

MARINE DIESEL ENGINEERING

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

1. With reference to starting air: (6)
- (a) describe what is meant by the air admission period; (4)
 - (b) describe how the air admission period is determined and controlled.
2. With reference to air coolers, explain the purpose of EACH of the following: (3)
- (a) zinc anodes; (3)
 - (b) vent cocks; (4)
 - (c) tube fins.
3. (a) Sketch a cross section through a resilient/flexible mounting for a diesel engine, labelling the MAIN components. (8)
- (b) State the special considerations necessary with respect to the engine attachments and pipework when using the type of mounting in part (a). (2)
4. (a) Describe the events leading to a crankcase explosion. (4)
- (b) State the methods of detecting the events of part (a) (2)
- (c) State how the severity of a crankcase explosion may be limited. (4)
5. With reference to microbiological contamination of fuel oil, explain EACH of the following:
- (a) why modern fuels are more prone to infection; (4)
 - (b) the indications that there is contamination in the fuel; (3)
 - (c) the process of removing the contamination. (3)
6. With reference to diesel engine cooling water:
- (a) explain why the water requires treatment; (6)
 - (b) describe the type of treatment that should be used. (4)

7. The air start pipework on a diesel engine attached to the cylinder head is becoming extremely hot.

Explain EACH of the following:

- (a) the probable cause; (3)
- (b) the consequences of this situation and the immediate action to be taken; (4)
- (c) how this problem can be minimised. (3)

8. With reference to the removal of a bottom end bearing of a large medium speed diesel engine:

- (a) describe the safety precautions necessary before commencement; (4)
- (b) describe the removal procedure. (6)

9. With reference to friction clutches, state EACH of the following:

- (a) THREE advantages of a wet clutch; (3)
- (b) THREE disadvantages of a wet clutch; (3)
- (c) ONE advantage of multiple plates; (1)
- (d) THREE disadvantages of multiple plates. (3)

10. With reference to reduction gearing, explain EACH of the following:

- (a) the purpose of the magnetic filter in the lubricating oil system; (3)
- (b) why the surface finish of the gear teeth is important; (4)
- (c) why EP lubricating oil is preferred. (3)

1. With reference to starting air: (6)
- (a) describe what is meant by the air admission period; (4)
- (b) describe how the air admission period is determined and controlled.

(a) Describe what is meant by the air admission period. (6)

- The **air admission period** is the **duration in terms of crank angle** (degrees of crankshaft rotation) during which **starting air is admitted into the engine cylinder** through the air starting valve.
- It begins when the air starting valve **opens** as actuated by the starting air distributor, and ends when the valve **closes**.
- The purpose of this period is to admit **high-pressure compressed air** to push the piston down, thereby rotating the crankshaft and initiating engine movement.
- Correct timing ensures that the air acts on the piston **after top dead centre (TDC)**, giving maximum turning effect and avoiding back pressure.
- Typically, the admission period is around **20° before TDC to 30° after TDC**, depending on engine design.

(b) Describe how the air admission period is determined and controlled. (4)

- The admission period is determined by the **design of the cam profile** (or equivalent control mechanism) in the **starting air distributor**.
- The **cam** controls the timing of pilot air delivery to the starting air valves.
- The **valve opening and closing** is therefore governed by the distributor's mechanical setting, which is synchronised with the crankshaft.
- Control is further ensured by:
 - The **pilot air valve** and distributor, which determine when each cylinder's starting valve operates.
 - **Safety interlocks**, preventing admission when the engine is already turning in the wrong direction or running.

2. With reference to air coolers, explain the purpose of EACH of the following: (3)
- (a) zinc anodes; (3)
- (b) vent cocks; (4)
- (c) tube fins.

(a) Zinc anodes (3)

- Zinc anodes are **sacrificial anodes** fitted inside the water side of the cooler.
 - They corrode preferentially, protecting the cooler's tubes and shell from **galvanic and electrolytic corrosion**.
 - Their purpose is to **extend the service life** of the cooler by preventing damage to the heat transfer surfaces.
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(b) Vent cocks (3)

- Vent cocks are small valves fitted at the **highest point of the cooler's water side**.
 - They allow the **release of trapped air or gases** when filling the cooler with water, ensuring proper circulation and heat transfer.
 - They are also used during **maintenance and testing** to confirm the cooler is fully primed with water.
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(c) Tube fins (4)

- Fins are attached to the tubes on the **air side** of the cooler.
- They **increase the effective surface area** for heat transfer between the cooling water and the compressed air.
- This improves cooling efficiency and allows the cooler to be more **compact and lightweight**.
- By lowering the air temperature effectively, fins also help increase the **density of charge air**, improving combustion efficiency.

3. (a) Sketch a cross section through a resilient/flexible mounting for a diesel engine, labelling the MAIN components. (8)
- (b) State the special considerations necessary with respect to the engine attachments and pipework when using the type of mounting in part (a). (2)

(a) Sketch a cross section through a resilient/flexible mounting for a diesel engine, labelling the MAIN components (8)

Description of Sketch (you should draw this in your notes):

- Engine bedplate sitting on **steel chocks or foundation plate**.
- **Resilient (flexible) element**: usually a **rubber, laminated rubber-metal, or spring pack** between the bedplate and ship's structure.
- **Holding down bolts**: pass through the mount, with washers and locking nuts.
- **Metal housing**: encapsulating the rubber or spring element to prevent lateral displacement.
- **Foundation plate**: part of the ship's hull structure, distributing the load.

Function:

- Isolates the **vibrations and shocks** from the engine.
 - Prevents transmission of vibrations to the hull and accommodation.
 - Allows for slight misalignment due to flexibility.
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(b) Special considerations for engine attachments and pipework (2)

- **Flexible couplings** must be fitted on **shafting, exhausts, fuel, lubricating oil, and cooling water pipework** to prevent stress from relative movement between engine and hull.
- Pipework should incorporate **expansion loops or bellows** to absorb vibration and prevent fracture.

4. (a) Describe the events leading to a crankcase explosion. (4)
- (b) State the methods of detecting the events of part (a) (2)
- (c) State how the severity of a crankcase explosion may be limited. (4)

(a) Events leading to a crankcase explosion (4)

1. Oil mist forms inside the crankcase due to overheating of bearings, hot spots, or friction surfaces.
 2. Oil droplets become suspended in the air, creating an **explosive mist-air mixture**.
 3. If the mist cloud comes into contact with a hot surface above the oil self-ignition temperature ($\sim 200^{\circ}\text{C}$), ignition occurs.
 4. This results in a **primary explosion**, and secondary explosions can follow if pressure builds.
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(b) Methods of detecting these events (2)

- **Oil mist detectors (OMD)**: continuously monitor the concentration of mist inside the crankcase.
 - **Bearing temperature monitoring / thermal sensors**: detect overheating early.
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(c) How the severity may be limited (4)

- **Crankcase relief valves**: release pressure safely and prevent structural damage.
- **Flame arrestor/deflector plates**: stop flames from escaping into the engine room.
- **Design of relief valves**: self-closing after pressure relief to contain fire inside.

- **Good maintenance practices:** regular checks on bearings, lubrication, and early detection of overheating to prevent buildup.

Model Answer Recap:

- (a) Oil mist forms → explosive mixture → ignition on hot spot → explosion.
- (b) Oil mist detector, bearing temp monitoring.
- (c) Relief valves with flame arrestors, pressure release, self-closing design, preventive maintenance.

5. With reference to microbiological contamination of fuel oil, explain EACH of the following:
- (a) why modern fuels are more prone to infection; (4)
 - (b) the indications that there is contamination in the fuel; (3)
 - (c) the process of removing the contamination. (3)

(a) Why modern fuels are more prone to infection (4)

- Modern fuels contain **bio-components (FAME – fatty acid methyl esters)** from renewable sources, which encourage microbial growth.
- Low sulphur fuels (required by MARPOL Annex VI) have **reduced natural biocidal properties**, making them easier for microbes to survive in.
- **Storage tanks and long bunkering intervals** allow condensation and water ingress → provides conditions for microbes.
- **Microbes thrive at the fuel–water interface**, where they feed and multiply.

(b) Indications of contamination in the fuel (3)

- **Blocked filters** and rapid clogging due to slime, sludge, or biomass.
- **Corrosion** of fuel tanks and pipework due to acidic by-products.
- **Poor combustion:** black smoke, loss of power, or rough running.
- Visual signs: dark sludge or stringy deposits at the bottom of tanks.

(c) Process of removing the contamination (3)

- **Biocides:** Add chemical biocides to kill microbial growth.

- **Fuel purification/filtration:** Centrifuging and filtering to remove sludge and dead organisms.
- **Tank cleaning:** Physical removal of sludge and residues from tank bottoms.
- Preventive measures: regular draining of water bottoms and good fuel housekeeping.

Model Answer Recap:

- (a) Biofuels + low sulphur + water condensation = more microbial growth.
- (b) Indications: clogged filters, sludge, corrosion, poor combustion.
- (c) Removal: biocides, purification/filtration, tank cleaning.

6. With reference to diesel engine cooling water:

(a) explain why the water requires treatment; (6)

(b) describe the type of treatment that should be used. (4)

(a) Why the water requires treatment (6)

Cooling water must be treated to avoid the following problems:

1. Scale formation:

- Minerals (e.g. calcium, magnesium salts) in untreated water deposit as scale on cooling surfaces.
- Scale reduces heat transfer efficiency and can cause overheating.

2. Corrosion:

- Dissolved oxygen and acidic conditions corrode cylinder liners, water jackets, and pipes.
- Leads to pitting and possible leakage.

3. Cavitation erosion:

- Caused by collapse of vapour bubbles near metal surfaces.
- Treatment additives reduce this risk.

4. Sludge and fouling:

- Rust, suspended solids, or microbiological growth can block passages and reduce flow.

5. pH control:

- Untreated water may be too acidic or too alkaline, causing either corrosion or scaling.

6. Freezing/boiling protection (where glycol is used):

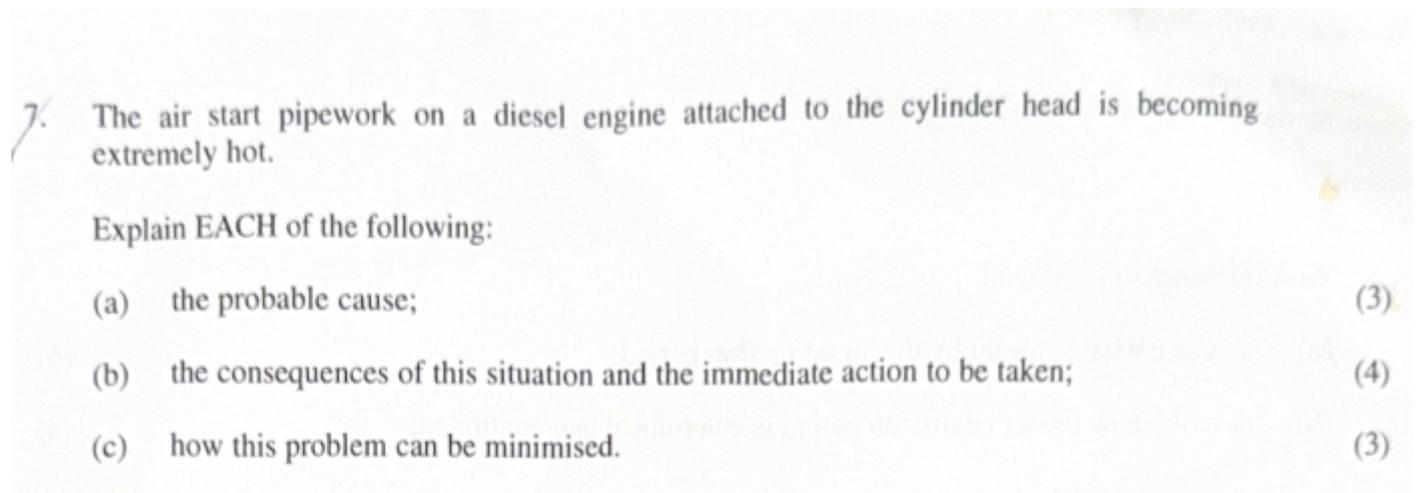
- Antifreeze agents protect against temperature extremes in some systems.

(b) Type of treatment that should be used (4)

- **Chemical inhibitors:**
 - Chromates/borates/phosphates (or modern nitrite/molybdate based inhibitors) form a protective film to prevent corrosion.
- **pH control:**
 - Maintain cooling water pH around 8.3–9.0 to minimise corrosion and scaling.
- **Scale inhibitors:**
 - Prevent deposition of salts and maintain clean heat transfer surfaces.
- **Biocides (if needed):**
 - Prevent microbiological growth in cooling circuits.
- **Antifreeze (glycol-based):**
 - In smaller vessels, prevents freezing and also raises boiling point.

✓ Model Answer Recap:

- (a) Treatment prevents scale, corrosion, cavitation, sludge, pH imbalance, and freezing/boiling issues.
- (b) Use corrosion inhibitors, scale inhibitors, pH control, antifreeze, and biocides if necessary.



7. The air start pipework on a diesel engine attached to the cylinder head is becoming extremely hot.

Explain EACH of the following:

- (a) the probable cause; (3)
- (b) the consequences of this situation and the immediate action to be taken; (4)
- (c) how this problem can be minimised. (3)

(a) The probable cause (3)

- The most likely cause is a **leaking or sticking starting air valve** on the cylinder head.
- This allows **hot combustion gases** from the cylinder to blow back into the air start pipework.
- The backflow heats the air manifold/pipework, creating a fire and explosion risk.

(b) Consequences and immediate action (4)

Consequences:

- Danger of **starting air manifold explosion** if hot gases ignite oil or carbon deposits.
- Possible **damage to cylinder head, valve, or pipework**.
- Risk to crew safety from fire or explosion.

Immediate action:

- Stop the engine immediately.
- Shut off the starting air isolating valve to prevent further backflow.
- Investigate and repair the faulty starting air valve before restarting.

(c) How this problem can be minimised (3)

- Regular inspection and **maintenance of starting air valves** to ensure correct seating and operation.
- Fit **flame arrestors / non-return valves** on the main starting air line to stop backflow.
- Keep air start lines clean and free of oil or carbon deposits to reduce explosion risk.

✓ Model Answer Recap:

- (a) Probable cause: leaking/sticking starting air valve → hot gas backflow.
- (b) Consequences: risk of explosion/fire → stop engine, shut air valve, repair fault.
- (c) Minimisation: good valve maintenance, flame arrestors, keep pipes clean.

8. With reference to the removal of a bottom end bearing of a large medium speed diesel engine:

- (a) describe the safety precautions necessary before commencement; (4)
- (b) describe the removal procedure. (6)

(a) Safety precautions before commencement (4)**1. Isolate and immobilise engine**

- Shut down engine, shut fuel, lubricating oil, and cooling water systems.
- Engage turning gear and secure the engine against accidental rotation.

2. Permit to work / safety preparations

- Inform bridge and engine control room.

- Follow company **permit-to-work system**.

3. Cool and ventilate

- Allow engine to cool before entry.
- Ensure crankcase doors are open and area well ventilated.

4. General safety

- Provide adequate lighting and safe access.
 - Use proper lifting gear, tested and certified.
 - Wear PPE: helmet, gloves, eye protection, safety shoes.
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(b) Removal procedure (6)

1. Preparation

- Open crankcase doors and locate the unit to be dismantled.
- Mark and check alignment of bearing caps for correct reassembly.

2. Remove securing bolts/nuts

- Loosen and remove the bottom end bearing bolts gradually and evenly to avoid distortion.

3. Support the connecting rod

- Fit a **rod sling** or support device to carry the weight of the connecting rod and prevent it falling.

4. Lower/remove bearing cap

- Use approved lifting gear to carefully remove the bottom end bearing cap from the crankpin.
- Place it on clean wooden blocks or bearing stand.

5. Remove bearing shells

- Take out the lower bearing shell from the cap.
- Remove the upper bearing shell from the rod (rotating crankshaft slightly if needed).

6. Inspection/cleaning

- Inspect crankpin and bearing shells for wear, scoring, or cracks.
 - Clean and store shells properly if they are to be reused.
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✓ Model Answer Recap:

- (a) Safety: secure engine, isolate systems, ventilate crankcase, permit to work, lifting gear and PPE.

- (b) Procedure: open crankcase, mark, loosen bolts, support rod, remove cap, remove shells, inspect.

9. With reference to friction clutches, state EACH of the following:
- (a) **THREE** advantages of a wet clutch; (3)
 - (b) **THREE** disadvantages of a wet clutch; (3)
 - (c) **ONE** advantage of multiple plates; (1)
 - (d) **THREE** disadvantages of multiple plates. (3)

(a) THREE advantages of a wet clutch (3)

1. **Better cooling and lubrication** — oil between plates removes heat during engagement.
 2. **Longer service life** — reduced wear due to lubrication.
 3. **Smoother operation** — oil dampens shock loads and prevents grabbing.
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(b) THREE disadvantages of a wet clutch (3)

1. **Lower torque transmission efficiency** — oil film reduces friction compared to dry clutches.
 2. **More complex construction** — requires oil supply, seals, and pumps.
 3. **Possible oil contamination** — wear particles or overheating can degrade clutch oil.
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(c) ONE advantage of multiple plates (1)

- **Increased torque capacity in a compact size** (more friction surfaces allow greater torque transmission without increasing clutch diameter).
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(d) THREE disadvantages of multiple plates (3)

1. **Increased complexity** — more plates mean more components to maintain.
 2. **Higher cost** — additional plates and precise machining required.
 3. **Increased wear points** — more friction surfaces mean faster cumulative wear and more frequent servicing.
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✓ Model Answer Recap:

- (a) Advantages of wet clutch: cooling, longer life, smoother operation.
- (b) Disadvantages of wet clutch: lower efficiency, more complex, oil contamination.
- (c) Advantage of multiple plates: higher torque in smaller size.
- (d) Disadvantages of multiple plates: complexity, cost, more wear points.

10. With reference to reduction gearing, explain EACH of the following:

- (a) the purpose of the magnetic filter in the lubricating oil system; (3)
- (b) why the surface finish of the gear teeth is important; (4)
- (c) why EP lubricating oil is preferred. (3)

(a) Purpose of the magnetic filter in the lubricating oil system (3)

- To **trap and remove ferrous (iron/steel) particles** that may be produced by wear of gears and bearings.
 - Prevents **abrasion and scoring** of highly loaded gear tooth surfaces.
 - Provides **early indication of wear** if excessive particles are found on inspection.
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(b) Why the surface finish of the gear teeth is important (4)

- A **smooth surface finish** reduces friction between meshing teeth.
 - Minimises **pitting, scuffing, and wear**, which occur if surfaces are rough.
 - Ensures an **even load distribution** across the teeth, avoiding local overstressing.
 - Reduces **noise and vibration**, improving efficiency and prolonging gear life.
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(c) Why EP lubricating oil is preferred (3)

- **EP (Extreme Pressure) oils** contain additives (e.g. sulphur–phosphorus compounds) that form a **protective film** under high pressure and temperature.
 - This prevents **metal-to-metal contact** during boundary lubrication conditions.
 - Reduces risk of **scuffing, welding, or seizure** of gear tooth surfaces under heavy loads.
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✓ Model Answer Recap:

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- (a) Magnetic filter removes ferrous particles, prevents damage, indicates wear.
- (b) Smooth gear tooth finish reduces friction, wear, stress, noise, and vibration.
- (c) EP oils protect surfaces under extreme pressure by chemical film action.