SQA Yacht Engineering Syllabus

Marine Diesel Engineering

1 Engine Working principles

1.1 Working principles of compression ignition (diesel) and spark ignition (petrol) type reciprocating trunk piston engines.

1.2 Working principles of diesel reciprocating trunk piston engines:

- a 2-stroke diesel engine cycle
- b 2-stroke diesel engine timing diagram
- c 2-stroke diesel engine PV diagram
- d Relationship between the 2-stroke timing diagram and PV diagram
- e 2-stroke scavenging process (Uniflow only)
- f Explanation and reasons for valve overlap
- g 2-stroke air start inlet timing
- h 4-stroke diesel engine cycle
- i 4-stroke diesel engine timing diagram
- j 4-stroke diesel engine PV diagram
- k Relationship between the 4-stroke timing diagram and PV diagram
- l 4-stroke scavenging process
- m Explanation and reasons for valve overlap
- n 4-stroke air start inlet timing

1.3 Basic knowledge of power balancing an engine

1.4 Basic knowledge about the importance of monitoring the combustion process

1.5 Basic knowledge about peak pressures, indicator diagrams

2 Turbo-chargers

2.1 Principles and reasons for turbo-charging

2.2 Simple turbo-charger construction

2.3 Pulsed turbocharger system

2.4 Constant pressure turbocharger system

2.5 Sequential (multistage) turbocharger system

2.6 Construction and components of a turbo-charger (air and water cooled)

2.7 Turbine, turbine blades, air intake filters, compressor, bearing types (plain, ball and roller), labyrinth glands

2.8 Reasons for charge air-cooling

2.9 Construction of charge air coolers

3 Engine construction

3.1 Constructional details of both 2-stroke and 4-stroke trunk piston, medium and high-speed, diesel engines used for main propulsion, electrical power generation and other auxiliary purposes

3.2 Bedplates (cast and fabricated); engine blocks; entablature; frames; horizontal and vertical tie-bolts

3.3 Holding down arrangements; bolts; cast iron and resin chocks; resilient (flexible) mountings

3.4 Crankshafts (solid forged, grain flow) and main bearings (bearing shells, materials, plain and thrust bearings, lubrication arrangements)

3.5 Conventional and hung crankshaft arrangements

3.6 Camshafts; camshaft drives, bearings, connecting rods (top and bottom end bearings, lubrication); cylinder liners; solid and composite pistons

3.7 Piston rings (theory of working; types, compression, oil control, clearances, sealing)

3.8 Cylinder heads (cooling; push rods; inlet valves; exhaust valves; fuel injectors; safety valves; air start valves; indicator cocks)

3.9 Setting tappet clearance

3.10 Effects of too small and too large tappet clearances

3.11 Flywheel; turning gear; barring over arrangements

3.12 Materials and processes (casting, forging, fabrication etc) commonly used in the manufacture of the engine constructional components.

3.13 Engine formats used in construction, including in-line (straight), V-type and opposed piston engines.

4 Engine safety devices

4.1 Basic principles of a simple hydraulic governor

4.2 Basic principles of a simple electronic governor

4.3 Principles and operation of a mechanical overspeed trip

4.4 Crankcase explosion doors, crankcase explosions

4.5 Oil mist detectors

4.6 Turning gear interlocks

5 Engine room layouts

5.1 Basic main propulsion system engine room layouts:

5.2 Single main diesel engine with reduction gearbox, single propeller shaft and fixed pitch propeller

5.3 Single main diesel engine with reduction gearbox, single propeller shaft and controllable pitch propeller

5.4 Twin main diesel engines with reduction gearboxes, twin propeller shafts and fixed pitch propellers

5.5 Twin main diesel engines with reduction gearboxes, twin propeller shafts and controllable pitch propellers

5.6 Twin main diesel engines with twin steerable water jet units

5.7 Twin main diesel engines with twin steerable water jet units and central fixed booster water jet

6 Engine auxiliary systems

6.1 Fuel oil supply system

6.2 Principles and operation of the following:

- a 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)
- b 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, spill return fuel coolers)
- c Construction and operation of the Bosch (jerk) type HP fuel pump
- d Construction and operation of basic fuel injector (atomisation process, penetration, turbulence, problems with injection, ignition quality, ignition delay)
- e Testing and setting a fuel injector lift pressure
- f Construction and operation of combined fuel pump and injector
- g 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

7.1 Health and safety associated with handling fuel oils

7.2 Knowledge of fuel oil standards (basic content of ISO 8217, CIMAC)

7.3 Knowledge of different types (distillate and residual) and grades of fuel (as per ISO 8217)

7.4 Compatibility and mixing of fuels from different bunker sources

7.5 Flash point (Regulation 15 SOLAS, minimum flash points)

7.6 Methods of testing flash point (closed and open flash point)

7.7 Ignition quality (Cetane and Calculated Carbon Aromaticity Index (CCAI))

7.8 Gross Specific Energy (GSE) and Net Specific energy (NSE)

7.9 Cloud point; Density; Pour point; Viscosity; Microbiological infestation;

7.10 Sodium; Sulphur; Vanadium; Water; Wax

8 Distillate fuel oil treatment

8.1 Types of fuel oil filters

8.2 Construction and operating principles of coalescent filters

8.3 Construction and operating principles of fuel oil centrifugal separators *[Note: NOT self cleaning type]*

8.4 Use of fuel oil centrifugal separators as purifiers and clarifiers

8.5 Problems with distillate fuels (water, fuel contamination, flash point, wax, microbiological)

9 lubrication

9.1 Reasons for lubrication (friction, wear, noise, lubrication, cooling, sealing, preserving)

9.2 Theory of lubrication with shafts rotating in bearings (boundary lubrication, hydro-dynamic lubrication, bearing clearances)

9.3 Types of lubricant

9.4 Lubricating oil characteristics

9.5 Health and safety associated with handling lubricating oils

9.6 Base number, BN; Colour, condition and odour

9.7 Flash point, dangers of fuel dilution

9.8 Microbiological infestation

9.9 Pour point; Viscosity, viscosity index; Water; Wax

9.10 Wear metals

10 Lubricating Oil Systems

10.1 Engine internal lubricating oil distribution systems (bearings, piston etc)

10.2 Basic lubricating oil cooling system, layout and components

10.3 Safety and protection devices fitted to the system and its components

10.4 Lubricating oil treatment

10.5 Lubricating oil filters;

10.6 Construction and operating principles of lubricating oil centrifugal separators (manual operation only)

10.7 Contamination of lubricating oil from blow-past from the combustion space (carbon, fuel dilution, flash point, water);

10.8 Effects of running with contaminated oil and sources of contamination

10.9 Simple lubricating oil testing (visual, smell, water, viscosity, viscosity comparison, spot test).

11 Cooling water systems

11.1 Self-contained engines, with engine driven pumps

11.2 Air-cooled with radiator system

11.3 Basic direct salt (raw) water cooling water system, layout and components

11.4 Basic fresh water jacket cooling water system, layout and components

11.5 Engines with independent (electric motor) driven pumps

11.6 Basic fresh water centralised jacket cooling water system (SW + LTCW + HTCW), layout and components

11.7 Safety and protection devices fitted to the systems and their components

11.8 Use of cooling water chemical inhibitors, dangers when used with fresh water makers

12 Heat exchangers

12.1 Construction and use of shell-tubular heat exchangers

12.2 Construction and use of plate heat exchangers

12.3 Construction and use of through-hull (exterior) heat exchangers

12.4 Advantages and disadvantages of each type of heat exchanger

12.5 Materials used in construction of heat exchangers

12.6 Anodic protection in heat exchangers

13 Engine starting systems

13.1 Air starting motors;

13.2 Hydraulic starting motors;

13.3 Hydraulic rack and pinion starting system (Bryce type gear);

13.4 Electric (battery) starting motors

14 Engine operation and maintenance

14.1 Describe the following procedures:

- a Preparing for sea and warming through
- b Shutting down and securing for maintenance
- c Overhaul of a unit
- d Overhaul of a main bearing
- e Overhaul of a main engine mounted high-pressure fuel pump
- f Overhaul and testing of a fuel injector
- g Routine servicing of a turbo-charger

14.2 Reference to manufacturers manuals

14.3 Reference to ships written procedures

14.4 Reading of engineering drawings

14.5 Causes and actions to be taken in the event of:

- a Black smoke in the exhaust
- b White smoke in the exhaust
- c Blue smoke in the exhaust
- d Contamination of sump lubricating oil
- e Unusual crankcase noise
- f Exhaust temperature of one unit falling
- g Leaking exhaust valve
- h Fuel filter blocking
- i Surging in turbo-chargers

Operational Procedures, Basic Hotel Services and Ship Construction

1 Legislation

1.1 The purpose of MCA Merchant Shipping, Marine Guidance Notices and Marine Information Notices

1.2 The Code of Safe Working Practices for Seamen

1.3 Basic working knowledge of the International Safety Management (ISM) Code and of the SOLAS, MARPOL and STCW Conventions

2 Watchkeeping

2.1 Watchkeeping procedures including:-

2.2 Regulations (STCW 95)

2.3 Taking over and accepting a watch.

2.4 Routine watchkeeping duties and responsibilities.

2.5 Keeping of the log and other records and understanding the significance of the readings taken.

2.6 Changeover of systems from remote/automatic to local control

2.7 Safety precautions to be observed during a watch and immediate actions in the event of equipment breakdown, fire, flooding or accident

2.8 Handing over a watch.

2.9 Basic voyage planning, including:-

- a Fuel
- b Water
- c Stores
- d Spares.

3 Maintenance

3.1 Maintenance procedures and records including:-

3.2 Maintenance systems (running hours, calendar intervals, break down etc.)

3.3 Condition monitoring and trends.

3.4 Written and computer based record systems.

4 Pollution

4.1 MARPOL

4.2 Restricted areas; oil record book; disposal of pollutants; garbage record book Action in response to a pollution incident on board; SOPEP manual Regulations (Marpol 73/78 - U.K. S.I.)

4.3 Construction and operation of oil-water separators and discharge monitors.

4.4 Oil record book.

4.5 Garbage pollution prevention. (Marpol 73/78)

4.6 Sewage pollution prevention including:-

4.7 Regulations. (Marpol 73/78)

4.8 Pollution by refrigerants (Montreal et-al)

5 **Bunkering**

5.1 Bunkering and fuel transfer procedures including:-

5.2 Monitoring fuel quality and contamination (correct grade, water, dirt, microbial, surfactants)

5.3 Transfer stability and free surface.

6 **Sewage plants**

6.1 Construction and operation of sewage treatment plants (continuous, zero discharge)

6.2 Difference between aerobic and anaerobic

6.3 Dangers associated with the operation of sewage treatment plants (anaerobic, H_2S, methane)

7 **Refrigeration**

7.1 Principles of refrigeration including:-

7.2 Construction and operation of basic refrigeration systems (direct and indirect expansion)

7.3 Refrigerants and oils.

7.4 Fault finding.

8 **Air Conditioning**

8.1 Principles of air conditioning including:-

8.2 Construction and operation of types of a.c. systems. (stand alone, chilled water, blown air)

8.3 Relative humidity and maintaining 'comfort zone.'

8.4 Dangers associated with the operation of a.c. plants (Legionella).

9 **Fresh Water**

9.1 Fresh water makers including:-

9.2 Construction and operation of a reverse osmosis plant

9.3 Basic knowledge of a fresh water distillation plant using a vacuum chamber

9.4 Water sterilisation methods. (chlorine, silver ion, ultra violet)

9.5 Neutralisation and palatability.

9.6 Inspection and cleaning of water tanks and system superchlorination.

10 **Motion control**

10.1 Types of motion (roll, pitch, yaw etc., damping coefficient)

10.2 Passive roll stabilisation systems.

10.3 Active roll stabilisation systems.

11 Fire fighting

11.1 Fire prevention; use and care of fire-fighting appliances; fixed machinery space installations; escape and breathing apparatus

11.2 Appropriate action in response to fires on board, within and external to machinery spaces; shut-down and isolation of plant and equipment

11.3 Organisation of emergency parties and drills; fire and safety plans, correct use of live-saving appliances and equipment. Organisation of abandon ship drills

12 **Ship construction**

12.1 Knowledge of the following terminology and definitions. Demonstrates the ability to sketch simple constructions:

- a Aft and fore perpendicular;
- b length between perpendiculars (LBP);
- c length overall (LOA);
- d midships line (LBP/2);
- e bilge;
- f breadth;
- g bulkhead;
- h camber;
- i centreline;
- j deck;
- k deckhead;
- l depth;
- m draft;
- n draft marks;
- o even keel;
- p freeboard;
- q keel;
- r load line marks and certification;
- s longitudinal;
- t midships;
- u rise of floor;
- v sheer;
- w stem;
- x transverse;
- y trim by the head;
- z trim by the stern;
- aa waterline

12.2 Deadweight; displacement; lightweight; gross tonnage; registered tonnage

12.3 A-bracket; bulbous bow; flare; stringer; panting stringer; propeller; rudder; transom

12.4 Materials, steel, aluminium, FRP, advantages/disadvantages of each

12.5 Jointing of aluminium and steel (bolted connection, explosion welding)

12.6 Protective coatings

12.7 Transverse and longitudinal stresses and causes.

12.8 Panting and pounding stresses and causes.

12.9 Transverse and longitudinal framing construction.

12.10 Vibration, cause and effect.

12.11 Structural fire protection and subdivision.

12.12 Watertight integrity and subdivision

12.13 Position, height and number of watertight bulkheads

12.14 Purpose of the collision bulkhead

12.15 Watertight bulkheads and penetrations (doors, vents, pipes, shafts, electric)

12.16 Static and dynamic condition of vessel in the water

12.17 Basic dry-docking procedures and preparation for docking

Auxiliary Equipment

1 **Valves**

1.1 Types of valves

1.2 Construction and application different types of valves:

- a Simple plug cock;
- b ball valve;
- c screw-lift valve;
- d screw-down non-return (SDNR) valve;
- e butterfly valve;
- f gate valve;
- g diaphragm valve;
- h quick closing valves;
- i 3-way valves;
- j valve chests
- k Basic valve symbols
- l Pressure relief valve - differentiate between a safety valve and a relief valve

1.3 Materials used in valve construction (cast iron/steel, bronze, brass, stainless steel etc).

1.4 Compatibility of the materials used in construction with fluids flowing through the valve, aspects of corrosion

2 **Pumps**

2.1 Types of pumps

2.2 Basic classification of pumps, positive displacement and centrifugal

2.3 Typical pump applications in systems

2.4 Basic pump symbols

2.5 Positive displacement pumps, construction and theory of operation

2.6 Types of positive displacement pumps:

- a electric motor driven reciprocating pump,
- b lobe pump; gear pump,
- c rotating piston pump;
- d screw pump,
- e vane pump

2.7 Positive displacement pump relief valves and system flow pulse damping

2.8 Centrifugal pumps, construction and theory of operation

2.9 Types of centrifugal pump, volute casing and diffuser

2.10 Problems associated with priming centrifugal pumps and methods of priming

2.11 Variable delivery pumps, construction and theory of operation

2.12 Types of variable delivery pump, swash plate type pump, Hele-Shaw type pump

3 **Compressed air system**

3.1 Knowledge that the compressed air system commonly has two pressure levels, 30-40 bar for starting air, and 7-10 bar for control air.

3.2 Basic compressed air system, layout and components (air compressors, air receivers)

3.3 Safety devices associated with the compressed air system, safety valves, fusible plugs, compressor bursting discs, compressor lifting heads etc

4 **Hydraulic and pneumatic control principles**

4.1 Basic hydraulic and pneumatic symbols (interpretation of system drawings)

4.2 Basic electro-hydraulic and electro-pneumatic control.

4.3 Hydraulic fluids, types, uses, characteristics

4.4 The importance of clean air supplies for pneumatic control systems

4.5 Basic control air supply system, layout and components (reducing valve, driers, filters, lubricators)

5 **Hydraulic control systems**

5.1 Application of hydraulic control systems

- a Constant pressure hydraulic system for deck machinery (crane, windlass etc)
- b Constant pressure hydraulic system for a stabiliser system
- c Constant pressure hydraulic system for a steering gear system
- d Variable pressure hydraulic system for a steering gear system

5.2 Steering gears

5.3 Basic functions of a steering gear

5.4 Required capabilities of the main and auxiliary steering gears as SOLAS Regulation 29

5.5 Types of steering gear construction, 2-ram and rotary vane

5.6 Operation of the hydraulic tele-motor control system, signal transmission from remote steering positions

5.7 Operation of the hunting gear

5.8 Steering gear protection and system redundancy (split hydraulics, dual pumping arrangements, isolating valves, by-pass valves, movement limiters, shock valves)

5.9 Statutory testing requirements for steering gears prior to sailing as SOLAS Regulation 26

6 **Clutches**

6.1 Applications of clutches (disconnecting drives, operational flexibility, shaft alignment, vibration damping)

6.2 Construction and operation of flexible clutches (simple friction, pneumatic, fluid)

6.3 Principles of shaft mis-alignment (lateral and angular) and methods of alignment

7 **Gearboxes**

7.1 Applications of gearboxes (speed reduction, reversing, operational flexibility)

7.2 Types of gear teeth (axial or straight, helical and double helical, bevel). The advantages and disadvantages of each type, including axial thrust.

7.3 Gearwheel manufacture and materials (forging, hobbing, case hardening)

7.4 Gear configurations (crown, pinion, spur, idler, simple gear trains, compound gear trains, step-up, step-down, reduction, double reduction, epicyclic)

7.5 Gearbox lubrication methods (splash, sprays etc).

7.6 Gearbox lubricating oil grades, extreme pressure (EP) and additives.

7.7 Gear box inspection and gear teeth faults (scoring, abrasion, pitting, exfoliation, fracture, scuffing, attrition etc.)

8 **Propellers and thrusters**

8.1 Basic theory of propellers (number of blades, skewed etc)

8.2 Methods of securing the propeller to the propeller shaft

8.3 Fixed and variable pitch configurations.

8.4 Controllable Pitch Propellers (CPP), advantages/disadvantages, construction, operation, control systems

8.5 Configurations and construction of transverse thrusters (fixed drive, fluid drive, water jet)

8.6 Safety devices and manual control (fail safe/fail set)

9 **Shafting and bearings**

9.1 Shaft support bearing types and construction (plain bearing, roller bearing)

9.2 Thrust bearings (angled roller bearing, thrust collar with tilting pads (Michell) bearing)

9.3 Bearing lubrication.

9.4 Stern tube bearings (linings, oil and water lubricated)

9.5 Stern seals (Simplex, Crane)

9.6 Rigid and flexible shaft connections (fitted coupling bolts, flange, hydraulic muff, steel diaphragm)

9.7 Basic shaft alignment (lateral and angular).

10 **Electrical plant**

10.1 Construction and operation of AC alternators (production of voltage and current, pole/speed relationship, exciters, speed control, auto-voltage regulators (AVR), response to change in load)

10.2 Synchronising and paralleling alternators manually and automatically (in phase, check synchroniser, synchroscope, synchronising lamps, load sharing, speed droop and voltage droop)

10.3 Switchboard safety devices. (alternator main breaker trip devices, earth leakage detection, preferential tripping, sequential starting and discrimination protection)

10.4 Fuse types and applications.

10.5 Shore power connection and safe operation.

10.6 Star and delta motor connections

10.7 Neutral point insulated distribution.

10.8 Construction and operation of 3-phase induction motors (direct on-line starting, alternative starting arrangements, torque and current characteristics, safety protection, fault finding, single phasing)

10.9 Construction and operation of batteries (lead-acid, alkaline, charging circuits, inspection and maintenance, safety)

10.10 Emergency power supplies (SOLAS legislation, typical installations, testing, recovery from blackout)

10.11 Electrical safety (legislation - COSWP, safe isolation, safe testing procedures)

10.12 Electrical maintenance.

10.13 Inverters

10.14 Intrinsically safe circuits and equipment.

Chief Engineer Statutory and Operational Requirements

1 International Conventions

1.1 The role of the International Maritime Organisation (IMO)

1.2 Basic knowledge of the structure and functions of IMO

1.3 Basic knowledge of the Instruments of IMO (Conventions, Codes and Guidelines, Protocols, Amendments, Resolutions)

1.4 SOLAS

- a Testing of steering gears
- b Musters, fire and boat drills
- c On-board training and instruction
- d Testing emergency equipment
- e International Safety Management (ISM) Code
- f International Ship and Port Security (ISPS) Code

1.5 MARPOL

- a Details of the content of Annexe I
- b Regulations for the prevention of pollution by oil
- c Regulations with respect to the discharge of oil overboard using oily-water separators
- d Approved oily-water separators and automatic by-pass equipment
- e International Oil Pollution Prevention (IOPP) Certificate
- f Shipboard Oil Pollution Emergency Plan (SOPEP)
- g Oil Record Book (ORB)
- h Entries required to be made in the ORB
- i Brief awareness of the existence of Annexe II
- j Brief awareness of the existence of Annexe III
- k Details of the content of Annexe IV
- l Regulations for the prevention of pollution by sewage from ships
- m Regulations with respect to the discharge of sewage overboard
- n Details of the content of Annexe V
- o Regulations for the prevention of pollution by garbage from ships
- p Regulations with respect to the discharge of garbage overboard
- q Garbage Record Book (GRB)
- r Entries required to be made in the GRB
- s Awareness of the existence of Annexe VI and its content
- t Knowledge and name the special areas, and relative regulations with respect to the MARPOL Annexes.

1.6 STCW

- a Principles of watchkeeping, performing watches
- b Standing orders
- c Watchkeeping at sea, setting, handing over and accepting a watch

d Watchkeeping in port, setting, handing over and accepting a watch

e Watchkeeping at anchor, setting, handing over and accepting a watch

f Watchkeeping with UMS class vessels, watchkeeper safety check systems

1.7 International Convention on Load Lines (ICLL)

a Strength and construction

b Watertight and weathertight integrity

c Stability and reserve of buoyancy

d Protection of crew on deck

2 International Labour Organisation (ILO)

2.1 Basic knowledge of the structure and functions of ILO

3 <u>Maritime and Coastguard Agency</u>

3.1 The role of an Administration, the UK Maritime Coastguard Agency (MCA)

3.2 Mandatory requirements with respect to the carrying of M-notices on UK flag vessels

3.3 M-notice types and functions, Merchant Shipping Notices (MSN), Marine Guidance Notes (MGN) and Marine Information Notes (MIN)

3.4 Where M-notices may be acquired (paper format, by subscription, computer internet web site)

3.5 Knowledge of the content of the Code of Safe Working Practice for Merchant Seamen (COSWP)

3.6 Health and Safety at Work Regulations

3.7 Safety Officials, Safety Officers, Safety Committee, Risk Assessment

3.8 Dangers of handling hazardous substances, asbestos, fuel oil, lubricating oil etc

3.9 Personal protective clothing and equipment

3.10 Permit to work system

3.11 Entering enclosed or confined spaces

3.12 Regulations associated with the testing and certification of lifting devices

3.13 Emergency procedures and fire precautions

3.14 Working in machinery spaces

3.15 Maintenance

3.16 Colour coding systems (safety signs, gas cylinders, pipelines, fire extinguishers)

3.17 Material Safety Data Sheets (MSDS) (product data sheets)

3.18 Knowledge of the content of the Code of Practice for Noise Levels in Ships

3.19 The role of the Marine Accident Investigation Bureau (MAIB)

3.20 Timescale requirements of continuous survey of ship's machinery and hull with appropriate certification as required by Flag State and Class Society

3.21 The role of a Port State Control (PSC)

3.22 The role of a Flag State Control (FSC)

3.23 Timescale requirements of continuous survey of ship's machinery and hull with appropriate certification as required by Flag State and Class Society

4 Classification Societies

4.1 The role of Classification Societies
4.2 To be able to name at least three major Classification Societies and their country of origin
4.3 The role of the International Association of Classification Societies (IACS)
4.4 Functions of a Classification Society
4.5 Understand about classification of ships and class rules and Certificates of Class
4.6 Timescale requirements of continuous survey of ship's machinery and hull with appropriate certification as required by Flag State and Class Society

5 Planned maintenance systems

5.1 Establishing a planned maintenance system (PMS)
5.2 Integrated maintenance and survey systems
5.3 Unplanned (unscheduled) maintenance
5.4 Planned (scheduled) maintenance
5.5 Calendar based system
5.6 Hours based system
5.7 Monitored / condition / performance based system
5.8 Monitoring by human senses
5.9 Monitoring by automatic control systems
5.10 Trend analysis
5.11 Recording data, log books, data loggers
5.12 Continuous class surveys
5.13 Approved maintenance systems
5.14 Power card analysis
5.15 Periodic calibration (bearings, liner wear etc)
5.16 Testing of fuel and lubricating oil
5.17 Vibration analysis
5.18 Developing an established PMS by trial and error to enhance operation(eg extending/reducing running hours between maintenance overhauls)
5.19 Spare gear

6 Surveys

6.1 Timescale requirements of continuous survey of ship's machinery and hull with appropriate certification as required by Flag State and Class Society
6.2 Hull, machinery, safety and radio surveys
6.3 Different types of surveyors (Government, Classification Society, Charter and Cargo, Insurance etc)
6.4 Statutory surveys
6.5 Harmonised System of Survey and Certification (HSSC)
6.6 In-water surveys (IWS)
6.7 Methods of hull and component testing, destructive and non-destructive

7 Dry-docking

7.1 Frequency of dry-docking
7.2 Types of dry-dock (wet dock; graving dock; floating dock; Synchro-lift; slipway; cradle lift)
7.3 Preparation for dry-dock; docking plan; plug plan; work list; survey requirements; services required when in dry-dock
7.4 Shore power and fire protection when in dry-dock
7.5 Entering dry-dock procedure; tank transfers; upright condition; trim by the stern; bilges pumped; tanks sounded; stability condition
7.6 Preliminary inspection of underwater hull and fittings

7.7 Pre-flooding of dry-dock procedure and safety checks
7.8 Floating-off and leaving dry-dock procedure and safety checks

8 Voyage Planning

8.1 General requirements as detailed in STCW:
8.2 Crew manning and certification; number of passengers; fuel consumption and reserves; lubricants consumption; water consumption; chemicals; refrigerant gases; expendable items; maintenance and survey requirements; machinery checks and alarm system tests; parts and tools; minimum spares inventory; cleaning materials and consumables; supplies and any other requirements

8.3 Consultation with ship's master on planned route, deviations from planned route and alternative ports in case of emergency

9 Fuel consumption

9.1 Specific fuel consumption (SFC) and units (g/kW.h or kg/kW.h)

9.2 Simple fuel consumption calculations, involving small vessel coefficients, or previous voyage experience

9.3 Use the equation:

9.4 Fuel consumption per day (tonnes) = $\frac{\Delta^{2/3} \times V^3}{\text{Fuel coefficent}}$

9.5 Where:

a Δ = Vessel displacement (tonnes)

b V = Velocity of vessel (knots)

9.6 Simple daily fuel consumption calculation

9.7 Use the formula

9.8 Daily fuel con. (tonnes) = SFC (kg/kW hr) x Power (kW) x [24 / 1000]

9.9 Simple estimated voyage fuel consumption calculation
9.10 Addition of fuel reserves to basic fuel consumption calculations and reasons for the reserves (diversion for emergency rescue, change of planned route, breakdown, weather etc)
9.11 Definition of maximum continuous rating (MCR)
9.12 Operation at the optimum (most economical) speed
9.13 Determining fuel consumptions at MCR and optimum speed from vessels specific fuel consumption (SFC) / power graphical curve

10 Emergency

10.1 Contingency plans dealing with flooding, to maintain intact buoyancy; watertight compartments, watertight doors, collision bulkheads, emergency bilge suctions etc.

10.2 Ship's fire equipment plans and fire fighting teams; construction, use and identification of various types of fire fighting equipment; contingency planning for fighting fires, including instruction of personnel in the use of various types of equipment, by organising and supervising 'fire drills' for fire fighting teams in emergency situations; flammable/explosive range limits and how they relate to possible shipboard situations, e.g. crankcase explosions and fuel fires.

Applied Marine Engineering

1 Materials

1.1 Materials technology

a Iron and steel

b Types of iron and steel (cast iron, wrought iron, mild steel, cast steel, alloyed steels)

c Definition of an alloy

d Effects of alloying elements in steels

e Stainless steels (Ferritic, Martensitic, Austenitic)

f Fibre reinforced plastics (FRP)

2 Heat treatment

2.1 Heat treatment of steels (normalising; annealing; stress relieving; hardening; tempering; case hardening; carburising; case carburising; pack carburising; gas carburising; cyaniding; nitriding; flame hardening)

2.2 Properties of aluminium

2.3 Properties of non-ferrous metals and alloys (zinc, copper, brasses, bronzes)

3 Testing materials

3.1 Properties of materials (brittleness; ductility; elasticity; hardness; malleability; plasticity; stiffness or resilience; softness; tenacity; toughness)

3.2 Stress and strain (stress formula; strain formula)

3.3 Forms of stress (tensile; compressive; shear)

3.4 Load, deformation, relationship between load and deformation

3.5 Destructive and non-destructive testing

3.6 Tensile and compression tests using a tensile test machine

3.7 Load – extension diagrams for ferrous and non-ferrous materials

3.8 Limit of proportionality; Hooke's Law; elastic limit; yield point; ultimate tensile strength (UTS); percentage elongation; percentage reduction in area

3.9 Proof stress diagram

3.10 Modulus of elasticity (Young's Modulus)

3.11 Working stress

3.12 Factor of safety

3.13 Hardness test (Brinell; Vickers; Rockwell; Shore)

3.14 Notch impact test (Izod; bend test)

3.15 Failure of materials (creep test, torsion test, fatigue test, types of cyclic stress, brinelling, fretting)

3.16 Surface defects (visual inspection, dye penetrant test, magnetic fluid test)

3.17 Under-surface defects (ringing, radiography, ultrasonics

4 Joining Materials

4.1 Basic welding and brazing methods (oxy-acetylene, mig / mag / tig)

4.2 Basic welding defects

4.3 Joining and bonding of steel with aluminium (insulated bolted joints, explosive welding)

5 Corrosion

5.1 Principles of metallic corrosion (oxidation, electro-chemical series, galvanic)

5.2 Corrosion protection (sacrificial anodes, impressed current, protective coatings, surface preparation)

6 Osmosis in GRP

6.1 Production and properties of glass (or fibre) reinforced plastic (GRP or FRP)

6.2 De-lamination and osmosis in GRP

7 Instrumentation

8 Temperature measuring instruments

8.1 Mercury in glass thermometers

8.2 Bi-metallic strip thermometers

8.3 Pyrometers

9 Pressure measuring instruments

9.1 Bourdon tube gauge

9.2 U-tube manometer

10 Level measuring instruments

11 Flow measuring instruments

11.1 U-tube manometer with venturi

11.2 Turbine impeller

12 Control engineering

12.1 Basic terminology associated with control systems:

12.2 Desired value (DV); measured value (MV); error (error = DV - MV); feedback; negative feedback; positive feedback; sensors; comparator; actuators

12.3 Open loop and closed loop systems

12.4 Terminology applied to a main engine cooler system, such as main engine LO or main engine jacket water (HTCW)

12.5 Data and power transmission media (mechanical, hydraulic, pneumatic, electrical, fibre optic, discrete, analogue, digital)

12.6 Transducers, methods of converting one transmission media into another (pressure-current, current-pressure etc.)

12.7 Types of sensor (pressure, temperature, flow, level, speed, displacement)

12.8 Types of actuator (bellows, diaphragm and piston operated devices, hydraulic, pneumatic and electrically operated devices)

12.9 Types of positioner associated with actuators: (Motion and Force balance Types)

12.10 Basic theory of PID controllers (proportional, integral, derivative)

12.11 One term, two term and three term controllers (P, P+I, P+I+D)

12.12 Graphical representation of a control system disturbance, proportional (P) control, proportional and integral (PI) control, proportional, integral and derivative (PID) control

12.13 Digital control (bang-bang or on-off control)

12.14 Pneumatic piston valve control symbols

12.15 Simple systems using pneumatic piston control valves

12.16 Types of control system, methods of control and applications (terminology, open/closed loop, two-step, modulating)

12.17 Examples of process control systems (single element, cascade, split range)

12.18 Main engine speed/load control

12.19 Mechanical governors

12.20 Basic principles of hydraulic governors

12.21 CPP propeller pitch/speed control with constant speed engine, graphical representation (system footprint)

12.22 CPP propeller pitch/speed control with variable speed engine, graphical representation (system footprint)

13 Engineering Drawing

13.1 Interpret engineering and system drawings

13.2 Use engineering system drawings to identify possible locations for faults.

13.3 Ability to produce a freehand sketch of an engineering component.

14 Fuels

14.1 **Properties of fuels**, including:-

14.2 Definitions of crude oil derived products (gases, petrol, paraffin, gas oil, distillates, residuals)

14.3 Definitions of fuel quality and simple testing (viscosity, density, flash point, pour point, calorific value, ignition quality, residual carbon, sulphur)

14.4 High and low temperature corrosion due to the presence of sodium, vanadium, water and sulphur contamination in fuel

14.5 Contaminants (water, dirt, microbes, surfactants)

14.6 Handling and storage of fuels (gravity separation, centrifugal separation, filtration)

14.7 Combustion requirements (viscosity, atomisation)

14.8 Diesel engine combustion process

15 Lubrication

15.1 Properties of lubricants, including:-

15.2 Theory of lubrication (boundary, dynamic, cooling effect, cleaning)

15.3 Qualities of base stock and additives (thermal/oxidation stability, volatility, alkalinity, detergency, anti-wear, extreme pressure, oxidation/corrosion protection, anti-emulsification, anti-foam)

15.4 Contamination and testing of oils (oil sampling, TBN, water, flash point, microbial, dirt)

15.5 Purification/clarification and filtration.

15.6 Use of greases (advantages/disadvantages)

15.7 Crankcase explosions

16 **Machinery Faults**

16.1 Action to be taken in event of :-

16.2 High bearing temperature.

16.3 High oil mist alarms.

16.4 High and low exhaust temperatures.

16.5 High crankcase pressure.

16.6 Testing of shut down devices.

16.7 Fault finding and diagnosis, including:-

16.8 Engine failing to start.

16.9 High/low exhaust temperatures.

16.10 Cooling water system faults.

16.11 Lubricating oil system faults.

16.12 Charge air faults.

17 **Electrical**

17.1 Electrical plant, including:-

17.2 Switchboard layout (main alternators, main switchboard, emergency alternator, emergency switchboard)

17.3 Switchboard protection devices

17.4 Main breakers and their safety protection devices

17.5 Rules and regulations associated with emergency diesel alternators (EDA)

17.6 Shore power connection and safe operation (voltage, current, frequency, phasing)

17.7 Essential and non-essential consumers

17.8 Earth lamps

17.9 Earth fault tracing

17.10 Construction & operation of a.c. generators (production of voltage & current, pole/speed relationship, excitation, speed control, a.v.r., response to change in load)

17.11 Synchronisation & load sharing (synchroscope, lamps, stable load sharing, speed droop, relationship between kW , kVAr & volt drop)

17.12 Operation and testing of switchboard safety devices. (alternator breaker trip devices, earth leakage detection, preferential tripping, sequential starting)

17.13 Distribution systems fault protection (fuse types and applications, circuit breakers)

17.14 Neutral point insulated and neutral point earthed distribution.

17.15 Construction & operation of 3 phase & 1 phase a.c. motors (d.o.l. starting, alternative starting arrangements, torque & current characteristics, safety protection, fault finding)

17.16 Construction & operation of batteries (lead-acid, alkaline, charging circuits, inspection and maintenance, safety)

17.17 Emergency power supplies (SOLAS legislation, typical installations, testing, recovery from blackout)

17.18 Electrical safety (legislation - COSWP, safe isolation, safe testing procedures)

17.19 Electrical maintenance.

18 Direct Air Start Systems

18.1 Simple direct air starting system with air distributor and cylinder fitted starting air valve (in-line and V-type engines)

18.2 Safety devices associated with an engine air start system,

- a automatic non-return valve,
- b drain valves, flame traps,
- c manifold safety valve,
- d interlock devices (turning gear interlock, zero pitch interlock, gearbox LO pressure interlock etc)

Advanced Hotel Services and Ship Construction

1 **Refrigeration**

1.1 Principles of refrigeration

1.2 Design, construction and operation of refrigeration systems (direct and indirect expansion)

1.3 Refrigeration compressors (sealed unit, reciprocating, rotary)

1.4 Safety features. (High, low, oil pressure cut-outs & trips. safety heads.)

1.5 Gases and oils.

1.6 Blended refrigerants

1.7 Understands the terms zoetrope, azeotrope, near-azeotrope and glide, when applied to blended refrigerants

1.8 Pollution (Montreal et-al)

1.9 Fault finding.

1.10 Types of refrigeration gas bottles (single valve, double valve, with/without dip-tube)

1.11 Handling and storage of refrigeration gas bottles

1.12 Charging a refrigeration system

1.13 Checking a refrigeration system for air, removing air from the system

1.14 Symptoms and effects of overcharging a refrigeration system

1.15 Symptoms and effects of undercharging a refrigeration system

1.16 Methods of draining a refrigerant from a system

2 **Air conditioning**

2.1 Principles of air conditioning including:-

2.2 Construction and operation of a.c. systems. (stand alone, chilled water, blown air)

2.3 Relative humidity and maintenance of 'comfort zone' - effects of extremes of humidity on fixtures and fittings.

2.4 Dangers associated with the operation of a.c. plants (Legionella).

3 **Fresh water**

3.1 **Fresh water makers** including:-

3.2 Construction and operation of a reverse osmosis plant

3.3 Basic knowledge of a fresh water distillation plant using a vacuum chamber

3.4 (note: these are very rarely found on yachts)

3.5 (note: all references to steam evaporators should be omitted)

3.6 Water sterilisation methods. (chlorine, silver ion, ultra violet)

3.7 Neutralisation and palatability.

3.8 Inspection and cleaning of water tanks and system superchlorination.

4 **Sewage systems**

4.1 Sewage pollution prevention including:-

4.2 Regulations. (Marpol 73/78)

4.3 Construction and operation of sewage treatment plants (continuous, zero discharge)

4.4 Difference between aerobic and anaerobic

4.5 Environmental impact of untreated sewage (B.O.D. sterilisation)

4.6 Dangers associated with the operation of sewage treatment plants (anaerobic conditions, H_2S, methane)

5 **Compressed air system**

5.1 Knowledge that the compressed air system commonly has two pressure levels, 30-40 bar for starting air, and 7-10 bar for control air.

5.2 Basic compressed air system, layout and components (air compressors, air receivers)

5.3 Safety devices associated with the compressed air system, safety valves, fusible plugs, compressor bursting discs, compressor lifting heads, and pressure cut outs.

5.4 Construction and operation of multi-stage high pressure air compressors.

5.5 Filtering and cleaning of high pressure breathing air.

5.6 Testing and certification of compressed air cylinders.

6 **Hydraulic systems**

6.1 Lifting appliances and winches including:-

6.2 Hydraulic applications (types of hydraulic circuit, identification of symbols, fluids)

6.3 Testing and certification of winches and lifting appliances.

6.4 Testing and certification of 'loose gear,' lifting strops and wires.

7 **Motion control**

7.1 Stabilisers, including:-

7.2 Types of motion (roll, pitch, yaw etc., damping coefficient)

7.3 Passive roll stabilisation (bilge keels, passive/controlled - active tanks, advantages/disadvantages)

7.4 Active roll stabilisation (retracting/fixed fins advantages/disadvantages)

8 **Volatile Fuel Storage**

8.1 Safe storage and use of alternative fuels and operation of recreational vessels including:-

8.2 Petrol and l.p.g.

8.3 Construction and safe operation of outboard motors.

8.4 Construction, handling and maintenance of inflatable and semi-inflatable craft.

8.5 Aviation fuels for helicopter use

9 **Ship construction**

9.1 Understands the terminology and definitions used in ship construction. Demonstrates the ability to sketch ship constructions :

a Aft and fore perpendicular;

b length between perpendiculars (LBP);

c length overall (LOA);

d midships line (LBP/2);

e bilge;

f breadth;

g bulkhead;

h camber;

i centreline;

j deck;

k deckhead;

l depth;

m draft;

n draft marks;

o even keel;

p freeboard;

q keel;

r load line marks and certification;

s longitudinal;

t midships;

u rise of floor;

v sheer;

w stem;

x transverse;

y trim by the head;

z trim by the stern;

aa waterline

9.2 test

a

9.3 Deadweight; displacement; lightweight; gross tonnage; registered tonnage

9.4 A-bracket; bulbous bow; flare; stringer; panting stringer; propeller; rudder; transom

9.5 Materials, steel, aluminium, FRP, advantages/disadvantages of each

9.6 Jointing of aluminium and steel (bolted connection, explosion welding)

9.7 Protective coatings

9.8 Transverse and longitudinal stresses and causes.

9.9 Panting and pounding stresses and causes.

9.10 Transverse and longitudinal framing construction.

9.11 Vibration, cause and effect.

9.12 Structural fire protection and subdivision.

9.13 Watertight integrity and subdivision

9.14 Position, height and number of watertight bulkheads

9.15 Understands the purpose, construction and regulations regarding the collision bulkhead

9.16 Watertight bulkheads and penetrations (doors, vents, pipes, shafts, electric)

9.17 Static and dynamic condition of vessel in the water

9.18 Basic dry-docking procedures and preparation for docking

9.19 The effect of yacht design and construction on the stability of the vessel.

9.20 Effect of modifications and moving weights on stability.