piston movement depends on the **swash plate angle**.

---

(1) Maximum Displacement

When the swash plate is at its **maximum angle**, the pistons have their **longest stroke**.

Sketch

```
                   Maximum Angle

                      /
                     /   Swash Plate
                    /
                   /
                  /

          ←──────────────→
           Long Piston Stroke

    O    O    O    O    O
   | |  | |  | |  | |  | |
==============================  Cylinder Block

Result:
• Maximum piston movement
• Maximum volume displaced
• Maximum pump output
```

Result:

• Maximum piston movement

• Maximum volume displaced

• Maximum pump output

---

(2) Reduced Displacement

When the swash plate angle is reduced, the piston stroke decreases.

Sketch

```
              Small Angle

                  /
                 /
                /
               /

         ←——→
     Shorter Stroke

   O    O    O    O    O
  | |  | |  | |  | |  | |
=============================

Result:
• Reduced piston movement
• Reduced flow output
```

=============================

Result:

• Reduced piston movement

• Reduced flow output

---

(3) Zero Displacement

When the swash plate is moved to the **zero-angle position**, it becomes perpendicular to the shaft axis.

Sketch

```
              Zero Angle

                 |
                 |
                 |
                 |

          No Stroke

   O    O    O    O    O
  | |  | |  | |  | |  | |
=============================

Result:
• Pistons do not reciprocate
• No liquid displaced
• Pump output = zero
```

Result:

• Pistons do not reciprocate

• No liquid displaced

• Pump output = zero

---

(4) Reversed Flow (Over-Centre Pumps)

In some variable displacement axial piston pumps, the swash plate can tilt to the opposite side of centre.

Sketch

```
                Reverse Angle

               \
                \
                 \
                  \

         ←―――――――――――――→
           Long Stroke

Result:
• Direction of piston pumping reverses
• Flow direction is reversed
```

Methods of Swash Plate Control

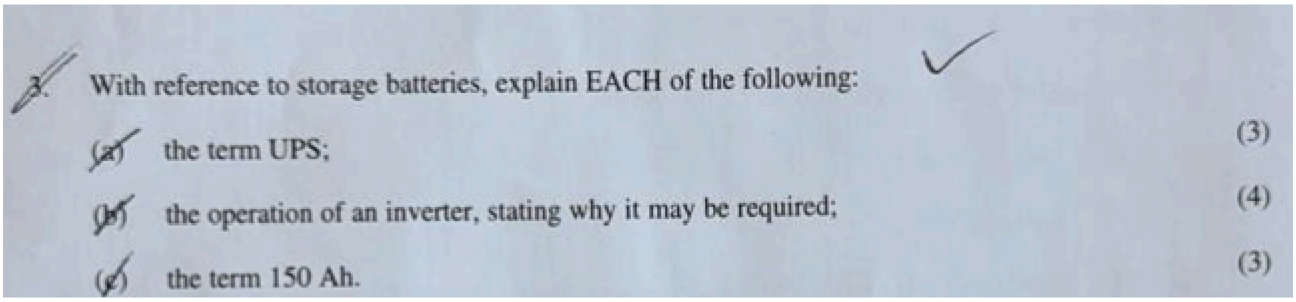
The swash plate angle may be adjusted by:

- Manual lever control,
- Hydraulic servo control,
- Pressure compensator mechanism,
- Electro-hydraulic control.

Pressure-compensated pumps automatically reduce the swash plate angle as system pressure rises, maintaining the desired pressure while reducing flow demand.

Exam Answer (10 marks)

> An axial piston pump varies the volume of liquid displaced by changing the angle of its swash plate. As the cylinder block rotates, pistons bear against the inclined swash plate and reciprocate. A larger swash plate angle produces a longer piston stroke and therefore greater displacement and flow. Reducing the angle shortens the piston stroke and decreases the output. At zero angle the pistons do not reciprocate and no fluid is delivered. In over-centre designs, tilting the swash plate to the opposite side reverses the direction of flow. The swash plate may be controlled manually or automatically by hydraulic or pressure-compensating mechanisms.



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)

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

(a) The term UPS. (3 marks)

UPS stands for **Uninterruptible Power Supply**.

A UPS is a system that provides an **immediate supply of electrical power from storage batteries** whenever the normal mains supply fails or falls outside acceptable limits.

It is used to ensure continuity of power to essential equipment such as:

- Navigation and communication equipment,
- Computer systems,
- Emergency lighting,
- Control and monitoring systems,
- Alarm and safety systems.

Exam Answer (3 marks)

> A UPS (Uninterruptible Power Supply) is a battery-backed power supply that automatically provides electrical power to essential equipment without interruption when the normal supply fails.

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

Operation

An **inverter** is an electronic device that converts **direct current (DC)** from storage batteries into **alternating current (AC)** at the required voltage and frequency.

Working Principle

```
Battery (DC)
      |
      ▼
  Inverter
(DC → AC conversion)
      |
      ▼
 AC Supply to Equipment
```

- The battery supplies DC power.
- Electronic switching devices (such as transistors or IGBTs) rapidly switch the DC current.
- The switching circuitry produces an AC output, usually 50 Hz or 60 Hz.
- The AC output is then supplied to the connected equipment.

Why it may be required

An inverter is required because:

- Most shipboard and domestic equipment operates on **AC power**.
- Storage batteries provide **DC power only**.
- During a mains failure, the inverter enables battery power to operate essential AC equipment.
- It forms part of a UPS system to provide uninterrupted operation.

Exam Answer (4 marks)

> An inverter converts DC electricity from storage batteries into AC electricity of the required voltage and frequency using electronic switching devices. It is required because batteries supply DC, whereas much of the equipment requiring emergency power operates on AC.

(c) The term 150 Ah. (3 marks)

Ah means **Ampere-hour**, which is a measure of the capacity of a battery.

A battery rated at **150 Ah** can theoretically supply:

- **150 A for 1 hour**, or
- **75 A for 2 hours**, or
- **30 A for 5 hours**, or
- Any equivalent combination of current and time.

Mathematically:

$$\text{Battery Capacity (Ah)} = \text{Current (A)} \times \text{Time (h)}$$

$$\text{Ah} = I \times t$$

In practice, the actual capacity may be lower at high discharge rates due to battery characteristics.

Exam Answer (3 marks)

> A rating of **150 Ah** means that the battery has a capacity of 150 ampere-hours and can theoretically deliver 150 amperes for one hour, or an equivalent current for a proportionately longer period before becoming discharged.

Exam Answer (10 marks)

> **(a)** A UPS is an Uninterruptible Power Supply that automatically provides power from batteries when the normal supply fails.
>
> **(b)** An inverter converts DC from storage batteries into AC by electronic switching and is required to operate AC equipment from a battery supply, particularly during power failures.
>
> **(c)** A battery rated at **150 Ah** has a capacity of 150 ampere-hours, meaning it can theoretically supply 150 A for 1 hour or an equivalent current-time combination.

With reference to a 3-phase motor supplied with a six terminal connection without links, describe, with the aid of sketches, how the phase ends can be identified and the motor connected to run in permanent delta mode. (10)

With reference to a 3-phase motor supplied with a six terminal connection without links, describe, with the aid of sketches, how the phase ends can be identified and the motor connected to run in permanent delta mode. (10 marks)

When a three-phase motor has **six unidentified terminals and no connecting links**, the winding pairs and their polarity (start and finish ends) must first be identified before the motor can be connected in **permanent delta**.

Step 1 – Identify the Three Separate Windings

Label the six terminals temporarily as:

```
A   B   C
D   E   F
```

Using an **ohmmeter (continuity tester):**

- Test between the terminals.
- Terminals showing continuity belong to the same winding.
- The three winding pairs are identified.

For example:

```
A ── D
B ── E
C ── F
```

Therefore:

- Winding 1 = A–D
- Winding 2 = B–E
- Winding 3 = C–F

Sketch

```
Ohmmeter

A ─────── D     ✓ Continuity
B ─────── E     ✓ Continuity
C ─────── F     ✓ Continuity
```

Step 2 – Determine the Start and Finish Ends

The polarity of each winding must now be established.

A common method is the **battery and voltmeter "kick" test**.

Procedure

- Connect two windings in series.
- Attach a low-voltage battery to one winding.
- Connect a centre-zero voltmeter across the second winding.
- Momentarily connect and disconnect the battery.

Sketch

```
Battery
+     -
|     |
A-----D

      B-----E
       |   |
Centre-zero
  Voltmeter
```

Interpretation

- If the voltmeter deflects **positive**, the connected ends have the same polarity.
- If it deflects **negative**, reverse one pair and repeat.
- Repeat until the starts and finishes are identified.

The terminals can then be marked:

```
U1   V1   W1   (starts)

U2   V2   W2   (finishes)
```

Step 3 – Connect the Motor in Permanent Delta

In a delta connection:

- The finish of one winding is joined to the start of the next.

Connections are made as follows:

```
U1 connected to W2
V1 connected to U2
W1 connected to V2
```

The three supply phases are then connected to the three junctions.

Delta Connection Sketch

```
        L1
        •
       / \
      /   \
    U1     W2
    |      |
    |      |
   Winding 1
    |      |
    U2     V1
      \   /
       \ /
        • L2


        • L3
       / \
      /   \
    V2     W1
    |      |
    |      |
   Winding 3
```

A clearer representation is:

```
        L1
        •
       / \
    U1     W2
    |      |
   (U)    (W)
    |      |
    U2-----V1
        • L2
         |
        (V)
         |
    V2-----W1
        • L3
```

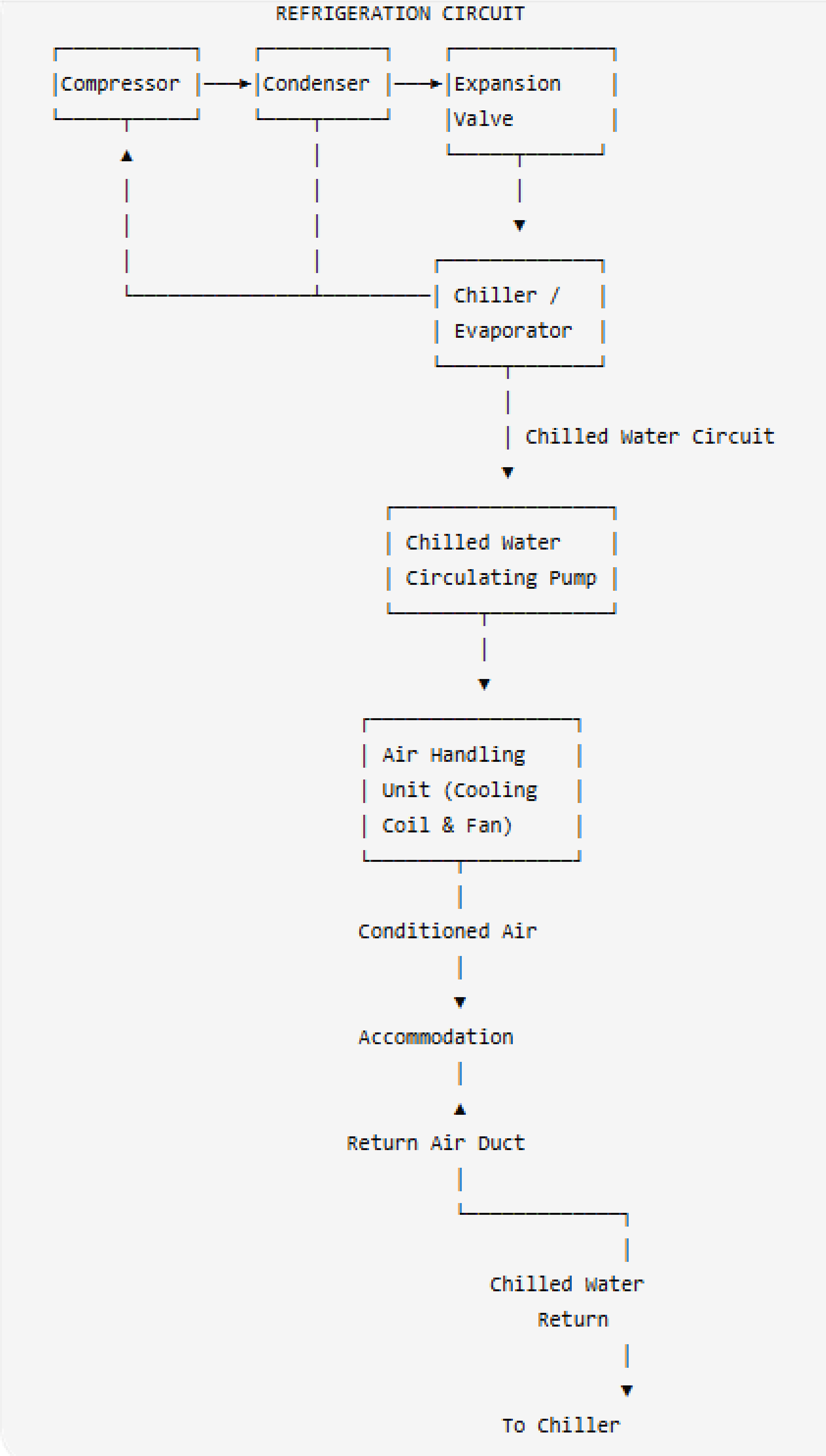
Final Exam Answer (10 marks)

The six terminals are first identified into three winding pairs using an ohmmeter. The polarity of each winding is then determined using a battery and centre-zero voltmeter "kick" test, enabling the winding starts and finishes to be marked U1, V1, W1 and U2, V2, W2. To connect the motor in permanent delta, the finish of each winding is connected to the start of the next; namely U1 to W2, V1 to U2, and W1 to V2. The three supply lines are connected to the three junction points of the delta connection, allowing the motor to operate continuously in delta mode.

Sketch an indirect expansion, chilled water air conditioning plant, labelling the MAIN components. (10)

Sketch an indirect expansion, chilled water air conditioning plant, labelling the MAIN components. (10 marks)

An **indirect expansion chilled water air conditioning plant** uses a refrigeration system to cool fresh water in a chiller. The chilled water is then circulated to air handling units where it cools the air supplied to accommodation spaces.



Main Components

Refrigeration Circuit

1. **Compressor**
   - Compresses low-pressure refrigerant vapour into a high-pressure, high-temperature vapour.
2. **Condenser**
   - Rejects heat to seawater or cooling water and condenses the refrigerant into a liquid.
3. **Expansion Valve**
   - Reduces the pressure and temperature of the refrigerant before it enters the evaporator.

4. **Chiller (Evaporator)**
    - Refrigerant evaporates and absorbs heat from the chilled water circuit.

Chilled Water Circuit

5. **Chilled Water Pump**
    - Circulates chilled fresh water through the system.
6. **Air Handling Unit (AHU)**
    - Contains:
        - Cooling coil,
        - Fan,
        - Air filter.
    - Warm return air passes over the cooling coil and is cooled and dehumidified.
7. **Supply Ducting**
    - Delivers conditioned air to accommodation spaces.
8. **Return Ducting**
    - Returns warm air to the air handling unit for recirculation.

Operation

1. The refrigeration plant cools the water in the **chiller (evaporator)**.
2. The **chilled water pump** circulates cold water to the AHU cooling coils.
3. The **AHU fan** draws return air through filters and across the chilled water coil.
4. Heat and moisture are removed from the air.
5. The cooled, dehumidified air is supplied to the accommodation spaces.
6. The warmed chilled water returns to the chiller to be cooled again.
7. The refrigeration cycle continuously removes the absorbed heat through the condenser.

Exam Answer (10 marks)

An indirect expansion chilled water air conditioning plant consists of a refrigeration circuit comprising a compressor, condenser, expansion valve, and chiller (evaporator). The evaporator cools a separate chilled water circuit. A chilled water pump circulates this water through air handling unit cooling coils. Fans draw return air across the coils where heat and moisture are removed before the conditioned air is supplied to the accommodation spaces. The warmed chilled water returns to the chiller and the cycle repeats continuously.

With reference to blended refrigerants, explain EACH of the following terms, stating the refrigerant state required for charging:

(a) azeotrope; (3)

(b) zeotrope; (4)

(c) near-azeotrope. (3)

6. With reference to blended refrigerants, explain EACH of the following terms, stating the refrigerant state required for charging:

(a) Azeotrope (3 marks)

Definition

An **azeotropic refrigerant blend** is a mixture of two or more refrigerants that behaves as a **single pure refrigerant**.

- The components have the same vapour and liquid composition.
- They evaporate and condense at a **constant temperature** at a given pressure.
- There is **no temperature glide** during phase change.
- Fractionation (separation of components) does not occur under normal operation.

Charging State

✅ **May be charged as either a liquid or a vapour.**

Examples

- **R-502**
- **R-507A**

Exam Answer

> An azeotrope is a blend of refrigerants that behaves as a single substance with no temperature glide and no change in composition during evaporation or condensation. It may be charged into the system as either a liquid or vapour.

(b) Zeotrope (4 marks)

Definition

A **zeotropic refrigerant blend** consists of two or more refrigerants with different boiling points.

- The liquid and vapour phases have **different compositions**.
- The refrigerant evaporates and condenses over a **range of temperatures** known as **temperature glide**.
- If leakage occurs, the components may separate (**fractionation**), changing the blend composition and affecting performance.

Charging State

✅ **Must always be charged as a liquid.**

Charging as a vapour could alter the composition of the blend because the more volatile components evaporate first.

Examples

- **R-404A**
- **R-407C**
- **R-409A**

Exam Answer

> A zeotrope is a refrigerant blend whose components have different boiling points and therefore exhibit temperature glide during phase change. Because fractionation can occur, it must always be charged into the system in the liquid state.

(c) Near-Azeotrope (3 marks)

Definition

A **near-azeotropic blend** has characteristics between those of an azeotrope and a zeotrope.

- It behaves almost like a single refrigerant.
- It exhibits only a **very small temperature glide**.
- Fractionation is minimal but still possible.

Charging State

✅ **Generally charged as a liquid to maintain the correct composition.**

Although the temperature glide is small, manufacturers recommend liquid charging.

Examples

- **R-410A**
- **R-404A** (often described as near-azeotropic in some references)

Exam Answer

A near-azeotrope is a refrigerant blend with a very small temperature glide and little tendency to fractionate. To preserve the correct composition, it is normally charged into the system as a liquid.

Summary Table

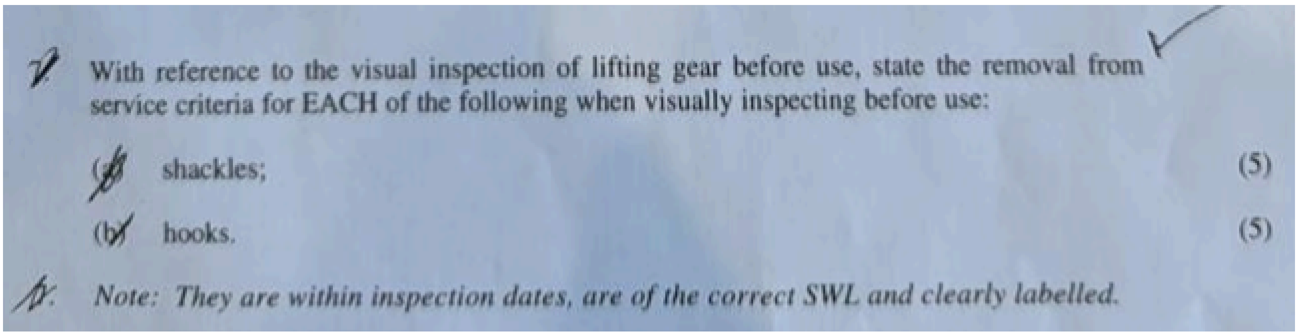
Blend Type	Temperature Glide	Fractionation	Charging State
Azeotrope	None	No	Liquid or vapour
Zeotrope	Significant	Yes	Liquid only
Near-azeotrope	Very small	Minimal	Liquid recommended

Complete Exam Answer (10 marks)

(a) An azeotrope is a refrigerant blend that behaves as a single refrigerant with no temperature glide or fractionation and may be charged as either a liquid or vapour.

(b) A zeotrope is a blend whose components have different boiling points and exhibit temperature glide. Because the composition can change through fractionation, it must be charged as a liquid.

(c) A near-azeotrope behaves almost as a pure refrigerant and has only a small temperature glide. To maintain the correct blend composition, it is normally charged in the liquid state.



With reference to the visual inspection of lifting gear before use, state the removal from service criteria for EACH of the following when visually inspecting before use:

(a) shackles; (5)

(b) hooks. (5)

Note: They are within inspection dates, are of the correct SWL and clearly labelled.

With reference to the visual inspection of lifting gear before use, state the removal from service

criteria for EACH of the following when visually inspecting before use:

Note: Assume that the items are within inspection dates, have the correct SWL, and are clearly labelled.

(a) Shackles (5 marks)

A shackle should be **removed from service immediately** if any of the following defects are found:

1. Bent or Distorted Body

- The bow or Dee shape is no longer symmetrical.
- Any twisting or deformation indicates overloading.

2. Excessive Wear

- Noticeable reduction in the diameter of the body or pin due to wear or corrosion.
- A common guideline is removal if wear exceeds **10% of the original diameter**.

3. Cracks or Fractures

- Any visible cracks, particularly around the crown, eyes, or threaded portions.
- Even small cracks render the shackle unsafe.

4. Damaged Threads or Pins

- Stripped, crossed, or damaged threads.
- Bent, distorted, seized, or incorrectly fitting pins.

5. Severe Corrosion or Pitting

- Heavy rusting or pitting which may reduce the strength of the shackle.

Exam Answer (5 marks)

> Shackles should be removed from service if they are bent or distorted, excessively worn, cracked, have damaged or incorrect pins or threads, or show severe corrosion or pitting.

(b) Hooks (5 marks)

A hook should be **removed from service immediately** if any of the following defects are observed:

1. Opening of the Hook Throat

- The throat opening has increased beyond the manufacturer's limit.
- This usually indicates overloading.

2. Bent or Twisted Hook

- The hook has lost its original shape or shows signs of twisting.

3. Cracks

- Any visible cracks, especially around the bowl, shank, or eye of the hook.

4. Excessive Wear

- Reduction in cross-sectional area due to wear, abrasion, or corrosion.
- Typically, removal is required if wear exceeds **10% of the original section**.

5. Defective Safety Catch

- Missing, damaged, distorted, or inoperative safety latch (where fitted).

6. Severe Corrosion or Heat Damage

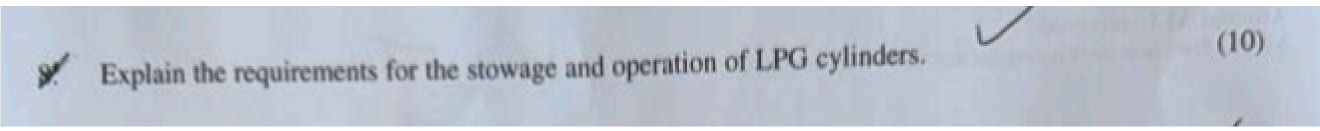
- Heavy pitting, rusting, discoloration, or evidence of welding or overheating.

Exam Answer (5 marks)

> Hooks should be removed from service if the throat opening has increased, the hook is bent or twisted, cracks are present, excessive wear or corrosion is evident, or the safety catch is missing or defective.

Complete Exam Answer (10 marks)

> **Shackles:** Remove from service if bent or distorted, excessively worn, cracked, severely corroded, or if the pin or threads are damaged or defective.
>
> **Hooks:** Remove from service if the throat opening has increased, the hook is bent or twisted, cracks are present, excessive wear or corrosion exists, or the safety catch is missing or unserviceable.


Explain the requirements for the stowage and operation of LPG cylinders. (10)

Explain the requirements for the stowage and operation of LPG cylinders. (10 marks)

Liquefied Petroleum Gas (LPG) cylinders present significant fire and explosion hazards. Therefore, strict requirements apply to both their **stowage** and **operation**.

1. Stowage Requirements

(a) Store in a Well-Ventilated Space

- LPG cylinders should be stowed in a **dedicated locker on the open deck**.
- The locker should be adequately ventilated to the open atmosphere.
- Ventilation openings should be arranged at a **low level**, as LPG vapour is heavier than air and tends to accumulate near the deck.

(b) Away from Sources of Ignition

- Cylinders should be kept away from:
  - naked flames,
  - hot surfaces,
  - electrical equipment,
  - smoking areas,
  - machinery exhausts.

(c) Upright Position

- Cylinders must be stowed **upright with valves uppermost**.
- They should be securely lashed or clamped to prevent movement in heavy weather.

(d) Dedicated LPG Locker

- The locker should be constructed of **non-combustible material**.
- It should be clearly marked:
  - **"LPG"**
  - **"HIGHLY FLAMMABLE"**
  - **"NO SMOKING"**
  - **"NO NAKED LIGHTS"**

(e) Separate from Accommodation

- LPG cylinders must not be stored:
  - inside accommodation spaces,
  - machinery spaces,
  - engine rooms,
  - escape routes.

(f) Protection from Heat

- Cylinders should be protected from direct sunlight and excessive heating.
- They should not be exposed to temperatures that may raise the internal pressure excessively.

2. Operational Requirements

(a) Check for Leaks

- Before use, inspect hoses, regulators, and connections.
- Leaks should be checked using a **soap solution**.
- **Never use a naked flame** to test for leaks.

(b) Correct Pressure Regulator

- Only approved regulators suitable for the cylinder and appliance should be used.

(c) Open Valves Slowly

- Cylinder valves should be opened slowly and only when required.

(d) Shut Off Supply After Use

- Close the cylinder valve when the appliance is not in use.
- Depressurise the line where appropriate.

(e) Emergency Isolation

- Isolation valves should be readily accessible.
- Personnel should know the emergency shut-off procedure.

(f) Replace Damaged Equipment

- Damaged hoses, regulators, clips, or fittings should be replaced immediately.
- Flexible hoses should be inspected regularly and renewed as recommended.

(g) Adequate Training

- Personnel using LPG equipment should be familiar with safe operating procedures and emergency actions.

Hazards of LPG

LPG is dangerous because:

- It is **highly flammable**.
- It is **heavier than air**, allowing gas to collect in low spaces.
- Accumulated gas can form an **explosive mixture** with air.
- Escaping liquid LPG can cause **cold burns (frostbite)**.

Exam Answer (10 marks)

LPG cylinders should be stowed upright in a dedicated, non-combustible, well-ventilated open-deck locker with low-level ventilation and clear warning notices. They must be secured against movement and kept away from accommodation spaces and ignition sources. During operation, approved regulators and fittings should be used, connections checked for leaks using a soap solution, and cylinder valves opened slowly and closed when not in use. Damaged equipment should be replaced, emergency isolation arrangements provided, and personnel instructed in safe operating procedures.

8. With reference to surface preparation for the painting of a vessels hull in dry-dock, list the advantages and disadvantages of EACH of the following methods:

(a) abrasive blasting; (5)

(b) hydroblasting. (5)

With reference to surface preparation for the painting of a vessel's hull in dry-dock, list the advantages and disadvantages of EACH of the following methods:

(a) Abrasive Blasting (5 marks)

Abrasive blasting (grit blasting) uses compressed air to propel abrasive material against the hull surface to remove rust, scale, old paint, and contaminants.

Advantages

1. **Produces a very clean surface**
   - Removes rust, mill scale, and old coatings effectively.
   - Can achieve recognised standards such as **Sa 2½ or Sa 3**.
2. **Provides an anchor profile**
   - Creates a roughened surface that improves paint adhesion.
3. **Fast and effective**
   - Large areas of hull can be prepared quickly.
4. **Suitable for heavily corroded surfaces**
   - Effective at removing thick coatings and severe corrosion.

Disadvantages

1. **Generates large amounts of dust**
   - Can create environmental and health hazards.
2. **Requires containment and protective equipment**
   - Workers need respiratory and eye protection.
   - Additional sheeting and collection systems may be required.
3. **High abrasive consumption**
   - Disposal and recovery of spent grit increases costs.
4. **Flash rusting can occur**
   - The cleaned steel must be primed quickly, particularly in humid conditions.

Exam Answer (5 marks)

> Abrasive blasting provides rapid and effective removal of rust and old coatings while producing a surface profile that promotes excellent paint adhesion. However, it creates significant dust, requires extensive protective measures and grit disposal arrangements, and the cleaned surface is susceptible to flash rusting if not coated promptly.

(b) Hydroblasting (5 marks)

Hydroblasting uses **high-pressure or ultra-high-pressure water jets** to clean the hull surface.

Advantages

1. **Little or no dust generation**
   - Safer for personnel and more environmentally acceptable.
2. **Removes salts effectively**
   - Soluble salts that promote corrosion are washed away.
3. **Reduced waste disposal**
   - No spent abrasive material to collect and dispose of.
4. **Can preserve sound coatings**
   - Removes loose coatings while leaving firmly adhered paint intact.
5. **Reduced environmental contamination**
   - Less airborne pollution around the dry-dock.

Disadvantages

1. **Does not provide a significant anchor profile**
   - May not roughen smooth steel surfaces sufficiently for some coating systems.
2. **Flash rusting may occur rapidly**
   - Surfaces require prompt drying and priming.
3. **Equipment costs are high**
   - Ultra-high-pressure pumps and accessories are expensive.
4. **Safety hazards from high-pressure jets**
   - Incorrect use can cause serious injury.
5. **Less effective on heavy mill scale**
   - Severe corrosion may require supplementary preparation methods.

Exam Answer (5 marks)

Hydroblasting removes contaminants and soluble salts without generating dust and eliminates the need for abrasive disposal. However, it produces little surface profile, requires expensive equipment, can lead to rapid flash rusting, and presents hazards associated with high-pressure water jets.

Complete Exam Answer (10 marks)

Abrasive blasting provides excellent cleaning and creates a surface profile that improves coating adhesion, but it generates dust, requires grit disposal, and may cause flash rusting.

Hydroblasting effectively removes salts and contaminants with minimal dust and environmental impact, but it produces little anchor profile, requires costly equipment, and surfaces must be coated quickly to prevent flash rusting.

10. With reference to a vessel's hull:

(a) explain the meaning of EACH of the following:

(i) dynamic stress; (3)

(ii) static stress; (3)

(b) state TWO examples of EACH type of stress explained in part (a). (4)

10. With reference to a vessel's hull:

(a) Explain the meaning of EACH of the following:

(i) Dynamic Stress (3 marks)

Dynamic stress is the stress imposed on a vessel's structure by **varying or fluctuating loads** that change in magnitude and direction with time.

These stresses are produced by the vessel's motion and the continually changing forces exerted by the sea.

Exam Answer (3 marks)

> Dynamic stress is stress caused by changing or cyclic loads acting on the ship's structure due to its movement and varying sea conditions.

(ii) Static Stress (3 marks)

Static stress is the stress produced by **steady or relatively constant loads** acting on the vessel's structure.

These loads remain essentially unchanged under normal conditions and do not vary rapidly with time.

Exam Answer (3 marks)

> Static stress is stress resulting from constant or slowly changing loads acting continuously on the ship's structure.

(b) State TWO examples of EACH type of stress explained in part (a). (4 marks)

Dynamic Stress – Examples

1. Wave-Induced Hogging and Sagging

- As a vessel passes over waves, the distribution of buoyancy changes continuously.
- This causes alternating bending stresses in the hull girder.

2. Slamming Stress

- Occurs when the bow or forward bottom strikes the sea surface heavily in rough weather.
- Produces sudden impact loads on the hull plating and structure.

Other acceptable examples:

- Panting stresses at the bow,
- Vibratory stresses from machinery and propellers,
- Torsional stresses caused by uneven wave action.

Static Stress – Examples

1. Weight of the Ship and Cargo

- The permanent load imposed by the hull structure, machinery, fuel, stores, and cargo.

2. Hydrostatic Pressure

- The continuous pressure exerted by seawater on the underwater hull.

Other acceptable examples:

- Weight of ballast water,
- Weight of deck equipment,
- Tank contents in calm conditions.

Complete Exam Answer (10 marks)

(a) Dynamic stress is caused by fluctuating loads due to the vessel's movement and changing sea conditions, whereas static stress is produced by constant or slowly varying loads acting on the ship's structure.

(b) Examples of dynamic stress include **hogging and sagging** and **slamming**. Examples of static stress include the **weight of the ship and its cargo** and **hydrostatic pressure acting on the hull**.