

maritime regulations. Awareness of mental health and psychological safety: fatigue, stress and respectful workplace.

Annexure II

Syllabus for MEO Class II Preparatory Course

Duration: Three months (12 weeks, 60 working days, 360 contact hours)

The Marine Engineer Officer (MEO) Class-II Preparatory Course shall be designed to prepare candidates for the Written and Oral Examinations leading to the award of the Marine Engineer Officer Class-II Certificate of Competency (CoC) in accordance with the requirements of Regulation III/2 and the relevant provisions of the STCW Convention, 1978, as amended, including the associated sections of the STCW Code.

The course shall be conducted as a fully offline programme over a duration of twelve (12) weeks, comprising 60 working days and 360 contact hours.

The course shall comprise the following syllabus:

MARINE ENGINEERING KNOWLEDGE (GENERAL) (Function 4: Marine Engineering at the Management Level):

The engineering knowledge demonstrated by candidates shall be commensurate with that required for the safe operation, management, maintenance, and troubleshooting of the machinery, equipment, and ship structure normally under the responsibility of a Marine Engineer Officer at the Management Level.

Candidates may be required to illustrate their answers by means of clear, freehand sketches wherever appropriate.

The scope of the subject shall include, but not be limited to, the following:

- 1. Technology of materials** - Metallurgy of Steel and Cast Iron, Properties and application of ferrous and non-ferrous material used in machinery on board ships, Destructive and non-destructive testing of material, Engineering processes used in construction and repair, Materials and welding.
- 2. Physical & chemical properties of fuel & lubricants** - Properties and characteristics of fuels and lubricants, Shore side and shipboard sampling and testing, Interpretation of test results, Contaminants including microbiological infection, Treatments of fuels and lubricants including storage, centrifuging, blending, pretreatment and handling.

Alternative Fuel Operations - System-level understanding, bunkering procedures, fuel properties, hazards, safety layers for methyl / ethyl alcohol, ammonia and hydrogen fuels.

- 3. Construction details**, and where applicable the manner of attachment to ship, principles involved and operation Surveillance & Performance assessment of :
 - (a) water gauge, thermometer, pyrometers, salinometer, ammeter, water meter, pressure gauge and other meters and gauges commonly used by engineers on board ships.

- (b) All auxiliary machineries of engine room including associated systems, pumps, pumping and piping systems, air compressors, waste heat recovery systems, purifiers, oily water separators, etc.
- (c) Thrust blocks, shafting, bearings, stern tubes, propellers, shipside fittings.
- (d) steering gear, stabilizers.
- (e) Refrigeration and air conditioning machinery, deck machinery.
- (f) Auxiliary boilers and steam plant.
- (g) Auxiliary compression ignition engines and associated plant.
- (h) turbo-electric, diesel electric, gas turbine drives.

4. Start Up and Shut down of Auxiliary Machinery, including associated system: Air compressors and compressed air systems, Hydraulic power system, Types of auxiliary boilers, Auxiliary steam system, Safety valves, Boiler water levels, Use of 'Sea water in Boilers', Use of 'Fresh Water in Boilers', Boiler Water Testing, Boiler Water Treatment, Auxiliary Steam turbines, Boiler defects, Boiler and Steam turbine survey and repairs, Evaporators, Thermal fluid heating system

- a) Safe and efficient operation, Surveillance & Performance assessment of electrical machines and systems.
- b) Requirements, including operations and maintenance of pumps and pumping systems including bilge, fire main, ballast, sewage & sludge systems.
- c) Refrigeration, working principles of air conditioning, cargo and domestic refrigeration plants. Refrigerants used in marine refrigeration plants, greenhouse effects and future refrigerants. Air conditioning, including psychometric process for heating, cooling and humidification.
- d) Steering gear systems, single failure criteria of steering gear Surveillance & Performance assessment.
- e) Operation and testing of pneumatic hydraulic and electric control systems.
- f) Functions and Mechanism of Automatic Control for auxiliary machinery: Generator distribution system, Steam boiler, Oil purifier, Refrigeration system, Pumping and piping system, Steering gear system, Cargo-handling equipment and deck machinery.
- g) Operation of cargo handling equipment and deck machinery.
- h) Operation of freshwater systems, fresh water generating systems and its performance assessment.
- i) Shipboard Personnel & Resource Management & emergency preparedness.

5. MASS – Autonomous Ships

Remote monitoring, fail-safe considerations.

MARINE ENGINEERING KNOWLEDGE (MOTOR) (Function 4: Marine Engineering at the Management Level):

1. Design of Marine machinery:

Design features and operating mechanisms of marine diesel engines, marine gas turbines and marine steam boilers. Technical communications for design.

2. Operations of marine machinery:

- (a) Propulsive characteristics of diesel engines and gas turbines, including speed, output and fuel consumption. Operating limits of the propulsion plants.
- (b) Safe and efficient operation and surveillance of, main propulsion plant and its systems and services. The determination of shaft power and recognition of irregularity in the performance

of the machinery and plant. Operation, monitoring and evaluation of engine performance and capacity.

- (c) Analysis and interpretation of information gained from monitoring equipment. Operation of gearing, clutches, air compressors.
- (d) Planning and scheduling of engine operations.
- (e) Functions and mechanism of automatic control of main engine.
- (f) Safety of engine equipment, systems and services.

- 3. Start up and Shut down main and auxiliary machinery, including associated system –**
Engine components, engine lubrication, fuel injection, scavenging and supercharging, starting and reversing, cooling systems, diesel engine control and safety, diesel engine emergency operation, multi-engine propulsion arrangement.

3.1 Engine components

- (a) Interpret static and dynamic loads and stresses, identifying service limitations of diesel engine components.
- (b) Evaluate different fabrication methods of diesel engine components, including: Welding, forging, utilizing composite materials, plasma-spraying, laser hardening and use of ceramics and other special materials.
- (c) Identify two and four stroke operating cycle forces, couples, and moments, relating these to design principles of: Crankshafts, bedplates, foundations, cross heads.
- (d) Explain out of balance gas and inertia forces, couples, and moments, and relate these to flywheels, balance weights, first/second order balancing, and hull vibration.
- (e) Explain factors contributing to torsional vibration and identify methods of minimizing or eliminating harmful effects of critical speeds.
- (f) Evaluate the calibration of: Pistons, cylinder liners, piston rings, bearings, crankshafts, to identify wear patterns, limits, and means of correction
- (g) Specify alignment and adjustment criteria of: Crankshafts, chain drives, gear drives, integral thrust bearings, crossheads
- (h) Compile specified working clearances and limits of all bearings, sliding surfaces, and interference fits of a typical diesel engine, using engine builders' manuals.

3.2 Engine Lubrication

- (a) Identify diesel engine lubricant types, properties, and applications. Outline principles of diesel engine lubrication. Contamination and deterioration of diesel engine lubricants - Discuss the sources/ causes types, and effects of contamination.
- (b) Describe typical testing and treatment methods, and Interpret typical results of testing, giving appropriate actions which should be undertaken.
- (c) Describe, using diagrams, the distribution of lubricating oil to diesel engines, in particular the: Guides and crosshead bearings of slow speed diesel engines, Top end bearings of medium speed engines, Bottom end bearing, Main bearings, Camshaft drives, showing direction of flow, typical clearances, and stating normal operating parameters.

3.3 Fuel Injection

- (a) Explain why atomization and penetration of fuel and the turbulence of air are essential to optimum combustion in a diesel engine.
- (b) State typical injection pressures and viscosities for different grades of fuel.
- (c) Describe how and why fuel pumps, camshafts, and injectors are altered for varying fuel types.
- (d) Describe, with the aid of simple sketches, the difference between constant and variable injection timing of fuel, showing materials, principal parts, methods of operation and adjustments of common types of fuel pump.

- (e) Electronic fuel injection control and monitoring systems; common rail fuel injection systems; fuel injection rate shaping; and operation of engines in economy and emission control modes; and principles of dual-fuel engines.
- (f) Compare injection requirements for slow speed, medium speed, and high-speed diesel engines, including pilot injection and pre-combustion chambers.
- (g) Identify common service faults, symptoms, and causes of combustion problems, specifying appropriate adjustments, including methods of fuel pump timing.
- (h) Summarize Occupational Health & Safety aspects of handling and testing fuel injection systems.
- (i) Explain, using relevant diagrams and stating normal operating parameters: Fuel valve cooling arrangement and Uni-fuel and dual-fuel systems (for high/medium viscosity fuel types)
- (j) Discuss the atmospheric pollution aspects of diesel engine combustion and give methods which reduce this pollution (especially SO_x and NO_x reduction).

3.4 Scavenging and Supercharging

Evaluate the need for scavenging diesel engines, Compare methods of scavenging diesel engines, Specify methods of providing pressurized air for combustion in diesel engines, Assess pressure charging methods for diesel engines, Assess pressure charging methods for diesel engines, Examine the working principles of turbochargers, Assess lubrication and cooling requirements of turbochargers, Analyze typical faults and identify appropriate actions to be undertaken with defective or damaged turbochargers.

3.5 Starting and Reversing

- (a) Describe starting procedures of diesel engines for power generation, propulsion, and emergency use.
- (b) Explain starting and maneuvering requirements/sequences for direct coupled reversible and geared propulsion diesel engines, for fixed and controllable pitch propeller applications
- (c) Describe, with labeled diagrams to indicate major components, typical maneuvering and reversing systems for propulsion diesel engines
- (d) Compare different methods of reversing direct coupled propulsion diesel engines
- (e) Identify common faults and identify appropriate actions to be undertaken with typical diesel engine starting and maneuvering systems
- (f) Compare the different methods of utilizing diesel engines for ship propulsion, including - Direct coupled, reversible slow and medium speed engines and Clutched and geared reversible and unidirectional medium speed engines with a fixed pitch propeller, Clutched and geared reversible and unidirectional medium speed engines with a controllable pitch propeller, and Diesel electric drive.

3.6 Cooling systems

- (a) Analyze the problems that may arise in cooling water spaces of diesel engines.
- (b) Evaluate common methods of diesel engine cooling water treatment.
- (c) State the importance of maintaining diesel engine thermal efficiency and evaluate thermal loads on engine components.
- (d) Justify cooling media selection and state the advantages and disadvantages of various diesel cooling methods.
- (e) Evaluate the tests used in the control of diesel engine cooling water treatment.
- (f) Enumerate the normal operating limits for diesel engine cooling water treatment.
- (g) Interpret the implications of out of limit readings from water treatment tests and state the corrective procedures which should be undertaken.

- (h) Itemize the sources and types of contamination of diesel engine cooling water and explain the effects of these contaminations on the reserves of treatment chemicals.
- (i) Compare the procedures which may be used to counter contamination of diesel engine cooling water.
- (j) Explain, using relevant diagrams and stating normal operating parameters, typical methods of cooling:
- (k) Medium and slow speed diesel engine pistons, Exhaust valves, Cylinders, Turbochargers, Cylinder heads.

3.7 Diesel Engine Control and Safety

3.8 Diesel Engine Emergency operation

3.9 Multi-engine Propulsion Arrangement

MARINE ENGINEERING KNOWLEDGE (STEAM) (Function 4: Marine Engineering at the Management Level):

1. Design features and operative mechanism of a Marine Steam Turbines and associated auxiliaries

- a) Describes with the aid of sketches/computer aided drawing, material selection and design features of steam turbines - Convergent and convergent/divergent nozzles and Nozzle boxes, Impulse and reaction turbines, Pressure and velocity compounding, Pressure/velocity diagrams, Optimum blade speeds, Hybrid blades, Materials of blades and other components, Turbine construction, Erosion shields, Bearings, thrust bearings, Turbine glands and gland steam systems, Astern turbines, Turbine casings, Diaphragms, Reheat turbines, Support and expansion of turbines.
- b) Describes with the aid of sketches the operative mechanism of steam turbines - Alarms and trips, warming through, Normal and emergency operation, Shut down procedures, Turbine performance, Sequential nozzle operation, Resonance, Critical speed, Vibration, Emergency control systems, Rotor straightening.
- c) Describes with the aid of sketches/computer aided drawing, material selection and design features of steam turbine gear box - Single and double reduction, Double helical involute gear teeth, Single and double locked gear trains, Epicyclic gearing, Flexible couplings, Nodal drive, Method of manufacturing of spur gears.

2. Design features and operative mechanism of Marine Steam Boiler and associated auxiliaries

- a) Describes with the aid of sketches/computer aided drawing, material selection and design features of marine steam boilers - Types of main steam boilers, Methods of construction, Boiler fittings and drum internals, Water circulation, Gas circulation, Operating parameters, Support and expansion, Super heaters and their temperature control, Soot blowers, Economizers, Air heaters, Steam to steam generation, Chemistry of combustion, Burners and burner registers, Local and remote water level indicators, Safety valves.
- b) Describes with the aid of sketches/computer aided drawing, material selection and design features of marine steam boiler feed water
- c) systems - Main feed systems, Condenser types, level control, construction, materials, support, expansion, operating parameters, loss of vacuum and leak testing, Air ejectors, Vacuum pumps, Extraction pumps, Gland condensers, Low pressure heaters, Drain coolers, High-pressure heaters, Turbo feed pumps, hydraulic balance, De-aerators.

3. Propulsive characteristics of Steam Turbine - Propeller curve, Propeller design point, Fouled hull, sea margin and heavy propeller, Continuous service rating, Limits for continuous operation, Limits for overload operation, Evaluate plant performance and analysis.

4. The efficient operation, surveillance, performance assessment and maintaining safety of propulsion plant and auxiliary machinery

- (a) Performance data of individual turbines and cycle components during sea trial
- (b) Periodic acquisition of above-mentioned data and comparison for location of deterioration,
- (c) Enthalpy drop test in superheated section of steam turbine
- (d) Quantification of stage efficiency losses – Leakage, Friction, Aerodynamic and Changes in flow passage areas.

5. Theoretical knowledge:

- (a) Ancillary feed water/ steam plant and combustion equipment.
- (b) Safe and efficient operation of steam plant. The determination of shaft power and the recognition of irregularity in the performance of machinery and plant. Analysis and interpretation of information gained from monitoring equipment.
- (c) Boiler and feed water testing and interpretation of results. Chemical treatment of feed water and boiler water. Effect of high chloride content, high phosphate reserve and high hydrazine reserve.
- (d) Methods of superheated temperature control, importance of steam purity and steam separation.
- (e) Boiler, steam pipeline, condenser and turbine support arrangement and expansion.
- (f) Procedure for warming up and cooling down of main turbines. Emergency lighting up procedure for main boilers.
- (g) Repair and maintenance procedure for refractory, insulation, water wall tubes (membrane type) water tubes, safety valve, retractable soot blowers, burners, steam traps and water level indicators.
- (h) Understanding of automatic combustion control system, burner management system, safety cut-outs and alarm system. Gas burning and monitoring system.
- (i) Types of auxiliary boilers, Auxiliary steam system, Safety valves, Boiler water level indicators, Use of Sea water in Boilers, Use of Fresh Water in Boilers, Boiler Water Testing, Boiler Water Treatment, Auxiliary Steam turbines, Boiler defects, Boiler survey and repairs, Evaporators, Thermal fluid heating system.

MARINE ELECTROTECHNOLOGY (Function-5: Electrical, Electronic and Control Engineering at the Management Level):

In addition to the basic Electro Technology knowledge acquired at the operational level as regards to Electromagnetism, Electromagnetic induction, simple magnetic circuits, simple magnetic theory, alternating current theory, A.C. circuits and distribution systems involving A. C. & D. C. Shipboard installations & associated protective devices; the following additional syllabus to be adhered for the function "Electrical, Electronic and Control Engineering at the Management Level".

1. Automatic Control Engineering and safety devices.

- a) Introduction - Open and closed control loops, Process control. Essential components in process control loops.
- b) Sensors and transmitters - Resistance temperature devices. Thermocouples. Flow and

pressure measurement. Level measurement. Ambient temperature compensation. Viscosity measurement. Torque measurement. Force balance transmitters. Oil/water interface and oil in water monitoring. The pneumatic flapper/nozzle system. Pneumatic 20 – 100 kPa, analogue 4 to 20 mA signals, Pneumatic pilot relays, Control air supply. Operational amplifiers. Electrical supply.

- c) Controllers and Basic Control Theory - Disturbances and time delays and means to reduce them. Two step, proportional, integral, and derivative control actions.
- d) Final Control Elements - Diaphragm operated control valves. Flow/lift characteristics of control valves. Control valve actuators and positioners. "Fail - safe", "fail - set" strategies. Wax element valves. Electrically operated valves.
- e) Control Loop Analysis - Temperature control systems. Level control systems. Pressure control systems. Split range and cascade control. Single, two and three element control.
- f) Governors - Need for governors. Governor terms, concepts and operation. Hydraulic governors. Digital governors, Power sharing. Governing systems.

2. Design features and system configuration of automatic control equipment and safety devices:

2.1 General Requirements

- (a) Electrical equipment designed for land use is often not suitable for use in ships.
- (b) As far as possible, all materials should be non-flammable explains where flame retardant materials may be used.
- (c) Meaning of the term flame retardant
- (d) Angles of heel and trim at which machinery should be capable of operating.
- (e) Effect of temperature changes on - Electromagnetic devices, Generator voltage.
- (f) Common maximum temperatures of air and sea water used for design purposes.
- (g) Axis of a rotating machine should not be placed athwart ships unless so designed.
- (h) Need to periodically check the security of all electrical connections.
- (i) Requirements regarding the provision of electrical power and lighting for normal operation and for an emergency.

2.2 Main Engine

- (a) Control Theory - Changing set points. Basic control system design. First order and second order systems. Transfer Functions. Control system stability. Natural frequency and control systems. Time lag and time constant. System response.
- (b) Tuning - System response. Control loop tuning. Ziegler-Nichols, Cohen-Coon tuning methods.
- (c) Signal Transmission Systems - Digital communication bus and fibre optic signal transmission systems
- (d) Final Control Elements - Control valve trim. Selecting control valves and their actuators. Valve sizing.
- (e) Electronic PID Controllers - Single loop digital controllers. Manual and automatic tuning of electronic controllers.
- (f) Monitoring & Control Systems - Boiler water level control. Advanced boiler combustion control. Diesel engine cooling control, Main engine control for FP and CP propellers. Alarm and monitoring systems. Programmable logic control and SCADA (supervisory control and data acquisition); Data logging and data transfer.
- (g) General requirements of automatic control equipment and safety devices - Monitoring system, Safety system, System independence, Local control, Failure mode and effect analysis, Power supply.
- (h) Remote control – Diesel propulsion, Control - electronic, electro-pneumatic, electro-hydraulic or pneumatic, Malfunctions – alarm, engine slow down, engine stop.

- (i) UMS Systems - Concept of Unattended Machinery Spaces (UMS). Requirements of UMS. Bridge control. Testing regime for UMS.
- (j) Software version control, construction and use of computer network on ships for bridge-based, engine room-based and commercial applications.

2.3 Generator and distribution system - Instrumentation and Safety in Generator and Distribution system, Auxiliary Diesel Generator Alarm and Shut Down, Automatic Starting of Propulsion Auxiliaries.

2.4 Steam boiler

- (a) Following failures will have alarms and display – feedwater high salinity, high water level, boiler pressure high and low, super heater outlet temperature high, fuel pump low outlet pressure, heavy fuel temperature high and low (or high and low viscosity), uptake high temperature, control system power failure, atomization steam / air pressure low
- (b) Following failures will have alarms, display and automatic shutdown of boiler – low water level, supply air pressure failure, ignition or flame failure.

3. Design features and system configuration of operational control equipment for electrical motors:

3.1 Three Phase A.C. Motors - Construction, principle of operation of 3-phase induction motors, Design features of star and delta motors, Starting, speed controlling and braking methods of 3-phase induction motors, Load-torque characteristics and protection.

3.2 Three Phase Synchronous Motors - Construction. Principle of operation. Load characteristics, Power factor improvement with synchronous motors.

3.3 Effect of varying frequency and voltage of A.C. Motors – Speed, Temperature, Torque, Power output and Starting time, current.

3.4 Motor control and protection - D. C. motors, A. C. motors.

3.5 Insulated Gate Bipolar Transistor (IGBT) motor speed control - Gate driving characteristics with high current, High frequency, high current switch, Advantages of IGBT in varying motor speed control.

3.6 Motor speed control - Application of thyristors and Variable Frequency Drive (VFD) in motor speed control.

3.7 Three Phase Generators - Construction. Salient and cylindrical rotor types, Shaft generators, Excitation methods, Automatic voltage regulation, Synchronization, Parallel operation, Generator trouble shooting.

3.8 Three Phase Transformers - Construction Polarity, Configurations in Star and Delta combinations, Open delta configuration.

3.9 Distribution - Main switchboard construction and configuration. Short circuit protection - fuses, main circuit breakers, the generator air circuit breaker, Protection co-ordination, Distribution configuration, Electrical equipment for tankers and hazardous areas and safety systems.

3.10 Emergency Power - Automatic starting arrangements for the emergency generator, Emergency power requirements, Essential and non-essential circuits, Batteries.

4. Electronics, Power Electronics

- (a) Semiconductor Devices - Uni-junction transistor, The Bipolar transistor, operation and characteristics, bias circuits, AC and DC current gain, data sheets. Field Effect Transistors, operation. Thyristors, SCRs, GTOs, DIACs and TRIACs operation and characteristics. Insulated gate bipolar transistor (IGBT), Snubber circuits, commutation, data sheets. Device applications in electronic control, surveillance and recording systems, power supplies, rectification, smoothing circuits, stabilization, switching, amplification, pulse shaping, clipping and clamping. PMOSFET (Power metal oxide semiconductor field-effect transistor). Design features of cycloconverter, variable frequency drives and their applications onboard ships.
- (b) Integrated Circuits - Ideal operational amplifier, characteristics, types, mounting methods and markings, advantages of ICs. Practical operational amplifier, circuit configurations, CMRR, instrumentation amplifier, 4-20mA circuit. Voltage regulators, multivibrators. IC applications and common circuits. Data sheets.
- (c) Electronic Fault Diagnosis - Interpretation and use of electronic systems and subsystem circuit diagrams, operation and maintenance manuals. Electronic test equipment, method of DMM display. Use of CRO as a testing and display instrument. Analysis of measurement and test result on components and circuits. Methods of fault detection.

5. High voltage systems:

Design features, operational and safety requirements for marine HV system. Mandatory rules for HV system in safe and flammable areas and with/ without earthing. Carrying out switching and isolation procedure.

6. Management of Troubleshooting & Restoration of electrical & electronic equipment to operating conditions.

6.1 Control System & Troubleshooting:

- (a) Troubleshooting of electrical and electronic control equipment - Electrical safety, Test equipment, Interpretation of circuit symbols, Logical six step trouble shooting procedure, Generation, Prime mover electrical control, Main air circuit breaker, Protection of generators, Electrical distribution systems, Motors, Electrical survey requirements, Calibrate and adjust transmitters and controllers, Control system fault finding.
- (b) Function test of electrical. Electronic control equipment and safety devices.
- (c) Troubleshooting of monitoring systems - Test and calibration of sensors and transducers of monitoring system.
- (d) Software version control - Programmable logic controllers (PLC), Microcontrollers, Digital techniques.

6.2 Maintenance & repair of the following:

Electrical and electronic systems operating in flammable areas, Carrying out safe maintenance and repair procedures, Detection of machinery malfunction, location of faults and action to prevent damage.

7. Cybersecurity – Management of Shipboard Cyber Risks

Cyber risk assessments, control system vulnerabilities, incident response, role of engineering officers.

MARINE ENGINEERING PRACTICE (Function-6: Maintenance and Repair at the Management Level):

1. Theory of maintenance:

Theoretical knowledge of Marine engineering practice and maintenance of machinery.

Methods of dealing with wear and tear of machinery, both electrical and mechanical. Alignment of machinery components. Correction of defects.

Detection of machinery malfunction, location of faults and action to prevent damage - Unplanned maintenance.

Temporary or permanent repairs in the event of breakdown:

- (a) Failure of cross-head bearing/ main bearing/ bottom end bearings of main engine
- (b) Breakage of chain drives of main engine
- (c) Breakdown on turbo chargers
- (d) Breakdown of main air conditioning and fridge system
- (e) Collapse/ failure of multiple boiler water tubes

2. Practice of maintenance:

Management and conduct of ship maintenance by planned maintenance and preventive maintenance as per ISM Code. Theory of condition monitoring and its application onboard ships. Principles of tribology and its practices.

Planning and execution of dry docking and other major repairs. Manageable breakdowns and emergency repairs.

Planning and execution of safe maintenance activity and repair procedures taking into account technical, legislative, safety procedurals specification, appropriate plan, specification of materials and equipment available for maintenance and repairs.

Risk assessment and evaluation before commencement of maintenance activity.

Destructive and non destructive testing.

Major contamination of main L.O. sump – Action/ handling/ rectification.

Severe flooding of engine room bilges – Action/ handling/ rectification.

Trials and restoration of the plant after repairs. Safe working practices.

Inspection and Adjustment of Equipment relevant to Marine Engineering.

3. Marine Engineering practice – Theoretical & Practical Knowledge

Classification society and class certificates, statutory certification of ships, Surveys for maintenance and renewal of class and statutory certificates.

Digitalisation / Data Driven Maintenance - Predictive analytics, digital twins, e-logbooks.

NAVAL ARCHITECTURE (Function-3: Controlling the Operation of the Ship and Care for Persons on Board (Management Level):

General. Wetted surface formulae. Simpson's rules applied to second moments of areas, volumes, centroids and centres of pressure. Hydrostatic curves.

1. Structural strength: Total Pressure on Vertical Bulkhead of various shapes, Center of Pressure, Diagrams of Shear force and bending moment, Longitudinal Bending Moment in Still Water and wave induced.

2. Transverse stability:

Effect of free liquid surface and sub-division of tanks. Dangers due to water accumulation during fire-fighting Practical requirements to ensure stability at sea. Management of water and fuel tanks. Filling and emptying tanks at sea. Movement of centre of gravity. Angle of Loll and Stability beyond Angle of Loll, Correcting an angle of loll. Stability during Dry docking and Grounding, Damaged Stability,

3. Longitudinal stability:

Longitudinal BM_L and GM_L , Centre of flotation and its calculation. Moment to change trim by one centimeter.

Trim: Changes due to adding or removing fuel, ballast or cargo. Changes due to alteration in density of sea water. Changes due to bilging of compartments, Using the Lost Buoyancy and Added Mass methods. Dynamical Stability, SOLAS, ILLC Convention requirement,

Forces on rudder and stress in rudder stock. Heel when turning, including effect of centrifugal force and of force on rudder.

4. Resistance and propulsion:

Resistance and Fuel Consumption, Propeller and Power, Rudders & Damage Control. Various Types of resistance, Geometry of Propeller, The law of corresponding speeds. Froude's law of comparison. Simple problems on the prediction of full scale resistance from model experiments. Elementary treatment of propeller and simple problems on pitch, pitch ratio, apparent slip, wake velocity, Thrust and Power. Bulbous Bow, Sea trials and interpretation of data recorded. Effects of fouling.

Drag and Lift of Propeller, Problems on propellers involving the use of wake factor, Effective Power, Delivered Power, Propulsive & Quasi Propulsive coefficient, Propeller efficiency, Bollard Pull, Computation of thrust and Power, Cavitation No, Cavitation Tunnel test of Model propeller, Co relation between Model and Full Propeller, Vibration in ships.

Ducted Propeller, Voith Schneider Propeller, Water Jet Propulsion.

Factors affecting trim and stability and measures necessary to preserve trim and stability. Effect on trim and stability of a ship in the event of damage to, and consequent flooding of, a compartment and countermeasures to be taken. IMO recommendations concerning ship stability

5. Ship construction:

Fundamental principles of ship construction and the theories and factors affecting trim and stability and measures necessary to preserve trim and stability Ship Types and Terms, Stresses in Ship Structures, Ship Dynamics, Hydrostatics, Displacement, TPC, Coefficients of Form, Areas and Volumes of ship shapes, 1st and 2nd Moments, Center of Gravity, Transverse Stability, Trim, Stability during dry docking and stability during grounding, Forces on ship under various

conditions, including the effect of panting and pounding. Construction of all parts of steel ships. Use of high tensile steel and aluminum.

Structural fire protection arrangements. Dry docking. Design features of ships for general and specialized trades.

Life saving equipment Operation and handling gear for lifeboats and life rafts. Ship measurement and classification. Meaning of 'classed' and 'unclassed' ships. Common terms used in measurement of modern steel ships. Common terms used in tonnage measurement e.g. gross tonnage, net tonnage.

SHIP'S SAFETY, ENVIRONMENTAL PROTECTION AND PERSONNEL CARE (Function-3: Controlling the Operation of the Ship and Care for Persons on Board (Management Level)):

1. Legislative requirements and measures to ensure safety of life at sea and protection of the marine environment

- a) Knowledge of Merchant Shipping Act, relevant International Maritime Law embodied in international agreements and conventions - United Nations Convention on the Law of Sea (UNCLOS), International Maritime Organization (IMO), World Health Organization (WHO), International Labour Organization (ILO), Treaties, conventions, protocols, rules and regulations, List of IMO Conventions & Authorities & Regulations.
- b) Certificates and other documents to be carried on board ships by international conventions (as per SOLAS Annex 1) and how they may be obtained and period of their legal validity.
- c) Responsibilities under the relevant requirements of the international convention on load lines.
- d) Responsibilities under the relevant requirements of the International Convention for the Safety of Life at Sea - Brief description of International Convention for the Safety of Life at Sea, Obligation - to carry out surveys and maintain validity of certificates, to maintain records and rights of master.
- e) Responsibilities under the relevant requirements of the International Convention for the Prevention of Pollution from Ships - Annex I, Annex II, Annex III, Annex IV, Annex V, Annex VI.
- f) Maritime declarations of Health and the requirements of the International Health Regulations - WHO's International Health Regulations 2005 (IHR), WHO's Guidelines for drinking water quality, International Medical Guide for ships (IMGS) and IMO's Medical First Aid Guide (MFAG)
- g) Responsibilities under International Instruments Affecting the Safety of the Ships, Passengers, Crew or Cargo:
 - ILO's Maritime Labour Convention 2006 (MLC 2006)
 - Convention on the International Regulation for Preventing Collisions at Sea (COLREG) 1972
 - International Convention on Salvage 1989; Lloyd's Standard Form of Salvage Agreement (LOF 2000)
 - Convention on Limitation of Liability of Maritime Claims 1976
 - International Convention for the unification of certain rules of law relating to Bills of Lading (Hague-Visby Rules)
 - Charter parties
 - Marine Insurance, General Average and P & I Club

- h) Methods and aids to prevent pollution of the environment by ships
 - (i) List of Conventions, Sources of Marine Pollution, Effects of Marine oil spills and Noise
 - (ii) International Convention for the Control and Management of Ship's Ballast Water and Sediments
 - (iii) International Convention for the Control of Harmful Anti-Fouling Systems on Ships (AFS) 2001
 - (iv) Regulations for prevention of oil pollution as per Annex I of MARPOL 73/78
 - (v) Regulations for control of pollution from noxious liquid substances carried in bulk as per Annex II of MARPOL 73/78
 - (vi) Regulations for the Prevention of Pollution by harmful substances carried by sea in packaged form as per Annex III of MARPOL 73/78
 - (vii) Requirements covering the carriage of dangerous goods by sea as per Chapter VII of the SOLAS Convention
 - (viii) Regulations for the Prevention of Pollution by Sewage from Ships as per Annex IV of MARPOL 73/78
 - (ix) Regulations for the Prevention of Pollution by Garbage from Ships as per Annex V of MARPOL 73/78
 - (x) Regulations for the Prevention of Air Pollution as per Annex VI of MARPOL 73/78
- i) National Legislation for implementing international agreements and Conventions.

2. Safety and security of the vessel, crew and passengers

- (a) Life Saving Appliances Regulations (SOLAS) - Life-Saving appliances and arrangements (Chapter III of SOLAS) and Life-Saving Appliance Code.
- (b) Organization of fire and abandon ship drill.
- (c) Maintenance, functions and use of Life Saving Appliances, Fire-Fighting and other safety systems.
- (d) Actions to protect and safeguard all persons on board in emergencies; rescue of persons from a vessel in distress or from a wreck; and Man-overboard procedures.
- (e) Action and means to limit damage and save the ship following fire, explosion, collision or grounding – Contingency plans for response to emergencies and Procedures for abandoning ship.

3. Develop Emergency and Damage Control Plans and Handle Emergency Situation

- (a) Methods and Aids for Fire Prevention, detection and extinction - Fire -fighting equipment.

4. Use Leadership and Managerial Skills

- (a) Knowledge of shipboard Personnel Management and Training - Engineer and Manager, Human Resource Management, Training and Development, Maintenance Management.
- (b) Knowledge of International Maritime Conventions and recommendations and related National Legislations - The ISM Code, STCW Convention, ILO's MLC 2006.
- (c) Ability to apply task and workload management – Communication, Team building, Planning and co-ordination, Personal assignments, Time and resource constraints, Prioritization.
- (d) Knowledge and ability to apply effective resource management - Allocation, assignment and prioritization of resources, Effective communication on board and ashore, Decisions reflect consideration of team experience.
- (e) Knowledge and ability to apply decision-making techniques - Management processes and functions, Negotiating skills, Situation and risk assessment, Identify and generate options, Select course of action, Evaluation of outcome effectiveness.
- (f) Development, implementation, and oversight of standard operating procedures - Project planning and controlling.
- (g) Mental Health, Psychological Safety & Sexual Assault and Sexual Harassment and bullying prevention.