

Second Engineer Officers on Small Vessels less than 9000kW, less than 3000GT, unlimited area, III/2 Written Examination Syllabus

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Marine Diesel Engineering

1. Engine working principles:

- a) Basic working principles of compression ignition (diesel) and spark ignition (petrol) type engines
- b) Working principle of 4- Stroke Diesel engine:
 - i) 4-stroke diesel engine cycle
 - ii) 4-stroke diesel engine timing diagram
 - iii) 4-stroke diesel engine PV diagram
 - iv) Relationship between the 4-stroke timing diagram and PV diagram
 - v) 4-stroke scavenging process
 - vi) Explanation and reasons for valve overlap
 - vii) 4 - stroke starting air timing (begin and end).
- c) Basic knowledge of power balancing an engine
- d) Combustion requirement (viscosity, atomisation, penetration)
- e) Diesel Engine Combustion Process
- f) Basic knowledge about the importance of monitoring the combustion process
- g) Basic knowledge about peak pressures and indicator diagrams

2. Turbochargers and superchargers

- a) Principles and reasons for turbo-charging and super-charging
- b) Turbo-charger construction, components (Turbine, turbine blades, air intake filters, compressor, bearing types (plain, ball and roller), labyrinth glands) and their functions
- c) Pulsed turbocharger system
- d) Constant pressure turbocharger system
- e) Sequential (multistage) turbocharger system
- f) Reasons for charge air-cooling
- g) Construction of charge air coolers

- h) Super charge system performance – assessment,

3. Engine construction

- a) Constructional details of medium and high-speed diesel engines used for main propulsion, electrical power generation and other auxiliary purposes
- b) Engine Bedplate, Block/Entablature and Tie bolts
- c) Holding down arrangements; bolts; resin chocks; resilient (flexible) mountings
- d) Crankshafts (solid forged, grain flow) and main bearings (bearing shells, materials, plain and thrust bearings, lubrication arrangements)
- e) axial vibration dampening arrangement or system
- f) Camshafts; camshaft drives, bearings, connecting rods (top and bottom end bearings, lubrication); cylinder liners; solid, composite and ceramic-coated pistons
- g) 4-stroke pistons, construction, crown, skirt, materials, cooling, gudgeon pin
- h) Piston rings (theory of working; types, compression, oil control, clearances, sealing)
- i) Cylinder heads (cooling; push rods; overhead cams; inlet valves; exhaust valves; fuel injectors; safety valves; air start valves; indicator cocks)
- j) Setting tappet clearance. Effects of too small and too large tappet clearances
- k) Flywheel; turning gear; barring over arrangements
- l) Materials and processes (casting, forging, fabrication etc) commonly used in the manufacture of the engine constructional components
- m) Engine formats used in construction, including in-line (straight) and V-type engines

4. Basic principles of simple hydraulic and Electronic governors

5. Engine safety and protection devices

- a) Diesel Engine safety devices, working principles, operations and testing of engine safety devices for alarm and trip e.g. Lub oil low pressure and over speed, Jacket cooling water and L.O. high temperature.
- b) Air starting system (direct) safeties (automatic non-return valve, manifold drain cocks, flame arrestor, manifold safety valve, interlocks – turning gear, zero pitch and gear box LO pressure).
- c) Crankcase explosion relief/safety valve, crankcase explosions
- d) Oil mist detectors
- e) Turning gear interlocks for starting system

6. Fuel oil supply system

- a) Principles and operation of the following:
- b) Basic distillate fuel oil system, layout and components (storage bunker tanks, settling tanks; centrifugal separator, day or service tank, transfer pumps, LP supply pumps, HP circulating or booster pumps, filters)
- c) Engine fuel components (fuel rail, individual HP pump [Bosch or jerk type], multiple HP fuel pump blocks, HP fuel pipes [double sheathed], fuel injectors, spill return)
- d) Construction and operation of the Bosch (jerk) type HP fuel pump
- e) Construction and operation of basic fuel injector (atomisation process, penetration, turbulence, problems with injection, ignition quality, ignition delay)
- f) Testing and setting a fuel injector lift pressure
- g) Construction and operation of combined fuel pump and injector
- h) Principles of operation and components of a common rail fuel system
- i) Safety and protection devices fitted to the fuel system and its components (overflow tanks, vents, flame traps, relief valves, double sheathed pipes, leak tanks, alarms, remote emergency stops, remote emergency valve trips etc)

7. Fuel oil characteristics

- a) Health and safety associated with handling fuel oils
- b) Knowledge of fuel oil standards (basic content of ISO 8217 and BS 2869)
- c) Compatibility and mixing of fuels from different bunker sources
- d) Flash point (Regulation 15 SOLAS, minimum flash points)
- e) Ignition quality (Cetane Number)
- f) Cloud point; Density; Pour point; Viscosity; Microbiological infestation
- g) Fuel storage temp – considering flash point & cloud/pour point
- h) Sulphur (low sulphur and ultra-low sulphur); Water; Wax, dirt, microbes, surfactants

8. Fuel Hygiene and treatment

- a) The need for fuel hygiene
- b) Types of fuel oil filters
- c) Construction and operating principles of coalescent filters
- d) Construction and operating principles of fuel oil centrifugal separators
- e) Use of fuel oil centrifugal separators as purifiers and clarifiers
- f) Problems with distillate fuels (water, fuel contamination, flash point, wax, microbiological)

9. Lubrication

- a) Reasons for lubrication (friction, wear, noise, lubrication, cooling, sealing, preserving)
- b) Theory of lubrication with shafts rotating in bearings (boundary lubrication, hydrodynamic lubrication, bearing clearances)
- c) Types of lubricant
- d) Lubricating oil characteristics
- e) Health and safety associated with handling lubricating oils
- f) Base number, BN; Colour, condition and odour
- g) Flash point, dangers of fuel dilution
- h) Contamination and testing (on board and shore) of oils (oil sampling, TBN, Flash point, microbial, dirt).
- i) Pour point; Viscosity, viscosity index; water; wax
- j) Wear metals
- k) Qualities of base stock and additives (thermal /oxidation stability, volatility, alkalinity, detergency, anti-wear, extreme pressure, oxidation/corrosion protection, anti-emulsification, anti-foam)
- l) Use of Greases (advantages and disadvantages)

10. Engine Lubricating Oil (LO) systems

- a) Engine internal lubricating oil distribution systems (bearings, piston etc)
- b) Basic lubricating oil cooling system, layout and components
- c) Safety and protection devices fitted to the system and its components
- d) Lubricating oil treatment
- e) Lubricating oil filters
- f) Construction and operating principles of lubricating oil centrifugal separators (manual operation only)
- g) Contamination of lubricating oil from blow-past from the combustion space (carbon, fuel dilution, flash point, water)
- h) Effects of running with contaminated oil and sources of contamination
- i) Simple lubricating oil testing (visual, smell, water, viscosity, viscosity comparison, spot test)

11. Cooling water systems

- a) Self-contained engines, with engine driven pumps
- b) Air-cooled with radiator system

- c) Basic direct salt (raw) water cooling water system, layout and components
- d) Basic fresh water jacket cooling water system, layout and components
- e) Engines with independent (electric motor) driven pumps
- f) Basic fresh water centralised jacket cooling water system (Sea water, Low/High temperature cooling water), layout and components
- g) Safety and protection devices fitted to the systems and their components
- h) Use of cooling water chemical inhibitors, dangers when used with fresh water makers.

12. Heat exchangers

- a) Construction and use of shell-tubular heat exchangers
- b) Construction and use of plate heat exchangers
- c) Construction and use of through-hull (exterior) heat exchangers
- d) Advantages and disadvantages of each type of heat exchanger
- e) Materials used in construction of heat exchangers
- f) Anodic protection in heat exchangers

13. Engine starting systems

- a) Manual hand cranking/barring over
- b) Air starting motors
- c) Hydraulic starting motors
- d) Electric (battery) starting motors
- e) Direct Air Starting System

14. Engine operation and maintenance

- a) Describe the following procedures:
 - i) Preparing for sea and warming through
 - ii) Shutting down and securing for maintenance
 - iii) Overhaul of a unit
 - iv) Overhaul of a main bearing
 - v) Routine servicing of a turbo-charger
- b) Reference to manufacturers manuals
- c) Reference to ships written procedures
- d) Reading of engineering drawings
- e) Causes and actions to be taken in the event of:

- i) Black smoke in the exhaust
- ii) White smoke in the exhaust
- iii) Blue smoke in the exhaust
- iv) Contamination of sump lubricating oil
- v) Unusual crankcase noise
- vi) Exhaust temperature of one unit falling or increased above acceptable level
- vii) Exhaust temperature of all units are above acceptable level.
- viii) Leaking exhaust valve
- ix) Fuel/Lub oil filter blocking
- x) Surging in turbo-chargers
- xi) High Cooling Water Temperature
- xii) High Lub oil Temperature
- xiii) High bearing temperature
- xiv) Losing Lub oil from crankcase (sump)
- xv) Engine starting failure
- xvi) High Oil Mist Alarm

15. Clutches

- a) Applications of clutches (disconnecting drives, operational flexibility, shaft alignment, vibration damping)
- b) Construction and operation of flexible clutches (simple friction, pneumatic, fluid)
- c) Principles of shaft mis-alignment (lateral and angular) and methods of alignment

16. Gearboxes

- a) Applications of gearboxes (speed reduction, reversing and operational flexibility)
- b) Types of gear teeth (axial or straight, helical and double helical, bevel). The advantages and disadvantages of each type, including axial thrust.
- c) Gear configurations (crown, pinion, spur, idler, simple gear trains, compound gear trains, step-up, step-down, reduction, double reduction, epicycle)
- d) Gearbox lubrication methods (splash, sprays etc)
- e) Gearbox lubricating oil grades, extreme pressure (EP) and additives
- f) Gear box inspection and gear teeth faults (scoring, abrasion, pitting, exfoliation, fracture, scuffing, attrition etc)

Auxiliary Equipment – I (Effective from 01/08/2018)

1. Valves

- a) Types of valves
- b) Construction and application of following valves:
 - i) Construction and application different types of valves:
 - ii) Simple plug cock
 - iii) Ball valve
 - iv) Screw-lift valve
 - v) Screw-down non-return (SDNR) valve
 - vi) Butterfly valve
 - vii) Gate valve
 - viii) Diaphragm valve
 - ix) Quick closing valves
 - x) 3-way valves
 - xi) Valve chests
 - xii) Basic valve symbols
 - xiii) Pressure relief valve - differentiate between a safety valve and a relief valve
- c) Materials used in valve construction (cast iron/ steel, bronze, brass, stainless steel, etc.)
- d) Compatibility of the materials used in construction with fluids flowing through the valve, aspects of corrosion and erosion.

2. Pumps

- a) Types of pumps
- b) Basic classification of pumps, positive displacement and centrifugal
- c) Typical pump applications in systems
- d) Basic pump symbols
- e) Positive displacement pumps, construction and theory of operation
- f) Types of positive displacement pumps:
 - i) electric motor driven reciprocating pump
 - ii) lobe pump;
 - iii) gear pump
 - iv) rotating piston pump
 - v) screw pump
 - vi) vane pump
- g) Positive displacement pump relief valves and system flow pulsation damping
- h) Centrifugal pumps, construction and theory of operation
- i) Types of centrifugal pump, volute casing and diffuser
- j) Problems associated with priming centrifugal pumps and methods of priming

3. Compressed air systems

- a) Knowledge that the compressed air system commonly has two pressure levels, 30-40 bar for starting air, and 7-10 bar for control air
- b) Basic compressed air system, layout and components (air compressors, air receivers)
- c) Compressed Air Safety and Safety devices associated with the compressed air systems: Isolation and draining of system, safety valves, fusible plugs, compressor bursting discs, compressor lifting heads, pressure cut outs

4 Hydraulic and Pneumatic control principles

- a) Basic hydraulic and pneumatic symbols (interpretation of system drawings)
- b) Hydraulic system safety: safety devices fitted to the system and equipment, safe working procedures on hydraulic system and equipment.
- c) Basic electro-hydraulic and electro-pneumatic control
- d) Hydraulic fluids, types, uses, characteristics
- e) The importance of clean air supplies for pneumatic control systems
- f) Basic control air supply system, layout and components (reducing valve, driers, filters, lubricators)

5 This section has been moved to 060-02 Section 7.

6 Steering gears

- a) Basic functions of a steering gear
- b) Types of steering gear construction, 2-ram and rotary vane
- c) Knowledge of signal transmission from remote steering positions.
- d) Feedback control within steering system
- e) Constant and Variable pressure hydraulic system for a steering gear system
- f) Steering gear protection and system redundancy (split hydraulics, dual pumping arrangements, isolating valves, by-pass valves, movement limiters, and shock valves)

7. Propulsion

- a) Basic theory of propellers (number of blades, skewed etc.)
- b) Methods of securing the propeller to the propeller shaft
- c) Fixed and variable pitch configurations including water jet, Azipod and Voith Schneider propulsions

- d) Controllable Pitch Propellers (CPP), advantages/disadvantages, construction, operation, control systems
- e) Configurations and construction of transverse thrusters (fixed drive, fluid drive, water jet)
- f) Safety devices and manual control (fail safe / fail set)

8. Transmission and Shaft arrangement

- a) Shaft support bearing types and construction (plain bearing, roller bearing)
- b) Thrust bearings (tapered roller bearing and thrust collar)
- c) Bearing lubrication
- d) Stern tube bearings (linings, oil and water lubricated)
- e) Stern seals (Lip seals, mechanical seals)
- f) Rigid and flexible shaft connections (fitted coupling bolts, flange, hydraulic muff, steel diaphragm)
- g) Basic shaft alignment and Shaft coupling alignment (lateral and angular)

9. Electrical Plant

- a) Basic construction and operational principles of AC alternators (production of voltage and current, pole/speed relationship, exciters, speed control, auto-voltage regulators (AVR), response to change in load)
- b) Synchronising and paralleling alternators manually and automatically (in phase, check synchroniser, synchroscope, synchronising lamps, load sharing, speed droop and voltage droop)
- c) Switchboard layout (main alternators, main switchboard, emergency alternator, Emergency switchboard)
- d) Switchboard safety devices list (alternator main breaker trip devices, earth leakage detection, preferential tripping, sequential starting and discrimination protection) and their functions
- e) Main breakers and their safety protection devices
- f) Fuse types and applications
- g) Shore power connection and safe operation
- h) Neutral point insulated distribution
- i) Essential and non-essential consumers
- j) Earth lamps
- k) Earth fault tracing

- l) Basic construction and operational principles of 3-phase and single phase motors (direct on-line starting, alternative starting arrangements, torque and current characteristics, safety protection, fault finding, single phasing)
- m) Basic construction and operational principles of batteries (lead-acid, alkaline, Ni-ion, charging circuits, inspection and maintenance, safety)
- n) Emergency power supplies (SOLAS legislation, typical installations, testing, and recovery from blackout)
- o) Electrical safety (legislation - COSWP, safe isolation, safe testing procedures)
- p) Electrical maintenance
- q) Understanding, maintenance, troubleshooting of Electrical Lighting Circuits including Navigation lights
- r) Basic transformer theory, safe working practice, routine maintenance
- s) Intrinsically safe circuits and equipment

Operational Procedures, Basic Hotel Services and Ship Construction

1. Legislation

- a) The purpose of MCA Merchant Shipping Notices, Marine Guidance Notes and Marine Information Notes
- b) The Code of Safe Working Practices for Seamen, risk assessment & assessment procedures, permit to work (entry into enclosed space, hot work, electrical work etc.)
- c) Basic working knowledge of the International Safety Management (ISM) Code and of the SOLAS, MARPOL and STCW Conventions

2. Watchkeeping

- a) Watchkeeping procedures including:
 - i) Regulations (STCW '78 as amended)
 - ii) Taking over and accepting a watch
 - iii) Routine watchkeeping duties and responsibilities
 - iv) Keeping of the log and other records and understanding the significance of the readings taken
 - v) Changeover of systems from remote / automatic to local control and manned to UMS
 - vi) Safety precautions to be observed during a watch and immediate actions in the event of equipment breakdown, fire, flooding, grounding and collision.
 - vii) Handing over a watch
- b) Basic voyage planning, including:
 - i) Fuel
 - ii) Water
 - iii) Stores
 - iv) Spares

3. Maintenance

- a) Maintenance procedures and records including:
 - i) Maintenance systems (running hours, calendar intervals, break down, etc.)
 - ii) Condition monitoring and trends
- b) Written and computer-based record systems

4. Pollution

- a) MARPOL and Annexes
- b) Restricted (Special) areas, PSSA (Particularly Sensitive Sea Areas) and SECAs; oil record book; disposal of pollutants; garbage record book; action in response to a pollution incident on board; SOPEP manual regulations (MARPOL 73/78)
- c) Construction and operation of oil-water separators and discharge monitors
- d) Sewage pollution prevention including regulations (MARPOL 73/78 Annex IV)
- e) Garbage pollution prevention.(MARPOL 73/78 Annex V)
- f) Atmospheric pollution (MARPOL 73/78 Annex VI and SECA/NECAs)

- g) Pollution by refrigerants (Montreal Protocol and F-Gas Regulations)
- h) Ballast Water Management

5) Bunkering and fuel transfer

- a) Bunkering and fuel transfer procedures including:
 - i) Planning (avoid mixing), checks as per established checklist, maximum allowable filling,
 - ii) Safety (fire risk and hazardous substances)
 - iii) Monitoring fuel quality and contamination (correct grade, water, dirt, microbial, surfactants, and retaining sample)
 - iv) Transfer stability and free surface
 - v) dispute procedures
 - vi) Record keeping and Oil Record Book entries.

6. Sewage systems

- a) Sewage pollution prevention including:
 - i) Construction and operation of sewage treatment plants (continuous, zero discharge)
 - ii) Difference between aerobic and anaerobic
 - iii) Environmental impact of untreated sewage (B.O.D. sterilisation)
 - iv) Dangers associated with the operation of sewage treatment plants (anaerobic conditions, hydrogen sulphide, methane, ammonia and confined spaces)

7. Refrigeration and Air Conditioning (AC) Plant

- a) Basic principles of Refrigeration and Air Conditioning.
- b) Function of the system components (Compressor, oil separator, condenser, expansion valve and evaporator)
- c) Checks on system components during operation.
- d) Safety features of cold rooms (door fittings) and precautions for cold room (vegetables and fruits) entry.
- e) Relative humidity and maintaining 'comfort zone.'
- f) Dangers associated with the operation of a.c. plants (Legionella and hazardous substances) and preventions.
- g) Handling and storage of refrigeration gas bottles.

8. Fresh water maker

- a) Fresh water makers including:
 - i) Construction and operation of a reverse osmosis plant
 - ii) Water sterilisation methods. (Chlorine, silver ion, ultra violet)
 - iii) Neutralisation and palatability
 - iv) Sampling and testing of potable water.
- b) Inspection and cleaning of water tanks and system.
- c) Superchlorination

9. Stabilisers

- a) Types of motion (roll, pitch, yaw etc., damping coefficient)
- b) Passive roll stabilisation systems
- c) Active roll stabilisation systems

10. Fire fighting

- a) Fire prevention; use and care of fire-fighting appliances; fixed machinery space installations; escape and breathing apparatus
- b) Appropriate action in response to fires on board, within and external to machinery spaces; shut-down and isolation of plant and equipment
- c) Organisation of emergency parties and drills; fire and safety plans. Correct use of live-saving appliances and equipment. Organisation of abandon ship drills

11. Ship construction

- a) Knowledge of the following terminology and definitions and demonstrates the ability to sketch simple constructions:
 - i) aft and fore perpendicular;
 - ii) length between perpendiculars (LBP);
 - iii) length overall (LOA);
 - iv) midships line (LBP/2);
 - v) bilge;
 - vi) breadth;
 - vii) bulkhead;
 - viii) camber;
 - ix) centreline;
 - x) deck;
 - xi) deckhead;
 - xii) depth;
 - xiii) draft;
 - xiv) draft marks;
 - xv) even keel;
 - xvi) freeboard;
 - xvii) keel;
 - xviii) load line marks and certification;
 - xix) longitudinal;
 - xx) midships;
 - xxi) rise of floor;
 - xxii) sheer;
 - xxiii) stem;
 - xxiv) transverse;
 - xxv) trim by the head;
 - xxvi) trim by the stern;
 - xxvii) waterline
- b) Deadweight; displacement; lightweight; gross tonnage; registered tonnage
- c) A-bracket; P-bracket, bulbous bow; flare; stringer; panting stringer; propeller; rudder; transom