INTERNATIONAL MARITIME ORGANIZATION

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SUB-COMMITTEE ON STANDARDS OF TRAINING AND WATCHKEEPING
44th session
Agenda item 3

STW 44/3/1
31 October 2012
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VALIDATION OF MODEL TRAINING COURSES

Model course – Electro-Technical Officer

Note by the Secretariat

SUMMARY

Executive summary:	This document provides a new draft model course on Electro-Technical Officer
Strategic direction:	5.2
High-level action:	5.2.2
Planned output:	5.2.2.5
Action to be taken:	Paragraph 3
Related document:	STW 40/14

1 Attached in the annex is a new draft model course on Electro-Technical Officer.

2 The preliminary new draft of this model course was forwarded to members of the validation panel for their comments. Relevant comments on the draft course have been received from the validation panel and have been incorporated as appropriate.

Action requested of the Sub-Committee

3 The Sub-Committee is invited to consider the above information and take action as appropriate.

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ANNEX

DRAFT IMO MODEL COURSE ON ELECTRO-TECHNICAL OFFICER

MODEL COURSE NO: X.XX

ELECTRO-TECHNICAL OFFICER

ACKNOWLEDGMENT

This course for Electro-Technical Officer is based on material developed by the Faculty of Marine Electrical Engineering, Gdynia Maritime University, Poland

IMO wishes to express its sincere appreciation to the governments of India, Iran, Malaysia, Ukraine and European Maritime Safety Agency for their valuable expert assistance and cooperation.

CONTENTS

Introduction

▪ Purpose of the model courses

The purpose of the IMO model courses is to assist maritime training institutes and their teaching staff in organizing and introducing new training courses, or in enhancing, updating or supplementing existing training material where the quality and effectiveness of the training courses may thereby be improved.

It is not the intention of the model course programme to present instructors with a rigid "teaching package" which they are expected to "follow blindly". Nor is it the intention to substitute audio-visual or "programmed" material for the instructor's presence. As in all training endeavours, the knowledge, skills and dedication of the instructors are the key components in the transfer of knowledge and skills to those being trained through IMO model course material.

The educational systems and the cultural backgrounds of trainees in maritime subjects vary considerably from country to country. For this reason the model course material has been designed to identify the basic entry requirements and trainee target group for each course in universally applicable terms, and to specify clearly the technical content and levels of knowledge and skill necessary to meet the technical intent of IMO conventions and related to recommendations.

This is the first edition of this Model Course. In order to keep the training programme up to date in future, it is essential that users provide feedback. New information will provide better training in safety at sea and protection of the marine environment. Information, comments and suggestions should be sent to the Head of the STCW and Human Element Section at IMO, London.

▪ Use of the model course

To use the model course the instructor should review the course plan and detailed syllabus, taking into account the information provided under the entry standards specified in the course framework. The actual level of knowledge and skills and the prior technical education of the trainees should be kept in mind during this review, and any areas within the detailed syllabus which may cause difficulties, because of differences between the actual trainee entry level and that assumed by the course designer, should be identified. To compensate for such differences, the instructor is expected to delete from the course, or reduces the emphasis on, items dealing with knowledge or skills already attained by the trainees. He should also identify any academic knowledge, skills or technical training which they may not have acquired.

By analysing the detailed syllabus and the academic knowledge required to allow training in the technical area to proceed, the instructor can design an appropriate pre-entry course or, alternatively, insert the elements of academic knowledge required to support the technical training elements concerned at appropriate points within the technical course.

Adjustment of the course objective, scope and content may also be necessary if in your maritime industry the trainees completing the course are to undertake duties which differ from the course objectives specified in the model course.

Within the course plan the course designers have indicated their assessment of the time which should be allotted to each area of learning. However, it must be appreciated that these allocations are arbitrary and assume that the trainees have fully met all entry requirements of the course. The instructor should therefore review these assessments and may need to reallocate the time required to achieve each specific learning objective or training outcome.

▪ Lesson plans

Having adjusted the course content to suit the trainee intake and any revision of the course objectives, the instructor should draw up lesson plans based on the detailed syllabus. The detailed syllabus contains specific references to the textbooks or teaching material proposed to be used in the course. Where no adjustment has been found necessary in the learning objectives of the detailed syllabus, the lesson plans may simply consist of the detailed syllabus with keywords or other reminders added to assist the instructor in making his presentation of the material.

▪ Presentation

The presentation of concepts and methodologies must be repeated in various ways until the instructor is satisfied, by testing and evaluating the trainee's performance and achievements, that the trainee has attained each specific learning objective or training objective. The syllabus is laid out in learning objective format and each objective specifies a *required performance* or, *what the trainee must be able to do* as the learning or training outcome. Taken as a whole, these objectives aim to meet the knowledge, understanding and proficiency specified in the appropriate tables of the STCW Code.

▪ Implementation

For the course to run smoothly and to be effective, considerable attention must be paid to the availability and use of:

- Properly qualified instructors
- Support staff
- Rooms and other spaces
- Workshops and equipment
- Suggested references, textbooks, technical papers
- Other reference material.

Thorough preparation is the key to successful implementation of the course. IMO has produced a booklet entitled "Guidance on the implementation of IMO model courses", which deals with this aspect in greater detail.

In certain cases, the requirements for some or all of the training in a subject are covered by another IMO model course. In these cases, the specific part of the STCW Code which applies is given and the user is referred to the other model course.

▪ Course objective

This model course comprises three functions at the operational level. On successful completion of the training and assessment trainees should be competent to carry out safely the electro-technical officer duties.

▪ Entry standards

Since the minimum age for certification is 18 years, it is expected that in most cases the entry age will be at least 16 years. It is envisaged that trainees will have been in fulltime education up to the commencement of training, although in some instances entry will no doubt be made available to those who, having completed full-time education, follow other paths first.

Administrations will wish to specify their own educational standards for entry.

With this in mind, attention is drawn to the fact that while the mathematical standards of the courses to be followed are not high, trainees continually use fundamental mathematics as a tool throughout the whole of their training; also, as the principles of applied science and engineering are included at an early stage, it is essential to ascertain the potential and interest in this kind of work before entry. In a similar manner, trainees have to accomplish a range of engineering craft skills, and therefore an aptitude and interest in this direction are also necessary.

Where entrants have not reached the required standards in mathematics or physical science it will be necessary to provide a preparatory course or courses to bring them to the desired level before starting the professional studies. Conversely, topics which have been adequately covered during their general education can be omitted and the allotted time reduced accordingly.

No previous maritime or engineering training is assumed, but those entering the course should be following an approved programme of shipboard training.

▪ Course intake limitations

Trainees spend a substantial proportion of their time acquiring engineering skills in workshops. During these periods it is recommended that there are not more than approximately ten trainees to each supervisor/instructor. Depending upon staffing levels and now the timetable and utilization of premises can be arranged, other subjects may be studied in class sizes of not more than 24 in order to allow the instructor to give adequate attention to individual trainees. Larger numbers may be admitted if extra staff and tutorial periods are provided to deal with trainees on an individual basis.

In addition, for scheduling access to learning facilities and equipment, attention to strict time management is necessary. In large classes students should have their own reference books, unless sufficient copies can be provided in a central library. Classrooms should be big enough to seat all students so they can see and hear the instructor.

▪ Textbooks

References to books are made in the syllabuses of the individual subjects to aid both instructors and trainees in finding relevant information and to help in defining the scope and depth of treatment intended.

The mention of a particular textbook does not imply that it is essential to use that book, only that it appeared to be best suited to the course at the time of its design. In many instances there are a number of suitable books, and instructors are free to use whatever texts they consider to be most suited to their circumstances and trainees.

Every effort has been made to quote the latest editions of the publications mentioned but new editions are constantly being produced. Instructors should always use the latest edition for preparing and running their courses.

Full use should be made of technical papers and other publications available from maritime and other professional organizations. Such papers contain new developments in techniques, equipment, design, management and opinion and are an invaluable asset to a maritime training establishment.

▪ Training and the STCW 2010 Convention

The standards of competence that have to be met by seafarers are defined in Part A of the STCW Code in the Standards of Training, Certification and Watchkeeping for Seafarers Convention, as amended in 2010. This IMO model course has been developed to cover the competences in STCW 2010. It sets out the education and training to achieve those standards.

This course covers the minimum standard of competence for electro-technical officers, see STCW Code Table A-lll/6.

For ease of reference, the course material is organised in three separate Functions as per the STCW Code. These functions are:

Function 1 Electrical, electronic and control engineering at the operational level,
Function 2 Maintenance and repair at the operational level,
Function 3 Controlling the operation of the ship and care for the persons on board at the operational level.

Each function is addressed in five parts: Part A which is common for all functions, Part B, Part C, Part D and Part E, which again addresses all the functions.

Part A provides the framework for the course with its aims and objectives and notes on the suggested teaching facilities and equipment. A list of useful teaching aids which includes videos, CBT, lMO references and textbooks is also included.

Part B provides the outline of lectures, demonstrations and exercises for the course. No detailed timetable is suggested. From the teaching and learning point of view, it is more important that the trainee achieves the minimum standard of competence defined in the STCW Code than that a strict time table is followed. Depending on their experience and ability, some student will naturally take longer to become proficient in some topics than in others.

Part C gives the Detailed Teaching Syllabus. This is based on the combined, theoretical and practical knowledge specified in the STCW Code. It is written as a series of learning objectives, in other words what the trainee is expected to be able to do as a result of the teaching and training. Each of the objectives is expanded to define a required performance of knowledge, understanding and proficiency. Suggested teaching aids including IMO references, textbook references, videos and CBT's are integrated to assist teacher in designing the lessons.

Part D gives the Instructor Manual, which contains guidance notes for the Instructor and additional explanations.

Part E provides the Evaluation which addresses all the functions. A separate IMO model course 3.12 also addresses Assessment of Competence. This course explains the use of various methods for demonstrating competence and criteria for evaluating competence as tabulated in the STCW Code. Extract of this model course is also included in Part E to aid the Instructors.

The Convention defines the minimum standards to be maintained In Part A of the STCW Code. Mandatory provisions concerning Training and Assessment are given in Section A-I/6 of the STCW Code. These provisions cover: qualification of instructors; supervisors as assessors; in-service training; assessment of competence; and training and assessment within an institution. The corresponding Part B of the STCW Code contains guidance on training and assessment.

The criteria for evaluating competence of electro-technical officer specified in the minimum standard of competence tables of Part A of the STCW Code have to be used in the assessment of all competences listed in those tables.

The STCW code 2010, also addresses the training of seafarers which can be imparted through distance learning and e-learning. A substantial portion of the course, especially learning in the cognitive domain, can be delivered as computer based learning modules over the web or through software programmes.

Section B-I/6 of the STCW code gives guidance on the training of seafarers which can be carried out by distance learning and e-learning in accordance with the standards of training and assessment set out in section A-I/6 of the STCW code.

Administrations are encouraged to approve the use of e-learning. The code includes guidelines for how the e-learning shall be conducted, but it is up to each administration to approve any e-learning provider. The administration must register approved training providers.

Web-based course with material delivered via a combination of text, presentations, webinar, recorded events and expert tutor assistance can be used. Student can select online learning material, online quiz, assessment, online discussion forum with other students and tutor. Live interaction and replying questions with tutor via Webinar session are some of the advantages of this type of learning.
As previously mentioned a separate model course 3.12 also addresses Assessment of Competence and use of the criteria for evaluating competence tabulated in the STCW Code.

▪ Responsibilities of Administrations

Administrations should ensure that training courses delivered by colleges and academies are such as to ensure officers completing training do meet the standards of competence required by STCW Regulation III/6 paragraph 2.

▪ Validation

The information contained in this document has been validated by the Sub-Committee on Standards of Training and Watchkeeping for use by technical advisers, consultants and experts for the training and certification of seafarers so that the minimum standards implemented may be as uniform as possible. *Validation* in the context of this document means that no grounds have been found to object to its content. The Sub-Committee has not granted its approval to the document, as it considers that this work must not be regarded as an official interpretation of the Convention.

Part A: Course Framework for all functions

▪ Aims

This model course aims to meet the mandatory minimum requirements for knowledge, understanding and proficiency in Table A-III/6 of STCW 2010 for the function Electrical, Electronic and Control Engineering at the Operational Level, for the function Maintenance and Repair at the Operational Level and the background knowledge to support Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level.

▪ Objective

Function 1

The syllabus for Function 1 covers the requirements of the 2010 STCW Convention Chapter lll, Section A-lll/6. This functional element provides the detailed knowledge to support the training outcomes related to Electrical, Electronic and Control Engineering at the Operational Level.

This section provides the background knowledge and practical work to support:

- monitor the operation of electrical, electronic and control systems
- monitor the operation of automatic control systems of propulsion and auxiliary machinery
- operate generators and distribution systems
- operate and maintain power systems in excess of 1,000 volts
- operate computers and computer networks on ships
- use English in written and oral form
- use internal communication systems

Function 2

The syllabus for Function 2 covers the requirements of the 2010 STCW Convention Chapter lll, Section A-lll/6. This functional element provides the detailed knowledge to support the training outcomes related to Maintenance and Repair at the Operational Level.

This section provides the background knowledge and practical work to support:

- maintenance and repair of electrical and electronic equipment monitor the operation of electrical, electronic and control systems
- maintenance and repair of automation and control systems of main propulsion and auxiliary machinery
- maintenance and repair of bridge navigation equipment and ship communication systems
- maintenance and repair of electrical, electronic and control systems of deck machinery and cargo-handling equipment
- maintenance and repair of control and safety systems of hotel equipment

Function 3

The syllabus for Function 3 covers the requirements of the 2010 STCW Convention Chapter lll, Section A-lll/6. This functional element provides the detailed knowledge to support the training outcomes related to Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level.

This section provides the background knowledge to support:

- compliance with pollution-prevention requirements
- prevention, control and fighting of fires on board ship *
- operation of life-saving appliances *
- provision of medical first aid on board ship *
- Application of Leadership and Team-working skills
- Contribute to safety of personnel and ship

* These topics are covered in separate IMO model courses.

This function includes topics such as ship stability, carriage of cargoes on deck, heavy lifts, containers, bulk cargoes, grain, dangerous goods, oil tankers and the IMO conventions.

▪ Entry standards

This course is principally intended for candidates for certification as electro-technical officers. Those wishing to enter this course should be following an approved programme of on-board training. Alternatively, trainees may complete approved seagoing service of not less than three years/or as approved by the administration.

▪ Course certificate

On successful completion of the course and assessments, a document may be issued certifying that the holder has successfully completed a course of training which meets or exceeds the level of knowledge and competence specified in Table A-lll/6 of STCW 2010.

A certificate may be issued only by centres approved by the Administration.

▪ Staff requirements

Instructors shell be qualified in the task for which training is being conducted and have appropriate training in instructional techniques and training methods (STCW Code Section Al/6). Depending on the complexity of the exercises set, an assistant instructor with similar experience is desirable for certain practical exercises.

▪ Teaching facilities and equipment

Below is a comprehensive list of Teaching Aids that may be used for the purpose of teaching in the course. It is not advocated that all the Aids mentioned here must be used nor does it mean that other Teaching Aids not mentioned here are excluded from being used. The Instructor is free to use additional teaching material that may be best suited for the transference of knowledge and skills to the trainees.

A classroom equipped with an overhead projector and a blackboard or interactive or flipchart should be provided for teaching the theory of the course and holding group discussions.

The following equipment is recommended:

- A.C. and D.C. electrical machines: generators, motors, transformers
- L.V. main switchboard with two low power synchronous generators or electric power plant simulator
- A.C. and D.C. motor starters and speed control systems
- PID control systems or adequate simulator
- PLC control and monitoring systems forming computer network
- engine room simulator
- cargo handling systems simulator
- bridge navigation and ship communication systems and / or simulator
- automatic telephone system, sound powered telephone system, talkback-intercom system, public address system
- electro-hydraulic and electro-pneumatic systems
- electrical engineering workshop for the training in the following types of work:
  - hand tools
  - machine tools
  - cable works, soldering, electric equipment testing
- electronic and power electronic elements and converters
- contactors, relays, time delay relays, thermal relays, over and under voltage relays, switches, circuit breakers, push buttons, control lamps, fuses etc.
- lighting fixtures, switches
- measurement equipment: ammeters, voltmeters, power meters, portable multi-meters, insulation testers, oscilloscope
- temperature, pressure, level and other measurement sensors and converters, temperature and pressure calibrators
- electrical equipment suitable for use in oil, gas and chemical tankers
- examples of electrical diagrams
- lead-acid and alkaline batteries, a charging circuit, distilled water, hydrometer

▪ Teaching aids (A)

A1 Instructor's Manual (Part D of this course)
A2 Manufacturers' manuals
A3 Video DVD player or computer
A4 Marlins English Language Study Pack 1 and Study Pack 2 with audio cassette and teachers' notes (www.marlins.co. uk)

▪ Videos (DVDs), CD-ROMs, CBT's (V)

Note: - Other equivalent videos, CD-ROMs, CBT's may be used as deemed fit by the instructor.

V1 Ship's electrical systems - safety and maintenance (Code No: 665)
V2 Electrical distribution (Code No: 666)
V3 Generators and main circuit breakers (Code No: 667)
V4 Motors and starters (Code No: 668)
V5 Ancillary electrical services (Code No: 669)
V6 Special electrical practice for oil, gas and chemical tankers (Code No: 670)
V7 Electrical survey requirements (Code No: 671)
V8 Electronic propulsion and high voltage practice (Code No: 672)
V9 Machinery alarms & protection devices (Code No: 528)
V10 Efficient operation of marine diesel engines (Code No: 693)
V11 An introduction to hydraulics (Code No: 66)
V12 Ignition risks from static electricity and stray currents (Code No: 714)
V13 Leadership and management course (Code No: 836)
V14 The international safety management code (Code No: 524)

Available from: Videotel Marine International Ltd
84 Newman Street, London W1P 3LD, UK
Tel: 44 171 299 1800
Fax; 44 171 299 1818
e-mail: mail @videotelmail.com
URL: www.videotel.co. uk

V15 Remote Control System, Autochief 4 (CBT # 0019)
V16 Operation of generators (CBT # 0041)
V17 Automation, viscosity control (CBT # 0083)
V18 Inert Gas Generator (CBT # 0007)
V19 Auxiliary Engine (CBT # 0024)
V20 AC4, Digital Governor System (CBT # 0034)
V21 SULZER medium speed diesel engine (CBT # 0074)
V22 AC4 SULZER DENIS 1 (CBT # 0110)
V23 AC4 MAN B AND W (CBT # 0116)
V24 Hull and machinery (CBT # 0029)

Available from: Seagull AS
P.O. Box 1062
N-3194 Horten, Norway
Phone: +47 33 03 09 10
Fax: +47 33 04 62 79
Email: seagull@sgull.com

V25 Static electricity on board tankers
V26 Enclosed lifeboat-on load release gear
V27 Free fall life boats release mechanism

Available from: A226/B341,
Oshiwara Industrial Centre,
New Link Road,
Goregaon (W)
Mumbai 400104
India
Tel:+91-22-67101229/28766205
H/P: +91-9821097101
Email: karco@karcoservices.com
www.karco.in

▪ IMO references (R)

R1 International Convention on Standards of Trainlng, Certification and Watchkeeping for seafarers STCW), 1978, as amended, 2011 Edition (lMO Sales No. IC938E)
R2 lnternational Convention for the Safety of Life at Sea, (SOLAS), 1974, as amended (lMO Sales No. 110)

R3 lnternational Convention for the Prevention of Pollution from Ships, (MARPOL), 1973/78, Consolidated Edition, 2006 IMO Sales No. IC520E, ISBN 978-92-801-42167
R4 lnternational Life Saving Appliance Code (LSA Code) (2010 edition), IMO Sales No. ID982E ISBN 978-92-801-15079
R5 lnternational Code for Fire Safety Systems (FSS Code), IMO Sales No. IA155E ISBN 978-92-801-14812
R6 International Code for Application of Fire Test Procedures (FTP Code)(1998 Edition), IMO Sales No. IB844E ISBN 978-92-801-14522
R7 Graphical symbols for fire control plans (2006 Edition), IMO Sales No. IA847E ISBN 978-92-801-42259

Details of distributors of IMO publications that maintain a permanent stock of all IMO publications may be found on the IMO web site at http://www.imo.org

▪ Textbooks (T)

Note: - Other textbooks may be used as deemed fit by the instructor.

T1 Ådnanes A.K., Maritime electrical installations and diesel electric propulsion, Tutorial, Report/Textbook, ABB Marine AS, Oslo, Norway, 2003
T2 Axelson Jan, The microcontroller idea book: circuits, programs, & applications featuring, Lakeview Research, USA; ISBN 0-9650819-0-7
T3 Barnes M., Practical variable speed drives and power electronics, Elsevier, 2003
T4 Berger H., Automating with STEP 7 in LAD and FBD: Simatic S7-300/400, SIEMENS
T5 Berger H., Programmable Controllers in STEP 7 Basic with SIMATIC S7-1200, SIEMENS
T6 Bird J., Electrical circuit theory and technology, Elsevier 2002
T7 Blakey T.N., English for maritime studies. 2nd ed., Hemel Hempstead, Prentice Hall International (UK) Ltd, 1987 (ISBN 0 13 281379-3)
T8 Bolton W., Programmable Logic Controllers, NEWNES: ISBN: 978-0750681124

T9 Bose B. K., Power electronics and motor drives - advances and trends, Elsevier, 2006
T10 Cadick J., Electrical safety in marine environment. Cadick Corporation, Technical Bulletin 010, January 2001
T11 Cadick J. et al, Electrical safety handbook, Third Edition, Mc Graw Hill 2005
T12 Code of safe working practices for merchant seamen, London. The Stationery Office Publications Centre, 1998
T13 Code of safe working practices for merchant seamen, Maritime and Coastguard Agency (MCA), London. The Stationery Office Publications Centre, Consolidated Edition, 2009 (ISBN 9780115530784)
T14 Computer data, including: Data Set, Electronical Data Interchange, Random Access, Computer Data Processing, Text File, Binary Code,… by Hephaestus Books
T15 2010 Elevator industry field employees' safety handbook
T16 Ellis Norman., Electrical interference handbook, Second edition, Publisher: NEWNES, ISBN-10: 9780750635479
T17 Fardo S.W, Patric D.R., Electrical power systems technology, The Fairmont Press, Lilburn 2009
T18 Fossen T., Marine control systems, Marine Cybernetics, Trondheim 2002
T19 GMDSS Manual 2009. IMO Publishing, London 2009
T20 Górski Z., Construction and operation of marine cleaning machinery. Trademar. Gdynia 2009
T21 Górski Z., Construction and operation of marine hydraulic machinery. Trademar. Gdynia 2008
T22 Górski Z., Construction and operation of marine pumps. Trademar. Gdynia 2010
T23 Górski Z., Construction and operation of marine steering gears, controllable pitch propellers and stern tubes. Trademar. Gdynia 2009
T24 Górski Z., Construction and working of marine compressors, blowers and fans. Fundacja Rozwoju Akademii Morskiej w Gdyni. Gdynia 2006
T25 Górski Z., Construction and working of marine heat exchangers. Fundacja Rozwoju Akademii Morskiej w Gdyni. Gdynia 2007
T26 Gross Ch. A., Electric machines, CRC Press Tylor & Francis Group, Boca Raton, FL, 2007
T27 Hall D. T., Practical marine electrical knowledge, London, Witherby & Co Ltd, 1999
T28 Hannah－Hillier, J., Applied mechanics. Harlow, Longman 1995. (ISBN 0582 25632.1)
T29 Hellerman H., Digital computer system principles
T30 Horovitz P., Hill W., The art of electronics, Cambridge University Press, 1989
T31 http://safety.elevatorworld.com/handbook.htm
T32 Huber M., Tanker operations, a handbook for the Person-in-Charge (PIC), Cornell Maritime Press, Centreville, Maryland, 2001
T33 Hubert C. I., Triebel W. A., Operation, testing and preventive maintenance of electrical power apparatus, Prentice Hall 2002
T34 IACS Guidelines and Recommendations No.35 Inspection and maintenance of electrical equipment installed in hazardous areas
T35 ICF, OCIMF & IAPH, International safety guide for oil tankers and terminals (ISGOTT). 5th ed. London, Witherby & Co. Ltd., 2006 (ISBN 1-85609-291-7)
T36 IEC 60079-series, Explosive atmospheres
T37 IEC 60092-series, Electrical installations in ships
T38 International Chamber of Shipping (ICS): Tanker safety guide (Liquefied Gas), London, Whiterby & Co. Ltd. 1978.

T39 International code for the construction and equipment of ships carrying dangerous chemicals in bulk (IBC Code), London IMO
T40 International code for the construction and equipment of ships carrying liquefied gases in bulk (IGC Code), London IMO
T41 Jackson L., Instrumentation and control systems, Thomas Reed Publications Ltd.1992
T42 Jackson L. and Morton T.D., General engineering knowledge for marine engineers. 5th ed. London, Thomas Reed Publications Ltd 1990. (ISBN 0947 637.761)
T43 Joel, R., Basic engineering thermodynamics in SI units. 4th ed. Harlow, Longman, 1996 (ISBN 0582 41626 4)
T44 Kasap S., Principles of electronic materials and devices, Third Edition, McGraw-Hill, 2006
T45 Kaźmierkowski M.P, Tunia H., Automatic control of converter-fed drives, Elsevier 1994
T46 Khanna Vinod Kumar., The insulated gate bipolar transistor: IGBT theory and design, A John Wiley & Sons, INC., Publication; ISBN 0-470-23845-7
T47 Kiameh Philip., Electrical equipment handbook: troubleshooting and maintenance, McGraw-Hill Professional; ISBN: 978-0071396035
T48 Kossowski K., Introduction to the theory of marine turbines. Foundation for the Promotion of Marine Industry. Gdańsk 2005
T49 Kossowski K., Ship Turbine Power Plants. Foundation for the Promotion of Marine Industry. Gdańsk 2005
T50 Kothari D. P., Nagrath I. J., Electric machines, Mac-Graw-Hill, New Delhi, 2006
T51 Kraal E.G.R., Basic electrotechnology for engineers, 3rd Edition, Thomas Reed Publications Ltd.1985
T52 Kuffel E., Zaengl W. S, Kuffel J., High voltage engineering, fundamentals, Second edition, Elsevier Ltd., 2000
T53 Kwaśniewski J., Programmable Logic Controllers, Published by WIMiR AGH, Kraków, 2002
T54 Lipo T. A., Jezernik K., AC Motor speed control, University of Wisconsin, Madison WI, U.S.A, University of Maribor, Maribor, Slovenia, 2002
T55 Lister Eugene, Rusch Robert, Electric circuits and machines, McGraw-Hill, ISBN: 9780028018096
T56 Love J., Process automation handbook, Springer 2007
T57 Mackay S., Wright E., Reynders D., Practical industrial data networks: design, installation and troubleshooting, Elsevier 2004
T58 Maini Anil K., Digital electronics: principles, devices and applications, Wiley; ISBN: 978-0470032145
T59 Manual for use by the maritime mobile and maritime mobile-satellite services, ITU Geneva 2011
T60 Mc George H.D., Marine electrical equipment and practice, Butterworth-Heinemann, Oxford 2004
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T62 Mc Guire and White, Liquefied gas handling principles, London, Whiterby Marine Publishing 1978
T63 Michalski L., Eckersdorf K., McGhee J., Temperature measurement, John Wiley & Sons, New York
T64 Milton J. H., Leach R.M., Marine steam boilers. Butterworth Marine Engineering Series. London – Boston 1980

T65 Mohan N., First course on power electronics and drives, NMPERE Minneapolis 2003
T66 Mohan N., Undeland T., Robbins W., Power electronics converters, applications and design, Third Edition, John Wiley, 2003, ISBN: 978-0-471-22693-2
T67 Morris A. S., Measurement & instrumentation principles, Butterworth- Heinemann, 3rd edition 2001
T68 Oil Companies International Marine Forum. Mooring equipment guidelines. London, Witherby 1997
T69 Pearce Durrance J. G., Sound-powered telephone talkers' training manual NAVEDTRA 14232 , Published by Naval Education and Training Professional Development and Technology Centre NAVSUP 1994
T70 Peek F. W., Dielectric phenomena in high voltage engineering, Watchmaker Publishing 2006
T71 Perez T., Ship motion control, Springer Verlag, London 2005
T72 Properties of gases and liquids, LGA Gastechnik GmbH, 1985.
T73 REED's Volume 6: Basic electrotechnology for engineers; E. G. R. Kraal, Publisher: London: Thomas Reed Publications, [1985] ISBN: 0900335963
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T75 REED's Volume 10: Instrumentation and control systems (REED's Marine Engineering Series) Leslie Jackson; Publisher: Thomas Reed Publications, ISBN: 0947637869 Edition: Paperback; 2002-12-07
T76 Reynders D., Mackay S., Wright E., Practical industrial data communications: best practice techniques, Elsevier 2005
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Electro-Technical Officer
Function 1:
Electrical, Electronic and Control Engineering at the Operational Level

Electro-Technical Officer

Function 1: Electrical, Electronic and Control Engineering at the Operational Level

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Part B1: Course Outline

Function 1 - Electrical, Electronic and Control Engineering at the Operational Level

▪ Timetable

No formal example of a timetable is included in this model course.

Development of a detailed timetable depends on the level of skills of the trainees entering the course and the amount of revision work of basic principles that may be required.

Lecturers must develop their own timetable depending on:

- the level of skills of trainees
- the numbers to be trained
- the number of instructors

and normal practices at the training establishment.

Preparation and planning constitute an important factor which makes a major contribution to the effective presentation of any course of instruction.

▪ Lectures

As far as possible, lectures should be presented within a familiar context and should make use of practical examples. They should be well illustrated with diagrams, photographs and charts where appropriate, and be related to matter learned during seagoing time.

An effective manner of presentation is to develop a technique of giving information and then reinforcing it. For example, first tell the trainees briefly what you are going to present to them; then cover the topic in detail; and, finally, summarize what you have told them. The use of an overhead projector and the distribution of copies of the transparencies as trainees hand-outs contribute to the learning process.

▪ Course outline

The tables that follow list the competencies and areas of knowledge, understanding and proficiency, together with the estimated total hours required for lectures and practical exercises. Teaching staff should note that timings are suggestions only and should be adapted to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

COURSE OUTLINE

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of required performance

Competence:

1.1 MONITOR THE OPERATION OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS

1.1.1	BASIC UNDERSTANDING OF THE OPERATION OF MECHANICAL ENGINEERING SYSTEMS			
	.1	Prime Movers, Including Main Propulsion Plant	20	
	.2	Engine Room Auxiliary Machinery	40	
	.3	Steering Systems	4	
	.4	Cargo Handling Systems	28	
	.5	Deck Machinery	18	
	.6	Hotel Systems	6	116
1.1.2	BASIC KNOWLEDGE OF HEAT TRANSMISSION, MECHANICS AND HYDROMECHANICS			14
1.1.3	ELECTRO-TECHNOLOGY AND ELECTRICAL MACHINES THEORY			75
1.1.4	FUNDAMENTALS OF ELECTRONICS AND POWER ELECTRONICS			45
1.1.5	ELECTRICAL POWER DISTRIBUTION BOARDS AND ELECTRICAL EQUIPMENT			60
1.1.6	FUNDEAMENTALS OF AUTOMATION, AUTOMATIC CONTROL SYSTEMS AND TECHNOLOGY			40
1.1.7	INSTRUMENTATION, ALARM AND MONITORING SYSTEMS			45
1.1.8	ELECTRICAL DRIVES			30
1.1.9	TECHNOLOGY OF ELECTRICAL MATERIALS			15
1.1.10	ELECTRO-HYDRAULIC AND ELECTRO-PNEUMATIC SYSTEMS			10
1.1.11	APPRECIATIONS OF THE HAZARDS AND PRECAUTIONS REQUIRED FOR THE OPERATION OF POWER SYSTEMS ABOVE 1,000 VOLTS			5

1.2 MONITOR THE OPERATION OF AUTOMATIC CONTROL SYSTEMS OF PROPULSION AND AUXILIARY MACHINERY

1.2.1	PREPARATION OF CONTROL SYSTEMS OF PROPULSION AND AUXILIARY MACHINERY FOR OPERATION			15

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of required performance
1.3 OPERATE GENERATORS AND DISTRIBUTION SYSTEMS		
1.3.1 COUPLING, LOAD SHARING AND CHANGING OVER GENERATORS	6	
1.3.2 COUPLING AND BREAKING CONNECTION BETWEEN SWITCHBOARDS AND DISTRIBUTION PANELS	6	
1.4 OPERATE AND MAINTAIN POWER SYSTEMS IN EXCESS OF 1,000 VOLTS		
1.4.1 HIGH VOLTAGE TECHNOLOGY	15	
1.4.2 SAFETY PRECAUTIONS AND TECHNOLOGY	5	
1.4.3 ELECTRICAL PROPULSION OF THE SHIPS, ELECTRICAL MOTORS AND CONTROL SYSTEMS	15	
1.4.4 SAFE OPERATION AND MAINTENANCE OF HIGH-VOLTAGE SYSTEMS	12	
1.5 OPERATE COMPUTERS AND COMPUTER NETWORKS ON SHIPS		
1.5.1 MAIN FEATURES OF DATA PROCESSING	45	
1.5.2 CONSTRUCTION AND USE OF COMPUTER NETWORKS ON SHIPS	30	
1.5.3 BRIDGE-BASED, ENGINE-ROOM-BASED AND COMMERCIAL COMPUTER USE	45	
1.6 USE ENGLISH IN WRITTEN AND ORAL FORM		
1.6.1 ENGLISH LANGUAGE	30	
See IMO Model Course 3.17		
1.7 USE INTERNAL COMMUNICATION SYSTEMS		
1.7.1 OPERATION OF ALL INTERNAL COMMUNICATION SYSTEMS ON BOARD	15	
Total for Function 1: Electrical, Electronic and Control Engineering at the Operational Level		**694**

Teaching staff should note that the hours for lectures and exercises are suggestions only as regards sequence and length of time allocated to each objective. These factors may be adapted by lecturers to suit individual groups of trainees depending on their experience, ability, equipment and staff available for teaching.

Part C1: Detailed Teaching Syllabus

▪ Introduction

The detailed teaching syllabus is presented as a series of learning objectives. The objective, therefore, describes what the trainee must do to demonstrate that the specified knowledge or skill has been transferred.

Thus each training outcome is supported by a number of related performance elements in which the trainee is required to be proficient. The teaching syllabus shows the *Required performance* expected of the trainee in the tables that follow.

In order to assist the instructor, references are shown to indicate IMO references and publications, textbooks and teaching aids that instructors may wish to use in preparing and presenting their lessons.

The material listed in the course framework has been used to structure the detailed teaching syllabus; in particular:

Teaching aids (indicated by A)
IMO references (indicated by R) and
Textbooks (indicated by T)

will provide valuable information to instructors.

▪ Explanation of Information Contained in the Syllabus Tables

The information on each table is systematically organised in the following way. The line at the head of the table describes the FUNCTION with which the training is concerned. A function means a group of tasks, duties and responsibilities as specified in the STCW Code. It describes related activities which make up a professional discipline or traditional departmental responsibility on board.

In this Model course there are three functions:

Electrical, electronic and control engineering at the operational level,
Maintenance and repair at the operational level,
Controlling the operation of the ship and care for the persons on board at the operational level.

The header of the first column denotes the **COMPETENCE** concerned. Each function comprises a number of competences. For example, the Function 1, Electrical, Electronic and Control Engineering at the Operational Level, comprises seven COMPETENCES. These competences are uniquely and consistently numbered in this model course.

The first competence is **Monitor the Operation of Electrical, Electronic and Control Systems**. It is numbered 1.1, that is the first competence in Function 1. The term competence should be understood as the application of knowledge, understanding,

proficiency, skills, experience for an individual to perform a task, duty or responsibility on board in a safe, efficient and timely manner.

Shown next is the required TRAINING OUTCOME. The training outcomes are the areas of knowledge, understanding and proficiency in which the trainee must be able to demonstrate knowledge and understanding. Each COMPETENCE comprises a number of training outcomes. For example, the competence **Monitor the Operation of Electrical, Electronic and Control Systems** comprises a total of ten training outcomes. The first is in MECHANICAL ENGINEERING SYSTEMS. Each training outcome is uniquely and consistently numbered in this model course. *Mechanical Engineering Systems* is numbered 1.1.1. For clarity, training outcomes are printed in black on grey, for example TRAINING OUTCOME.

Finally, each training outcome embodies a variable number of required performances – as evidence of competence. The instruction, training and learning should lead to the trainee meeting the specified required performance. For the training outcome Mechanical Engineering Systems, there are seven areas of performance. These are:

1.1.1.1 Prime Movers, Including Main Propulsion Plant
1.1.1.2 Engine Room Auxiliary Machinery
1.1.1.3 Steering Systems
1.1.1.4 Cargo Handling Systems
1.1.1.5 Deck Machinery
1.1.1.6 Hotel Systems

Following each numbered area of required performance there is a list of activities that the trainee should complete and which collectively specify the standard of competence that the trainee must meet. These are for the guidance of teachers and instructors in designing lessons, lectures, tests and exercises for use in the teaching process.

IMO references (Rx) are listed in the column to the right hand side. Teaching aids (Ax), videos (Vx) and textbooks (Tx) relevant to the training outcome and required performances are placed immediately following TRAINING OUTCOME.

It is not intended that lessons are organised to follow the sequence of required performances listed in the Tables. The Syllabus Tables are organised to match with the competence in the STCW Code Table A-III/6. Lessons and teaching should follow college practices. It is not necessary, for example, for Mechanical Engineering Systems to be studied before Electrical Drives. What is necessary is that all the material is covered and that teaching is effective to allow trainees to meet the standard of the required performance.

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-III/6
1.1.1 BASIC UNDERSTANDING OF THE OPERATION OF MECHANICAL ENGINEERING SYSTEMS	
1.1.2 BASIC KNOWLEDGE OF HEAT TRANSMISSION, MECHANICS AND HYDROMECHANICS	
1.1.3 ELECTRO-TECHNOLOGY AND ELECTRICAL MACHINES THEORY	
1.1.4 FUNDAMENTALS OF ELECTRONICS AND POWER ELECTRONICS	
1.1.5 ELECTRICAL POWER DISTRIBUTION BOARDS AND ELECTRICAL EQUIPMENT	
1.1.6 FUNDAMENTALS OF AUTOMATION, AUTOMATIC CONTROL SYSTEMS AND TECHNOLOGY	
1.1.7 INSTRUMENTATION, ALARM AND MONITORING SYSTEMS	
1.1.8 ELECTRICAL DRIVES	
1.1.9 TECHNOLOGY OF ELECTRICAL MATERIALS	
1.1.10 ELECTRO-HYDRAULIC AND ELECTRO-PNEUMATIC SYSTEMS	
1.1.11 APPRECIATIONS OF THE HAZARDS AND PRECAUTIONS REQUIRED FOR THE OPERATION OF POWER SYSTEMS ABOVE 1,000 VOLTS	

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

1.1.1 BASIC UNDERSTANDING OF THE OPERATION OF MECHANICAL ENGINEERING SYSTEMS

Textbooks: T20, T21, T22, T23, T24, T25, T28, T42, T43, T48, T49, T64, T68, T80, T93, T95

Teaching aids: A1, A2, A3, V10, V11, V19, V20, V21, V22, V23, V24

Required performance:

1.1 Prime Movers, Including Main Propulsion Plant (20 hours)
- describes and explains construction and operation of diesel engines, steam and gas turbines, steam boilers and ship electric propulsion motors
- describes ship main propulsion plant configuration and efficiency
- describes and explains configuration and operation of engine room and ship piping systems
- describes and explains operation of ship propellers and propulsors

1.2 Engine Room Auxiliary Machinery (20 hours)
- describes and explains construction and operation of pumps, compressors, blowers, fans, heat exchangers, cleaning machinery, and stern tubes sealing arrangements

1.3 Steering Systems (4 hours)
- describes and explains construction and operation of steering gears, rudder propellers, azipods and cycloid propulsors

1.4 Cargo Handling Systems (28 hours)
- describes and explains construction and operation of cargo handling machinery of general cargo ships, reefer containers, tankers, LNG carriers and chemical carriers

1.5 Deck Machinery (18 hours)
- describes and explains construction and operation of cargo winches, deck cranes, mooring winches, windlasses, hatch cowers and watertight doors

1.6 Hotel Systems (6 hours)
- describes and explains construction and operation of ship HVAC systems ,toilet systems, water supply and dosing systems

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

1.1.2 BASIC KNOWLEDGE OF HEAT TRANSMISSION, MECHANICS AND HYDROMECHANICS

Textbooks: T21, T22, T25, T43

Teaching aids: A1, A2, A3

Required performance:

2.1 Heat Transmission, Mechanics, Hydromechanics (14 hours)

- states and explains basic information concerning heat transmission: processes of heat transmission
- states and explains basic information concerning mechanics: scalar and vector quantities, graphical representation of force, resultants, moment of force, equilibrium
- states and explains basic information concerning hydromechanics: hydrostatics, hydromechanics and fluid flow

1.1.3 ELECTRO-TECHNOLOGY AND ELECTRICAL MACHINES THEORY

Textbooks: T6, T26, T50, T55, T73, T74

Teaching aids: A1, A2, A3, V3

Required performance:

3.1 Basic concepts and laws (6 hours)

- provides definitions of: current, voltage resistance, capacitance, inductance, electrical power and energy
- names and converts units for respective quantities

3.2 DC circuits (10 hours)

- states Ohm's law and calculates resistance of resistors connected in series and in parallel
- states Kirchhoff's laws and uses the laws in solving electrical circuits
- states Thevenin's theorem and uses the theorem in solving electrical circuits
- calculates star-delta transformation

3.3 AC circuits (15 hours)

- explains differences between AC and DC
- defines r.m.s. value of alternate current
- describes representation of sinusoidal quantities by vectors
- sketches phasor diagram for RL, RC and RLC circuits

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

- calculates series and parallel RL, RC and RLC circuits using complex numbers
- describes phenomenon of resonance in series and parallel circuits
- provides relations between phase and line voltages in three-phase systems on the basis of phasor diagram
- explains concepts of active, reactive power, apparent power and power factor in single and three-phase AC circuits
- explains methods of measurement of active, reactive power, apparent power and power factor in three-phase four-wire and three-wire systems
- describes nonsinusoidal voltage and current
- explains usage of concept of Fourier series for nonsinusoidal voltage and current representation
- describes the phenomena in RL, RC and RLC circuits in transient states
- states basic method of calculating RL, RC and RLC circuits in transient states
- calculates transient currents in the simple RL, RC and RLC circuits

3.4 Magnetism and electromagnetic induction (10 hours)

- describes the influence of magnetic field on conductor carrying current
- uses Fleming's rule to determine the directions of magnetic field, motion and current
- states Faraday's law
- states Lenz's law
- describes principles of self and mutual induction as well as self and mutually induced e.m.f
- compares coil inductance with and without iron core

3.5 Fundamentals of electrical machines (6 hours)

- defines the term "electrical machine" and provides the classification of electrical machines
- describes the typical structures of various machines and used materials
- explains the efficiency concept of electrical machines and characterizes the sources of energy losses
- explains the importance of proper cooling of the electrical machine
- names particular features of electrical machines for marine applications and rules of their design, including high voltage machines (above 1 kV)
- lists marine applications of electrical machines

3.6 DC machines (5 hours)

- describes operation principles and properties of DC motors and generators
- on an actual machine, or by using a given diagram that shows an arrangement of DC machine, identifies and explains the function of: the armature, the commutator, brushes and springs, field poles, field coils
- differentiates features and applications of shunt series and compound DC motors
- characterizes methods of DC motors start-up and speed control

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

3.7 Transformers (5 hours)

- describes structures and operating principles of single and three-phase transformers
- sketches equivalent circuit and phazor diagram of transformer
- characterizes connection groups of three-phase transformers
- explains consequences of variations of voltage magnitude and frequency on operation of transformers
- describes phenomena which occurs during operation of two transformers in parallel

3.8 Asynchronous machines (9 hours)

- describes structures and operating principles of asynchronous machines
- sketches equivalent circuit and phazor diagram of asynchronous motor
- on an actual machine, or by using a given diagram that shows an arrangement of asynchronous motor, identifies: rotor (and cage if applicable), field winding, fan, terminals, windings connection
- sketches graph showing relations between speed and load as well as between current and load, from no load to full load
- for a given frequency and motor structure calculates synchronous speed and explains the term of slip
- describes methods of AC motors start-up and speed control
- characterizes double squirrel-cage and deep slot motors
- given a motor name plate, explains the meaning of all the information displayed
- explains consequences of supply voltage and frequency variation on operation of asynchronous motors

3.9 Synchronous machines (6 hours)

- describes structures and operating principles of synchronous machines
- describes properties of synchronous generator
- explains armature reaction
- sketches equivalent circuit and phazor diagram of synchronous generator
- explains work of synchronous machine as motor and pf compensator
- compares properties of cylindrical and salient pole machines

3.10 Special machines (3 hours)

- describes construction and operating principle of: of AC commutator motors, AC single phase motors, reluctance and permanent magnet machines

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

1.1.4 FUNDAMENTALS OF ELECTRONICS AND POWER ELECTRONICS

Textbooks: T3, T9, T16, T30, T44, T45, T46, T60, T65, T79, T96, T97

Teaching aids: A1, A2, A3

Required performance:

4.1 Electronics and power electronics (45 hours)

- knows the structure, principle of operation, parameters and application of different semiconductor elements: diodes, SCR, GTO and IGCT thyristors, field effect transistors - MOSFET and JFET, IGBT transistors
- presents classification of power electronic converters and areas of their application on ships
- knows parameters, properties and basic applications of integrated stabilizers and operational amplifiers
- gives example and describes structure and operation of analog and impulse DC power supplies
- lists and describes the construction and operation of controlled rectifiers
- describes the construction and operation of AC voltage controllers
- describes principle of operation and properties of MSI inverters
- describes principle of operation and properties of cycloconverters
- knows diagnostics, methods of assembly and replacement of semiconductor elements
- lists the requirements for electronic and power electronic systems installed on ships

1.1.5 ELECTRICAL POWER DISTRIBUTION BOARDS AND ELECTRICAL EQUIPMENT

Textbooks: T17

Teaching aids: A1, A2, A3, V1, V2, V3

Required performance:

5.1 Basic parameters, processes and environment influences (14 hours)

- describes marine environmental exposures for electrical devices
- states typical technical parameters of electric devices – in e.g.: nominal voltage, on-load voltage, test voltage, protection grade, nominal current, peak power, power factor, etc.
- explains process of electrical devices heating while: continues load, intermittent load, part-time load or short circuit load
- draws a graph showing temperature dependence on working time
- describes electrical arc and electrical arc protection devices
- states formation reasons and consequences of short circuit, describes

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

short circuit current characteristics
- states short circuit tolerance of electrical devices

5.2 Power distribution boards (12 hours)

- describes the transmission and distribution of electrical power
- sketches exemplary single line distribution chart
- describes following structural parts of power distribution system:
  - feeder lines
  - branch circuits
  - distribution boards
  - switchgear boards
  - tie-breaker boards
- describes structure of electrical switchboards
- explains protective devices selectivity

5.3 Electrical Devices for Power Distribution (12 hours)

- describes following electrical devices used for power distribution:
  - fuses
  - automatic circuit breakers
  - disconnect switches
  - lightning arrestors
  - protective relays (overcurrent, thermal overload, undervoltage, etc.)
  - contactors
  - insulation monitoring devices
- explains structure of automatic circuit breakers, describes structure of contacts, arc extinguishing methods, dynamic forces working on contacts
- explains purpose of lightning arrestors
- explains the purpose of voltage transformers and current transformers
- describes principles of voltage transformers and current transformers and investigates its characteristics
- explains why secondary loop of current transformer should work on short circuit and why secondary side winding should be grounded
- explains current to time characteristics of fuses and automatic circuit breakers
- determines fuses and overload relays to protect an example electrical device
- determines automatic circuit breaker settings to protect particular electrical device
- explains purpose of insulation monitoring devices
- sketches leakage current to time characteristics, states component currents

5.4 Cables (10 hours)

- classifies marine cables and wires
- describes cable marks and identification system
- determines the cross-section of cables considering long-period current tolerance and acceptable voltage drop

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

- determines cable type and its cross-section for supplying particular electrical device
- calculates voltage drop in particular electrical circuit
- describes basic rules of cable arrangement
- describes rules and purposes of cable shielding

5.5 Other marine electrical devices (12 hours)

- explains principles and classifies types of marine rechargeable batteries
- calculates proper charging current for particular battery
- describes batteries maintenance procedure
- describes operating principles of fluorescent lamp
- explains stroboscopic phenomenon and states danger caused by it
- describes operating principles of incandescent lamps and halogen lamps
- describes operating principles of vapour lamps
- states differences between mercury-vapour lamps and sodium-vapour lamps
- describes principles of Impressed Current Cathodic Protection
- describes purpose and construction of UPS

1.1.6 FUNDAMENTALS OF AUTOMATION, AUTOMATIC CONTROL SYSTEMS AND TECHNOLOGY

Textbooks: T2, T8, T29, T53, T56, T92

Teaching aids: A1, A2, A3

Required performance:

6.1 Automation, Automatic Control Systems And Technology (40 hours)

- explains basic structures of control systems, defines and characterizes digital and analog control circuits
- explains methods of control systems description
- defines and describes typical elements of control: P, I and D
- defines and characterizes typical controllers: P, PI, PID
- characterizes digital and analog controllers
- describes measurement principles and structures in the process control
- describes various sensors used in process control
- characterizes data processing in process control
- describes actuators used in process control
- characterizes digital control systems, defines Moore - automat and Mealy - automat
- describes and explains principles and control functions of single controlled objects, groups of objects and hierarchical structures
- characterizes principles of industrial sequence control
- defines and characterizes Programmable Logic Controllers and
- Programmable Automatic Controllers
- sketches and explains the structure and programming principles of PLC

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

- characterizes modular and compact PLC devices
- characterizes reliability of computer control systems
- describes maintenance of PC and PLC on board

1.1.7 INSTRUMENTATION, ALARM AND MONITORING SYSTEMS

Textbooks: T60, T61, T63, T67, T84, T75, T83, T90, T96

Teaching aids: A1, A2, A3

Required performance:

7.1 Instrumentation, Alarm and Monitoring Systems (45 hours)

- describes the construction of distributed monitoring systems for engine room and for deck if required
- explains methods of the communication among individual PLC of distributed monitoring and control systems
- describes construction and properties of sensors, widely used in IAMCS systems: Pt-100, thermocouple, thermistor, strain gauge
- explains principle of two wires current standard 4-20mA
- explains methods of communication with smart transducers using HART protocol
- explains principle of communication with programmable transducers using Foundation Fieldbus or Profibus PA protocol
- describes construction of typical long distance analog measuring lines for:
  - temperature with:
    - Pt-100 sensor (two-, three-, and four connections)
    - thermocouple (extension wires)
    - thermistor
  - pressure
  - level
- describes construction of typical long distance digital (on-off) measuring lines:
  - classical on-off contact only
  - with supervision of the wires (brake or/and short circuit wires, respectively with one resistor or two resistors)
- describes the construction of typical long distance digital (on-off) measuring lines with proximity switches for:
  - two wires (NAMUR)
  - three-, four wires
- describes construction of control line for control solenoids (on-off) and analog valves (4-20 mA)
- explains purpose, structure and functions of fire detection systems (different kind of sensors for fire, smoke, temperature...)
- describes monitoring methods of explosive conditions in engine crankcase (oil mist detection systems for bearings' temperature measurement)
- describes the principle of operation of photoelectric oil detection systems

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

- explains the purpose, structure and functions of the oxygen and other gases detection systems

1.1.8 ELECTRICAL DRIVES

Textbooks: T3, T9, T45, T60, T65, T79

Teaching aids: A1, A2, A3, V4

Required performance:

8.1 A.C. Motors (20 hours)

- states the normal supply for three-phase induction motors
- names the types of motor commonly used on board ship, giving their applications
- given the actual components from a three-phase induction motor, identifies:
  - field windings
  - rotor cage
  - terminals
  - starter
  - bearings
  - method of lubrication
  - fan
- explains the differences between the following motor enclosure, describing how cooling is achieved in each case:
  - drip-proof
  - totally enclosed
  - deck watertight
  - flameproof
- sketches a graph showing the relationship between speed and load and between current and load, from no load to full load
- given a motor name plate, explains the meaning of the information displayed
- explains in simple terms how the driving torque is produced in an induction motor
- explains why slip is essential
- describes the variation of current during direct start of induction motor and its effect on the motor windings and on other electrical equipment
- states which motors might have means of reduced-voltage starting
- sketches a schematic arrangement of direct on-line starter, naming the main parts and explaining their function
- explains the reason for starting up induction motor with its stator windings star-connected
- given a labelled circuit diagram for an automatic star-delta starter, describes the starting sequence
- explains the results if a motor is allowed to continue running in its starting (star-connected) stage
- explains starting of induction motor using autotransformer starter

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

- explains basic reason of motor protection
- explains principles of the most common over current relays
- explains the difference between the largest possible overload current and a fault current
- describes the function of overcurrent trip, time delays and fuses with both overload and fault currents
- explains the principles upon which fuses are selected
- explains the principle of a thermal relay, including the means of its adjustment
- explains what is meant by single phasing and its effect on a motor:
  - when running
  - when starting
  - if continued attempts to start are made
- describes in principle the protection against running with a phase open-circuit
- explains why undervoltage trips are necessary
- states applications where the following speeds are suitable:
  - single fixed speed
  - two or three fixed speeds
  - infinitely variable speed
- describes briefly how stepped speeds can be provided
- lists the means of producing variable speed
- describes the principle of Ward-Leonard drive
- explains the principle of variable-frequency motor

8.2 D.C. Motors (10 hours)

- explains what does it mean the back E.M.F. (E_b) of a motor
- relates supply voltage to the back E.M.F. and to voltage drop in armature ($V = E_b + I_a R_a$)
- explains why starting current is high comparing to the load current
- explains the principle of DC motor starter
- states that rotational speed (N) is approximately proportional to:
  $\frac{\text{applied voltage}}{\text{field flux}}$ or $N \propto \frac{V}{\Phi}$
- from the above objective, explains how the rotational speed is affected by:
  - varying the voltage
  - varying the strength of the magnetic field
- describes typical applications of:
  - shunt motors
  - series motors
- in compound motors, explains what is meant by:
  - long shunt
  - short shunt
  - cumulatively connected

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

1.1.9 TECHNOLOGY OF ELECTRICAL MATERIALS

Textbooks: T44, T98

Teaching aids: A1, A2, A3

Required performance:

9.1 Conductivity (1 hour)

- describes differences between conductivity of conductors, semiconductors and insulators
- explains the factors which govern the variation of conductivity of various materials

9.2 Conductors (2 hours)

- using given value of resistivity, calculates the resistance of single conductors of various length and diameter
- using given value of temperature coefficient of resistivity, calculates approximate resistance of metal conductors in various temperatures, explains the limitations of the adopted approach
- describes properties of copper and its application in electrical engineering
- names common materials used as conductors, resistors and electric contacts

9.3 Superconductors (1 hour)

- explains the term "superconductor" and describes its general properties
- presents classification of superconducting materials
- states applications of superconductors

9.4 Semiconductors (1 hour)

- explains properties of semiconductors
- names common semiconductors
- describes properties of varistors and thermistors
- explains how thermistors are used in marine applications

9.5 Dielectric materials (6 hours)

- describes origins of dielectric materials polarization
- explains the term "dielectric constant"
- names origins of dielectric losses
- explains the dielectric strength and reasons of break-down of insulation
- explains the short- and long-term influence of temperature on insulators properties
- states maximum temperatures which common insulation material can withstand and the maximum ambient air temperature used in design

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

describes general physical characteristic of plastics and their thermal properties
- names criteria of choice of materials for cable insulation and sheath
- states common dielectrics used on shipboard and their applications
- names various risk factors for insulating materials in marine environment

9.6 Magnetic materials (4 hours)

- explains what is meant by "magnetic material"
- explains magnetic constant
- describes hysteresis loop including saturation, coercion field and residual magnetism
- defines Curie temperature
- explains what is meant by "soft magnetic materials" and "hard magnetic materials"
- describes the factors which govern the losses in magnetic materials
- states the methods of decreasing losses in magnetic materials
- compares properties of magnetic steel with and without silicon doping
- compares magnetic properties of oriented and non-oriented steels
- names common magnetic materials
- states applications of various magnetic materials in marine engineering

1.1.10 ELECTRO-HYDRAULIC AND ELECTRO-PNEUMATIC SYSTEMS

Textbooks: T21

Teaching aids: A1, A2, A3, V11

Required performance:

10.1 Electro-Hydraulic and Electro-Pneumatic Systems (10 hours)

- states and explains basic principles of hydraulic and pneumatic drives
- describes and explains construction and operation of hydraulic systems components
- describes and explains construction and operation of pneumatic systems components
- describes and explains construction and operation of hydraulic systems control and operation
- describes examples of marine hydraulic and pneumatic machinery

Competence 1.1	Monitor The Operation of Electrical, Electronic and Control Systems	IMO Reference

1.1.11 APPRECIATIONS OF THE HAZARDS AND PRECAUTIONS REQUIRED FOR THE OPERATION OF POWER SYSTEMS ABOVE 1,000 VOLTS

Textbooks: T52

Teaching aids: A1, A2, A3, V8

Required performance:

11.1 Hazards and Precautions Required for the Operation of Power Systems Above 1,000 Volts (5 hours)

- explains relation between shock voltage and shock current
- explains the possibility of distance electrical shock
- explains the possibility of the electrical shock by the electrostatic charge
- explains the influence of shock current on human body
- explains the difference of electric shock caused by low and high voltage
- understands meaning of warning signs
- understands the possibility of essential lengthening and migration of electric arc at the voltages above 1kV
- explains basic parameters of electric arc: the temperature, the energy etc.

Competence 1.2	**MONITOR THE OPERATION OF AUTOMATIC CONTROL SYSTEMS OF PROPULSION AND AUXILIARY MACHINERY**	**IMO Reference**

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-III/6
1.2.1 PREPARATION OF CONTROL SYSTEMS OF PROPULSION AND AUXILIARY MACHINERY FOR OPERATION	

Competence 1.2	MONITOR THE OPERATION OF AUTOMATIC CONTROL SYSTEMS OF PROPULSION AND AUXILIARY MACHINERY	IMO Reference

1.2.1 PREPARATION OF CONTROL SYSTEMS OF PROPULSION AND AUXILIARY MACHINERY FOR OPERATION

Textbooks: T27, T41, T51, T56, T94

Teaching aids: A1, A2, A3, V10, V15, V19, V20, V22, V23

Required performance:

1.1 Propulsion control systems (9 hours)

- explains the functions and tasks of control systems of the main propulsion and auxiliary machinery
- sketches block diagrams of main propulsion control systems
- describes main propulsion control systems used in normal conditions and in emergency
- explains the principle of propulsion control changeover in emergency (use of engine telegraph)
- describes the safety systems of main propulsion (the blockade of the start, shut-down and slow-down)
- describes the electronic and electrical control systems operating parameters of the main propulsion
- describes the speed control and reversing systems of main engine with fixed and variable pitch propeller
- explains procedures for :
    - preparations to start main engine
    - clutching main engine
    - change over main engine control
    - stopping and preparing main engine to harbour condition

1.2 Auxiliary machinery control systems (6 hours)

- describes automatic control systems and explains procedures for preparation and starting of air compressors
- describes the automatic control systems of auxiliary boilers; steering gear; fuel oil, cooling and lubricating oil systems
- describes automatic control systems including fuel temperature and viscosity control and explains boiler starting and stopping procedures
- describes automatic control systems of FO and LO purifiers and explains procedures for starting and stopping of FO and LO purifiers
- describes the sequential re-starting for auxiliary machinery
- describes cut-in arrangements for auxiliary of unmanned machinery space
- describes the automatic control systems of provision and cargo refrigeration plant and explains their starting and stopping procedures
- describes automatic control systems of air conditioning plant and explains starting and stopping procedures for summer and winter conditions

Competence 1.3	OPERATE GENERATORS AND DISTRIBUTION SYSTEMS	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-III/6
1.3.1 COUPLING, LOAD SHARING AND CHANGING OVER GENERATORS	
1.3.2 COUPLING AND BREAKING CONNECTION BETWEEN SWITCHBOARDS AND DISTRIBUTION PANELS	

Competence 1.3	OPERATE GENERATORS AND DISTRIBUTION SYSTEMS	IMO Reference

1.3.1 COUPLING, LOAD SHARING AND CHANGING OVER GENERATORS

Textbooks: T27, T41, T51, T56, T94

Teaching aids: A1, A2, A3, V3, V5, V16

Required performance:

1.1 Coupling, Load Sharing And Changing Over Generators (6 hours)

- explains rules of parallel working of generators
- explains methods of synchronization of the generators to the busbar and describes the differences between the following methods :
  - automatic synchronization
  - semiautomatic synchronization
  - choking-coil synchronization
  - manual synchronization
- describes generator voltage and frequency control systems
- describes control systems for distribution of active and reactive power of the generators
- explains meaning of the power factor
- describes excitation systems of generators and explains why rotating rectifiers are essential
- describes safety systems of generators and their diesel engines
- lists parameters and limits of the following generator and diesel engine protections :
  - short-circuit protection
  - overload protection
  - reverse power protection
  - under and overvoltage protection
  - under and overfrequency protection
  - asymmetrical voltage and current protection
  - open circuit , wire fault and earth-fault monitoring
  - diesel engine shutdown protection and preparing next diesel for start
- describes methods of frequency and voltage stabilization of shaft generators
- describes the principle of power management with specific reference to:
  - control of start release of big consumers directly supplied from main switchboard
  - automatic three-step disconnection of non-essential power consumers
  - load depending start and stop of generator and automatic load sharing
- describes conditions for automatic start of emergency generator and starting methods
- describes the electrical energy balance of the ship

Competence 1.3	OPERATE GENERATORS AND DISTRIBUTION SYSTEMS	IMO Reference

1.3.2 COUPLING AND BREAKING CONNECTION BETWEEN SWITCHBOARDS AND DISTRIBUTION PANELS

Textbooks: T27, T33, T41, T51, T67, T94

Teaching aids: A1, A2, A3, V1, V2

Required performance:

2.1 Coupling and Breaking Connection Between Switchboards and Distribution Panels (6 hours)

- describes systems of generation and distribution of electrical energy on ships
- explains the construction, equipment and the service of main switchboard
- explains construction, equipment and service of emergency switchboard and distribution panels
- describes construction and operation principle of measuring instruments used in main and emergency switchboards and distribution panels with specific reference to:
  - voltmeter
  - ammeter
  - wattmeter
  - frequency meter
  - synchroscope
  - power factor meter
  - earth fault meter
- explains construction and operation principle of circuit breakers and their tripping devices
- explains procedures for restarting ship equipment, after power supply failure (black-out) on board
- describes connection between main and emergency switchboards and necessary safeguards
- lists equipment typically supplied from emergency switchboard
- explains procedure for change-over to shore-connection supply

Competence 1.4	OPERATE AND MAINTAIN POWER SYSTEMS IN EXCESS OF 1,000 VOLTS	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-III/6
1.4.1 HIGH VOLTAGE TECHNOLOGY	
1.4.2 SAFETY PRECAUTIONS AND TECHNOLOGY	
1.4.3 ELECTRICAL PROPULSION OF THE SHIPS, ELECTRICAL MOTORS AND CONTROL SYSTEMS	
1.4.4 SAFE OPERATION AND MAINTENANCE OF HIGH-VOLTAGE SYSTEMS	

Competence 1.4	OPERATE AND MAINTAIN POWER SYSTEMS IN EXCESS OF 1,000 VOLTS	IMO Reference

1.4.1 HIGH VOLTAGE TECHNOLOGY

Textbooks: T52, T70

Teaching aids: A1, A2, A3, V8

Required performance:

1.1 High Voltage Technology (15 hours)

- explains nature and forming of electric stresses in general, electric stresses in laminar structures and HV insulation structure
- explains the break-down strength of gases, discharge development in gases, critical voltage and stress, partial discharges, static and impulse air break-down strength, low and high pressure-gases insulation system break-down strength
- explains the break-down strength of solid dielectrics, discharge mechanism in solids
- describes the break-down strength of operation insulation systems, high voltage insulation systems on ships
- describes the general overvoltage characteristics, short-circuit and weak reactive current switching overvoltage
- explains the ageing of electrical insulation
- describes the circumstances causing development of high voltage power systems on ships
- explains construction and operation of HV equipment:
  - circuit breakers, vacuum type and pressurised gas type (SF6) for arc quenching, fuses, over current protection etc.
  - electrical machines: motors, generators, transformers
  - switchboards
  - instrumentation
- describes overvoltage protection, protectors and arresters, insulation systems coordination, voltage disturbances and threats elimination

1.4.2 SAFETY PRECAUTIONS AND TECHNOLOGY

Textbooks: T52, T70

Teaching aids: A1, A2, A3

Required performance:

2.1 Safety Precautions and Technology (5 hours)

- explains and describes general HV protection measures: housings, partitions, distances, insulation mats, insulation materials, access restrictions, markings and warnings, HV equipment access monitoring and locks
- explains and describes how to use fixed and portable HV measurement

Competence 1.4	OPERATE AND MAINTAIN POWER SYSTEMS IN EXCESS OF 1,000 VOLTS	IMO Reference

and control apparatus for testing insulation resistance of HV machines, cables and another equipment,
- explains how to check and use HV testers

1.4.3 ELECTRICAL PROPULSION OF THE SHIPS, ELECTRICAL MOTORS AND CONTROL SYSTEMS

Textbooks: T1, T54, T66

Teaching aids: A1, A2, A3, V8

Required performance:

3.1 Electrical Propulsion of the Ships, Electrical Motors and Control Systems (15 hours)

- describes advantages of ship electrical propulsion
- presents configurations of electrical propulsion:
  - Electric Propulsion Systems with classic shaft lines
  - Podded Propulsion Systems
- draws up general block diagram of electrical propulsion system with all main components
- states High Voltage Supply and Power range of electric propulsion systems used on ships
- describes main features of electric motors used in Main Propulsion systems:
  - types of electric motor
  - mechanical construction
  - excitation
  - motor cooling
- describes propulsion supply equipment:
  - transformers (air cooled and liquid cooled) with protection
  - slip rings with arc monitoring circuit
- names types of frequency drives used in main propulsion systems, draws up their block diagrams and explains main features:
  - Frequency Converter (with current source inverter and voltage source inverter)
  - Cycloconverter
- names methods of electric motor control used in Propulsion Drives, draws up their block diagrams and explains main features:
  - vector control
  - direct torque control
- describes remote control system of podded propulsion:
  - rpm control
  - steering angle control
  - combined rpm and steering angle control during ship manoeuvring
  - describes the harmonic distortion related to power electronic systems and use of harmonic filters

Competence 1.4	OPERATE AND MAINTAIN POWER SYSTEMS IN EXCESS OF 1,000 VOLTS	IMO Reference

1.4.4 SAFE OPERATION AND MAINTENANCE OF HIGH-VOLTAGE SYSTEMS

Textbooks: T52, T70

Teaching aids: A1, A2, A3, V8

Required performance:

4.1 Safe Operation and Maintenance of High-Voltage Systems (12 hours)

- knows how to use HV personal protection equipment (PPE): insulated gloves, goggles, insulating bars, insulating footwear, mates, earthing cables, HV testers
- knows terms of certification of personal protection equipment
- explains HV safety procedures:
  - permission and co-ordination of HV works
  - information, warnings and protection against unauthorized influence on safety
  - assistance during HV work
  - checking for voltage presence before any work starts

Competence 1.5	OPERATE COMPUTERS AND COMPUTERNETWORKS ON SHIPS	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-III/6
1.5.1 MAIN FEATURES OF DATA PROCESSING	
1.5.2 CONSTRUCTION AND USE OF COMPUTER NETWORKS ON SHIPS	
1.5.3 BRIDGE-BASED, ENGINE-ROOM-BASED AND COMMERCIAL COMPUTER USE	

Competence 1.5	OPERATE COMPUTERS AND COMPUTER NETWORKS ON SHIPS	IMO Reference

1.5.1 MAIN FEATURES OF DATA PROCESSING

Tex books: T4, T5, T8, T14, T58

Teaching aids: A1, A2, A3

Required performance:

1.1 Main Features of Data Processing (45 hours)

- characterizes data types and defines data description methods in digital systems
- describes computer or PLC work memory structure
- specifies memory areas, defines and describes memory addresses
- presents methods of memory access: byte access, word access
- explains bit - data processing, defines logical functions, bit memories, time functions, counters, edges
- understands Boolean Algebra and its use for logic circuits
- explains byte and word data processing, defines logical functions, memory operations: move, shift, rotate, compare
- explains "For…next" and "if… else" operations and operations on addresses
- characterizes measurement data storage principles and methods, defines operations on stored measurements
- describes PLC and PC program structures: subroutines, interrupts, sequential control relays
- defines and characterizes combinatorial systems, presents minimizing of system logic functions, describes and creates output functions, describes simple practical examples by block diagrams of system functions
- defines and characterizes sequential systems, explains transition functions, system states, the state variables and the output function
- presents examples of sequential control system using graphs and diagrams
- explains digital PID Control method, defines controller parameters, describes interrupt processing of control loops
- explains filtering of measurement data and smoothing methods, defines smoothing factor

Competence 1.5	OPERATE COMPUTERS AND COMPUTER NETWORKS ON SHIPS	IMO Reference

1.5.2 CONSTRUCTION AND USE OF COMPUTER NETWORKS ON SHIPS

Textbooks: T57, T76, T77, T84, T88

Teaching aids: A1, A2, A3

Required performance:

2.1 Construction and Use of Computer Networks on Ships (30 hours)

- characterizes industrial networks in process control, describes their purpose and structures
- explains OSI/ISO Model, specifies nodes functions
- names and characterizes basic binary codes in data exchange
- defines and describes serial transmission data busses, characterizes RS 232, RS 422, RS 485, describes cable connectors and terminators
- describes Internet and Ethernet protocols: OSI/ISO, TCP/IP
- names and explains medium access methods: master-slave, master-slave with cyclical polling, token ring, token ring with master-slave polling, CSMA/CD, CSMA/CA
- defines Profibus DP network, characterizes nodes, structures, objects of configuration, programming of data exchange
- describes Industrial Ethernet network, characterizes nodes, structures, configuration, data exchange configured objects: connections, transfers, calls the instructions, principles of data exchange programming
- describes the USS network, characterizes nodes, structures, configuration, data exchange
- characterizes Modbus network, describes the nodes, structures, configured objects

1.5.3 BRIDGE-BASED, ENGINE-ROOM-BASED AND COMMERCIAL COMPUTER USE

Textbooks: Various technical documentation of ships devices and systems

Teaching aids: A1, A2, A3

Required performance:

3.1 Bridge-Based, Engine-Room-Based and Commercial Computer Use (45 hours)

- explains purpose, construction and functions of Integrated Navigation Systems (for example VMS Sperry)
- explains purpose, structure and functions of Voyage Data Recorder (VDR system)
- explains purpose, structure and functions of Dynamic Positioning System
- explains purpose, construction and operation of ship fuel consumption

Competence 1.5	OPERATE COMPUTERS AND COMPUTER NETWORKS ON SHIPS	IMO Reference

optimizing systems (e.g. NAPA, ENIRAM)
- explains purpose, structure and functions of PLC or PC based power management systems
- explains purpose, structure and functions of PLC or PC based systems for fuel storage, transport and preparation
- explains purpose, structure and functions of PLC or PC based refrigeration systems
- explains the purpose, structure and functions of Electronic Alarm Recorder (e.g. Prilog)
- explains purpose, structure and functions of Computer Systems for critical equipment condition monitoring (for example METALSCAN, SWANTECH)
- explains the purpose, structure and functions of Load and Hull - Stress calculation systems

Competence 1.6	USE ENGLISH IN WRITTEN AND ORAL FORM	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-III/6

1.6.1 ENGLISH LANGUAGE

Competence 1.6	**USE ENGLISH IN WRITTEN AND ORAL FORM**	**IMO Reference**

1.6.1 ENGLISH LANGUAGE

Textbooks: T7

Teaching aids: A4

Required performance:

1.1 English Language R1

- use English in written and oral form to:
  - perform the officer's duties
  - use general maritime vocabulary
  - use marine technical terminology

1.2 English Language for Marine Engineers

- use English in written and oral form to:
  - perform the officer's duties
  - read manufactures' manuals
  - use shipboard drawings
  - use other engineering publications

Competence 1.7	USE INTERNAL COMMUNICATION SYSTEMS	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-III/6
1.7.1 OPERATION OF ALL INTERNAL COMMUNICATION SYTEMS ON BOARD	

Competence 1.7	**USE INTERNAL COMMUNICATION SYSTEMS**	**IMO Reference**

1.7.1 OPERATION OF ALL INTERNAL COMMUNICATION SYTEMS ON BOARD

Textbooks: T69

Teaching aids: A1, A2, A3

Required performance:

1.1 Automatic Telephone System (8 hours)

- explains the role of Automatic Telephone System on board modern ship
- explains meaning of various terms and abbreviations used in Automatic Telephone System (PBX, PABX, POTS, DECT, ISDN, VoIP)
- presents block diagrams of typical PBX used on ships (e.g. Alcatel, Ericsson, Midel)
- presents examples of PBX hardware modules and their functions (e.g. Alcatel Cristal Technology)
- names and explains various functions of PBX: Auto attendant, Auto dialing, Automatic ring back, Call accounting, Call blocking, Call forwarding, Call transfer, Call waiting, Conference call, Call intrusion, Music on hold, Public address voice paging, Voice mail, Voice message broadcasting, Welcome message
- presents examples of basic PBX software maintenance and configuration for selected PBX
- presents basic information about hardware and software of DECT cordless phone system used on ships with advanced PABX
- presents basic information about hardware, software and functions of Pager system still used on some ships.

1.2 Emergency Sound Powered Telephone System (1 hour)

- explains purpose of use Sound Powered Telephones on ships
- explains principle of operation of Sound Powered Telephone and its difference to Automatic Telephone System
- briefly explains the principle and design of Dynamic Microphones used in Sound Powered Telephones
- explains design and operation of calling circuit
- presents an example of typical Sound Powered Telephone network on ship

1.3 Talkback – Intercom System (1 hour)

- explains purpose of use Talkback Systems on ships
- explains principle of operation of Talkback System
- presents an example of typical Talkback network on ship and its components for various environmental conditions

Competence 1.7	USE INTERNAL COMMUNICATION SYSTEMS	IMO Reference

1.4 Public Address System (PA) (4 hours)

- explains purpose of use PA systems on various types of ships
- describes principle of operation and main components of PA System: input sources, preamplifiers, signal routers, amplifiers, speakers, control and monitoring equipment
- presents an example of advanced PA system e.g. from passenger ship

1.5 UHF communication system (1 hour)

- presents basic information about marine UHF radio communication: frequencies, range, simplex and duplex channels
- explains purpose and principle of operation of UHF repeaters
- presents an example of programming UHF digital radio set used with repeater system

Part D1: Instructor's Manual

Function 1 - Electrical, Electronic and Control Engineering at the Operational Level

▪ Guidance Notes

The following notes are intended to high light the main objectives or training outcomes of each part of the function. The notes also contain some material on topics which are not adequately covered in the quoted references.

This function covers the theoretical knowledge, understanding and proficiency for the safe operation of electrical, electronic and control systems.

Function 1 - Electrical, Electronic and Control Engineering at the Operational Level

These notes have been included to provide additional information where appropriate.

1.1 MONITOR THE OPERATION OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS

1.1.1 BASIC UNDERSTANDING OF THE OPERATION OF MECHANICAL ENGINEERING SYSTEMS — 116 hours

The training in this topic provides the basic knowledge of:

- types, configuration and efficiency of ship propulsion plants
- main propulsion plant configuration and efficiency
- ship propellers and propulsors
- engine room and ship piping systems
- construction and operation of ship main engines: diesel engines, steam and gas turbines, steam boilers and ship electric propulsion motors
- construction and operation of ship auxiliary machinery including among others: pumps, valves, filters, pipelines, compressors, purifiers, heat exchangers, pneumatic and hydraulic systems, cleaning machinery, steering gear, shafts, bow thrusters and stabilizers
- construction and operation of steering gears, rudder propellers, azipods and cycloid propulsors
- construction and operation of cargo handling machinery of general cargo ships, containers, tankers, LNG carriers and chemical carriers
- construction and operation of cargo winches, deck cranes, capstans, mooring winches, hatch cowers and watertight door

1.1.2 BASIC KNOWLEDGE OF HEAT TRANSMISSION, MECHANICS AND HYDROMECHANICS — 14 hours

The training in this topic provides the basic knowledge of:

- basic information concerning heat transmission: processes of heat transmission,
- basic information concerning mechanics: scalar and vector quantities, graphical representation of force, resultants, moment of force, equilibrium
- basic information concerning hydromechanics: hydrostatics, hydromechanics and fluid flow

1.1.3 ELECTRO-TECHNOLOGY AND ELECTRICAL MACHINES THEORY — 75 hours

The training in this topic provides the basic knowledge of:

- definitions of fundamental terms in electricity and used units
- fundamental laws and theorems behind electric and magnetic circuits
- single and three phase systems
- methods of solving of basic circuits
- operation principles and structure of various DC and AC machines
- motion of various DC and AC machines in transient and steady-state
- properties and usage of various DC and AC machines

1.1.4 FUNDAMENTALS OF ELECTRONICS AND POWER ELECTRONICS — 45 hours

The training in this topic provides the basic knowledge of:

- fundamentals of electronics and power electronics (basic elements)
- basic electronic circuits used in the drive control systems
- power electronic converters used in the drive systems
- starting and speed control of D.C. and A.C. motors, using power electronic converters
- controlled electrical drives of engine room auxiliary machinery, deck and cargo handling equipment
- power electronic converters used in ship main propulsion

1.1.5 ELECTRICAL POWER DISTRIBUTION BOARDS AND ELECTRICAL EQUIPMENT — 60 hours

Upon completion of this unit trainee should have understood following issues:

- fundamentals of electrical distribution systems
- power distribution boards
- switching and protection equipment used in power distribution systems
- cables
- lighting fixtures and other marine electrical devices

1.1.6 FUNDAMENTALS OF AUTOMATION, AUTOMATIC CONTROL SYSTEMS AND TECHNOLOGY 40 hours

The training in this topic provides the basic knowledge of:

- fundamentals of control theory, analogue and digital systems
- digital control systems, sequence control, automation of single controlled objects, groups of objects and hierarchical structures
- Programmable Logic Controllers and Programmable Automatic Controllers

1.1.7 INSTRUMENTATION, ALARM AND MONITORING SYSTEMS 45 hours

The training in this topic provides the basic knowledge of:

- distributed monitoring and control systems for engine room and deck
- measurement and control lines in the distributed monitoring and control systems (temperature, pressure, level, salinity, voltage, current, frequency, etc.)
- sensors and transducers for nonelectrical values
- smart or intelligent transducers
- safety systems
- fire-detection systems, flame detection sensors, temperature detection sensors, smoke detection sensors
- watch keeping systems
- oil detector
- gas detector systems
- oxygen detector systems

1.1.8 ELECTRICAL DRIVES 30 hours

The training in this topic provides the basic knowledge of:

- fundamentals of electrical drives
- starting, speed control and electric braking of D.C. and A.C. motors
- power electronic converters used in the drive systems
- electrical drives of engine room auxiliary machinery, deck and cargo handling equipment
- drive system protections

Most modern, large ships have A.C. electrical supplies. Even so, some ships may have D.C. motors, fed by a rectified supply, for certain variable-speed applications. For these reasons, A.C. and D.C. practice must also be included.

1.1.9 TECHNOLOGY OF ELECTRICAL MATERIALS 15 hours

The training in this topic provides the basic knowledge of:

- properties of electrical materials and factors which cause their variations
- criteria of selection of proper material for given application
- influence of marine environment on electrical materials durability
- future development in technology of electrical materials for marine applications

1.1.10 ELECTRO-HYDRAULIC AND ELECTRO-PNEUMATIC SYSTEMS 10 hours

The training in this topic provides the basic knowledge of:
- ship applications of hydraulic and pneumatic machinery
- hydraulic and pneumatic machinery operation principles
- basic principles of hydraulic and pneumatic drives
- components of hydraulic systems and machinery
- components of pneumatic systems
- hydraulic and pneumatic machinery operational control
- examples of ship hydraulic and pneumatic machinery
- ship steering gears

1.1.11 APPRECIATIONS OF THE HAZARDS AND PRECAUTIONS REQUIRED FOR THE OPERATION OF POWER SYSTEMS ABOVE 1,000 VOLTS 5 hours

The training in this topic provides the basic knowledge of:
- hazards of electrical shock at the voltage above 1kV
- effects of electric shock at the voltage above 1kV
- operation procedures for electrical equipment above 1kV
- electric arc effects at the voltage above 1kV

1.2 MONITOR THE OPERATION OF AUTOMATIC CONTROL SYSTEMS OF PROPULSION AND AUXILIARY MACHINERY

1.2.1 PREPARATION OF CONTROL SYSTEMS OF PROPULSION AND AUXILIARY MACHINERY FOR OPERATION 15 hours

The training in this topic provides the basic knowledge of:
- functions and tasks of control systems of main propulsion
- block diagrams of control systems of the main propulsion
- safety systems of main propulsion and parameters checks of the main propulsion
- speed control systems of the propulsion and remote control of the pitch propeller
- procedures to prepare to: start main engine, clutch main engine, change over the main engine control, stop and prepare main engine for harbour condition
- automation of auxiliary machinery and procedures for use of auxiliary machinery

1.3 OPERATE GENERATORS AND DISTRIBUTION SYSTEMS

1.3.1 COUPLING, LOAD SHARING AND CHANGING OVER GENERATORS 6 hours

The training in this topic provides the basic knowledge of:
- rules of the parallel working of generators

- methods of the synchronization of the generators to the busbar
- control systems voltage and frequency of generators
- methods of the excitation generators and safety systems of the generators
- the principles of power management
- the principles of starting emergency generator

1.3.2 COUPLING AND BREAKING CONNECTION BETWEEN SWITCHBOARDS AND DISTRIBUTION PANELS — 6 hours

The training in this topic provides the basic knowledge of:

- power distribution systems of the electrical energy on the ships
- construction of main and emergency switchboards
- instruments used in synchronization process
- construction and the operation principle of circuit breakers and their trips
- rules of procedure after the black-out and connections between the main switchboard and emergency switchboard procedure of change-over to shore-connection supply

1.4 OPERATE AND MAINTAIN POWER SYSTEMS IN EXCESS OF 1,000 VOLTS

1.4.1 HIGH VOLTAGE TECHNOLOGY — 15 hours

The training in this topic provides basic knowledge of:

- nature and forming of electric stresses, electric stresses in laminar structures, surface discharges
- break-down strength of solid dielectrics, discharge mechanism in solids
- overvoltage and surge protection methods and devices
- ships HV systems: HV apparatus, cables, electrical machines, switchboards, fuses, etc.

1.4.2 SAFETY PRECAUTIONS AND TECHNOLOGY — 5 hours

The training in this topic provides basic knowledge of:

- HV measurement and control equipment and apparatus
- ageing of electrical insulation
- testing of electrical insulation strength

1.4.3 ELECTRICAL PROPULSION OF THE SHIPS, ELECTRICAL MOTORS AND CONTROL SYSTEMS — 15 hours

The training in this topic provides basic knowledge of:

- electric propulsion configuration and components
- electric motors and frequency drives used in ship propulsion systems
- methods of el. motor control used in ship propulsion systems

1.4.4 SAFE OPERATION AND MAINTENANCE OF HIGH- VOLTAGE SYSTEMS 12 hours

The training in this topic provides basic knowledge of:

- personal safety equipment for HV works,
- testing equipment for HV works,
- safety procedures for HV works.

Practical training in the operation of high-voltage systems could be extended on the basis of courses organised by specialized training centres which must adhere to relevant national legislation.

1.5 OPERATE COMPUTERS AND COMPUTER NETWORKS ON SHIPS

1.5.1 MAIN FEATURES OF DATA PROCESSING 45 hours

The training in this topic provides basic knowledge of:

- data types and data description in digital systems
- computer or PLC work memory structure and access methods
- bit, byte and Word Data processing, logical functions, bit memory, time functions, counters, edges
- typical computer programming instructions: logical instructions, move, shift and rotate instructions, for…next and if… else
- data storage, operations on stored values and addresses
- PLC and PC program structures, combinatorial systems and sequential systems, functions and description of systems
- digital PID control, data measurement and filtering

1.5.2 CONSTRUCTION AND USE OF COMPUTER NETWORKS ON SHIPS 30 hours

The training in this topic provides basic knowledge of:

- Industrial networks, purpose and structures, OSI/ISO Model, binary codes
- serial transmission of data busses, Internet and Ethernet protocols, OSI/ISO, TCP/IP medium access methods
- Profibus DP network, Industrial Ethernet network, USS network, Modbus network

1.5.3 BRIDGE-BASED, ENGINE-ROOM-BASED AND COMMERCIAL COMPUTER USE 45 hours

The training in this topic provides basic knowledge of:

- bridge based computer systems: Integrated Navigation Systems, Voyage Data Recorder, Dynamic Positioning System, fuel

consumption optimizing system, load and hull - stress calculation systems engine room based systems: PLC and PC for power management systems, fuel storage, transport and preparation, refrigeration systems, fire detection systems
- programmable monitoring and control systems, Electronic Alarm Recorder, systems for critical equipment condition monitoring

1.6 USE ENGLISH IN WRITTEN AND ORAL FORM

1.6.1 ENGLISH LANGUAGE — 30 hours

See IMO Model Course 3.17

IMO model course 3.17 on Maritime English is based on a clearly defined entry standard in general English, deals with maritime terminology and the use of English sufficient to allow the use of engineering publications and the performance of electro-technical duties concerned with the ship's safety and operation.
The course also includes the vocabulary needed to make use of and understand manufacturers' technical manuals and specifications to converse with technical shore staff concerning ship and machinery repairs.

1.7 USE INTERNAL COMMUNICATION SYSTEMS

1.7.1 OPERATION OF ALL INTERNAL COMMUNICATION SYSTEMS ON BOARD — 15 hours

The training in this topic provides the basic knowledge of operation and skills to maintain and repair the following ship Internal Communication Systems:
- Automatic Telephone System
- Emergency Sound Powered Telephone System
- Talk Back System
- Public Address System
- UHF internal communication system

Electro-Technical Officer
Function 2:
Maintenance and Repair at the Operational Level

Electro-Technical Officer
Function 2: Maintenance and Repair at the Operational Level

Part B2: Course Outline

Function 2 - Maintenance and Repair at the Operational Level

▪ Timetable

No formal example of a timetable is included in this model course.

Development of a detailed timetable depends on the level of skills of the trainees entering the course and the amount of revision work of basic principles that may be required.

Lecturers must develop their own timetable depending on:

- the level of skills of trainees
- the numbers to be trained
- the number of instructors

and normal practices at the training establishment.

Preparation and planning constitute an important factor which makes a major contribution to the effective presentation of any course of instruction.

▪ Lectures

As far as possible, lectures should be presented within a familiar context and should make use of practical examples. They should be well illustrated with diagrams, photographs and charts where appropriate, and be related to matter learnt during seagoing time.

An effective manner of presentation is to develop a technique of giving information and then reinforcing it. For example, first tell the trainees briefly what you are going to present to them; then cover the topic in detail; and, finally, summarize what you have told them. The use of an overhead projector and the distribution of copies of the transparencies as trainees hand outs contribute to the learning process.

▪ Course outline

The tables that follow list the competencies and areas of knowledge, understanding and proficiency, together with the estimated total hours required for lectures and practical exercises. Teaching staff should note that timings are suggestions only and should be adapted to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

COURSE OUTLINE

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of required performance
Competence:		
2.1 MAINTENANCE AND REPAIR OF ELECTRICAL AND ELECTRONIC EQUIPMENT		
2.1.1 SAFETY REQUIREMENTS FOR WORKING ON SHIPBOARD ELECTRICAL SYSTEMS	15	
2.1.2 MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEM EQUIPMENT, SWITCHBOARDS, ELECTRIC MOTORS, GENERATOR AND DC ELECTRICAL SYSTEMS AND EQUIPMENT	20	
2.1.3 DETECTION OF ELECTRIC MALFUNCTION, LOCATION OF FAULTS AND MEASURES TO PREVENT DAMAGE	10	
2.1.4 CONSTRUCTION AND OPERATION OF ELECTRICAL TESTING AND MEASURING EQUIPMENT	15	
2.1.5 FUNCTION, CONFIGURATION AND PERFORMANCE TESTS OF MONITORING SYSTEMS, AUTOMATIC CONTROL DEVICES, PROTECTIVE DEVICES	20	
2.1.6 THE INTERPRETATION OF ELECTRICAL AND ELECTRONIC DIAGRAMS	30	
2.2 MAINTENANCE AND REPAIR OF AUTOMATION AND CONTROL SYSTEMS OF MAIN PROPULSION AND AUXILIARY MACHINERY		
2.2.1 MAINTENANCE AND REPAIR OF AUTOMATION AND CONTROL SYSTEMS OF MAIN PROPULSION AND AUXILIARY MACHINERY	30	
2.3 MAINTENANCE AND REPAIR OF BRIDGE NAVIGATION EQUIPMENT AND SHIP COMMUNICATION SYSTEMS		
2.3.1 MAINTENANCE AND REPAIR OF BRIDGE NAVIGATION EQUIPMENT	45	
2.3.2 MAINTENANCE AND REPAIR OF SHIP COMMUNICATION SYSTEMS	15	

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of required performance
2.4 MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF DECK MACHINERY AND CARGO-HANDLING EQUIPMENT		
2.4.1 MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF DECK MACHINERY	15	
2.4.2 MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF CARGO HANDLING EQUIPMENT	20	
2.4.3 ELECTRICAL AND ELECTRONIC SYSTEMS OPERATING IN FLAMMABLE AREAS	15	
2.4.4 SAFETY AND EMERGENCY PROCEDURES	5	
2.5 MAINTENANCE AND REPAIR OF CONTROL AND SAFETY SYSTEMS OF HOTEL EQUIPMENT		
2.5.1 MAINTENANCE AND REPAIR OF CONTROL AND SAFETY SYSTEMS OF HOTEL EQUIPMENT	30	
Total for Function 2: Maintenance And Repair at Operational Level		**285**

Part C2: Detailed Teaching Syllabus

Introduction

The detailed teaching syllabus is presented as a series of learning objectives. The objective, therefore, describes what the trainee must do to demonstrate that the specified knowledge or skill has been transferred.

Thus each training outcome is supported by a number of related performance elements in which the trainee is required to be proficient. The teaching syllabus shows the *Required performance* expected of the trainee in the tables that follow.

In order to assist the instructor, references are shown to indicate IMO references and publications, textbooks and teaching aids that instructors may wish to use in preparing and presenting their lessons.

The material listed in the course framework has been used to structure the detailed teaching syllabus; in particular,

Teaching aids (indicated by A)
IMO references (indicated by R) and
Textbooks (indicated by T)

will provide valuable information to instructors.

Explanation of Information Contained in the Syllabus Tables

The information on each table is systematically organised in the following way. The line at the head of the table describes the FUNCTION with which the training is concerned. A function means a group of tasks, duties and responsibilities as specified in the STCW Code. It describes related activities which make up a professional discipline or traditional departmental responsibility on board.

In this Model course there are three functions:

Electrical, electronic and control engineering at the operational level,
Maintenance and repair at the operational level,
Controlling the operation of the ship and care for the persons on board at the operational level.

The header of the first column denotes the **COMPETENCE** concerned. Each function comprises a number of competences. For example, the Function 2, Maintenance and Repair at the Operational Level, comprises five COMPETENCES. These competences are uniquely and consistently numbered in this model course.

The first competence is **Maintenance and Repair of Electrical and Electronic Equipment**. It is numbered 2.1, that is the first competence in Function 2. The term 'competence' should be understood as the application of knowledge, understanding,

proficiency, skills, experience for an individual to perform a task, duty or responsibility on board in a safe, efficient and timely manner.

Shown next is the required TRAINING OUTCOME. The training outcomes are the areas of knowledge, understanding and proficiency in which the trainee must be able to demonstrate knowledge and understanding. Each COMPETENCE comprises a number of training outcomes. For example, the competence is **Maintenance and Repair of Electrical and Electronic Equipment** comprises a total of six training outcomes. The first is in SAFETY REQUIREMENTS FOR WORKING ON SHIPBOARD ELECTRICAL EQUIPMENT. Each training outcome is uniquely and consistently numbered in this model course. *Safety requirements for working on shipboard electrical equipment* is numbered 2.1.1. For clarity, training outcomes are printed in black on grey, for example TRAINING OUTCOME.

Finally, each training outcome embodies a variable number of Required performances – as evidence of competence. The instruction, training and learning should lead to the trainee meeting the specified Required performance.

Following each numbered area of Required performance there is a list of activities that the trainee should complete and which collectively specify the standard of competence that the trainee must meet. These are for the guidance of teachers and instructors in designing lessons, lectures, tests and exercises for use in the teaching process.

IMO references (Rx) are listed in the column to the right hand side. Teaching aids (Ax), videos (Vx) and textbooks (Tx) relevant to the training outcome and required performances are placed immediately following TRAINING OUTCOME.

lt is not intended that lessons are organised to follow the sequence of Required performances listed in the Tables. The Syllabus Tables are organised to match with the competence in the STCW Code Table A-III/6. Lessons and teaching should follow college practices. lt is not necessary, for example, for Safety Requirements for Working on Shipboard Electrical Equipment to be studied before Construction and Operation of Electrical Testing and Measuring Equipment. What is necessary is that all the material is covered and that teaching is effective to allow trainees to meet the standard of the Required performance.

Competence 2.1	Maintenance and Repair of Electrical and Electronic Equipment	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:

STCW Code Table A-III/6

2.1.1 SAFETY REQUIREMENTS FOR WORKING ON SHIPBOARD ELECTRICAL EQUIPMENT

2.1.2 MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEM EQUIPMENT, SWITCHBOARDS, ELECTRIC MOTORS, GENERATORS AND DC ELECTRICAL SYSTEMS AND EQUIPMENT

2.1.3 DETECTION OF ELECTRIC MALFUNCTION, LOCATION OF FAULTS AND MEASURES TO PREVENT DAMAGE

2.1.4 CONSTRUCTION AND OPERATION OF ELECTRICAL TESTING AND MEASURING EQUIPMENT

2.1.5 FUNCTION, CONFIGURATION AND PERFORMANCE TESTS OF MONITORING SYSTEMS, AUTOMATIC CONTROL DEVICES, PROTECTIVE DEVICES

2.1.6 THE INTERPRETATION OF ELECTRICAL AND ELECTRONIC DIAGRAMS

Competence 2.1	Maintenance and Repair of Electrical and Electronic Equipment	IIMO Reference

2.1.1 SAFETY REQUIREMENTS FOR WORKING ON SHIPBOARD ELECTRICAL EQUIPMENT

Textbooks: T10, T11, T12, T13

Teaching aids: A1, A2, A3, V1, V7

Required performance:

1.1 Safety Requirements for Working on Shipboard Electrical Equipment (15 hours)

- names safety hazards which can be present when working on shipboard electrical equipment: electric shock, arc blast, transient overvoltage, movable (rotating) parts, environmental factors like high temperature, humidity, water, fuel, steam leaks, rain, wind, ship rolling or pitching
- names and is able to select proper Personal Protective Equipment (PPE) to be used when working on various shipboard electrical equipment: coveralls, safety or insulation shoes, safety glasses or full face shield, insulation gloves, insulation mates, hearing protection equipment, safety harness, hard hat, rubber apron, dust mask
- describes overvoltage installation categories (IEC 1010-1 Standard)
- explains how to choose safe electric meter for different overvoltage categories
- explains Lockout - Tagout procedures
- explains Job Safety Analysis process, performs JSA for given electrical task
- explains how Work Permit System works
- explains use of fixed and portable earthing devices and how to apply them safely
- describes safety precautions when performing various maintenance or repair tasks on ship elevators, like releasing people trapped in elevator, checking of safety circuit and other safety functions, working with landing door open

2.1.2 MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEM EQUIPMENT, SWITCHBOARDS, ELECTRIC MOTORS, GENERATORS AND DC ELECTRICAL SYSTEMS AND EQUIPMENT

Textbooks: T27, T33, T41, T47, T51, T81, T82, T94

Teaching aids: A1, A2, A3, V1, V7

Required performance:

2.1 Maintenance and Repair of Electrical System Equipment, Switchboards, Electric Motors, Generator and DC Electrical Systems and Equipment (20 hours)

Competence 2.1	Maintenance and Repair of Electrical and Electronic Equipment	IIMO Reference

- describes the principle of major and periodic overhaul, periodic and daily maintenance, survey after damage with the use of technical documentation
- explains the principle of organization of maintenance , repairs and describes how to document maintenance, repairs and trials
- describes how to manage maintenance intervals, repairs and spare parts in the computer system (e.g. AMOS)
- explains principles of maintenance and repair of equipment installed in main switchboard, emergency switchboard and distribution panels with specific reference to:
  - circuit breakers
  - tripping devices
  - contactors
  - relays
  - thermal relays
  - fuses
  - busbars
  - terminal strips
  - measuring instruments
  - PLC controllers and monitoring panels
  - heating and ventilation circuits
- explains principles of maintenance and repair of generators with specific reference to:
  - generator winding condition
  - main exciter winding condition
  - bearings inspection
  - air filters and cleaning procedures
  - automatic voltage regulator inspection
  - exciter, rotating rectifier, varistor and residual voltage check
  - PMG (Permanent Magnet Generator)
  - main terminal connections
  - slip rings and brushes
- explains principles of maintenance and repair of the AC and DC electric motors with specific reference to:
  - motor bearings, windings and terminals
  - heating and cooling systems
  - couplings
  - electromagnetic brakes
  - starters
  - speed control systems
- explains principles of maintenance and repair of batteries of different types
- explains principles of maintenance and repair of frequency converters, rectifiers and backup-UPS
- explains principles of maintenance and repair of electronic tank content measuring systems
- explains principles of maintenance and repair of electronic diagnostic systems for testing diesel engine

Competence 2.1	Maintenance and Repair of Electrical and Electronic Equipment	IIMO Reference

2.1.3 DETECTION OF ELECTRIC MALFUNCTION, LOCATION OF FAULTS AND MEASURES TO PREVENT DAMAGE

Textbooks: T27, T33, T41, T47, T51, T67, T81, T82, T94

Teaching aids: A1, A2, A3, V1, V7

Required performance:

3.1 Detection of Electric Malfunction, Location of Faults and Measures to Prevent Damage (10 hours)

- explains the methods for detection of electrical failures, and describes needed measuring instruments and methods of their use
- explains how to find fault using electrical wiring diagrams
- on a given electrical circuit diagram ,carries out logical procedure to detect the location of an earth fault, using insulation testing instruments
- explains why fault protection is essential
- describes how to take measurement before and after the running of the device in order to determine its condition
- describes practical way how to take measurement after damage and repair
- explains principles of interpretation of measurement results

2.1.4 CONSTRUCTION AND OPERATION OF ELECTRICAL TESTING AND MEASURING EQUIPMENT

Textbooks: T48

Teaching aids: A1, A2, A3

Required performance:

4.1 Construction and Operation of Electrical Testing and Measuring Equipment (15 hours)

- explains construction and operation principle of analogue and digital instruments for basic electrical quantities measurements, as voltage, current, frequency, power, time and phase displacement
- explains basic rules for using and connection of instruments to the electrical circuit for measurement of voltage, current, frequency and power
- interprets the results from oscilloscope
- explains the construction and principle of operation of insulation tester, fixed and portable

Competence 2.1	Maintenance and Repair of Electrical and Electronic Equipment	IMO Reference

2.1.5 FUNCTION, CONFIGURATION AND PERFORMANCE TESTS OF MONITORING SYSTEMS, AUTOMATIC CONTROL DEVICES, PROTECTIVE DEVICES

Textbooks: T41, T47, T56, T60, T61, T75, T79

Teaching aids: A1, A2, A3, V9

Required performance:

5.1 Function, Configuration and Performance Tests of Monitoring Systems, Automatic Control Devices, Protective Devices (20 hours)

- explains how and why to connect simulators or calibrators in place of sensors to the terminals of PLC or other type of monitoring system
- explains the influence of capacity and resistivity of long cables on measurement accuracy
- explains the function of extension wires in the temperature measurement line with thermocouple
- prepares hard copy or/and electronic reports following computer maintenance programs
- explains the principle of using smart transducer as calibrator by programming via HHC (hand held communicator- HART protocol)
- explains the use of pressure calibrators
- explains the use of 4-20 mA calibrator
- explains the maintenance of fire detection systems

2.1.6 THE INTERPRETATION OF ELECTRICAL AND ELECTRONIC DIAGRAMS

Textbooks: T91

Teaching aids: A1, A2, A3

Required performance:

6.1 Graphic symbols (6 hours)

- draws up and explains the symbols of electric generators, motors, transformers
- draws up and explains the symbols of electrical apparatus: contacts, switches, breakers, relays, time-delay relays, thermal relays, contactors, signal lights, fuses
- draws up and explains the symbols of measurement sensors and electric measuring devices
- draws up and explains the symbols of lighting fixtures, switches, sockets, connection boxes,
- draws up and explains the symbols of electronic elements: diodes, bipolar transistors, thyristors (SCRs), GTOs, TRIACs, MOSFETs, IGBTs, IGCTs

Competence 2.1	Maintenance and Repair of Electrical and Electronic Equipment	IMO Reference

6.2 Diagrams (8 hours)

- explains the basic differences between the following electrical diagrams:
  - block
  - system
  - circuit
  - wiring (connection)
  - view (layout)

6.3 Technical documentation (6 hours)

- explains the contents of shipyard technical documentation
- explains the contents of operating manuals of ship equipment

6.4 Interpretation of diagrams (10 hours)

- correctly interprets examples of various types of diagrams

Competence 2.2	MAINTENANCE AND REPAIR OF AUTOMATION AND CONTROL SYSTEMS OF MAIN PROPULSION AND AUXILIARY MACHINERY	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-III/6
2.2.1 MAINTENANCE AND REPAIR OF AUTOMATION AND CONTROL SYSTEMS OF MAIN PROPULSION AND AUXILIARY MACHINERY	

Competence 2.2	MAINTENANCE AND REPAIR OF AUTOMATION AND CONTROL SYSTEMS OF MAIN PROPULSION AND AUXILIARY MACHINERY	IMO Reference

2.2.1 MAINTENANCE AND REPAIR OF AUTOMATION AND CONTROL SYSTEMS OF MAIN PROPULSION AND AUXILIARY MACHINERY

Textbooks: T27, T41, T51, T56, T82, T94

Teaching aids: A1, A2, A3, V9, V15, V17, V20, V22

Required performance:

1.1 Maintenance and Repair of Automation and Control Systems of Main Propulsion and Auxiliary Machinery (30 hours)

- explains principles of maintenance and repair of electrical, mechanical, pneumatic, hydraulic components and automation equipment of main propulsion and auxiliary machinery
- explains principles of maintenance and repair of PID controllers
- explains principles of maintenance and repair of actuators
- describes principle of controller optimal settings according to the Ziegler-Nichols rule and manual adjustment of controller according to observed control errors
- explains principles of maintenance and repair of propulsion remote control systems on the example of arbitrarily chosen standard, for example "Denis"
- explains principles of maintenance and repair of main propulsion with specific reference to:
  - power supply
  - mechanical installation
  - cabling and grounding
  - switchboards, terminal strips, connectors and cards replacement
  - indication lamps
  - ventilation, heat, ambient condition
  - RPM and pitch indication
  - overload indication
  - responsibility system
  - clutch remote control
  - RPM remote control
  - pitch remote control
  - back up control
  - alarms and control set points
  - outputs and inputs PLC
  - emergency stop and start
  - shutdown and slowdown
  - broken wire alarm
  - systems of reversing propeller shaft
  - tacho-generator
- explains principles of maintenance and repair of fuel temperature and viscosity automatic control system

Competence 2.2	MAINTENANCE AND REPAIR OF AUTOMATION AND CONTROL SYSTEMS OF MAIN PROPULSION AND AUXILIARY MACHINERY	IMO Reference

- explains principles of maintenance and repair of compressed air automatic control system
- explains principles of maintenance and repair of lubrication, fuel and cooling automatic control systems
- explains principles of maintenance and repair of variable pitch propeller control system
- explains principles of maintenance and repair of steam production automatic control system
- explains principles of maintenance and repair of ship refrigeration plants control systems: provision, refrigerated cargo holds and containers, air condition
- explains principles of maintenance and repair of the following engine auxiliary control systems: oil and fuel separators, sewage treatment plant, evaporator and osmotic fresh water generators, incinerators
- explains principles of maintenance and repair of steering gear control system

Competence 2.3	MAINTENANCE AND REPAIR OF BRIDGE NAVIGATION EQUIPMENT AND SHIP COMMUNICATION SYSTEMS	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-III/6
2.3.1 MAINTENANCE AND REPAIR OF BRIDGE NAVIGATION EQUIPMENT	
2.3.2 MAINTENANCE AND REPAIR OF SHIP COMMUNICATION SYSTEMS	

Competence 2.3	**MAINTENANCE AND REPAIR OF BRIDGE NAVIGATION EQUIPMENT AND SHIP COMMUNICATION SYSTEMS**	**IMO Reference**

2.3.1 MAINTENANCE AND REPAIR OF BRIDGE NAVIGATION EQUIPMENT

Textbooks: T18, T71, T87

Teaching aids: A1, A2, A3

Required performance:

1.1 Basics of Navigation (6 hours)

- gives definition of navigation
- defines basic navigational terms and their measuring units: latitude, longitude, position, speed, distance, bearing, heading, waypoint, track, cross track error
- describes the principle of navigation charts, basic information they contain and their various types: paper charts, electronic charts (Raster, ECDIS)
- names and describes various types of navigation: terrestrial (Dead Reckoning), celestial, radar, radio, satellite, inertial

1.2 Radars (9 hours)

- explains radar principle of operation
- names main components of radars and their location on board, describes their function
- draws up block diagram showing configuration of bridge radar system with interswitch
- explains how to find and use radar diagnostic functions and troubleshooting documentation
- explains how radar performance monitor works
- describes how to change magnetron assembly and tune the radar in after the repair
- describes periodic maintenance jobs for radar system
- explains definition, principle and terminology used in Automatic Radar Plotting Aids (ARPA)

1.3 Global Navigation Satellite Systems (4 hours)

- presents basic knowledge of operation, maintenance and troubleshooting of Global Navigation Satellite Systems
    - explains principle of operation of Global Navigation Satellite Systems: GPS, GLONASS, Galileo
    - names main components of GPS system on board and explains their functions
    - explains operation of DGPS system and its accuracy comparing to GPS
    - explains how GPS receiver is interfaced with other navigation equipment and how to test GPS output signals

Competence 2.3	MAINTENANCE AND REPAIR OF BRIDGE NAVIGATION EQUIPMENT AND SHIP COMMUNICATION SYSTEMS	IMO Reference

1.4 Inertial Navigation System (2 hours)

- presents basic knowledge of operation of inertial navigation system

1.5 Ship Compass Equipment (6 hours)

- presents basic knowledge of operation, maintenance and repairs of ship compass equipment:
  - explains principle of operation and names main components of gyro compass with spinning gyroscope
  - explains synchronization process and deviations of gyrocompass
  - describes periodic maintenance work required for gyrocompass with spinning gyroscope and other moving parts
  - explains principle of operation and names main components of Fiber Optic Gyrocompass (FOG) and Ring Laser Gyroscope (RLG)
  - explains how gyrocompass is interfaced to other navigation equipment on the bridge
  - explains principle of operation and names main components of magnetic compass with remote repeater system

1.6 Speed Logs (5 hours)

- presents basic knowledge of construction, operation, maintenance and troubleshooting of various speed logs:
  - Doppler Log System
  - Electromagnetic Log System
  - Pitometer Log System

1.7 Echosounder Systems (2 hours)

- presents basic knowledge of construction, operation, configuration, maintenance and troubleshooting of echosounder system

1.8 Marine Autopilots (6 hours)

- describes principle of operation
- presents various modes of operation
- presents an example of modern autopilot and its features

1.9 Voyage Data Recorders, Navigation Lights, Search Lights, Ship Horns and Sound Signal Systems, Wind Trackers (5 hours)

- describes basic knowledge of operation and periodic maintenance of Voyage Data Recorder
- presents basic knowledge of operation, maintenance and repair of Navigation Lights Control and Alarm System
- presents basic knowledge of operation, maintenance and troubleshooting of Search Lights and its Remote Control System
- presents basic knowledge of operation, maintenance and repair of ship Horns and Sound Signal Control System

Competence 2.3	MAINTENANCE AND REPAIR OF BRIDGE NAVIGATION EQUIPMENT AND SHIP COMMUNICATION SYSTEMS	IMO Reference

- presents basic knowledge of operation, configuration, maintenance and troubleshooting of wind tracker and its relative and true wind repeaters

2.3.2 MAINTENANCE AND REPAIR OF SHIP COMMUNICATION SYSTEMS

Textbooks: T19, T59

Teaching aids: Teaching aids: A1, A2, A3

Required performance:

2.1 Ship Communication Systems (15 hours)

- presents basic knowledge of frequency ranges used in marine communication and electromagnetic waves propagation for various frequencies
- draws up block diagram showing main components of receiving and transmitting lines of radio communication equipment
- describes various antenna types used in marine communication and their maintenance
- describes disturbances which can affect operation of ship communication systems
- explains meaning of GMDSS, describes its purpose and structure
- lists components of GMDSS and briefly describes their purpose, operation and maintenance: Inmarsat Sat C, NBDB telex terminal with MF/HF transceiver, DSC, NAVTEX, EPIRB, SART
- describes main and emergency power supply of ship communication systems, their maintenance and testing
- describes structure, range, operation and maintenance of Inmarsat Satellite Communication System
- describes structure, range, operation and maintenance of Iridium Satellite Telephone System
- describes structure, range, operation, testing and maintenance of Automatic Identification System (AIS)
- describes structure, range, operation, testing and maintenance of Long Range Identification and Tracking System (LRIT)
- describes structure, operation, testing and maintenance of Ship Security Alert System (SSAS)

Competence 2.4	MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF DECK MACHINERY AND CARGO-HANDLING EQUIPMENT	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-III/6
2.4.1 MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF DECK MACHINERY	
2.4.2 MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF CARGO HANDLING EQUIPMENT	
2.4.3 ELECTRICAL AND ELECTRONIC SYSTEMS OPERATING IN FLAMMABLE AREAS	
2.4.4 SAFETY AND MERGENCY PROCEDURES	

Competence 2.4	MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF DECK MACHINERY AND CARGO-HANDLING EQUIPMENT	IMO Reference

2.4.1 MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF DECK MACHINERY

Textbooks: T27, T41, T51, T82, T94

Teaching aids: A1, A2, A3, V24

Required performance:

1.1 Deck machinery (15 hours)

- explains principle of operation and names main components of electrical, electronic and control systems of deck machinery, with specific reference to:
  - mooring winches with manual and automatic control
  - windlasses with manual and automatic control
  - accommodation ladder winches
  - lifesaving boat winches
  - hatch covers winches
- explains principles of routine inspection, maintenance and repair of deck machinery equipment, with specific reference to:
  - power supply
  - cabling and grounding
  - switchboards, terminal strips, connectors
  - control panels
  - PLC outputs and inputs
  - electrical motors and brakes
  - power electronic converters
  - limit switches
  - safety devices
  - electric control of hydraulic pumps, motors, valves and brakes
  - ventilation, heating

2.4.2 MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF CARGO HANDLING EQUIPMENT

Textbooks: T27, T41, T47, T51, T82, T94

Teaching aids: A1, A2, A3

Required performance:

2.1 Deck cranes (5 hours)

- explains principle of operation and names main components of electrical, electronic and control systems of deck cranes, with specific reference to:

Competence 2.4	MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF DECK MACHINERY AND CARGO-HANDLING EQUIPMENT	IMO Reference

- single deck cranes
- double deck cranes
- gantry cranes

– explains principles of routine inspection, maintenance and repair of deck cranes equipment, with specific reference to:

- power supply (slip ring unit)
- cabling and grounding
- switchboards, terminal strips, connectors
- control panels
- portable controllers
- PLC outputs and inputs
- electrical motors and brakes
- power electronic converters
- limit switches
- safety devices
- electric control of hydraulic pumps, motors and brakes
- electric control of grabs, container spreaders and other cargo lifting facilities
- ventilation, heating

2.2 Reefer Containers (6 hours)

– explains principles of routine inspection, maintenance and repair of reefer containers

2.3 Cargo systems on tankers (9 hours)

– explains principle of operation and names main components of electrical, electronic and control systems of cargo systems on tankers, with specific reference to:
- cargo pumps with turbine, electric and hydraulic drive
- ballast pumps
- inert gas system
- cargo and ballast tanks level measuring and alarm systems
- cargo and ballast valves

– explains principles of routine inspection, maintenance and repair of cargo systems on tankers, with specific reference to:
- power supply
- cabling and grounding
- switchboards, terminal strips, connectors
- control panels
- PLC outputs and inputs
- safety devices
- electric motors
- power electronic converters
- electric control of hydraulic pumps and motors
- electric control of steam turbines
- electric control system of cargo and ballast valves
- ventilation and heating
- tank level measurement sensors and systems

Competence 2.4	MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF DECK MACHINERY AND CARGO-HANDLING EQUIPMENT	IMO Reference

2.4.3 ELECTRICAL AND ELECTRONIC SYSTEMS OPERATING IN FLAMMABLE AREAS

Textbooks: T27, T32, T34, T35, T36, T37, T38, T39, T40, T72

Teaching aids: A1, A2, A3, V6, V12, V25

Required performance:

3.1 Electrical and Electronic Systems Operating in Flammable Areas (15 hours)

- explains parameters of flammable substances as:
  - LEL, UEL
  - temperature class
  - split on groups and subgroups
- split hazardous area on zones or divisions
- explains explosion-proof type of protection of electrical equipment for gas-explosive area:
  - flameproof enclosures "d"
  - pressurized enclosures "px, py, pz"
  - powder filling "q"
  - oil immersion "o"
  - increased safety "e"
  - intrinsic safety "ia, ib, ic"
  - non-incendive "nA, nC, nL, nR, nP"
  - encapsulation "ma, mb, mc"
  - optical radiation "op is, op pr, op sh"
- explains explosion-proof type of protection of electrical equipment for dust-explosive area
- lists type of protection of non-electrical equipment
- explains rules of cabling running in hazardous area
- explains marking of explosionproof equipment
- describes principles of maintenance of electrical explosion-proof equipment
- explains meaning of IECEx, ATEX and North America approach
- explains meaning of Ex certificate

Competence 2.4	**MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF DECK MACHINERY AND CARGO-HANDLING EQUIPMENT**	**IMO Reference**

2.4.4 SAFETY AND EMERGENCY PROCEDURES

Textbooks: T38, T62

Teaching aids: A1, A2, A3

Required performance:

4.1 Safety And Emergency Procedures (5 hours)

- explains safety and emergency procedures during alarms:
  - fire
  - man over board (MOB)
  - abandon ship
- explains and describes permission to work and co-ordination of work for :
  - jobs in confined spaces
  - hot works
  - jobs carried out at height,
  - jobs in other hazardous areas hazardous area
  - another hazard
- describes duties of Safety Electrician and assisting person assigned for dangerous job, who is familiar with safety procedures in case of accident
- draws up a plan of carrying out exemplary dangerous job assigned by instructor

Competence 2.5	MAINTENANCE AND REPAIR OF CONTROL AND SAFETY SYSTEMS OF HOTEL EQUIPMENT	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-III/6
2.5.1 MAINTENANCE AND REPAIR OF CONTROL AND SAFETY SYSTEMS OF HOTEL EQUIPMENT	

Competence 2.5	**MAINTENANCE AND REPAIR OF CONTROL AND SAFETY SYSTEMS OF HOTEL EQUIPMENT**	**IMO Reference**

2.5.1 MAINTENANCE AND REPAIR OF CONTROL AND SAFETY SYSTEMS OF HOTEL EQUIPMENT

Textbooks: T15, T31

Teaching aids: A1, A2, A3

Required performance:

1.1 Elevators (8 hours)

- names main parts of ship elevator: shaft, pit, machinery room, electric motor with gearbox and brake, motor drive, car, counterweight, car door, landing doors, hoisting ropes with pulleys, overspeed governor, tachogenerator, control cabinet, cabin call system
- explains elevator working modes: normal, inspection, learning, priority, fire, hospital, luggage
- explains operation of elevator safety devices: safety circuit, emergency stops, car door light barrier and overcurrent protection, overspeed governor,
- describes maintenance procedures for main elevator components:
  - hoisting ropes and rope diverting pulleys
  - equipment in the elevator shaft
  - car with guides and car door
  - landing doors
  - electric motor with gearbox and cooling fan
- motor drive and control cabinet
- describes use of elevator diagnostic system for troubleshooting and repairs
- explains operation, testing and repair of elevator trap alarm or intercom

1.2 Galley Equipment (6 hours)

- describes power supply circuits for galley equipment and harsh environmental conditions this equipment is subject to
- describes operation, maintenance and repairs of typical hot equipment used in ship galleys, e.g. hot plates, deep fat fryers, ovens, grills, food warmers, soup cattles, pressure cookers
- describes operation, maintenance and repairs of typical cold equipment used in ship galleys, e.g. grinders, mixers, cutters
- describes operation, maintenance and repairs of dishwashing machines

1.3 Laundry equipment (5 hours)

- describes operation, maintenance and repairs of typical heavy duty washing machines used on ships with bigger number of crew or passengers (e.g. cruise ships or ferries)
- describes operation, maintenance and repairs of tunnel washer system
- describes operation, maintenance and repairs of automatic ironing and folding machines

Competence 2.5	MAINTENANCE AND REPAIR OF CONTROL AND SAFETY SYSTEMS OF HOTEL EQUIPMENT	IMO Reference

1.4 Hotel safety and alarm systems (6 hours)

- describes structure and operation of advanced Fire Detection and Control System installed on ships with bigger number of crew or passengers (e.g. cruise ships or ferries)
- describes maintenance, diagnostics and repairs of selected example of advanced Fire Detection and Control System
- describes operation, maintenance and repairs of Hospital Call System
- describes operation, maintenance and repair of cold room trap alarms

1.5 Hotel lighting systems (5 hours)

- presents structure of advanced lighting systems installed on ships with bigger number of crew or passengers (e.g. cruise ships or ferries) – main lighting, emergency lighting, sign lighting, effect (decoration) lighting
- describes methods of remote control of advanced lighting systems and their programming with emphasis on energy saving
- describes main features of various types of lights used in modern advanced lighting systems.

Part D2: Instructor's Manual

Function 2 - Maintenance and Repair at the Operational Level

▪ Guidance Notes

The following notes are intended to high light the main objectives or training outcomes of each part of the function. The notes also contain some material on topics which are not adequately covered in the quoted references.

Before tackling the parts of this function concerned with maintenance the trainees must be competent in the use of hand tools and power tools.

Trainees will acquire practical skills and gain experience in:
- the maintenance of machine tools to ensure that they are kept in good working order and ready for use;
- selecting appropriate machine tools for any given task;
- using safe working practices at all times (dismantling procedures, use of lifting gear, inspection techniques testing and test running);
- using and wearing correct protective clothing and equipment.

Function 2 - Maintenance and Repair at the Operational Level

These notes have been included to provide additional information where appropriate.

2.1 MAINTENANCE AND REPAIR OF ELECTRICAL AND ELECTRONIC EQUIPMENT

In this function trainee will acquire skills and gain experience in:

2.1.1 SAFETY REQUIREMENTS FOR WORKING ON SHIPBOARD ELECTRICAL EQUIPMENT 15 hours

Training in this topic provides knowledge of:
- various safety hazards present when working on shipboard electrical equipment
- Personal Protective Equipment (PPE)
- Work Permit System and Lockout – Tagout procedures
- elevators maintenance and repair safety

2.1.2 MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEM EQUIPMENT, SWITCHBOARDS, ELECTRIC MOTORS, GENERATOR AND DC ELECTRICAL SYSTEMS AND EQUIPMENT 20 hours

The training in this topic provides basic knowledge of:
- types, periods of maintenance and repair and their organization
- maintenance and repair of generators and electric motors
- maintenance and repair of switchboards and their equipment

- maintenance and repair of DC electrical systems and their equipment
- maintenance of batteries

2.1.3 DETECTION OF ELECTRIC MALFUNCTION, LOCATION OF FAULTS AND MEASURES TO PREVENT DAMAGE 10 hours

The training in this topic provides basic knowledge of:

- methods of the detection of malfunction of electrical equipment and electrical systems
- detection of electric malfunction, location of faults and measures to prevent damage
- construction and operation of electrical testing and measuring equipment
- carrying out preventive measure against damage
- interpretation of measurement results

2.1.4 CONSTRUCTION AND OPERATION OF ELECTRICAL TESTING AND MEASURING EQUIPMENT 15 hours

The training in this topic provides basic knowledge of:

- fixed instruments, digital and analogue:
  - voltmeters (AC, DC)
  - ammeters (AC, DC)
  - frequency meter
  - wattmeter
  - VAR meter
  - cosϕ meter
  - synchroscope
- portable multimeter
- portable insulation tester
- oscilloscope

2.1.5 FUNCTION, CONFIGURATION AND PERFORMANCE TESTS OF MONITORING SYSTEMS, AUTOMATIC CONTROL DEVICES, PROTECTIVE DEVICES 20 hours

The training in this topic provides basic knowledge of:

- calibrators, simulators, validators of temperature sensors (Pt-100, THC)
- pressure calibrators
- inspection, troubleshooting, reparation, calibration and configuration of measurement and control lines in the distributed monitoring and control systems (temperature, pressure, level, voltage, current, frequency, etc.)
- configuration of smart or intelligent transducers
- inspection of the fire-detection systems
- span gas

2.1.6 THE INTERPRETATION OF ELECTRICAL AND ELECTRONIC DIAGRAMS 30 hours

The training in this topic provides basic knowledge of:
- electrical and electronic graphic symbols used in the diagrams
- types of electrical and electronic diagrams
- technical documentation of ship equipment and machinery
- methods of interpretation of electrical and electronic diagrams

2.2 MAINTENANCE AND REPAIR OF AUTOMATION AND CONTROL SYSTEMS OF MAIN PROPULSION AND AUXILIARY MACHINERY

2.2.1 MAINTENANCE AND REPAIR OF AUTOMATION AND CONTROL SYSTEMS OF MAIN PROPULSION AND AUXILIARY MACHINERY 30 hours

The training in this topic provides basic knowledge of:
- principles of maintenance and repair of main propulsion and auxiliary machinery automation elements
- principles of maintenance and repair of control systems with PID controller and PID controllers
- principles of maintenance and repairs and maintenance periods of main propulsion automation control systems
- principles of maintenance and repairs and maintenance periods of auxiliary machinery automation

2.3 MAINTENANCE AND REPAIR OF BRIDGE NAVIGATION EQUIPMENT AND SHIP COMMUNICATION SYSTEMS

2.3.1 MAINTENANCE AND REPAIR OF BRIDGE NAVIGATION EQUIPMENT 45 hours

Training in this topic provides basic knowledge of navigation and next construction, function and diagnostics of various bridge navigation equipment useful during its maintenance and repairs: Radars, Automatic Radar Plotting Aids (ARPA), Navigation Satellite Systems, Gyrocompasses, Speed Logs, Autopilots, Echosounders, ECDIS, Voyage Data Recorders, Wind Trackers, Navigation Lights, Horns, Searchlights

2.3.2 MAINTENANCE AND REPAIR OF SHIP COMMUNICATION SYSTEMS 15 hours

Training in this topic provides basic knowledge of radio frequencies used in marine communication, disturbances affecting radio communication, construction and function of ship communication equipment useful for its maintenance and repairs:

- GMDSS Equipment (Inmarsat Sat C, NBDB terminal with MF/HF transceiver, DSC, NAVTEX, EPIRB, SART)
- Satellite Communication Equipment (Inmarsat, Iridium)
- Automatic Identification Systems (AIS, LRIT)
- Ship Security Alert System (SSAS)

2.4 MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF DECK MACHINERY AND CARGO-HANDLING EQUIPMENT

2.4.1 MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF DECK MACHINERY 15 hours

The training in this topic provides the basic knowledge of maintenance and repair of the deck machinery electrical, electronic and control systems, with specific reference to:

- mooring winches with manual and automatic control
- windlasses with manual and automatic control
- accommodation ladder winches
- lifesaving boat winches
- hatch covers winches

2.4.2 MAINTENANCE AND REPAIR OF ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS OF CARGO HANDLING EQUIPMENT 20 hours

The training in this topic provides basic knowledge of maintenance and repair of electrical, electronic and control systems of cargo handling equipment, with specific reference to:

- deck cranes
- gantry cranes
- reefer containers
- cargo handling equipment on tankers:
    - cargo pumps
    - ballast pumps
    - inert gas system
    - cargo and ballast tanks levels measuring and alarm systems
    - cargo and ballast valves

2.4.3 ELECTRICAL AND ELECTRONIC SYSTEMS OPERATING IN FLAMMABLE AREAS — 15 hours

The training in this topic provides basic knowledge of:
- recognizing of hazardous area (gas, dust)
- types of explosion proof protection for electrical equipment
- operation and maintenance of electrical equipment in hazardous area
- IECEX versus ATEX and North America approach
- certificate Ex

2.4.4 SAFETY AND EMERGENCY PROCEDURES — 5 hours

The training in this topic provides basic knowledge of:
- safety procedures during fire, MOB and abandon ship alarms
- work permit system for jobs in hazardous areas
- proper planning and coordination of dangerous jobs from safety point of view

2.5 MAINTENANCE AND REPAIR OF CONTROL AND SAFETY SYSTEMS OF HOTEL EQUIPMENT

2.5.1 MAINTENANCE AND REPAIR OF CONTROL AND SAFETY SYSTEMS OF HOTEL EQUIPMENT — 30 hours

Training in this topic provides basic knowledge of construction and function of various hotel equipment useful for its maintenance and repairs:
- elevators
- galley equipment
- laundry equipment
- alarm and safety systems like Fire Detection and Control System, hospital call system, cold rooms trap alarm
- hotel lighting systems

Electro-Technical Officer
Function 3:
Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level

Electro-Technical Officer
Function 3: Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level
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Part B3: Course Outline

Function 3 - Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level

Timetable

No formal example of a timetable is included in this model course.

Development of a detailed timetable depends on the level of skills of the trainees entering the course and the amount of revision work of basic principles that may be required.

Lecturers must develop their own timetable depending on:

- the level of skills of trainees
- the numbers to be trained
- the number of instructors

and normal practices at the training establishment.

Preparation and planning constitute an important factor which makes a major contribution to the effective presentation of any course of instruction.

Lectures

As far as possible, lectures should be presented within a familiar context and should make use of practical examples. They should be well illustrated with diagrams, photographs and charts where appropriate, and be related to matter learned during seagoing time.

An effective manner of presentation is to develop a technique of giving information and then reinforcing it. For example, first tell the trainees briefly what you are going to present to them; then cover the topic in detail; and, finally, summarize what you have told them. The use of an overhead projector and the distribution of copies of the transparencies as trainees hand-outs contribute to the learning process.

Course outline

The tables that follow list the competencies and areas of knowledge, understanding and proficiency, together with the estimated total hours required for lectures and practical exercises. Teaching staff should note that timings are suggestions only and should be adapted to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

COURSE OUTLINE

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of required performance

Competence:

3.1 ENSURE COMPLIANCE WITH POLLUTION PREVENTION REQUIREMENTS

3.1.1	THE PRECAUTIONS TO BE TAKEN TO PREVENT POLLUTION OF THE MARINE ENVIRONMENT		
	.1 MARPOL 73/78	2	2
3.1.2	ANTI-POLLUTION PROCEDURES AND ASSOCIATED EQUIPMENT		
	.1 Regulation 26 – Annex 1 MARPOL 73/78	2	
	.2 Anti-Pollution Equipment	1	3
3.1.3	IMPORTANCE OF PROACTIVE MEASURES	2	2

3.2 PREVENT CONTROL AND FIGHT FIRE ON BOARD

See IMO Model Course No 2.03 and STCW 2010 Regulation VI/3

3.3 OPERATE LIFE-SAVING APPLIANCES

See IMO Model Course No 1.23 and STCW 2010 Regulation VI/2 paragraph 1-2

3.4 APPLY MEDICAL FIRST AID ON BOARD SHIP

See IMO Model Course No 1.14 and STCW 2010 Regulation VI/4 paragraph 1-3

3.5 APPLICATION OF LEADERSHIP AND TEAMWORKING SKILLS

3.5.1	INTRODUCTION TO MANAGEMENT	2	
3.5.2	RELATED CONVENTIONS AND NATIONAL LEGISLATIONS	2	
3.5.3	APPLIES TASK AND WORKLOAD MANAGEMENT	10	
3.5.4	APPLIES EFFECTIVE RESOURCE MANAGEMENT AND DECISION MAKING	10	24

3.6 CONTRIBUTE TO THE SAFETY OF PERSONNEL AND SHIP

3.6.1 KNOWLEDGE OF PERSONAL SURVIVAL TECHNIQUES

See STCW 2010 Regulation A-VI/1 paragraph 2

3.6.2 KNOWLEDGE OF FIRE PREVENTION AND ABILITY TO FIGHT AND EXTINGUISH FIRES

See STCW 2010 Regulation A-VI/1 paragraph 2

3.6.3 KNOWLEDGE OF ELEMENTARY FIRST AID

See STCW 2010 Regulation A-VI/1 paragraph 2

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of required performance
3.6.4 KNOWLEDGE OF PERSONAL SAFETY AND SOCIAL RESPONSIBILITIES		
See STCW 2010 Regulation A-VI/1 paragraph 2		
Total for Function 3: Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level		**31**

Part C3: Detailed Teaching Syllabus

Introduction

The detailed teaching syllabus is presented as a series of learning objectives. The objective, therefore, describes what the trainee must do to demonstrate that the specified knowledge or skill has been transferred.

Thus each training outcome is supported by a number of related performance elements in which the trainee is required to be proficient. The teaching syllabus shows the *Required performance* expected of the trainee in the tables that follow.

In order to assist the instructor, references are shown to indicate IMO references and publications, textbooks and teaching aids that instructors may wish to use in preparing and presenting their lessons.

The material listed in the course framework has been used to structure the detailed teaching syllabus; in particular,

Teaching aids (indicated by A)
IMO references (indicated by R) and
Textbooks (indicated by T)

will provide valuable information to instructors.

Explanation of Information Contained in the Syllabus Tables

The information on each table is systematically organised in the following way. The line at the head of the table describes the FUNCTION with which the training is concerned. A function means a group of tasks, duties and responsibilities as specified in the STCW Code. It describes related activities which make up a professional discipline or traditional departmental responsibility on board.

In this Model course there are three functions:

Electrical, electronic and control engineering at the operational level,
Maintenance and repair at the operational level,
Controlling the operation of the ship and care for the persons on board at the operational level.

The header of the first column denotes the **COMPETENCE** concerned. Each function comprises a number of competences. For example, the Function 3, Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level, comprises a number of COMPETENCES. Each competence is uniquely and consistently numbered in this model course.

In this function the competence **is Ensure compliance with pollution prevention requirements**. It is numbered 3.1, that is the first competence in Function 3. The term competence should be understood as the application of knowledge, understanding,

proficiency, skills and experience for an individual to perform a task, duty or responsibility on board in a safe, efficient and timely manner.

Shown next is the required TRAINING OUTCOME. The training outcomes are the areas of knowledge, understanding and proficiency in which the trainee must be able to demonstrate knowledge and understanding. Each COMPETENCE comprises a number of training outcomes. For example, the above competence comprises two training outcomes.

The first is concerned with the PRECAUTIONS TO BE TAKEN TO PREVENT POLLUTION OF THE MARINE ENVIRONMENT. Each training outcome is uniquely and consistently numbered in this model course. That concerned with precautions to be taken to prevent pollution of the marine environment is 4.1.1. For clarity training outcomes are printed in black on grey, for example TRAINING OUTCOME.

FinaIly, each training outcome embodies a variable number of Required performances – as evidence of competence. The instruction, training and learning should lead to the trainee meeting the specified Required performance. For the training outcome concerned with precautions to be taken to prevent pollution of the marine environment, there is just one area of performance. This is:

3.1.1.1 MARPOL 73/78

Following each numbered area of Required performance there is a list of activities that the trainee should complete and which collectively specify the standard of competence that the trainee must meet. These are for the guidance of teachers and instructors in designing lessons, lectures, tests and exercises for use in the teaching process. For example, under the topic 3.1.1.1, to meet the Required performance, the trainee should be able to:

- define for the purpose of MARPOL 73/78: a harmful substance, a discharge, and ship and an incident
- state that violations of the Convention are prohibited and that sanctions should be established for violations
- describe the inspections which may be made by port state authorities and outlines actions which they may take

and so on.

lMO references (Rx) are listed in the column to the right hand side. Teaching aids (Ax), videos (Vx) and textbooks (Tx) relevant to the training outcome and required performances are placed immediately following TRAINING OUTCOME title.

lt is not intended that lessons are organised to follow the sequence of Required performances listed in the Tables. The Syllabus Tables are organised to match with the competence in the STCW Code Table A-lll/6. Lessons and teaching should follow college practices. lt is not necessary, for example, for anti-pollution procedures and associated equipment to be studied before the precautions to be taken to prevent pollution of the marine environment. What is necessary is that all the material is covered and that teaching is effective to allow trainees to meet the standard of the Required performance.

Competence 3.1	**ENSURE COMPLIANCE WITH POLLUTION PREVENTION REQUIREMENTS**	**IMO Reference**

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-III/1
3.1.1 THE PRECAUTIONS TO BE TAKEN TO PREVENT POLLUTION OF THE MARINE ENVIRONMENT	
3.1.2 ANTI-POLLUTION PROCEDURES AND ASSOCIATED EQUIPMENT	
3.1.3 IMPORTANCE OF PROACTIVE MEASURES	

Competence 3.1	ENSURE COMPLIANCE WITH POLLUTION PREVENTION REQUIREMENTS	IMO Reference

3.1.1 THE PRECAUTIONS TO BE TAKEN TO PREVENT POLLUTION OF THE MARINE ENVIRONMENT

Textbooks: T13, T35,

Teaching aids: A1, A2,

Required performance:

International Convention for the Prevention of Pollution from Ships, 1973, and the Protocol of 1978 relating thereto (MARPOL 73/78) (2 hours)

– defines, for the purpose of MARPOL 73/78:
  - harmful substance
  - discharge
  - ship
  - incident

R3

– states that violations of the Convention are prohibited and that sanctions should be established for violations, wherever they occur, by the Administration of the ship concerned

– describes the inspections which may be made by port State authorities and outlines actions which they may take

– describes the provisions for the detection of violations and enforcement of the Convention

– states that reports on incidents involving harmful substances must be made without delay

Annex I – Oil

– states that the condition of the ship and its equipment should be maintained to conform with the provisions of the Convention

– states the conditions under which oily mixtures may be discharged into the sea from an oil tanker

– states the condition under which oily mixtures from machinery -space bilges may be discharged into the sea

– explains the conditions under which the provisions do not apply to the discharge of oily mixtures from machinery spaces where the oil content without dilution does not exceed 15 parts per million

Competence 3.1	ENSURE COMPLIANCE WITH POLLUTION PREVENTION REQUIREMENTS	IMO Reference

Annex II – Noxious Liquid Substances in Bulk

- explains that noxious liquid chemicals are divided into four categories, A, B, C, D, such that substances in category A pose the greatest threat to the marine environment and those in category D the least — R3

Annex III – Harmful Substances Carried by Sea in Packaged Forms, or in Freight Containers, Portable Tanks or Road and Rail Tank Wagons

- states that for the purpose of this annex, empty receptacles, freight containers and portable road and rail tank wagons which have been used previously for the carriage of harmful substances are treated as harmful substances themselves unless precautions have been taken to ensure that they contain no residue that is hazardous to the marine environment — R3

Annex IV – Sewage — R3

- describes the provisions regarding the discharge of sewage into the sea

Annex V – Garbage

- states that the disposal into the sea of all plastics is prohibited

3.1.2 ANTI-POLLUTION PROCEDURES AND ASSOCIATED EQUIPMENT — R3

Textbooks:

Teaching aids: A1, A2

Required performance:

2.1 Basic knowledge of Regulation 26 Annex I MARPOL 73/78

- describes the key points in a typical shipboard oil pollution emergency plan

2.2 Basic knowledge of anti-pollution equipment required by national legislation

- for example, lists that equipment required under OPA 90 of the United States

Competence 3.1	**ENSURE COMPLIANCE WITH POLLUTION PREVENTION REQUIREMENTS**	**IMO Reference**

3.1.3 IMPORTANCE OF PROACTIVE MEASURES

R3

Textbooks:

Teaching aids: A1, A3

Required performance:

– describes the importance of proactive measures to protect the marine environment in terms of compliance with the concerning international and national laws or regulations
– describes the responsibilities of master, officer and rating each on board for protecting the marine environment
– describes the impacts on marine environment brought about by pollution substances
– explains what tasks concerning pollution substances are carried out on board ships
– lists actual proactive measures to be taken on board ships when:
  - bunkering
  - transferring oil and other pollution substances
  - disposing of waste

Competence 3.2	PREVENT CONTROL AND FIGHT FIRE ON BOARD	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Section A-VI/3
3.2.1 FIRE PREVENTION	
3.2.2 ORGANISING FIRE DRILLS	
3.2.3 CHEMISTRY OF FIRE	
3.2.4 FIRE-FIGHTING SYSTEMS	
3.2.5 THE ACTION TO BE TAKEN IN THE EVENT OF FIRE, INCLUDING FIRES INVOLVING OIL	
See IMO Model Course No 2.03 and the requirements of STCW Table A-VI/3 for Competence in Advanced Fire Fighting	STCW Code Table A-VI/3

Competence 3.3	Operate Life-saving Appliances	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:

3.3.1	ORGANIZING ABANDON SHIP DRILLS AND THE OPERATION OF SURVIVAL CRAFT AND RESCUE BOATS, THEIR LAUNCHING APPLIANCES AND ARRANGEMENTS, THEIR EQUIPMENT, INCLUDING RADIO-LIFE-SAVING APPLIANCES, SATTELITE EPIRBs, SARTs, IMMERSION SUITS AND THERMAL PROTECTIVE AIDS	STCW Code Section A-VI/2 Paragraph 1-2
3.3.2	SURVIVAL AT SEA TECHNIQUES	
See IMO Model Course No 1.23 and the requirements of STCW Table A-VI/2-1 for Competence in Survival Craft and Rescue Boats other than Fast Rescue Boats		STCW Code Table A-VI/2-1

Competence 3.4	Apply Medical First Aid on Board Ship	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Section A-VI/4 Paragraph 1-6
3.4.1 PRACTICAL APPLICATION OF MEDICAL GUIDES AND ADVICE BY RADIO, INCLUDING THE ABILITY TO TAKE EFFECTIVE ACTION BASED ON SUCH KNOWLEDGE IN THE CASE OF ACCIDENTS OR ILNESSES THAT ARE LIKELY TO OCCUR ON BOARD THE SHIP	
See IMO Model Course No 1.14 and the requirements of STCW Table A-VI/4-1 for Proficiency in Medical First Aid	STCW Code Table A-VI/4

Competence 3.5	APPLICATION OF LEADERSHIP AND TEAMWORKING SKILLS	IMO Reference

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-III/6
3.5.1 INTRODUCTION TO MANAGEMENT	
3.5.2 RELATED CONVENTIONS AND NATIONAL LEGISLATION	
3.5.3 APPLIES TASK AND WORKLOAD MANAGEMENT	
3.5.4 APPLIES EFFECTIVE RESOURCE MANAGEMENT AND DECISION MAKING	

Competence 3.5	APPLICATION OF LEADERSHIP AND TEAMWORKING SKILLS	IMO Reference

3.5.1 INTRODUCTION TO MANAGEMENT

Textbooks:

Teaching aids: V13, V14

Required performance:

1.1 Introduction to Management (2 hours)

– defines the term "Management"
– describes the following management activities:
  - Planning
  - Organizing and Staffing
  - Directing
  - Controlling
– describes the roles of company's objectives and goals
– describes the management policy with respect to ships
– describes managerial issues on:
  - Operations
  - Finance
  - Communications
– describes the company's expectations for ship's officers

3.5.2 RELATED CONVENTIONS AND NATIONAL LEGISLATION

Textbooks:

Teaching aids: R1

Required performance:

2.1 Related Conventions and National Legislation (2 hours)

– Explains objectives and aims of the Maritime Labour Convention, 2006 (MLC)
– Describes outlines of the relevant provisions in the MLC concerning conditions of employment, and compliance and enforcement
– Describes the relevant provisions in the STCW Convention and Code concerning responsibilities of seafarers and shipping industries, and fitness for duties for working on shipboard tasks
– Explains what national legislations concerned they have and how the legislations are implemented, referring to relevant regulations/recommendations

Competence 3.5	APPLICATION OF LEADERSHIP AND TEAMWORKING SKILLS	IMO Reference

3.5.3 APPLIES TASK AND WORKLOAD MANAGEMENT

Textbooks:

Teaching aids:

Required performance:

3.1 Applies Task and Workload Management (10 hours)

– describes the following types of planning:
  - Long—range planning
  - Intermediate planning
  - Short—range planning
– explains the importance of planning and use of resources for executing a job
– describes the following activities in the planning process:
  - Official goals
  - Development of plans
  - Preparation of detailed plans
  - Preparation of budgets
– describes the following essential steps to make planning effective:
  - Using established techniques
  - Participative planning
  - Communication with subordinates
  - Simplicity of plans
  - Flexibility of plans
  - Monitoring of implemented activities
– describes the following barriers to planning:
  - Environment of the organization
  - Reluctance to establish goals
  - Inadequate reward system
  - Resistance to change
  - Time and expense
– describes the following techniques that can be used to overcome the barriers to a planning process:
  - Support from upper management
  - Communication to all
  - Participation of all members
  - Review and updates of plans
  - Sharing of information
– describes the following:
  - Decision making under certainty
  - Decision making under risk
  - Decision making under uncertainty
– describes the following basic elements of organizational structure:
  - Work specialization based
  - Departmentation
  - Pattern of authority

Competence 3.5	APPLICATION OF LEADERSHIP AND TEAMWORKING SKILLS	IMO Reference

- Span of control
- Coordination of activities

– describes the following three sets of employee behaviours:
- Participation
- Effort
- Performance

– describes the typical traits of the following personality types:
- Risk takers
- Authoritarian
- Dogmatic
- Focus of control
- Tolerant of ambiguity
- Machiavellianism
- Self—Monitoring

– describes motivation and explains why is it important in an organization
– defines "goal" and explains the functions of goals
– describes the role of the following attributes of goals, in success achieving goals:
- Specificness of goals
- Goal difficulty
- Goal acceptance

3.5.4 APPLIES EFFECTIVE RESOURCE MANAGEMENT AND DECISION MAKING

Textbooks:

Teaching aids:

Required performance:

4.1 Applies Effective Resource Management and Decision Making
(10 hours)

– defines "communication"
– describes the importance of the following functions of the communication process:
- Information
- Motivation
- Control
- Emotion

– describes the process of communication with regards to the following:
- Encoder
- Transmitter
- Receiver
- Decoder

– describes the following common causes of failure of communication:
- Noise
- Distraction
- Misrepresentation
- Information retention
- Stereotyping the sender

Competence 3.5	APPLICATION OF LEADERSHIP AND TEAMWORKING SKILLS	IMO Reference

– demonstrates the ability to "effectively communicate" (Oral, Written & Non - Verbal) with others
– interprets and carry out verbal instructions
– describes the following types of leaders:
  - Transactional leaders
  - Transformational leaders
  - Democratic leaders
  - Autocratic leaders
– explains the following types of leader ship behaviours:
  - Directive leadership
  - Supportive leadership
  - Participative leadership
  - Achievement－oriented leadership
– describes the following factors that influence the way the leaders' behaviour affects subordinates' response:
  - Job pressure
  - Job satisfaction
  - Subordinates' need for information
  - Subordinates' expectations
– describes the following stages of a group development:
  - Membership
  - Sub-grouping
  - Confrontation
  - Individual differentiation
  - Collaboration
– describes and elaborates on the process of group meeting management, with regards to the following:
  - Defining the group assignment
  - Planning the group effort
  - Organizing and staffing the committee
  - Direct and control the committee
– describes the following sources of organizational conflict:
  - Task interdependence
  - Goal incompatibility
  - Shared resources
  - Departmental differences
  - Uncertainty
  - Reward system
– describes the following techniques for preventing group conflicts:
  - Organization goals over unit goals
  - Predictable and stable task structure
  - Efficient interdepartmental communication
  - Avoid "win-lose" situations
– describes how some of the following techniques may be ineffective in managing group conflicts:
  - No action
  - Delayed action
  - Secrecy
– describes the use of stringent rules and regulations to resolve conflicts

Competence 3.5	APPLICATION OF LEADERSHIP AND TEAMWORKING SKILLS	IMO Reference

– describes the process and importance of control systems to an organization
– describes the following activities in the control process:
  - Monitoring the environment
  - Determining direction
  - Assessing ongoing operations
  - Assessing the control system
– describes the following five stages of problem solving:
  - Define the problem
  - Generate alternatives
  - Evaluate and choose
  - Implement decision
  - Control decision
– describes the methods of identify and consider generated option
– describes the difference between formal and personal authority and discuss how/when to best exercise each type
– compares and contrasts between "Large" and "Small" power distance culture within different nationalities
– describes the importance of pre－planning whenever carrying out major and/or critical jobs
– describes the importance of carryout situation and risk assessment before commencing major operation
– describes the concept of delegation and it's benefits
– describes & analyses some important factors that may affect group behaviour, discipline and the amount of work done by the crew
– describes an efficient method of establishing an open communication style on board that encourages challenges and appropriate responses from the team
– describes the need for evaluation of outcomes effectiveness

Competence 3.6	**CONTRIBUTE TO THE SAFETY OF PERSONNEL AND SHIP**	**IMO Reference**

TRAINING OUTCOMES

Demonstrates a knowledge and understanding of:	STCW Code Table A-VI/1 paragraph 2
3.6.1 KNOWLEDGE OF PERSONAL SURVIVAL TECHNIQUES See IMO Model Course 1.19, and the requirements of STCW Code Table A-VI/1-1 for Competence in personal survival techniques	STCW Code Table A-VI/1-1
3.6.2 KNOWLEDGE OF FIRE PREVENTION AND ABILITY TO FIGHT AND EXTINGUISH FIRES See IMO Model Course 1.20, and the requirements of STCW Code Table A-VI/1-2 for Competence in fire prevention and fire fighting	STCW Code Table A-VI/1-2
3.6.3 KNOWLEDGE OF ELEMENTARY FIRST AID See IMO Model Course 1.13, and the requirements of STCW Code Table A-VI/1-3 for Competence in elementary first aid	STCW Code Table A-VI/1-3
3.6.4 KNOWLEDGE OF PERSONAL SAFETY AND SOCIAL RESPONSIBILITIES See IMO Model Course 1.21, and the requirements of STCW Code Table A-VI/1-4 for Competence in personal safety and social responsibility	STCW Code Table A-VI/1-4

Part D3: Instructor's Manual

Function 2 – Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level

▪ Guidance Notes

The following notes are intended to high light the main objectives or training outcomes of each part of the function. The notes also contain some material on topics which are not adequately covered in the quoted references.

Trainees will be aware of the need and the practical measures required by law to prevent pollution of the environment. They will understand the requirements of MARPOL 73/78, (R3) the technical annexes, control of oil from machinery spaces and the Oil Record Book (Part 1).

Function 3 – Controlling the Operation of the Ship and Care for Persons on Board at Operational Level

Training concerned with Advanced Training in Fire-fighting is covered in lMO model course 2.O3.

Training concerned with proficiency in survival craft and rescue boats other than fast rescue boats is covered in IMO model course 1.23.

Training concerned with proficiency in medical first aid on board ship is covered in lMO model course 1.14.

3.1 ENSURE COMPLIANCE WITH POLLUTION-PREVENTION REQUIREMENTS

In this function trainee will acquire skills and gain experience in:

3.1.1 THE PRECAUTIONS TO BE TAKEN TO PREVENT POLLUTION OF THE MARINE ENVIRONMENT — 2 hours

Prevention of Pollution
In implementing this section of the course, the instructor should bear in mind that any officer aboard tankers will have completed a tanker familiarization course which should include the relevant requirements on pollution prevention related to tanker operations. This section is intended to provide outline knowledge of the MARPOL Convention. ln the following sections, detailed treatment should be confined to those requirements of the Convention which apply to all ships (V1, V2).

MARPOL technical annexes
The annexes set out the rules for the construction and equipment of ships and for ships' operations which may result in marine pollution.

3.1.2 ANTI-POLLUTION PROCEDURES AND ASSOCIATED EQUIPMENT 3 hours

Annex I

Oil is defined in Annex I as any mineral oil and includes petrochemical products other than those listed in Annex II.

Compliance with construction and equipment requirements is enforced through the International Oil Pollution Prevention (IOPP) Certificate and regular surveys to ensure that the ship continues to comply with the requirements of the certificate. Port States verify that a ship has a certificate and may, if necessary, carry out a survey and demand rectification of deficiencies. The Port State also inspects the Oil Record Book to check that the ship is adhering to the required operating procedures. Coastal States may enforce Annex I by regular air patrols which keep a watch for oil slicks.

Control of oil from machinery spaces
Waste oil is generated in lubricating oil and fuel oil purifiers. Under Annex I, discharge of this sludge into the sea is not permitted.

The equipment required for machinery spaces is set out in the regulations. The discharge provisions are similarly governed.

3.1.3 IMPORTANCE OF PROACTIVE MEASURES 2 hours

Importance of proactive measures to protect the marine environment encourages electro-technical officers to observe regulations concerned in the actual tasks on board ships which give direct impacts on the marine environment. Trainees therefore, need to learn about that careful treatment of pollution substances is strictly required.

3.2 PREVENT CONTROL AND FIGHT FIRE ON BOARD

The requirements of the STCW Convention are covered by IMO model course, Basic Fire Fighting. That course is based on the recommendations set out in IMO Assembly resolution and the IMO/ILO Document for Guidance (R5, R6, R7).

Trainees should undertake this course as soon as possible in their career, preferably during the pre-sea stage at a shore-based establishment.

IMO Assembly resolution states "Masters, officers and as far as practicable key personnel who may wish to control fire-fighting operations should have advanced training in techniques for fighting fire with particular emphasis on organization, tactics and command".

IMO model course, Advanced Training in Fire Fighting is suitable for this purpose and Administrations may wish this course to be completed before trainees qualify as electro-technical officer. See also IMO Model Course No 2.03.

3.3 OPERATE LIFE-SAVING APPLIANCES

The requirements of the STCW Convention are fully covered by IMO model course 1.23, Proficiency in Survival Craft and Rescue Boats other than Fast Rescue Boats, which is based on the requirements of the STCW Convention. Trainees who have successfully completed that course and have been issued with a certificate of proficiency in survival craft have demonstrated the ability and knowledge necessary to satisfy the requirements of the regulations.

3.4 APPLY MEDICAL FIRST AID ON BOARD SHIP

The requirements of the STCW Convention are covered by IMO model courses 1.14.

3.5 APPLICATION OF LEADERSHIP AND TEAMWORKING SKILLS

In today's highly demanding shipboard environment, the ship's officers are expected to act as managers and leaders to their crew and colleagues as well as interact with external parties.
It is vital that they possess the knowledge and abilities of managing people, plan and coordinate activities on board as well as make the decisions through proper judgment and analysis of the situation at the time. At the same time, officers are required to ensure the company's objectives are achieved in a timely manner, thus he/she will require the knowledge and understanding of organizing and getting things done through others and in this instance, the team working skills are important in ensuring success.

3.5.1	INTRODUCTION TO MANAGEMENT	2 hours
3.5.2	RELATED CONVENTIONS AND NATIONAL LEGISLATIONS	2 hours
3.5.3	APPLIES TASK AND WORKLOAD MANAGEMENT	10 hours
3.5.4	APPLIES EFFECTIVE RESOURCE MANAGEMENT AND DECISION MAKING	10 hours

3.6 CONTRIBUTE TO THE SAFETY OF PERSONNEL AND SHIP

3.6.1 KNOWLEDGE OF PERSONAL SURVIVAL TECHNIQUES

The requirements of the STCW Convention are covered by IMO model courses 1.19.

3.6.2 KNOWLEDGE OF FIRE PREVENTION AND ABILITY TO FIGHT AND EXTINGUISH FIRES

The requirements of the STCW Convention are covered by IMO model courses 2.03.

3.6.3 KNOWLEDGE OF ELEMENTARY FIRST AID

The requirements of the STCW Convention are covered by IMO model courses 1.13.

3.6.4 KNOWLEDGE OF PERSONAL SAFETY AND SOCIAL RESPONSIBILITIES

The requirements of the STCW Convention are covered by IMO model courses 1.21.

Part E: Evaluation

The effectiveness of any evaluation depends to a great extent on the precision of the description of what is to be evaluated. The detailed teaching syllabus is thus designed to assist the Instructors with descriptive verbs, mostly taken from the widely used Bloom's taxonomy.

Evaluation/Assessment is a way of finding out if learning has taken place. It enables the assessor (Instructor) to ascertain if the learner has gained the required skills and knowledge needed at a given point in a course or in working towards a qualification.

The purpose of evaluation/assessment is:

- to assist student learning;
- to identify students' strengths and weaknesses;
- to assess the effectiveness of a particular instructional strategy;
- to assess and improve the effectiveness of curriculum programs;
- to assess and improve teaching effectiveness.

The different types of evaluation/assessment can be classified as follows:

Initial / Diagnostic assessment

This should take place before the trainee commences a course to ensure the trainee is on the right path. Diagnostic assessment is an evaluation of a trainee's skills, knowledge, strength and areas for development. This can be carried out in an individual or group setting by the use of relevant tests.

Formative assessment

An integral part of the teaching/learning process and is a "Continuous" assessment. It provides information on the trainee's progress and may also be used to encourage and motivate.

The purpose of formative assessment is:

- to provide feedback to students;
- to motivate students;
- to diagnose students' strengths and weaknesses;
- to help students to develop self-awareness.

Summative assessment

It is designed to measure the trainee's achievement against defined objectives and targets. It may take the form of an exam or an assignment and takes place at the end of a course.

Purpose of summative assessment:

- to pass or fail a trainee;
- to grade a trainee.

Evaluation for Quality assurance

Evaluation can also be required for quality assurance purposes.

Purpose of assessment with respect to quality assurance:

- to provide feedback to Instructors on trainee's learning;
- to evaluate a module's strengths and weaknesses;
- to improve teaching.

Assessment Planning

Assessment planning should be specific, measurable, achievable, realistic and time-bound (SMART).

Some methods of assessment that could be used depending upon the course/qualification are as follows and all should be adapted to suit individual needs:

- observation (In oral examination, simulation exercises, practical demonstration);
- questions (written or oral);
- tests;
- assignments, activities, projects, tasks and/or case studies;
- simulation (also refer to section A-I/12 of the STCW code 2010);
- computer based training (CBT).

Validity

The evaluation methods must be based on clearly defined objectives, and must truly represent what is meant to be assessed; e.g. against only the relevant criteria and the syllabus or course guide. There must be a reasonable balance between the subject topics involved and also, in the testing of trainees' KNOWLEDGE, UNDERSTANDING AND PROFICIENCY of the concepts.

Reliability

Assessment should also be reliable (if the assessment was done again with a similar group/learner, would similar results be achieved). Different group of learners may have the same subject at different times. If other assessors are also assessing the same course/qualification, there is need to ensure all are making the same decisions.

To be reliable an evaluation procedure should produce reasonably consistent results, no matter which set of papers or version of the test is used.

If instructors are assessing their own trainees, they need to know what they are to assess and then decide how to do this. The, what, will come from the standards/learning outcomes of the course/qualification they are delivering. The, how, may already be decided for them if it is in assignments, tests or examinations.

The instructors need to consider the best way to assess the skills, knowledge and attitudes of their learners, whether this will be formative and/or summative and the validity and reliability of the assessment.

All work assessed should be valid, authentic, current, sufficient and reliable; this is often known as VACSR – "valid assessments create standard results":

- valid – the work is relevant to the standards/criteria being assessed;
- authentic – the work has been produced solely by the learner;
- current – the work is still relevant at the time of assessment;
- sufficient – the work covers all the standards/criteria;
- reliable – the work is consistent across all learners, over time and at the required level.

It is important to note that no single method can satisfactorily measure knowledge and skill over the entire spectrum of matters to be tested for the assessment of competence.

Care should therefore be taken to select the method most appropriate to the particular aspect of competence to be tested, bearing in mind the need to frame questions which relate as realistically as possible to the requirements of the officer's tasks at sea.

STCW 2010 Code

The training and assessment of seafarers required under the Convention are administered, supervised and monitored in accordance with the provisions of section A-I/6 of the STCW Code.

Column 3 - Methods for demonstrating competence - and Column 4 - Criteria for evaluating competence – in Table A-III/6 (Specification of minimum standard of competence for electro-technical officers) of the STCW Code, set out the methods and criteria for evaluation.

Instructors should refer to this table when designing the assessment.

Assessment is also covered in detail in another IMO Model Course, however to assist and aid instructors some extracts from the Model course are used to explain in depth.

Compiling tests

Whilst each examining authority establishes its own rules, the length of time which can be devoted to assessing the competence of candidates for certificates of competency is limited by practical, economic and social restraints. Therefore, a prime objective of those responsible for the organization and administration of the examination system is to find the most efficient, effective and economical method of assessing the competency of candidates. An examination system should effectively test the breadth of a candidate's knowledge of the subject areas pertinent to the tasks he is expected to undertake. It is not possible to examine candidates fully in all areas, so in effect the examination samples a candidate's knowledge by covering as wide a scope as is possible within the time constraints and testing his depth of knowledge in selected areas.

The examination as a whole should assess each candidates comprehension of principles, concepts and methodology; ability to apply principles, concepts and methodology; ability to organize facts, ideas and arguments and abilities and skills in carrying out the tasks to perform in the duties he or she is to be certificated to undertake.

All evaluation and testing techniques have their advantages and disadvantages. An examining authority should carefully analyse precisely what it should be testing and can test. A careful selection of test and evaluation methods should then be made to ensure that the best of the variety of techniques available today is used. Each test shall be that best suited to the learning outcome or ability to be tested.

Quality of test items

No matter which type of test is used, it is essential that all questions or test items used should be as brief as possible, since the time taken to read the questions themselves lengthens the examination. Questions must also be clear and complete. To ensure this, it is necessary that they be reviewed by a person other than the originator. No extraneous information should be incorporated into questions; such inclusions can waste the time of the knowledgeable candidates and tend to be regarded as 'trick questions'. In all cases, the questions should be checked to ensure that they measure an objective which is essential to the job concerned.

When the evaluation consists of oral and practical tests, which many topics in the table A-III/6, column 2, Knowledge, understanding and proficiency, require, the following should be taken into consideration.

Advantages and disadvantages of oral and practical tests

It is generally considered advisable that candidates for certificates of competency should be examined orally. Some aspects of competency can only be properly judged by having the candidate demonstrate his ability to perform specific tasks in a safe and efficient manner. The safety of the ship and the protection of the marine environment are heavily dependent on the human element. The ability of candidates to react in an organized, systematic and prudent way can be more easily and reliably judged through an oral/practical test incorporating the use of models or simulators than by any other form of test.

One disadvantage of oral/practical tests is that they can be time-consuming. Each test may take up about 1 to 2 hours if it is to comprehensively cover the topics concerned.

Equipment must also be available in accordance with the abilities that are to be tested. Some items of equipment can economically be dedicated solely for use in examinations.

APPENDICES

MARINE ENGINEERING AT THE OPERATIONAL LEVEL

▪ Purpose

This syllabus covers the knowledge of basic engineering science which is deemed to provide the depth of knowledge required by the Standards of Competence in Table A-III/6 of Section A-III/6 of the STCW 2010 Code for a candidate for certification as electro-technical officer.

It is recommended that the appended subjects area be considered as providing pre−requisite level of knowledge required before attempting the main functional competencies.

▪ Training objectives

This function provides the background knowledge to support:

An understanding of the physical principles underlying the behaviour of the ship and its environment and the functioning of equipment upon which to build professional studies. Trainees will also be better able to understand technical specifications and instructions regarding equipment with which they are not familiar.

▪ Entry standards

Trainees should be proficient in calculations involving the basic arithmetical operations of addition, subtraction, multiplication and division, including the use of fractions and decimal fractions. They should also have some knowledge of elementary algebra and be capable of solving problems leading to simple equations, including transposition of equations, if necessary.

Some previous study of a science subject, involving experimental work and the making, recording and processing of measurements, would be an advantage. It is worth mentioning Maths, Physics and Chemistry at High School level.

▪ Teaching facilities and equipment

In addition to ordinary classroom facilities, which may be used for the teaching of theory, a laboratory suitably equipped with work benches and apparatus for practical work and demonstrations will be required.

▪ Guidance notes

These notes are included to provide additional information where appropriate.

Appendix 1 – Basic Engineering Science

The subject has been presented in this manner in an effort to introduce engineering principles for all training outcomes in order that trainees will, from the beginning, know the relationship between quantities when they are later taught separately about:

- thermodynamics
- mechanical science, and
- marine electrotechnology

These basics should, as recommended, be a pre-requisite to the main programme and should ideally be completed before the three engineering science subjects are commenced.

The guidance which follows refers to specific topics.

The term "specific gravity" is still in widespread use and attention should be drawn to this when covering training outcome 1.1, Mass and volume.

Measuring density and temperature is intended to give trainees an opportunity to recognize and use simple instruments.

It is very important that trainees learn the meaning of velocity and acceleration and the units.

The use of graphs in training outcome 1.2, Dynamics is introduced for the first time in this subject; they should be simple, showing constant speed, instant change of speed and uniform, change of speed. Trainees must learn the difference between weight and mass and they must also be made aware of the misconceptions common in daily life.

The treatment of friction is intended to be simple but should include recognition of the fact that resistance occurs when bodies move on rough and on smooth surfaces, in air and in liquids.

When covering training outcome 1.3, Energy Work and Power, petroleum fuel oils should be used as examples of fuels and others could be mentioned.

The treatment of inertia should be simple and not include difficult calculations.

The area under a force-distance graph, representing work done, will often occur in later studies and should be treated with relevant importance.

Care should be taken to ensure that trainees understand the difference between work and power.

Trainees should be made aware that numerous ways are used to express pressure; however, they should use S.I. units.

Opportunity should be taken to show how very high forces occur when moderate pressures are applied to large surface areas.

A simple treatment of calorific values is required at this stage of training and realistic marine fuel values should be used.

Various marine examples of expansion and contraction should be used, such as expansion of pipes (including compensation bends etc.), shrinking metal by cooling or heating to obtain built－up construction such as crankshafts, rudder stocks, etc.

Appendix 2 － Mathematics

Trainees will probably enter the course already in possession of some mathematical ability. This being so, it would be advisable to give a simple test to establish their level of understanding.

There is a possibility that some revision will be necessary for trainees to meet the training outcomes, even if they have covered the work elsewhere.

Trainees need to be able to handle indices in their work on thermodynamics. Although trainees may not require to use logarithms in their duties, it is considered that such knowledge is of fundamental importance. The evaluation of numbers raised to powers will be necessary in other subjects. Trainees are likely to encounter graphs with logarithmic scales later in their experience.

It is very important that the symbols for S.I. units are understood and used throughout.
The prefixes for multiples of ten are in widespread use in marine work.

Trainees should be capable of evaluating expressions by using both a calculator and logarithms, as well as by basic arithmetic where applicable.

Trainees will have to perform algebraic processes in many applications. The examples used in training outcome 1.5 are typical.

It is quite adequate to be able to solve quadratic equations by one method.

Training outcomes in 1.6 are all used in the subject "electro technology" in the chief and second engineer's course (IMO Model Course 7.02).

A marine engineer frequently has to interpret graphs and occasionally has to plot them; hence training outcome 1.8.

Trainees do not have to carry out differentiation or integration; nevertheless, some insight into these concepts and their application would be of value.

Rates of change are of importance in control engineering; often the expression dy/dx occurs, particularly in technical journals, and trainees therefore need to be familiar with its meaning.

Appendix 3 － Thermodynamics

The terminology and concepts required in this subject are introduced in a simple manner in Appendix 1, Basic Engineering Science.

In some cases the book references develop the theory to a stage beyond that required for the watchkeeping certificate. Care must therefore be taken to ensure that trainees reach the level defined by the specific training outcome. Teaching beyond that level should only take place in rare instances, when it is absolutely necessary in order to give a clear understanding of the specific training outcome. The trainee should not be expected to achieve a level higher than that specified. For this reason the instructor is advised to prepare notes which give clear indication to the trainees of the work they need to do.

Training outcomes are intended to serve as reinforcement of earlier work. Pressure-measuring devices should already have been covered and should not have to be repeated.

Internal and Intrinsic energy have reference to chapter 1.6 of the textbook (T25). It is questionable whether the descriptions of the early misconceptions should be used. Trainees may be in danger of becoming confused and remembering the wrong things.

Trainees will learn the difference between a non−flow system and a steady−flow system; the latter will be introduced when studying for more advanced certificates.

Energy change is included in order to provide a basis for **Vapours**.

The problems in training objectives referring to heat transfer should be simple, such as to find the final temperature of a mixture of liquids or of a solid placed in a liquid when all other required information is known. Heat losses can be mentioned but their inclusion in problems may cause confusion. Similarly, water equivalents can be introduced but should not be over-emphasized. Laboratory work can be introduced provided heat losses can be minimized.

Marine engineers are concerned with a number of vapours; however, steam and the refrigerants are the only vapours commonly used in cyclic processes. Although the references in the textbook are concerned mainly with steam, opportunity should be taken to introduce work involving the use of thermodynamic properties of refrigerants, using the appropriate tables.

A throttling calorimeter can be used to good effect providing the results obtained can be realistic.

In place of "perfect gas", as for all practical purposes the behaviour of a gas deviates slightly, the term "ideal" is used. As far as practising marine engineers are concerned, the difference is of little importance. Problems should be concerned with practical compression and expansion in diesel engines and compressors.

Thermodynamic processes, the versatility of the equation $(PV)^n = C$ should be emphasized. Description should be given of processes which are nearly adiabatic and in practice are usually taken to be so. The second law of thermodynamics is introduced and should be related to practical applications. To handle problems concerned with polytrophic processes, trainees require to calculate values of, say, $5^{1.3}$. This is covered in **Mathematics**, but may require some revision. Such evaluation could be by use of a suitable electronic calculator.
It is important that the evaluation is not allowed to obscure the principles being learnt.

It is recommended that any calculations used to ascertain values of *n* are kept simple and practical.

Appendix 4 − Mechanical Science

The term "couple" is frequently used in technical papers, and trainees should therefore become familiar with its meaning.

Relative velocity should include that of two objects on converging and diverging paths.

It is intended that retardation, i.e. negative acceleration, should be included.

It is not intended to include friction on the inclined plane.

The principle of the pressure created by a head of liquid in a vertical pipe is very important to a marine engineer and should be illustrated by the use of realistic problems. This can also be demonstrated if the appropriate apparatus is available.

Energy changes in a moving liquid can be demonstrated if the equipment is available. It is also possible that the training outcome can be verified experimentally, using the same apparatus. It is not intended that the coefficient of discharge should be used in calculations at this stage.

Appendix 5 – Industrial Chemistry

It is not intended that trainees should learn to handle chemical equations, and the objectives clearly indicate this. If, however, trainees enter the course already with a sound background in chemistry, the instructor may find it more acceptable to use equations and other more advanced processes to arrive at the same objectives. The important issue is to ensure that trainees achieve the standard laid down. Later, when studying for more advanced certificates, each topic is taken further, but even then the chemistry is not taken to any greater theoretical depth.

"Fundamentals", includes amongst its training outcomes, a series of definitions; as these are not covered in the recommended textbook, suggested definitions are given in the guidance notes. If definitions are to be used from of other sources, care should be taken to ensure that they are not so comprehensive as to obscure the purpose described above.

In many cases training outcomes may be best achieved by trainees performing experiments and tasks; the time suggested allows for this.

Simple definitions are adequate; examples are given below:

An atom is the smallest particle of an element which can take part in a chemical reaction.

A molecule is the smallest particle of a substance capable of independent existence while still retaining its chemical properties: it consists of more than one atom.

Chemical element: a substance which cannot be decomposed by chemical means – there are 92 stable elements.

Chemical compound: a substance composed of two or more elements in definite proportions by mass.

Chemical reaction: a process in which a substance is changed into another – involves rearrangement of molecular structure.

Trainees will see chemical symbols and equations in books, technical papers, or on instrument display faces etc. and familiarity with them will therefore be an advantage. However, a seagoing marine engineer does not normally have to use symbols and equations except possibly as shorthand in reports.

Solution: a mixture (of variable composition) of two or more substances, one of which is usually a liquid.

Solubility: the ability of a substance to dissolve in a solvent.

Saturated solution: a solution which can exist in equilibrium with excess of the dissolved substance.

Suspension: a fluid in which denser particle cannot settle out and are distributed throughout. Opportunity should be taken to demonstrate these conditions by adding, say, sodium can be dissolved.

In later work, when preparing for a higher qualification, trainees will cover the determination of alkalinity of boiler feed water by more accurate methods.

Samples of common metals with passive oxide films should be shown.

Seawater as an electrolyte can be easily demonstrated by setting up a cell, using seawater as the electrolyte, and a galvanometer.

If available, show pictures or samples of metals affected by graphitization and dezincification.

Opportunity can be taken to measure the density of salts in solution to demonstrate metallic salts.

It is sufficient for a marine engineer to consider the carbon content of each fuel stated to be reasonably constant. The increase in sulphur content is of particular importance as fuel become "heavier". The same applies to the ash and water contents, which are zero or negligible for petrol and kerosene; both ash and water are usually present, sometimes in disturbing quantities, in "heavy" fuels.

Introduction to fuels and lubricants should include precautions with pipework, storage, venting, heating, protection against opening pressurized filters, sources of ignition, discharge from relief valves, operation of sludge valves, drip trays, cofferdams and pipe shrouding.

If laboratory equipment and time are available, trainees would benefit from at least witnessing the tests specified in training outcomes. In any case, trainees should be made familiar with the crude tests which can be performed on board ship.

Teaching aids (A)

A classroom equipped with a black/white board and an overhead projector is required for the theory of the course.

A1 Instructor Guidance.

Textbooks (T)

There are many textbooks which cover mathematics at the level of this syllabus. The choice of textbook is left to the discretion of the instructor

T28 Hannah－Hillier, J. Applied Mechanics. Harlow, Longman 1995. (ISBN 0582 25632.1)
T42 Jackson L. and Morton, T.D. General Engineering Knowledge for Marine Engineers. 5th ed. London, Thomas Reed Publications Ltd 1990. (ISBN 0947 637.761)
T43 Joel, R. Basic Engineering Thermodynamics in SI Units. 4th ed. Harlow, Longman, 1996 (ISBN 0582 41626 4)

APPENDICES – SUPPORTING KNOWLEDGE OUTLINE

Knowledge, understanding and proficiency	Total hours for lectures and laboratory work	Total hours
Appendix 1		
1.1 BASIC ENGINEERING SCIENCE		
1.1.1 Mass and Volume	3	
1.1.2 Dynamics	14	
1.1.3 Energy, Work and Power	12	
1.1.4 Fluids	12	
1.1.5 Heat	9	50
Appendix 2		
2.1 MATHEMATICS		
2.1.1 Calculations with Positive and Negative Integers	18	
2.1.2 Simplifying Expressions	12	
2.1.3 Indices	9	
2.1.4 Calculations	9	
2.1.5 Algebra	18	
2.1.6 Trigonometry	18	
2.1.7 Mensuration	10	
2.1.8 Graphs	6	100[1]
Appendix 3		
3.1 THERMODYNAMICS		
3.1.1 Thermodynamic Properties	4	
3.1.2 Thermodynamic Energy	8	
3.1.3 Thermodynamic Systems	1	
3.1.4 Energy Change	6	
3.1.5 Heat Transfer	16	
3.1.6 Vapours	16	
3.1.7 Ideal Gases	15	
3.1.8 Thermodynamic Processes	12	
3.1.9 Work Transfer	12	90

[1] These hours will need to be substantially increased if trainees commence the course without a reasonable mathematical background.

Knowledge, understanding and proficiency	Total hours for lectures and laboratory work	Total hours
Appendix 4		
4.1 MECHANICS		
4.1.1 Statics	24	
4.1.2 Dynamics	20	
4.1.3 Hydrostatics	10	
4.1.4 Hydraulics	6	60
Appendix 5		
5.1 INDUSTRIAL CHEMISTRY		
5.1.1 Chemical Fundamentals	6	
5.1.2 Acidity/Alkalinity	3	
5.1.3 Corrosion	12	
5.1.4 Water Testing and Treatment	12	
5.1.5 Introduction to Fuels and Lubricants	12	45

APPENDIX 1: BASIC ENGINEERING SCIENCE (50 hours)

Textbooks: T28, T43

Teaching aids: A1

TRAINING OUTCOME

Demonstrates a knowledge and understanding of:

1.1 Mass and Volume (3 hours)

- Defines:
  - volume p
  - mass
  - centre of gravity
  - density as mass/volume – units are kg/m^3
  - relative density
- explains that for homogeneous masses the centre of gravity lies at the centre of volume
- solves simple problems involving the above objectives
- measures density of liquids, using a hydrometer

1.2 Dynamics (14 hours)

The Relationship Between Speed, Acceleration, Mass, Force and Resistance

- defines speed as $\frac{\text{distance travelled:}}{\text{time}}$ units are m/s or km/h
- calculates mean speeds, given time and distance
- defines acceleration (for motion in a straight line) as $\frac{\text{change of speed}}{\text{time}}$
- plots speed – time graphs for straight – line motion
- defines free fall acceleration as 9.8 m/s^2
- solves problems using distance = speed x time
- uses the equation $v = u + st$ to solve problems
- states that, in order to accelerate a mass, a force has to be applied
- states that the unit of force is the Newton (N)
- states that one Newton is the force which causes a mass of one kilogram to accelerate at the rate of 1m/s^2
- states Newton's first law
- states Newton's second law
- defines weight as a force caused by gravitational attraction towards the centre of the earth
- uses the equation $F = ma$ to solve simple problems
- identifies practical examples of the effect of friction
- defines friction
- states that force is required to overcome the effects of friction
- explains in general terms the factors which affect frictional resistance to motion

1.3 Energy, Work and Power (12 hours)

The Relationship Between Forms of Energy, Work and Power

- states that common fuels such as hydrocarbons are sources of energy
- defines work as force × distance travelled (Newtons × metres); unit is the joule (J)

- define the relationship between energy and work
- defines potential energy
- defines kinetic energy and derives the equation $\frac{mv^2}{2}$
- solves simple problems involving force, distance and work
- relates the work done to accelerate an object to its change of kinetic energy
- defines inertia
- using given data, draws graphs of force and distance moved and relates the area under the graphs to work done
- gives examples of the conversion of energy from one form to another
- defines efficiency in terms of input and output
- defines power as the rate of transferor energy or the rate of doing work, i.e. $\frac{\text{energy transfer (Joules)}}{\text{time taken (seconds)}}$
- states that the unit of power is the watt (W)
- solves simple problems relating to the above objectives

1.4 Fluids (12 hours)

The Effect of Pressure, its Relationship to Depth of Liquid and Force

- defines a fluid
- defines pressure, i.e. $\frac{\text{force (Newtons)}}{\text{area (metres}^2\text{)}}$
- states that the unit of pressure is the pascal (Pa)
- states that a practical unit of pressure is 10^5 newton/m^2 and is 1 bar
- states that atmospheric pressure is approximately 1 bar
- solves problems involving force, area and pressure
- states that the pressure at any level in a fluid is equal in all directions
- states that pressure acts in a direction normal to a surface
- states that the pressure at any level in a liquid depends upon the vertical height to the liquid surface (its head) and the density of the liquid
- explains in simple terms what is meant by:
  - atmospheric pressure
  - vacuum
  - partial vacuum
  - absolute zero pressure
  - gauge pressure
- draws a simple diagram of a:
  - piezometer
  - manometer
  - simple barometer
  - bourdon pressure gauge
- solves simple problems involving 9.8 × head × density

1.5 Heat (9 hours)

The Relationship Between Temperature, Heat Energy and Heat Transfer

- explains what is meant by the temperature of a substance
- defines the Celsius scale and its fixed points
- defines the Kelvin
- measures temperature, using a mercury—in—glass thermometer

- defines the calorific value of a fuel
- solves simple problems, using the equation: heat transfer = mass of fuel x calorific value
- solves problems involving calorific value, mass of fuel, work done, energy transfer, fuel flow rates and efficiency
- defines specific heat capacity
- solves problems involving mass, specific heat capacity and temperature change
- explains in simple terms what is meant by:
    - conduction
    - convection
    - radiation
- gives examples of heat transfer by each of the processes described in the above objective
- explains the effect of raising their temperature on the physical dimensions of solids, liquids and gases
- gives examples where the above objective:
    - has to be allowed for
    - is used to advantage

APPENDIX 2: MATHEMATICS (100 hours)

The mathematics presented in this Appendix covers the teaching required to support marine engineering knowledge, understanding and proficiency for:

Officer in Charge of an Engineering Watch (Model Course 7.04), Chief and Second Engineer Officer (Model Course 7.02), and this Model Course.

Textbooks:

Teaching aids:

TRAINING OUTCOME

Demonstrates a knowledge and understanding of:

1.1 Calculations with positive and negative integers (15 hours)

- perform calculations with positive and negative integers involving the following presses:
  - addition
  - subtraction
  - multiplication
  - division
- defines the parts of a fraction as the numerator and denominator
- simplifies fractions by cancellation
- adds, subtracts, multiplies and divides fractions and simplifies the results
- solves problems, using one or more of the operations in the above objective

1.2 Simplifying expressions (15 hours)

- solves problems, using ratios
- applies the four basic arithmetic operations to expressions involving decimals
- converts a decimal to a fraction and vice versa
- recognizes recurring decimals as non-terminating decimals
- reduces a decimal number to a specified number of decimal places
- reduces a decimal number to a specified number of significant figures
- adds and subtracts decimal numbers
- multiplies and divides decimal numbers, giving answers to a specified number of decimal places and significant figures
- solves problems involving more than one of the operations in the above objectives

1.3 Indices (9 hours)

- Recognizes numbers involving indices, powers and roots
- applies the following rules, where *m* and *n* are integers:

$$a^m \times a^n = a^{m+n}$$

$$\frac{a^m}{a^n} = a^{m-n}$$

- deduces that $a^0 = 1$ and that $a^{-n} = \frac{1}{a^n}$
- expresses a binary number in the standard form of mantissa and exponent
- converts to normal decimal form a number given in standard form
- adds, subtracts, multiplies and divides two numbers given in standard form
- defines logarithms to the base of 10 and to the base of e (i.e. 2.718)

- uses logarithm tables to solve problems
- evaluates numbers raised to powers ranging from powers of 1.2 to 1.9
- states the meaning of and the symbol for prefixes for powers to ten, including: mega, kilo, hecto, deca, centi, milli, micro, nano and pico

1.4 Calculations (9 hours)

- defines percentage
- expresses one quantity as a percentage of another
- expresses increase and decrease as a percentage
- estimates the appropriate value of arithmetic problems and compares with given correct and false answers
- adds, subtracts, multiplies and divides numbers
- determines reciprocals, squares, square roots and fractional indices
- performs arithmetic operations on a calculator
- evaluates expressions, using realistic problems and the processes covered by the above objectives

1.5 Algebra (18 hours)

- states that an algebraic expression is a statement in which numerical quantities have been replaced by letters or other suitable symbols
- reduces an algebraic expression to its simplest form
- factorizes expressions by the extraction of a common factor
- applies any of the arithmetic expressions
- simplifies expressions when quantities are placed within brackets
- simplifies expressions when positive or negative signs are placed in front of a bracket
- solves linear equations with one unknown
- applies the rules which govern the transposition of quantities such as:

$$V = IR; A = x^2, L_1 = L(1+t);\ v = u + at;\ E = \frac{mv^2}{2}$$

- expands the following:

$(a+b)^2$
$(a+b)^3$
$(a+b)(a-b)$

- solves simultaneous equations with two unknowns
- solves problems by forming an equation, initially in algebraic, finally in numeric form
- solves quadratic equations by using the formula method

1.6 Trigonometry (18 hours)

- describe the measurement of angles in degrees and radians
- sketches and names the following angles: obtuse, right, complementary, supplementary and reflex
- defines a degree as 1 /360 of a revolution and a minute as 1/60 of a degree
- defines a radian
- converts angular measurement into radians and vice versa
- defines sine, cosine and tangent from trigonometric tables
- uses the theorem of Pythagoras to find the length of one side in a right－angled triangle
- states that the sum of angles inside a triangle is 180°
- applies numerical solutions in respect of the side and angles of a right－angled triangle
- solves problems, given the equations, using:

  - the sine rule
  - the cosine rule
- demonstrates that $cos\omega t = \sin(\omega t + \frac{\pi}{2})$
- shows that $sin^2\omega t = 1 - cos^2\omega t$
- shows that $sin\theta\, cos\theta = \frac{sin2\theta}{2}$
- applies positive and negative values as appropriate to the sines, cosines and tangents of angles between 0°and 360°

1.7 Mensuration (10 hours)

- states and applies formulae to find the area of the following:
  - a circle
  - a sector of a circle
  - a triangle
  - parallelogram
  - a trapezium
- defines a centroid
- states the position of the centroid of common regular shapes
- deduces a formula for the areas of a segment of a circle
- defines volume, for shapes having a constant cross—sectional area, as the product of area and length
- applies formulae to find the volume of the following:
  - a cube
  - a cylinder
  - a sphere
  - a triangular prism
- defines centre of volume
- states the position of the centre of volume of common solids
- uses the mid—ordinate rule to find the area of irregular figures
- uses Simpson's 1st and 2nd rules to find the area of irregular figures
- uses Simpson's 1st and 2nd rules to find the volume of irregular objects

1.8 Graphs (6 hours)

- draws axes for positive values
- defines and labels axes
- from given data, determines suitable scales
- plots points accurately, given-coordinates
- draws smooth graphs through plotted points
- plots sine waves
- plots cosine waves
- determines the co-ordinates of intersecting curves or lines
- draws graphs of values with positive, negative and mixed co-ordinates
- states that the average value of a sine wave and a cosine wave is zero
- indicates changing rates on graphs
- explains the concept of $\frac{dy}{dx}$
- defines an elemental area
- explain the concept of integration

APPENDIX 3: THERMODYNAMICS (90 hours)

Textbooks:

Teaching aids:

TRAINING OUTCOME

Demonstrates a knowledge and understanding of:

1.1 Thermodynamic Properties (4 hours)

- describes the properties used to specify the state, or condition, of a substance, the units in which the property is measured and the usual symbol, e.g.
  - pressure
  - temperature
  - volume
  - energy
- explains what is meant by:
  - absolute quantities
  - specific quantities
  - intensive values
  - extensive values
- explains that a substance can exist in three states, or phases, which are:
  - solid
  - liquid
  - gaseous
- describes the energy required to change phase as:
  - enthalpy of fusion (solid–liquid)
  - enthalpy of evaporation (liquid–vapour)
- states that a change of phase is a constant–temperature process
- explains that fluids can have a liquid or a gaseous form

1.2 Thermodynamic Energy (8 hours)

- states that "internal" or "intrinsic" energy(*U*) is related to the motions of the molecules of a substance or a system
- states that internal energy is derived only from molecular motions and vibrations, is dependent only on thermodynamic temperature and is energy stored in the molecules
- states that the total energy stored in a body, or system, is termed enthalpy (*H*)
- defines total stored energy the sum of internal energy and the product of pressure (*P*) and volume (V), *i.e.* $H = U + PV$
- defines potential energy as energy stored in the molecules by virtue of their vertical position above some datum level
- defines kinetic energy as energy stored in molecules by virtue of their velocity; kinetic energy has a value of $\frac{v^2}{2}$ (i.e. 0.5 of velocity squared) per unit mass of substance
- states that energy in transition between bodies or systems can only be heat flow (or Heat transfer) (*Q*) and work flow (or work transfer) (*W*)
- defines the first law of thermodynamics as "the energy stored in any given thermodynamic system can only be changed by the transition of energies *Q* and/or *W*"
- solves problems to demonstrate the above objectives

1.3 Thermodynamic Systems (1 hour)

- states that systems are identified in terms of mass of substance (i.e. molecules) contained within a system and/or the mass entering and leaving
- states that this identification is of importance when evaluating property changes taking place during thermodynamic operations

1.4 Energy Change (6 hours)

- explains that the "non−flow" equation derives directly from the first law of thermodynamics and is applicable only to "'closed" systems (i.e. no molecules of substance are entering or leaving the system during the thermodynamic operation)
- defines the general form of the non−flow equation as $(U_2 - U_1) = \pm W \pm Q$
- explains that the mathematical sign associated with the transition energies of *Q* and *W* will be governed by "direction", i.e. whether the energy transfer is "into" or "out of" the closed system
- solves simple problems concerning energy changes in practice

1.5 Heat Transfer (16 hours)

- states that heat transfer can take place by conduction, convection and radiation and that when substances at different temperatures are placed in contact they will, in time, reach a common temperature through transfer of heat
- defines specific heat capacity as the heat transfer, per unit mass, per unit of temperature change, for any given body or system
- uses laboratory equipment to determine:
  - specific heat capacity of substances
  - final temperature of mixtures, and verifies the observed value by calculation
- states that the Fourier law for the conduction of heat through a substance as given by
  $Q = \frac{\lambda A \theta t}{x}$
- identifies the quantities in the Fourier law as
  Q = heat flow, measured in joules
  A = surface area, measured in square metres
  e = temperature difference between the surface, measured in ℃
  t = time interval, measured in seconds
  x = distance travelled between the surface by the heat, measured in metres
  λ = the coefficient of thermal conductivity
- explains that the units for the coefficient of thermal conductivity are watts per metre per kelvin
  i.e. $\frac{\text{joules} \times \text{metres}}{\text{second} \times \text{metres}^2 \times \text{kelvin}}$
- solves simple numerical problems involving heat transfer between substances when placed in contact with each other; to include mixtures of liquids and solids placed in liquids
- solves simple problems on the application of the Fourier law to solid homogeneous materials
- performs laboratory work to verify the above objective

1.6 Vapours (16 hours)

- defines the vapour phase as intermediate stage between the solid and the perfect gas state, and the property values, such as pressure, energy, volume
- states that the important fluids in this group are H_2O (i.e. steam) and the refrigerants
- defines the following conditions:
  - saturated vapour
  - dry vapour
  - wet vapour

  - dryness fraction
  - superheated vapour
- explains and uses the "corresponding" relationship that exists between pressure and temperature for a saturated liquid or saturated vapour
- demonstrates the above objective, using laboratory equipment
- uses tables of thermodynamic properties to determine values for enthalpy, internal energy and volume at any given condition of pressure and/or temperature defined in the above objective

1.7 Ideal Gases (15 hours)

- states the "critical temperature" as being the limit of the liquid phase
- defines an "ideal" gas as one which behaves almost as a perfect gas, whose temperature is above the critical one and whose molecules have a simple monatomic structure
- states that an "ideal" gas cannot be liquefied by alteration of pressure alone
- states the laws of Boyle and Charles and identifies the following statements with them:
  $P \times V = a$ constant – Boyle
  $\frac{V}{T} = a$ constant – Charles
- sketches a $P-V$ curve demonstrating Boyle's law
- sketches a graph of V and T, demonstrating Charles' law
- states that the result of combining the laws of Boyle and Charles is:
  $\frac{PV}{T} = a$ constant
- defines the specific ideal gas equation as:
  $\frac{PV}{T} = R$ per unit mass of gas
- explains that R will have a different numerical value for each ideal gas or mixture of Ideal gases
- applies simple numerical calculations involving the elements of the above objectives

1.8 Thermodynamic Processes (12 hours)

- defines a thermodynamic process as "an operation during which the properties of state, pressure, volume and temperature may change, with energy transfer in the form of work and/or heat flow taking place"
- states that the following processes are applicable to ideal gases and vapours:
- heat transfer: heating and cooling
- work transfer; compression and expansion
- explains in simple terms the second law of thermodynamics
- explains with the aid of a sketched $P-V$ diagram, where appropriate, the following "standard" processes;
- pressure remaining constant
- volume remaining constant
- temperature remaining constant
- zero heat transfer
- polytrophic expansion and compression
- describes a process of constant temperature as "isothermal"
- describes a process in which there is no heat transfer as "adiabatic"
- describes practical applications of the process described in the above objectives
- solves simple numerical problems relating to the elements in the above objectives

1.9 Work Transfer (12 hours)

- explains that "work" is calculated by force × distance moved by that force
- sketches a *P*—*V* diagram relating the area of the diagram to the work done when a fluid exerts constant pressure on a piston in a cylinder
- explains the work transfer for a vapour or an ideal gas terms of pressures and volumes
- sketches a *P*—*V* diagram, relating the area of the diagram to work done on or by a piston in a cylinder during polytrophic expansion and compression
- states the equation for work transfer, i.e.

$$W = \frac{P_1V_1 - P_2V_2}{n-1}$$

where: *W* is the work done, in joules
P is the pressure at specific points in the process, in newtons / m^2
V is the volume at the same points as for pressure, in m^3
n is a numerical index

- states that the numerical index *n* is derived by experiment, using the equation

$$(P_1V_1)^n = (P_2V_2)^n$$

- states that, for most practical operations, *n* has numerical values between 1.2 and 1.5
- applies simple numerical calculations related to the elements in the above objectives

APPENDIX 4: MECHANICAL SCIENCE (60 hours)

Textbooks:

Teaching aids:

TRAINING OUTCOME

Demonstrates a knowledge and understanding of:

1.1 Statics (24 hours)

- defines scalar and vector quantities, giving examples, e.g. mass and weight
- defines force
- shows force as a graphic representation
- uses the parallelogram of forces to obtain the resultant of two forces acting as a Common point
- states the principle of equilibrium
- defines the equilibrant
- states the necessary conditions for three forces to be in equilibrium
- defines the triangle of forces
- describes the polygon of forces
- defines the condition for equilibrium in the polygon of forces
- defines the net effect of a number of forces acting at a common point as the resultant
- defines the moment of a force about a point
- determines the moment produced by a couple
- describes the conditions required for equilibrium when a number of forces and moments act on a body
- balances moments
- resolves a force into a force and a couple
- defines the factors which govern the stabil1ty and overturning of a box
- states that the centre of gravity of a mass suspended from a single point lies vertically below the point of suspension
- states that the centre of gravity of a mass supported by a single point lies vertically above the point of support
- solves simple numerical and graphical problems related to the elements in the above objectives

1.2 Dynamics (20 hours)

Velocity and the Effect of Change of Direction

- defines velocity as a vector quantity
- plots graphs of velocity against time
- defines relative velocity
- determines average velocity from initial and final values of velocity
- states that the area enclosed by a velocity—time curve is distance
- defines acceleration in terms of initial and final values of velocity
- solves simple problems, using the equations

$$V = U \pm at$$
$$v^2 = u^2 \pm 2as$$
$$s = ut \pm \frac{at^2}{2}$$

- defines velocity as a graphic representation
- uses the parallelogram and the triangle of velocities to obtain resultant velocity

Friction

- defines friction in the horizontal plane
- defines the force required to overcome friction in the horizontal plane as

$$F = \mu N$$

where: F = force in newtons
N = normal (i.e. 90°) reaction force between contact surfaces
μ= coefficient of friction

- solves simple numerical problems related to the elements in the above objectives

1.3 Hydrostatics (10 hours)

- states the formulae for the pressure exerted by a liquid at any given vertical depth
- deduces the equation $F = 9{,}81 \times head \times density \times area$, to give the force on the surfaces of a rectangular tank when filled with liquid
- defines the effect of 'sounding pipes', 'air release pipes' or other 'standpipes' when containing liquid
- defines, with the aid of sketches, a hydraulic lifting machine
- applies simple numerical calculations related to the elements in the above objectives

1.4 Hydraulics (6 hours)

- describes the different energies stored in a liquid when in motion as potential energy, pressure energy and kinetic energy
- defines the "head of a liquid"
- states the energy components in a moving liquid in terms of its head
- states the expression to give the volumetric flow of liquid as its $velocity \times cross-sectional\ area$, measured in m^3/second
- states the expression to give the mass flow of liquid as its $velocity \times cross-sectional\ area \times density$, measured in kilogram/second
- solves simple problems concerning the above objectives

APPENDIX 5: INDUSTRIAL CHEMISTRY (45 hours)

Textbooks:

Teaching aids:

TRAINING OUTCOME

Demonstrates a knowledge and understanding of:

1.1 Fundamentals (6 hours)

- defines an atom
- describes a molecule
- defines:
  - chemical elements
  - chemical compounds
- explains the difference between compounds and mixtures and names of:
  - elements
  - compounds
  - mixtures
- defines a chemical reaction
- defines an oxide
- uses as necessary the convention denoting elements, compounds and mixtures by letters and numbers; for example, carbon dioxide represented by CO_2
- explains what is meant by:
  - solution
  - solubility
  - saturated solution
  - suspension
  - precipitation

1.2 Acidity/Alkalinity (3 hours)

- defines the composition of an atom
- explains the result of an atom gaining or losing electrons
- defines a hydrogen ion
- defines a hydroxyl ion
- given pH values, demonstrates whether a solution is alkaline, neutral or acidic, indicating its strength or weakness
- uses an indicator such as litmus paper to determine whether a solution is acid or alkaline

1.3 Corrosion (12 hours)

- defines how metallic hydroxide is formed when an iron is immersed in an acidic solution
- defines the effect of dissolved oxygen and high acidity on polarization
- states that boiler water should be alkaline and contain little or no dissolved oxygen
- explains the fundamental process of corrosion
- names common engineering materials which produce passive oxide films
- states the main cause of corrosion
- names the components of a galvanic cell and applies these to the corrosion of a metal

- defines that seawater is an electrolyte
- defines an anode
- from a list of common metals, selects relative anodes
- defines metals as being noble or base relative to each other
- defines the use of sacrificial anodes
- recognizes the problems if graphite grease is used when seawater is present
- defines practical means of reducing galvanic action in the choice of metal and exposed …..surface area
- defines pitting corrosion
- recognizes the process of graphitization of cast iron
- defines the reasons why corrosion increases when seawater velocity increases
- defines the terms and what is meant by stress corrosion and names the metals in which it commonly occurs
- explains what is meant by dezincification and de-aluminification
- defines how the process in the above objective can be prevented
- explains what is meant by fretting corrosion
- defines the factors which increase the rate of fretting
- defines what is meant by corrosion fatigue
- identifies the major factors affecting the corrosion process as:
    - differential temperatures
    - stresses within the metal structure
    - variation in crystal structure of the metal
    - distribution/concentration of impurities in the metal crystals
    - flow of oxygen to the cathode
    - flow of carbon dioxide to the anode and cathode
    - hydroxyl ion concentration of the aqueous solution
- recognizes that some films and coatings on metal surfaces can provide protection so long as they remain intact
- recognizes that surface preparation prior to the application of protective coatings is very important
- identifies the important methods of surface protection as:
    - paints
    - chemical films
    - metallic coatings
    - anodizing

1.4 Water testing and treatment (12 hours)

- recognizes the importance of controlling the pH value of aqueous solutions within the minimum corrosive range
- identifies the chemical additives that can be used to obtain the condition required in the above objective
- knows the importance of maintaining a gas－free condition in the water used to "feed" a steam boiler or to circulate in an engine cooling system
- identifies the methods in common use for conditioning the water content of marine power plant, e.g. trisodium phosphate, hydrazine
- explains that natural water supplies contain metallic salts in solution
- demonstrates the standard method of measuring metallic salt content, i.e. state the actual quantity of metallic salt present in a specified quality of water

- knows the standard measurement given in the above objective as in units of "parts per million" (ppm) or less accurately in '32's' (seawater density measurement)
- lists the main metallic salts found in:
  - fresh water
  - average seawater
- defines:
  - permanent hardness
  - temporary hardness
- defines briefly how scale and sludge are produced in a steam boiler
- explains the different effects of using seawater, fresh water and distilled water as boiler feedwater
- defines the principal objects of treatment of boiler feedwater

1.5 Introduction to fuels and Lubricants (12 hours)

- identifies the average carbon, hydrogen, sulphur and ash content of the following fuels:
  - petrol
  - kerosene
  - marine diesel fuel
  - boiler fuel oil
- defines flashpoint and explains its importance for marine fuels and lubricants
- knows flashpoint temperature for the following hydrocarbons:
  - petrol
  - kerosene
  - marine diesel fuel
  - boiler fuel oil
  - lubricating oil
- identifies the minimum closed flashpoint of marline fuels
- states the maximum temperature to which fuel oil may be raised
- describes precautions taken on board ship to prevent accidental ignition of the oils listed in the above objective
- defines viscosity in terms of resistance to flow
- demonstrates why it is necessary to raise the temperature of some fuel oils
- carries out tests on fuels and lubricants for:
  - flashpoint
  - viscosity
- explains the reason why values of flashpoint or of viscosity need to be known for the following:
  - fuels and lubricants in storage
  - transfer of fuels and lubricants
- carries out tests on fuels and lubricants for water content