

## **CERTIFICATE OF COMPETENCY EXAMINATION**

**EXAMINATIONS ADMINISTERED BY THE  
SCOTTISH QUALIFICATIONS AUTHORITY  
ON BEHALF OF  
MARITIME AND COASTGUARD AGENCY**

**SMALL VESSEL EOOW**

**060-01 - MARINE DIESEL ENGINEERING**

**FRIDAY, 02 May 2025**

**1400-1600 hrs**

Examination paper inserts:

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Notes for the guidance of candidates:

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| <ol style="list-style-type: none"><li>1. Candidates should note that 100 marks are allocated to this paper. To pass candidates must achieve 50 marks.</li><li>2. Non-programmable calculators may be used</li><li>3. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.</li></ol> |
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Materials to be supplied by examination centres:

Candidate's examination workbook
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**MARINE DIESEL ENGINEERING****Attempt ALL questions****Marks for each part question are shown in brackets**

1. (a) Sketch a four stroke timing diagram, showing the position of fuel valve, exhaust valve and inlet valve operation. (8)
- (b) Explain the meaning of the term *valve overlap*, stating its purpose. (2)
  
2. (a) Describe the procedure for setting tappet clearance on diesel engine inlet/exhaust valves. (6)
- (b) Explain the importance of tappet clearances. (4)
  
3. Describe a procedure for manually testing the set points on a diesel engine lubricating oil low pressure alarm and shut down using a pressure calibrator. (10)
  
4. With reference to the viscosity of diesel engine lubricating oil:
  - (a) explain the meaning of the term viscosity, stating why it is important to the operation of a diesel engine: (3)
  - (b) describe an on board viscosity test to determine if engine lubricating oil is fit for further use; (3)
  - (c) list the factors which will influence the viscosity of oil in service. (4)
  
5. (a) Describe FOUR factors influencing centrifugal separator efficiency. (4)
- (b) Explain how oil loss occurs in a separator, stating how this can be minimised. (4)
- (c) State the factors determining the discharge frequency of an engine lubricating oil purifier. (2)
  
6. With reference to diesel engine cooling water treatment, explain EACH of the following:
  - (a) why the treatment is necessary; (4)
  - (b) how the treatment is achieved; (3)
  - (c) how the effectiveness of the treatment can be determined. (3)

7. With reference to leaking cylinder air start valves:
- (a) describe how this may be detected whilst the engine is running; (2)
  - (b) describe the procedure on discovery; (4)
  - (c) list FOUR possible causes. (4)
8. Describe the possible causes and remedies for EACH of the following diesel engine faults:
- (a) low lubricating oil pressure; (3)
  - (b) overheating; (3)
  - (c) unstable speed. (4)
9. With reference to fluid couplings for the main propulsion shaft:
- (a) explain the principle of operation; (5)
  - (b) state how the transmitted torque may be varied; (2)
  - (c) state THREE advantages. (3)
10. (a) Describe a gearbox inspection. (6)
- (b) State, with reasons, TWO gear tooth faults. (4)

1. (a) Sketch a four stroke timing diagram, showing the position of fuel valve, exhaust valve and inlet valve operation. (8)
- (b) Explain the meaning of the term *valve overlap*, stating its purpose. (2)

**(a)**

### Sketch a four-stroke timing diagram (8)

👉 You would need to draw this in your exam answer book. The diagram is a circle (crank angle diagram) with the following main points marked:

1. **Inlet valve**
  - Opens **before TDC** (typically 10–20° before TDC on exhaust stroke).
  - Closes **after BDC** (typically 30–40° after BDC on compression stroke).
2. **Exhaust valve**
  - Opens **before BDC** (typically 40–60° before BDC on power stroke).
  - Closes **after TDC** (typically 10–20° after TDC on induction stroke).
3. **Fuel injection (fuel valve)**
  - Starts **before TDC** of compression stroke (10–20° depending on engine design).
  - Ends shortly after TDC (to ensure efficient combustion).

#### Sketch layout:

- Circle divided into 720° (two revolutions).
- Mark **TDC** (top of circle) and **BDC** (bottom of circle).
- Show inlet, exhaust, and fuel valve events clearly with arrows and angles.

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### (b) Valve overlap: meaning and purpose (2)

- **Meaning:** Valve overlap is the period when both **inlet and exhaust valves are open at the same time**, usually around **TDC between the exhaust and induction strokes**.
- **Purpose:**
  - Helps **scavenge exhaust gases** from the cylinder.
  - Improves **charging of fresh air/fuel mixture** into the cylinder.
  - Increases **volumetric efficiency** and combustion efficiency.

2. (a) Describe the procedure for setting tappet clearance on diesel engine inlet/exhaust valves. (6)
- (b) Explain the importance of tappet clearances. (4)

(a)

### Procedure for setting tappet clearance (6)

#### 1. Shut down and secure the engine

- Stop engine, isolate fuel supply, engage turning gear.

#### 2. Ensure engine is cold

- Valve clearances are set with the engine at ambient temperature (unless manufacturer specifies otherwise).

#### 3. Turn engine to correct position

- Rotate engine so that the cylinder to be adjusted is at **TDC on the compression stroke** (both inlet and exhaust valves fully closed).

#### 4. Check clearance

- Insert a **feeler gauge** between the valve stem and rocker arm/tappet.
- Compare with manufacturer's specified clearance.

#### 5. Adjust if necessary

- Loosen the lock nut on the adjusting screw.
- Turn the screw until the correct clearance is obtained.
- Re-tighten lock nut while holding the screw in position.

#### 6. Re-check clearance

- Confirm clearance again with the feeler gauge after tightening.
- Repeat procedure for all inlet and exhaust valves.

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### (b) Importance of tappet clearances (4)

- **Thermal expansion compensation:** Allows for expansion of valve stem and pushrod when the engine heats up.
- **Ensures proper valve timing:** Correct clearance ensures valves open/close at the designed times.
- **Prevents loss of compression and power:** Too little clearance may cause valves to remain slightly open.
- **Prevents mechanical damage:** Too much clearance leads to hammering, noise, and accelerated wear of valve train components.

**✓ Model Answer Recap:**

- (a) Steps: engine secured → cold engine → cylinder at TDC compression → measure with feeler gauge → adjust → lock nut → re-check.
- (b) Importance: allows for thermal expansion, ensures correct timing, prevents leakage, avoids wear and damage.

3. Describe a procedure for manually testing the set points on a diesel engine lubricating oil low pressure alarm and shut down using a pressure calibrator. (10)

**Procedure for testing set points****1. Preparation / Safety**

- Inform bridge/engine control room that test is being carried out.
- Obtain permit-to-work if required.
- Isolate engine from operation (engine stopped or in test mode).
- Ensure lubricating oil system is safe, and pressure source is available.

**2. Connection of calibrator**

- Locate the lubricating oil pressure sensor or pressure switch.
- Disconnect the pressure line to the sensor.
- Connect a **pressure calibrator (hand pump with gauge, or deadweight tester)** to the sensor port.

**3. Application of pressure**

- Slowly increase pressure with the calibrator and check that the sensor responds correctly on the control panel/indicator.
- Reduce pressure gradually while observing alarm and shutdown points.

**4. Testing the alarm**

- Note the pressure at which the **low lubricating oil pressure alarm** is activated.
- Compare with manufacturer's set value (typically just above the shutdown set point).

**5. Testing the shutdown**

- Continue reducing pressure.
- Note the pressure at which the **automatic shutdown** is initiated.
- Compare with set value in engine manual.

**6. Recording results**

- Record both alarm and shutdown pressures in the engine logbook.
- Verify that the differential between alarm and shutdown is correct (usually 0.1–0.2 bar difference).

## 7. Restoration

- Disconnect pressure calibrator and reconnect the actual lubricating oil line.
- Check for leaks.
- Reset alarms/shutdowns and return system to normal operation.

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## Key Points for Marks

- Clear safety preparation (inform, isolate, permit-to-work).
- Proper connection of calibrator.
- Stepwise testing of **alarm** first, then **shutdown**.
- Comparison with manufacturer's set points.
- Recording and restoring the system.

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## ✓ Model Answer Summary:

Use a pressure calibrator connected to the sensor → simulate falling oil pressure → note alarm and shutdown activation points → compare with set values → record → restore system.

### 4. With reference to the viscosity of diesel engine lubricating oil:

- (a) explain the meaning of the term viscosity, stating why it is important to the operation of a diesel engine: (3)
- (b) describe an on board viscosity test to determine if engine lubricating oil is fit for further use; (3)
- (c) list the factors which will influence the viscosity of oil in service. (4)

(a)

## Meaning of viscosity and its importance (3)

- **Viscosity:** the measure of a fluid's resistance to flow (or internal friction between layers of the fluid).
- **Importance in diesel engines:**
  1. It determines the **oil film thickness** between moving parts (bearings, pistons, liners).
  2. Ensures **adequate lubrication** to prevent metal-to-metal contact.
  3. Too low viscosity → poor lubrication, wear, leakage. Too high viscosity → poor circulation, higher friction losses, pump difficulties.

**(b) Onboard viscosity test (3)**

- A **simple flow test** can be carried out using a **viscosity comparator cup**:
    1. Fill the instrument with lubricating oil.
    2. Measure the time taken for a set volume of oil to flow through a calibrated orifice at a controlled temperature.
    3. Compare flow time with a reference oil sample (new oil).
  - If the used oil flows significantly faster (lower viscosity) or slower (higher viscosity) than reference, it is considered degraded.
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**(c) Factors influencing viscosity of oil in service (4)**

1. **Temperature**: Viscosity decreases as temperature rises.
  2. **Contamination**: Fuel dilution lowers viscosity; water contamination may increase apparent viscosity.
  3. **Oxidation and ageing**: Leads to polymerisation and sludge formation, increasing viscosity.
  4. **Soot and carbon particles**: Increase viscosity in high-load engines.
  5. **Shear of additives**: Breakdown of viscosity index improvers under high shear reduces viscosity stability.
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**✓ Model Answer Recap:**

- (a) Viscosity = resistance to flow; importance = proper lubrication, film thickness, efficiency.
- (b) Onboard test = flow comparator vs reference sample.
- (c) Factors = temperature, contamination (fuel, water), oxidation, soot, additive shear.

5. (a) Describe FOUR factors influencing centrifugal separator efficiency. (4)
- (b) Explain how oil loss occurs in a separator, stating how this can be minimised. (4)
- (c) State the factors determining the discharge frequency of an engine lubricating oil purifier. (2)

**(a) FOUR factors influencing centrifugal separator efficiency (4)**

1. **Speed of the bowl** – Higher rotational speed increases centrifugal force, improving separation.
2. **Throughput rate** – Too high flow rate reduces separation efficiency; must match design.

3. **Temperature of oil** – Correct heating reduces viscosity, allowing contaminants/water to separate more easily.
  4. **Condition of discs and internals** – Clean and undamaged disc stack ensures effective separation. (Other possible points: gravity disc size selection, correct interface position, maintenance condition of bowl seals.)
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## (b) How oil loss occurs in a separator & how it can be minimised (4)

### Causes of oil loss:

- Incorrect **gravity disc size** → wrong oil/water interface position.
- Excessive **sludge accumulation** displacing oil.
- **Emulsification** of oil and water due to poor heating or contamination.
- Malfunctioning bowl seals or damaged discharge ports.

### Minimisation:

- Select correct gravity disc according to oil density.
  - Maintain correct operating temperature.
  - Discharge sludge at proper intervals.
  - Regular inspection and cleaning of sealing rings and internals.
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## (c) Factors determining discharge frequency of a lubricating oil purifier (2)

1. **Amount and type of contamination** (sludge, soot, water, oxidation products).
  2. **Operating hours and engine load conditions** (high load = more contamination = more frequent discharge).
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### ✓ Model Answer Recap:

- (a) Efficiency depends on bowl speed, throughput, temperature, disc condition.
- (b) Oil loss occurs from wrong gravity disc, sludge, emulsification; minimise with correct disc, heating, sludge discharge, maintenance.
- (c) Discharge frequency depends on contamination level and engine load/operating hours.

6. With reference to diesel engine cooling water treatment, explain EACH of the following:
- (a) why the treatment is necessary; (4)
  - (b) how the treatment is achieved; (3)
  - (c) how the effectiveness of the treatment can be determined. (3)

(a)

### Why the treatment is necessary (4)

- **Prevents corrosion** of engine cooling passages, liners, cylinder heads, and heat exchangers.
  - **Prevents scale formation** (from salts like calcium carbonate) which reduces heat transfer efficiency.
  - **Prevents cavitation/erosion** around wet liners caused by bubble collapse.
  - **Maintains system cleanliness**, avoiding sludge deposits that reduce cooling efficiency and flow.
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### (b) How the treatment is achieved (3)

- By **adding chemical inhibitors** (e.g., nitrites, molybdates, phosphates) to prevent corrosion and scale.
  - By **maintaining correct pH** (typically around 8.3–9.5) to avoid acidic or alkaline attack.
  - By **regular dosing and circulation** of treatment chemicals to ensure even distribution in the cooling system.
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### (c) How the effectiveness of the treatment can be determined (3)

- **Regular testing** of cooling water samples (pH, nitrite/molybdate concentration, reserve alkalinity).
  - **Observation of engine components** during inspections (absence of scale, sludge, corrosion).
  - **Use of test kits** supplied by chemical manufacturers to measure inhibitor concentration and chloride content.
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### ✓ Model Answer Recap:

- (a) Necessary to prevent corrosion, scale, cavitation, and deposits.
- (b) Achieved by chemical inhibitors, maintaining pH, and dosing.
- (c) Determined by regular testing, inspections, and chemical concentration checks.

7. With reference to leaking cylinder air start valves:

- (a) describe how this may be detected whilst the engine is running; (2)
- (b) describe the procedure on discovery; (4)
- (c) list FOUR possible causes. (4)

**(a) How this may be detected whilst the engine is running (2)**

- **High temperature** of the air start pipe leading to the cylinder (felt by hand carefully or measured with a temperature gun).
  - **Noise or hissing sound** of leaking air from the air start manifold.
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**(b) Procedure on discovery (4)**

1. **Reduce engine load** gradually, if possible.
  2. **Shut off the air start isolating valve** to the affected cylinder.
  3. **Monitor the temperature** of the air start pipework closely to avoid risk of fire/explosion.
  4. **Rectify at the earliest opportunity** by stopping the engine, dismantling, inspecting, and renewing/repairing the faulty air start valve.
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**(c) Four possible causes (4)**

- **Carbon deposits** on the valve seat preventing proper sealing.
  - **Burnt or pitted valve seat** due to repeated leakage.
  - **Weak or broken return spring** failing to close the valve properly.
  - **Mechanical damage or sticking of the valve spindle** due to poor lubrication or contamination.
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**✓ Model Answer Recap:**

- (a) Detected by hot pipe/hissing.
- (b) Shut off isolator, reduce load, monitor, repair at next stop.
- (c) Causes: carbon deposits, burnt seat, weak spring, spindle sticking/damage.

8. Describe the possible causes and remedies for EACH of the following diesel engine faults:

- (a) low lubricating oil pressure; (3)
- (b) overheating; (3)
- (c) unstable speed. (4)

### (a) Low lubricating oil pressure (3)

#### Possible Causes:

- Insufficient oil in sump.
- Worn bearings or oil pump.
- Blocked suction strainer or relief valve stuck open.

#### Remedies:

- Check oil level and top up.
  - Inspect/repair bearings and oil pump.
  - Clean strainer and check relief valve operation.
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### (b) Overheating (3)

#### Possible Causes:

- Insufficient cooling water flow (pump fault or blocked sea chest/filters).
- Thermostat stuck closed.
- Scale or deposits in cooling passages.

#### Remedies:

- Ensure pumps are operational, clean filters/sea chest.
  - Check and replace faulty thermostat.
  - Descale or chemically clean cooling system.
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### (c) Unstable speed (4)

#### Possible Causes:

- Governor malfunction or incorrect adjustment.

- Air/fuel ratio imbalance (fuel pump fault, sticking injector).
- Air in fuel lines.
- Load variations not matched by governor response.

**Remedies:**

- Service/adjust governor.
- Inspect and repair/replace injectors or fuel pump.
- Bleed air from fuel system.
- Check load management system.

**9. With reference to fluid couplings for the main propulsion shaft:**

- (a) explain the principle of operation; (5)
- (b) state how the transmitted torque may be varied; (2)
- (c) state **THREE** advantages. (3)

**(a) Principle of operation (5)**

- A fluid coupling transmits torque from the driving shaft (input, connected to engine) to the driven shaft (output, connected to propeller) through a working fluid (usually oil).
  - It consists of two main elements: the **impeller (pump wheel)** and the **runner (turbine wheel)** enclosed in a casing.
  - The impeller is connected to the driving shaft and accelerates the oil in a circular path.
  - The moving oil strikes the blades of the runner, imparting momentum and turning the output shaft.
  - Torque is transferred by the **hydrodynamic action** of the fluid, not by direct contact, allowing slip between input and output.
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**(b) How the transmitted torque may be varied (2)**

- By varying the **amount of fluid** in the coupling (more oil = greater torque transmission).
  - By changing the **relative speed (slip)** between impeller and runner (higher slip = less efficient torque transmission).
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**(c) Three advantages (3)**

1. Provides **smooth transmission of power** without mechanical shock.
2. Allows **overload protection**, as slip prevents excessive torque being passed to the shaft.
3. Reduces vibration and torsional stresses on the propulsion system.

(Other possible advantages: enables gradual acceleration of the propeller, requires little maintenance, and protects against engine stalling under sudden load).

10. (a) Describe a gearbox inspection. (6)
- (b) State, with reasons, TWO gear tooth faults. (4)

### (a) Describe a gearbox inspection (6)

A gearbox inspection involves:

1. **Safety precautions** – Isolate machinery, drain oil, and ensure gearbox is safe to open.
2. **External checks** – Examine for oil leaks, loose fastenings, vibration, and abnormal noises.
3. **Oil inspection** – Take oil samples for contamination (metallic particles, water, sludge).
4. **Internal inspection** (after opening):
  - Check **gear teeth** for pitting, scoring, cracks, or wear.
  - Examine **bearings** for wear, overheating, or damage.
  - Check for **alignment** and correct backlash between meshing gears.
5. **Lubrication system** – Inspect oil pumps, filters, strainers, and oil passages for blockage or damage.
6. **General condition** – Inspect seals, gaskets, and couplings for integrity before reassembly.

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### (b) TWO gear tooth faults (with reasons) (4)

1. **Pitting** – Small cavities form on gear tooth surfaces due to **surface fatigue** under repeated contact stresses.
  - Reason: Overloading, poor lubrication, or misalignment.
2. **Scoring** – Scratches or grooves along the gear tooth face caused by **metal-to-metal contact**.
  - Reason: Inadequate lubrication or contamination leading to boundary lubrication failure.

(Other valid faults: spalling, wear, plastic deformation, tooth breakage).