MODEL COURSE 7.02

CHIEF ENGINEER OFFICER AND SECOND ENGINEER OFFICER

2014 EDITION

Electronic edition

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IMO INTERNATIONAL MARITIME ORGANIZATION

MODEL COURSE 7.02

CHIEF ENGINEER OFFICER AND SECOND ENGINEER OFFICER

2014 EDITION

ELECTRONIC EDITION

INTERNATIONAL MARITIME ORGANIZATION PUBLISHING

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Foreword

Since its inception the International Maritime Organization (IMO) has recognized the importance of human resources to the development of the maritime industry and has given the highest priority to assisting developing countries in enhancing their maritime training capabilities through the provision or improvement of maritime training facilities at national and regional levels. IMO has also responded to the needs of developing countries for postgraduate training for senior personnel in administrations, ports, shipping companies and maritime training institutes by establishing the World Maritime University in Malmö, Sweden, in 1983.

Following the adoption of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW), a number of IMO Member Governments had suggested that IMO should develop model training courses to assist in the implementation of the Convention and in achieving a more rapid transfer of information and skills regarding new developments in maritime technology. IMO training advisers and consultants also subsequently determined from their visits to training establishments in developing countries that the provision of model courses could help instructors improve the quality of their existing courses and enhance their implementation of the associated Conference and IMO Assembly resolutions.

In addition, it was appreciated that a comprehensive set of short model courses in various fields of maritime training would supplement the instruction provided by maritime academies and allow administrators and technical specialists already employed in maritime administrations, ports and shipping companies to improve their knowledge and skills in certain specialized fields. With the generous assistance of the Government of Norway, IMO developed model courses in response to these generally identified needs and now keeps them updated through a regular revision process taking into account any amendments to the requirements prescribed in IMO instruments and any technological developments in the field.

These model courses may be used by any training institution and, when the requisite financing is available, the Organization is prepared to assist developing countries in implementing any course.

K. SEKIMIZU
Secretary-General

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Introduction

■ Purpose of the model courses

The purpose of the IMO model courses is to assist maritime training institutes and their teaching staff to introduce and organize new training courses and enhance existing training material, whereby the quality and effectiveness of the training may 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.

Rather, this document should be used as a guide with the course duration given as indicative of the expected time required to cover the required outcomes. The parties may modify this course to suit their respective training schemes.

For those following planned training schemes approved by the Administration, it is intended that this training may form an integral part of the overall training plan and be complementary to other studies. The training may be undertaken in progressive stages; for such candidates, it is not appropriate to specify the duration of the learning, provided achievement of the specified learning outcomes is properly assessed and recorded.

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 recommendations.

This is the first major revision to 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 Maritime Training 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 reduce 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.

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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 that should be allotted to each area of learning. However, it must be appreciated that these allocations are arbitrary and do not indicate a minimum or maximum number of hours 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 re-allocate 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. 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 outcome. 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, bibliography
- other reference material.

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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 four functions at the management level. On successful completion of the course and the requisite watchkeeping experience, officers will be prepared for taking full responsibility for the safety of the ship, its passengers, crew and cargo. They will be aware of their obligations under international agreements and conventions concerning safety and the protection of the marine environment and will be prepared for taking the practical measures necessary to meet those obligations.

In this model course, one combined course has been written for both chief engineer officer and second engineer officer. The material is set out so that it can be run separately from the course for officer in charge of an engineering watch, but this is not intended to imply that it has to be run separately. It has been written in this manner so as to give Administrations the opportunity to arrange a structure best suited to their needs.

The teaching schemes should be carefully scrutinized to ensure that all of the tabulated training outcomes are covered, that repetition is avoided and that essential underpinning knowledge at any stage has already been covered. A certain amount of duplication under different subjects will probably occur, provided it is not excessive, the different approaches can provide useful reinforcement of work already learned. Care should be taken to see that items not included in the syllabus or treatment beyond the depth indicated by the objectives have not been introduced except where necessary to meet additional requirements of the Administration. The teaching scheme should be adjusted to take account of those matters and the timing of any modular courses (such as training in firefighting), that are to be included.

■ Entry standards

Entrants should have successfully completed a course covering the minimum standards required for certification as officer in charge of an engineering watch in a manned engine-room or designate duty engineer in a periodically unmanned engine-room (see IMO model course 7.04, Officer in charge of an engineering watch).

■ Course intake limitations

Class sizes should be limited to 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

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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.

During practical sessions and group activities, there will be additional restraints on class size. Where applicable, a recommendation on class size is contained in the framework for each of the individual functions.

■ Textbooks, videos and bibliography

References to books, videos and bibliography are made in the Instructor Manual 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.

■ Computer applications

In view of the rapid growth of information technology (IT) and widespread use of computers aboard ship, it is recommended that at the discretion of the Administration, computer applications at an advanced level should be included in the training for chief engineer officer and second engineer officer. If this topic has not been covered during training as officer in charge of an engineering watch some basic training will also be required.

Particulars of the training will depend upon the computer facilities available and the needs of the trainees. The following outline provides guidance on topics that could be included:

- care and storage of magnetic media; use of simple utility programs for identifying disk problems and fixes; LAN maintenance; back-up management; virus protection
- IT and the use of applications, for communications (email, data, etc.), the internet, intranets and the worldwide web (www)
- installation and set-up of multi-media applications.

In addition, applications of computers and micro-processors to instrumentation and control systems, including:

- simple digital circuits, binary logic switches, bi-stable circuits

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- logic gates, truth tables of simple logic circuits
- representation of data by bits, bytes and words, binary and hexadecimal representation
- binary-coded decimal representation, fixed- and floating-point numbers, ASCII Code
- analog to digital and digital to analog converters
- computer architecture, information transfer between principal units
- memory, ROM, RAM, direct access memory, virtual memory
- input and output devices, data transfer, modems, multiplexers
- block diagrams of computer supervisory control systems and direct digital control systems
- automatic monitoring, data-recording and alarm systems.

The use of multi-media applications can enhance learning in topics in many areas of knowledge and prove of value to chief engineer officer and second engineer officer. Many of the IMO rules and Assembly resolutions are available on CD-ROM. Up-to-date details may be found on the IMO website at http://www.imo.org

■ Training and the STCW Convention 1978, as amended

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, 1978, as amended. This IMO model course has been revised and updated to cover the competences in STCW Code. It sets out the education and training to achieve those standards.

In common with the Convention, the course is organized under the seven functions at three levels of responsibility. Specifically, this course covers the minimum standard of competence for chief engineer officers and second engineer officers on ships powered by main propulsion machinery of 3,000 kW propulsion power or more, see STCW Code, table A-III/2.

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

Function 1 Marine engineering at the management level

Function 2 Electrical, electronic and control engineering at the management level

Function 3 Maintenance and repair at the management level

Function 4 Controlling the operation of the ship and care for the persons on board at the management 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.

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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, videos, CBTs, IMO references, textbooks and bibliography is included, which affects all four functions.

Part B provides an 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 timetable is followed. Depending on their experience and ability, some students 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 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. The objective, therefore, describes what the trainee must do to demonstrate that the specified knowledge or skill has been transferred.

Part D gives the Instructor Manual, which contains guidance notes for the instructors and additional explanations. Suggested teaching aids, videos, CBTs, IMO references, textbooks and bibliography are included to assist the teacher in preparing and presenting their lessons.

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.

■ Responsibilities of Administrations

Administrations should ensure that training courses delivered by approved training institutions are such as to ensure officers completing training do meet the standards of competence required by STCW regulation III/2, 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 approved this document, as it considers that the document must not be considered an official interpretation of the Convention.

■ Conventions, Regulations and Legislation

These are constantly being revised and updated. It is essential that the up-to-date version of these are being used and that all references to particular versions in this model course should be taken to include all future amendments and revisions.

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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/2 of STCW Code for the function Marine Engineering at the Management Level, for the function Electrical, Electronic and Control Engineering at the Management Level, for the function Maintenance and Repair at the Management Level and the background knowledge to support Controlling the Operation of the Ship and Care for Persons on Board at the Management Level.

■ Objective

Function 1

The syllabus covers the requirements of the 2010 STCW Convention, chapter III, section A-III/2. This functional element provides the detailed knowledge to support the training outcomes related to Marine Engineering at the Management Level.

This section provides the background knowledge to support the tasks, duties and responsibilities in:

- managing the operation of propulsion plant machinery
- planning and scheduling operations *Theoretical knowledge*
- operation, surveillance, performance assessment and maintaining safety of propulsion plant and auxiliary machinery *Practical knowledge*
- managing fuel, lubrication and ballast operations.

Function 2

The syllabus covers the requirements of the STCW Convention, chapter III, section A-III/2. This functional element provides the detailed knowledge to support the training outcomes related to Electrical, Electronic and Control Engineering at the Management Level.

This section provides the background knowledge to support the tasks, duties and responsibilities in:

- managing operation of electrical and electronic control equipment *Theoretical knowledge*
- managing troubleshooting and restoration of electrical and electronic control equipment to operating condition *Practical knowledge*

Function 3

The syllabus covers the requirements of the STCW Convention, chapter III, section A-III/2. This functional element provides the detailed knowledge to support the training outcomes related to Maintenance and Repair at the Management Level.

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This section provides the background knowledge to support the tasks, duties and responsibilities in:

- managing safe and effective maintenance and repair procedures
- detecting and identifying the cause of machinery malfunctions and correct faults *Practical knowledge*
- ensuring safe working practices *Practical knowledge.*

Function 4

The syllabus covers the requirements of the STCW Convention, chapter III, section A-III/2. 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 Management Level.

This section provides the background knowledge to support the tasks, duties and responsibilities in:

- controlling trim, stability and stress
- monitoring and controlling compliance with legislation to ensure safety of life at sea and protection of the marine environment
- maintaining safety and security of crew and passengers and the operational condition of safety systems
- developing emergency and damage control plans and handling emergency situations
- using leadership and managerial skills.

These include topics such as ship construction and stability, search and rescue, personnel management and contingency planning.

■ Entry standards

This course is principally intended for officers for certification as chief engineer and second engineer on ships powered by main propulsion machinery of 3000 kW propulsion power or more. Entrants should have successfully completed a course covering the minimum standards required for certification as officer in charge of an engineering watch (see IMO model course 7.04, Officer in charge of an engineering watch) and have approved seagoing service (see STCW regulation III/2). For those officers who want to take up the steam propulsion module it is recommended that they have practical experience onboard steam powered vessels.

■ 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-III/2 of STCW Code, for the function.

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

■ Staff requirements

Instructors shall be qualified in the task for which training is being conducted and have appropriate training in instructional techniques and training methods (STCW Code, section A-I/6). As well as instructors, additional staff will be required for the maintenance of machinery and equipment and for the preparation of materials, work areas and supplies for all practical work.

■ Teaching facilities and equipment

A classroom equipped with appropriate teaching facilities should be provided for teaching the theory of the course and holding group discussions.

Administrations may wish to consider the provision of a large workshop, equipped to facilitate all of the engineering practice, in a single space. Such an arrangement can be quite efficient in the use of staff, materials, stores, tools, etc.

■ Teaching aids (A)

The list of teaching aids and references are recommendations only and are intended to support the learning outcomes of the course.

A1 Instructor Manual (Part D of this course)
A2 Ship's Drawings/Plan (GA, Shell expansion, Deck plan and Mid section)
A3 Videos (DVDs), CD-ROMs, CBT's (V)
- V1 DIESEL ENGINE CRANKCASE LUBRICATING OILS Code No. 126
- V2 HANDLING & TREATMENT OF HEAVY FUELS Code No. 143
- V3 INTERNAL CARE OF MARINE BOILERS Code No. 150
- V4 HYDRAULIC OIL CONTAMINATION Code No. 166
- V5 DIESEL FUEL INJECTION PUMPS Code No. 302
- V6 MICROBIAL PROBLEMS IN FUELS Code No. 322
- V7 PRINCIPLES OF LUBRICATION & GENERAL APPLICATION Code No. 442
- V7A LUBRICATION, SLOW & MEDIUM SPEED MARINE DIESEL ENGINES Code No. 443
- V8 LUBRICATION OF ANCILLARY EQUIPMENT – PART 3 Code No. 444
- V9 MACHINERY ALARMS & PROTECTION DEVICES Code No. 528
- V10 FUEL OIL BURNER THEORY AND DIAGNOSTICS Code No. 604
- V11 AN INTRODUCTION TO HYDRAULICS Code No. 66
- V12 EFFICIENT OPERATION OF MARINE DIESEL ENGINES Code No. 693
- V13 SHIP'S ELECTRICAL SYSTEMS – SAFETY AND MAINTENANCE Code No. 665
- V14 ELECTRICAL DISTRIBUTION Code No. 666
- V15 GENERATORS AND MAIN CIRCUIT BREAKERS Code No. 667
- V16 MOTORS AND STARTERS Code No. 668
- V17 ANCILLARY ELECTRICAL SERVICES Code No. 669
- V18 SPECIAL ELECTRICAL PRACTICE FOR OIL, GAS & CHEMICAL TANKERS Code No. 670
- V19 ELECTRICAL SURVEY REQUIREMENTS Code No. 671

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V20 ELECTRIC PROPULSION AND HIGH VOLTAGE PRACTICE Code No. 672
V21 MARPOL ANNEX VI – PREVENTION OF AIR POLLUTION FROM SHIPS (Ed Code No. 1119
V22 FIGHTING POLLUTION – PREVENTION OF POLLUTION FROM SHIPS EDIT Code No. 1122
V23 CRISIS MANAGEMENT Code No. 507
V24 FIRE PARTY OPERATIONS Code No. 509
V25 THE INTERNATIONAL SAFETY MANAGEMENT CODE Code No. 524
V26 LOAD LINE SURVEYS – PART 1 Code No. 544
V27 SAFETY CONSTRUCTION SURVEY – PART 2 Code No. 545
V28 SAFETY EQUIPMENT SURVEY – PART 3 Code No. 546
V29 PERSONAL SAFETY IN THE ACCOMMODATION Code No. 554
V30 PERSONAL SAFETY ON DECK Code No. 555
V31 PERSONAL SAFETY IN THE ENGINE ROOM Code No. 556
V32 PERSONAL SAFETY ON BULK CARRIERS Code No. 558
V33 PERSONAL SAFETY ON GENERAL CARGO SHIPS Code No. 559
V34 PERSONAL SAFETY ON CONTAINER SHIPS Code No. 560
V35 PERSONAL SAFETY ON CAR CARRIERS & ROROS Code No. 562
V36 PERSONAL SAFETY ON PASSENGER SHIPS Code No. 563
V37 THE SHIPBOARD MANAGEMENT ROLE (EDITION 2) Code No. 969
V38 PERSONAL SAFETY ON TANKERS (EDITION 2) Code No. 970
V39 PERSONAL SAFETY ON CHEMICAL TANKERS Code No. 980
V40 THE ISM AUDIT Code No. 575
V41 BUNKERING OPERATIONS – SAFE OIL TRANSFER PROCEDURES Code No. 588
V42 MARINE RISK ASSESSMENT – THE FLEET Code No. 735
V43 MANAGEMENT ON BOARD – PART 1 Code No. 607
V44 GET SMART: ORGANISATION AND PLANNING – PART 2 Code No. 608
V45 GET RESULTS: PLANNING FOR PROFIT – PART 3 Code No. 609
V46 TEAMWORK – PART 4 Code No. 610
V47 MOTIVATING INDIVIDUALS – PART 5 Code No. 611
V48 COMMUNICATION – PART 6 Code No. 612
V49 PERMIT TO WORK Code No. 621
V50 SEVEN STEPS TO SHIP STABILITY PART 1 Code No. 622
V51 SEVEN STEPS TO SHIP STABILITY PART 2 Code No. 623
V52 WASTE AND GARBAGE MANAGEMENT Code No. 627
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V58 CREW RESOURCE MANAGEMENT – ENGINE ROOM Code No. 929

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URL: www.videotel.co.uk

V60 BALLAST WATER MANAGEMENT – WHAT YOU REALLY NEED TO KNOW
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Fax: +44 (0)1375 489 794
Email: sales@walport.com
URL: www.walport.com

V61 REMOTE CONTROL SYSTEM, AUTOCHIEF 4 (CBT # 0019)
V62 OPERATION OF GENERATORS (CBT # 0041)
V63 AUTOMATION, VISCOSITY CONTROL (CBT # 0083)
V64 INERT GAS GENERATOR (CBT # 0007)
V65 FUELGAS PLANT (CBT # 0008)
V66 FUELOIL SYSTEM (CBT # 0009)
V67 MARINE FUEL HANDLING (CBT # 0010)
V68 STEERING GEAR (CBT # 0017)
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Part B1: Course Outline

■ 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 officers 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 handouts 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.

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COURSE OUTLINE

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
Competence:		
1.1 MANAGE THE OPERATION OF PROPULSION PLANT MACHINERY		
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.5 Combustion	6	
.6 Heat transfer	12	
.7 Air conditioning	3	54
1.2.2 MECHANICS AND HYDROMECHANICS		
.1 Balancing	4	
.2 Simple harmonic motion	6	
.3 Stress & strain	10	
.4 Torsion	8	
.5 Combined stress	4	
.6 Fluid mechanics	12	54
1.2.3 PROPULSIVE CHARACTERISTICS OF DIESEL ENGINES, STEAM AND GAS TURBINES, INCLUDING SPEED, OUTPUT AND FUEL CONSUMPTION		
.1 Propeller and load diagrams		
.2 Propulsion characteristics diesel		
.3 Propulsion characteristics steam plant		
.4 Propulsion characteristics gas turbines		20

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Knowledge, understanding and proficiency		Total hours for each topic	Total hours for each subject area of Required performance
1.2.4	HEAT CYCLE, THERMAL EFFICIENCY AND HEAT BALANCE OF THE FOLLOWING		
	.1 Marine diesel engine	5	
	.2 Marine steam boiler and steam turbine	10	
	.3 Marine gas turbine	5	20
1.2.5	REFRIGERATORS AND REFRIGERATION CYCLE		
	.1 Refrigeration and air conditioning system design, operation and maintenance	10	10
1.2.6	PHYSICAL AND CHEMICAL PROPERTIES OF FUELS AND LUBRICANTS		
	.1 Shore side and shipboard sampling and testing	1	
	.2 Interpretation of test results	1	
	.3 Contaminants including microbiological infection	2	
	.4 Treatments of fuels and lubricants including storage, centrifuging, blending, pretreatment and handling	4	8
1.2.7	TECHNOLOGY OF MATERIAL		
	.1 Destructive and non-destructive testing of material	3	
	.2 Engineering processes used in construction and repair	4	7
1.3	**OPERATION, SURVEILLANCE, PERFORMANCE ASSESSMENT AND MAINTAINING SAFETY OF PROPULSION PLANT AND AUXILIARY MACHINERY *Practical knowledge***		
1.3.1	START UP AND SHUT DOWN MAIN AND AUXILIARY MACHINERY, INCLUDING ASSOCIATED SYSTEMS		
	.1 Main machinery and associated systems	7	
	.2 Steam boilers and associated systems	6	
	.3 Auxiliary prime mover and associated systems	4	
	.4 Other auxiliary machinery	3	20
1.3.2	OPERATING LIMITS OF PROPULSION PLANTS	-	8
1.3.3	EFFICIENT OPERATION, SURVEILLANCE, PERFORMANCE ASSESSMENT AND MAINTAINING SAFETY OF PROPULSION PLANT AND AUXILIARY MACHINERY		
	.1 Diesel engines	10	
	.2 Engine components	18	
	.3 Engine lubrication	8	
	.4 Fuel injection	12	
	.5 Scavenging and supercharging	10	
	.6 Starting and reversing	8	
	.7 Cooling systems	4	

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Knowledge, understanding and proficiency		Total hours for each topic	Total hours for each subject area of Required performance
.8	Diesel engine control and safety	4	
.9	Diesel engine emergency operation	2	
.10	Multi-engine propulsion arrangement	2	
.11	Air compressors and compressed air systems	3	
.12	Hydraulic power system	6	
.13	Types of auxiliary boilers	9	
.14	Auxiliary steam system	2	
.15	Safety valves	4	
.16	Boiler water level indicators	6	
.17	Use of sea water in boilers	0.5	
.18	Use of fresh water in boilers	0.5	
.19	Boiler water testing	3	
.20	Boiler water treatment	9	
.21	Auxiliary steam turbines	9	
.22	Boiler defects	3	
.23	Boiler and steam turbine survey and repairs	6	
.24	Evaporators	6	
.25	Thermal fluid heating system	3	148
1.3.4	FUNCTIONS AND MECHANISM OF AUTOMATIC CONTROL FOR MAIN ENGINE	-	
.1	Diesel engines	4	
.2	Steam turbines	3	
.3	Gas turbines	3	10
1.3.5	FUNCTIONS AND MECHANISM OF AUTOMATIC CONTROL FOR AUXILIARY MACHINERY		
.1	Generator and distribution system	4	
.2	Steam boiler	5	
.3	Oil purifier	3	
.4	Refrigeration system	3	
.5	Pumping and piping system	1	
.6	Steering gear system	2	
.7	Cargo handling equipment and deck machinery	1	19
1.4	**MANAGE FUEL, LUBRICATION AND BALLAST OPERATIONS**		
1.4.1	OPERATION AND MAINTENANCE OF MACHINERY, INCLUDING PUMPS AND PUMPING SYSTEM		
.1	Bilge and ballast	2	
.2	Prevention of pollution of the sea by oil	4	
.3	Sewage and sludge	4	10
Total for Function 1: Marine Engineering at the Management Level			**428 hours**

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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)
- Textbooks (indicated by T) and
- Bibliography (indicated by B)

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 four functions:

- Marine Engineering at the Management Level
- Electrical, Electronic and Control Engineering at the Management Level
- Maintenance and Repair at the Management Level
- Controlling the Operation of the Ship and Care for the Persons on Board at the Management Level.

The header of the first column denotes the **COMPETENCE** concerned. Each function comprises a number of competences. For example, Function 1, Marine Engineering at the Management Level, comprises a total of four COMPETENCES. Each competence is uniquely and consistently numbered in this model course.

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The first is **Manage the Operation of Propulsion Plant Machinery**. 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 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 competence **Manage the Operation of Propulsion Plant Machinery** comprises a total of seven training outcomes. The first concerns DESIGN FEATURES AND OPERATIVE MECHANISM OF MARINE DIESEL ENGINE AND ASSOCIATED AUXILIARIES. Each training outcome is uniquely and consistently numbered in this model course. Design features and operative mechanism of marine diesel engine and associated auxiliaries is numbered 1.1.1. and thermodynamics and heat transmission is numbered 1.2.1. 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 1.2.1 *Thermodynamics and heat transmission*, there are twelve areas of performance. These are:

1.2.1.1 Thermodynamic fundamentals

1.2.1.2 Perfect gas

1.2.1.3 Second law

and so on.

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 1.2.1.1 Thermodynamic Fundamentals, to meet the required performance, the trainee should be able to explain:

- system and working substance
- SI units
- property and state
- reversible and irreversible processes
- reversible work of compression or expansion

and so on.

Note that it is not intended that lessons are organized to follow the sequence of required performances listed in the Tables. The Tables are organized to match with the competence in the STCW Code, table A-III/2. Lessons and teaching should follow college practices. It is not necessary, for example, for Materials for construction and repair to be studied before Safe working practices. What is necessary is that all the material is covered and that teaching is effective to allow trainees to meet the standard of required performance.

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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 non-mandatory guidance on training and assessment.

The criteria for evaluating competence specified in the competence tables of part A of the STCW Code have to be used in the assessment of all competences listed in those tables.

A separate IMO model course 3.12 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.

■ Ships with main propulsion plant operated by steam boilers and steam turbines

The function Marine Engineering at the Management Level includes competences concerned with the operation of main steam boilers and main steam turbine. These are addressed in the detailed teaching syllabus in Part B and Part C at competence 1.1.7. Candidates for certification for service on ships in which main steam boilers and main steam turbines do not form part of their main propulsion plant may omit the competence 1.1.7. Certificates so awarded should not be valid for service on ships in which main steam boilers and main steam turbines form part of their propulsion machinery until the engineer officer meets the standard of competence in the items previously omitted. Such limitations are required to be shown on the certificate and in the endorsement.

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COMPETENCE 1.1	Manage the Operation of Propulsion Plant Machinery	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 1.1.1 DESIGN FEATURES AND OPERATIVE MECHANISM OF MARINE DIESEL ENGINE AND ASSOCIATED AUXILIARIES 1.1.2 DESIGN FEATURES AND OPERATIVE MECHANISM OF MARINE STEAM TURBINE AND ASSOCIATED AUXILIARIES 1.1.3 DESIGN FEATURES AND OPERATIVE MECHANISM OF MARINE GAS TURBINE AND ASSOCIATED AUXILIARIES 1.1.4 DESIGN FEATURES AND OPERATIVE MECHANISM OF MARINE STEAM BOILER AND ASSOCIATED AUXILIARIES 1.1.5 DESIGN FEATURES AND OPERATIVE MECHANISM OF PROPELLER SHAFT AND ASSOCIATED ANCILLARIES		STCW Code table A-III/2

Note

Trainees should be familiar with the content regarding the design features and operative mechanisms of the above machinery from IMO model course 7.04. This knowledge is considered so fundamental for much of the management level content within this course that there is merit in reviewing the operational level content quickly before covering the additional elements required at management level. The learning time has been reduced for many elements on the basis that trainees will be reviewing rather than learning much of this content at this level.

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COMPETENCE 1.1	Manage the Operation of Propulsion Plant Machinery	IMO Reference

1.1.1 DESIGN FEATURES AND OPERATIVE MECHANISM OF MARINE DIESEL ENGINE AND ASSOCIATED AUXILIARIES

Textbooks/Bibliography: T10, T15, T20, T21, T22, T40, T41, T44

Teaching aids: A1, V5, V12, V70, V78

Required performance:

1.1 Design features and operative mechanism of marine diesel engine and associated auxiliaries (15 hours)

- describes with the aid of sketches/computer aided drawing, material selection and design features of the structure of diesel engine:
  - structure of the bedplate
  - bedplate connection to the tank top
  - arrangement of holding down bolts
  - structure of A-frames and columns
  - arrangement of tie bolts
  - cylinder block and entablature
  - arrangement of main bearing caps
  - arrangement of piston rod gland assembly
  - arrangement of turbochargers and air coolers
- describes with the aid of sketches/computer aided drawing, material selection and design features of the running gear of diesel engine:
  - crankshaft
  - main bearing
  - thrust block and bearing
  - bottom end bearing
  - connecting rod
  - cross head and bearing
  - guides and guide shoes
  - lubrication of main bearing, bottom end bearing and cross head bearing
  - cam shaft drive arrangement
  - gear wheel transmission
  - chain wheel transmission
  - cam shaft bearing arrangement
- describes with the aid of sketches/computer aided drawing, material selection and design features of the fuel injection equipment of diesel engine:
  - fuel injection pumps including fuel pumps for common rail system
  - fuel injectors
  - arrangement of fuel injectors
  - variable injection timing

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COMPETENCE 1.1	Manage the Operation of Propulsion Plant Machinery	IMO Reference

– describes with the aid of sketches/computer aided drawing, material selection and design features of the combustion chamber components of diesel engine:
  – cylinder cover and mountings/excess pressure release method
  – cooling of cylinder cover
  – cylinder liner and cooling arrangements
  – piston crown
  – piston assembly
  – geometry of combustion chamber
  – exhaust valve and cooling arrangement
– describes with the aid of sketches/computer aided drawing, material selection and design features of piston rings, compatibility to cylinder liner and cylinder lubrication employed in a diesel engine:
  – cylinder liner material
  – piston rings material
  – manufacturing methods of cylinder liner
  – manufacturing methods of piston rings
  – types of cylinder lubrication and mechanism
  – selection of cylinder lubrication oil
– describes with the aid of sketches the operative mechanism of diesel engine system:
  – starting and reversing system
  – cooling water system
  – lubrication oil system
  – fuel oil system
  – scavenging, supercharging and exhausting
  – engine safety system
  – engine emergency operating system

1.1.2 DESIGN FEATURES AND OPERATIVE MECHANISM OF MARINE STEAM TURBINE AND ASSOCIATED AUXILIARIES

Textbooks/Bibliography: T8, T38, T42, T45

Teaching aids: A1, V10, V74

Required performance:

2.1 Design features and operative mechanism of marine steam turbine and associated auxiliaries (5 hours)

– describes with the aid of sketches/computer aided drawing, material selection and design features of steam turbine:
  – convergent and convergent/divergent nozzles and nozzle boxes
  – impulse and reaction turbines

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COMPETENCE 1.1	Manage the Operation of Propulsion Plant Machinery	IMO Reference

- pressure and velocity compounding
- pressure/velocity diagrams
- optimum blade speeds
- hybrid blades
- materials of blades and other components
- turbine construction
- erosion shields
- bearings, thrust bearings
- turbine glands and gland steam systems
- astern turbines
- turbine casings
- diaphragms
- reheat turbines
- support and expansion of turbines

– describes with the aid of sketches the operative mechanism of steam turbine:
  - alarms and trips
  - warming through
  - normal and emergency operation
  - shutdown procedures
  - turbine performance
  - sequential nozzle operation
  - resonance
  - critical speed
  - vibration
  - emergency control systems
  - rotor straightening

– describes with the aid of sketches/computer aided drawing, material selection and design features of steam turbine gear box:
  - single and double reduction
  - double helical involute gear teeth
  - single and double locked gear trains
  - epicyclic gearing
  - flexible couplings
  - nodal drive
  - method of manufacturing of spur gears

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COMPETENCE 1.1	Manage the Operation of Propulsion Plant Machinery	IMO Reference

1.1.3 DESIGN FEATURES AND OPERATIVE MECHANISM OF MARINE GAS TURBINE AND ASSOCIATED AUXILIARIES

Textbooks/Bibliography: T2, T22, T64

Teaching aids: A1, V65

Required performance:

3.1 Design features and operative mechanism of marine gas turbine and associated auxiliaries (5 hours)

- describes with the aid of sketches/computer aided drawing, material selection and design features of gas turbine:
  - analyse the flow of air and gas through a simple marine gas turbine
  - identify the materials and construction of a gas turbine compressor, combustion system, and turbine for single and two shaft design
  - discuss the design features related to maintenance requirements associated with optimum performance of a marine gas turbine plant
- describes with the aid of sketches the operative mechanism of a marine gas turbine:
  - lubrication system
  - fuel system
  - starting system
  - monitoring and control system
  - other ancillary equipment

1.1.4 DESIGN FEATURES AND OPERATIVE MECHANISM OF MARINE STEAM BOILER AND ASSOCIATED AUXILIARIES

Textbooks/Bibliography: T8, T38, T42, T45

Teaching aids: A1, V10, V74

Required performance:

4.1 Design features and operative mechanism of marine steam boiler and associated auxiliaries (10 hours)

- describes with the aid of sketches/computer aided drawing, material selection and design features of marine steam boiler:
  - types of main steam boilers
  - methods of construction
  - boiler fittings and drum internals
  - water circulation
  - gas circulation
  - operating parameters
  - support and expansion
  - superheaters and their temperature control

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COMPETENCE 1.1	Manage the Operation of Propulsion Plant Machinery	IMO Reference

- soot blowers
- economizers
- air heaters
- steam to steam generation
- chemistry of combustion
- burners and burner registers
- local and remote water level indicators
- safety valves

– describes with the aid of sketches/computer aided drawing, material selection and design features of marine steam boiler feed water systems:

- main feed systems
- condenser types, level control, construction, materials, support, expansion, operating parameters, loss of vacuum and leak testing
- air ejectors
- vacuum pumps
- extraction pumps
- gland condensers
- low pressure heaters
- drain coolers
- high pressure heaters
- turbo feed pumps, hydraulic balance
- de-aerators

1.1.5 DESIGN FEATURES AND OPERATIVE MECHANISM OF PROPELLER SHAFT AND ASSOCIATED ANCILLARIES

Textbooks/Bibliography: T7, T11, T19, T35, T36

Teaching aids: A1

Required performance:

5.1 Design features and operative mechanism of propeller shaft and associated ancillaries (5 hours)

- establishing the shaft centre line
- deviation while building
- alignment deviation in service
- fair curve alignment
- shaft checks

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COMPETENCE 1.1	Manage the Operation of Propulsion Plant Machinery	IMO Reference

– shaft bearings
  – plain bearings
  – tilting pad bearings
  – roller bearings
– coupling bolts
– stern tubes
– stern tube sealing arrangements
– fixed pitch propellers
– methods of mounting fixed pitch propellers
  – keyed propellers
  – keyless propellers
– controllable pitch propellers
– gears and clutches
– reverse reduction gearbox
– flexible couplings
– air operated clutches		

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COMPETENCE 1.2	**Plan and Schedule Operations *Theoretical knowledge***	**IMO Reference**
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 1.2.1 THERMODYNAMICS AND HEAT TRANSMISSION 1.2.2 MECHANICS AND HYDROMECHANICS 1.2.3 PROPULSIVE CHARACTERISTICS OF DIESEL ENGINES, STEAM AND GAS TURBINES, INCLUDING SPEED, OUTPUT AND FUEL CONSUMPTION 1.2.4 HEAT CYCLE, THERMAL EFFICIENCY AND HEAT BALANCE OF THE FOLLOWING .1 Marine diesel engine .2 Marine steam boiler and steam turbine .3 Marine gas turbine 1.2.5 REFRIGERATORS AND REFRIGERATION CYCLE 1.2.6 PHYSICAL AND CHEMICAL PROPERTIES OF FUELS AND LUBRICANTS 1.2.7 TECHNOLOGY OF MATERIAL		

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COMPETENCE 1.2	Plan and Schedule Operations *Theoretical knowledge*	IMO Reference

1.2.1 THERMODYNAMICS AND HEAT TRANSMISSION (54 hours)

Textbooks/Bibliography: T2, T18

Teaching aids: A1

Required performance:

1.1 Gas cycles/engine analysis (12 hours)

demonstrates knowledge and understanding of:

- constant pressure and constant volume air standard cycles
- reciprocating internal combustion engine performance parameters: indicator diagrams, power, mean effective pressure, thermal efficiency, brake specific fuel consumption, mechanical efficiency, energy balance
- open and closed gas turbine systems
- power, isentropic efficiency and thermal efficiency for gas turbines

1.2 Properties of vapours (6 hours)

demonstrates knowledge and understanding of:

- saturation, dryness fraction and superheat
- t-s, p-h, p-v, h-s diagrams
- fluid properties using steam tables
- throttling and separating calorimeters
- air in condensers

1.3 Steam cycles (9 hours)

demonstrates knowledge and understanding of:

- Rankine cycle. Turbine isentropic efficiency
- feed heating
- thermal efficiency
- cycle on t-s diagram

1.4 Refrigeration (6 hours)

demonstrates knowledge and understanding of:

- vapour compression cycle
- refrigerant properties and hazards
- refrigerant tables
- cycle on p-h diagram
- coefficient of performance
- refrigerant mass flow
- compressor calculations
- secondary refrigerants

1.5 Combustion (6 hours)

demonstrates knowledge and understanding of:

- combustion equations
- fuel composition
- air-fuel ratio
- excess air

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COMPETENCE 1.2	Plan and Schedule Operations *Theoretical knowledge*	IMO Reference

– volumetric analysis of combustion products
– calorific value

1.6 Heat transfer (12 hours)

demonstrates knowledge and understanding of:

– conduction, radiation and convection
– composite walls. Insulation
– film coefficient
– interface temperature
– Stefan-Boltzmann Law
– parallel flow and cross flow heat exchangers
– logarithmic mean temperature difference

1.7 Air conditioning (3 hours)

demonstrates knowledge and understanding of:

– comfort conditions
– psychrometric charts
– wet and dry bulb temperatures
– humidity
– dew point
– dehumidifying and humidifying processes
– air conditioning systems

1.2.2 MECHANICS AND HYDROMECHANICS (54 hours)

Textbooks/Bibliography: T1, T17

Teaching aids: A1

Required performance:

2.1 Balancing (4 hours)

demonstrates knowledge and understanding of:

– primary and secondary forces
– primary and secondary couples
– complete balancing of reciprocating machinery
– critical speed

2.2 Simple harmonic motion (6 hours)

demonstrates knowledge and understanding of:

– equation of simple harmonic motion
– amplitude, frequency and periodic time
– vibrating spring mass systems
– springs
– resonance
– transmissibility
– vibrations of flywheels and gearwheels

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COMPETENCE 1.2	Plan and Schedule Operations *Theoretical knowledge*	IMO Reference

2.3 Stress and strain (10 hours)

demonstrates knowledge and understanding of:

- stress and strain relationships in thin cylindrical and spherical shells
- stress in thin, rotating rims
- thermal stress
- stress in compound bars
- elastic strain energy
- stresses due to gradually applied and shock loads

2.4 Torsion (8 hours)

demonstrates knowledge and understanding of:

- stress, strain and strain energy due to torsion
- fundamental torsion equation
- reciprocating engine crank effort
- rudder stock turning moment from steering gear
- deflection of helical springs

2.5 Combined stress (4 hours)

demonstrates knowledge and understanding of:

- stresses on an oblique plane
- material subjected to two perpendicular stresses
- axial and bending stress
- mohr's stress circle. Principal stresses and strains
- combined bending and twisting

2.6 Fluid mechanics (12 hours)

demonstrates knowledge and understanding of:

- volume and mass flow
- venturi meter
- bernouilli's equation
- jets. Orifice coefficients
- dynamic and kinematic viscosity
- reynolds' number
- flow losses in pipes and fittings
- darcy's formula
- centrifugal pumps

1.2.3 PROPULSIVE CHARACTERISTICS OF DIESEL ENGINES, STEAM AND GAS TURBINES INCLUDING SPEED, OUTPUT AND FUEL CONSUMPTION (20 hours)

Textbooks/Bibliography: T20, T21, T22

Teaching aids: A1

Required performance:

3.1 Propeller and load diagrams

explains the following with the aid of sketches where applicable:

- propeller curve

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COMPETENCE 1.2	Plan and Schedule Operations *Theoretical knowledge*	IMO Reference

– propeller design point
– fouled hull, sea margin and heavy propeller
– constant ship speed lines

3.2 Propulsion characteristics diesel

explains the following with the aid of sketches where applicable:

– continuous service rating
– engine margin
– limits for continuous operation
– limits for overload operation
– specific fuel oil consumption (SFOC)
– SFOC based on reference ambient conditions stated in ISO 3046/1-1986
– adjustment of SFOC for lower calorific value of fuels and ambient conditions different from ISO reference conditions

3.3 propulsion characteristics steam plant

explains the following with the aid of sketches where applicable:

– continuous service rating
– engine margin
– constant ship speed lines
– limits for continuous operation
– specific fuel oil consumption (SFOC)
– SFOC based on reference ambient conditions stated in ISO 3046/1-1986
– adjustment of SFOC for lower calorific value of fuels and ambient conditions different from ISO reference conditions
– performance data of individual turbines and cycle components during sea trial
– periodic acquisition of above mentioned data and comparison for location of deterioration
– enthalpy drop test in superheated section of steam turbine
– quantification of stage efficiency losses
  – leakage
  – friction
  – aerodynamic
  – changes in flow passage areas

3.4 Propulsion characteristics gas turbines

explains the following with the aid of sketches where applicable:

– continuous service rating
– engine margin
– limits for continuous operation
– limits for overload operation
– specific fuel oil consumption (SFOC)
– SFOC based on reference ambient conditions stated in ISO 3046/1-1986
– adjustment of SFOC for lower calorific value of fuels and ambient conditions different from ISO reference conditions

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COMPETENCE 1.2	Plan and Schedule Operations *Theoretical knowledge*	IMO Reference

1.2.4 HEAT CYCLE, THERMAL EFFICIENCY AND HEAT BALANCE OF THE FOLLOWING

Textbooks/Bibliography: T2, T18

Teaching aids: A1

Required performance:

4.1 Marine diesel engine (5 hours)

explains the following with the aid of sketches where applicable:

- dual cycle
- thermal efficiency of dual cycle
- heat balance of marine diesel engine

4.2 Marine steam boiler and steam turbine (10 hours)

explains the following with the aid of sketches where applicable:

- Rankine cycle
- thermal efficiency of Rankine cycle
- heat balance of a marine steam plant
- boiler/turbine performances
- boiler/turbine efficiency

4.3 Marine gas turbine (5 hours)

explains the following with the aid of sketches where applicable:

- Brayton cycle
- thermal efficiency of Brayton cycle
- heat balance of marine gas turbine plant

1.2.5 REFRIGERATORS AND REFRIGERATION CYCLE

Textbooks/Bibliography: T48, T49

Teaching aids: A1, V76

Required performance:

5.1 Refrigeration and air conditioning system (10 hours)

- assesses common refrigerants used on board, using factors such as their properties, economics of use, handling, health hazards and environmental impact
- explains the environmental concerns of traditional refrigerants and the methods used to address these concerns
- explains correct procedures for the recovery of refrigerants from refrigeration systems
- analyses functions and operation of all components including fittings and safety devices of refrigeration and air conditioning plants
- interprets symptoms, effects and remedial actions for common faults in refrigeration and air conditioning systems
- precautions during cargo operations – re-circulation system of AHU
- explains the purposes and procedures for pumping down, leak test, refrigerant charging and oil changing
- recordkeeping of refrigerant consumption

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COMPETENCE 1.2	Plan and Schedule Operations *Theoretical knowledge*	IMO Reference

1.2.6 PHYSICAL AND CHEMICAL PROPERTIES OF FUELS AND LUBRICANTS

Textbooks/Bibliography: T7, T11

Teaching aids: A1, V6, V10, V67

Required performance:

6.1 Shore side and shipboard sampling and testing (1 hour)

- appraises the importance and implications of continual monitoring of quality of fuels and lubricants in efficient operation of machinery
- explains the procedures available for testing fuels and lubricants, including viscosity, water in oil, density, pour point, total base number (TBN), microbiological contamination and other contamination

6.2 Interpretation of test results (1 hour)

- describes the facilities available for laboratory testing of fuels and lubricants, the properties that can be determined, and how the results can be interpreted and utilised in maintenance programme

6.3 Contaminants including microbiological infection (2 hours)

- outlines procedures for dealing with contamination of oils by water, fuel in lubricating oil, solid debris or other contaminants, including recognition of unacceptable levels and possible consequences
- examines the causes, symptoms, effects and methods of treatment of oils that have been infected with microbiological organisms

6.4 Treatment of fuels and lubricants including storage, centrifuging, blending, pretreatment and handling (4 hours)

- details bunkering procedures and arrangements, explaining the importance of following correct procedures
- evaluates the operation of centrifugal separators and analyse the factors that affect optimum separation
- explains the function and operation of a shipboard fuel blender and alternative fuel treatments

1.2.7 TECHNOLOGY OF MATERIAL

Textbooks/Bibliography: T7, T11, T44

Teaching aids: A1

Required performance:

7.1 Destructive and non-destructive testing of material (3 hours)

- describes common methods of non-destructive testing of materials and their application to main and auxiliary machinery components
- discusses destructive tests on specimens such as stress tests, hardness tests and metallographic tests

7.2 Engineering processes used in construction and repair (4 hours)

- evaluates common fabrication techniques, including welding, forging, and casting
- assesses common repair techniques

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COMPETENCE 1.3	**Operation, Surveillance, Performance Assessment and Maintaining Safety of Propulsion Plant and Auxiliary Machinery** ***Practical knowledge***	**IMO Reference**
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 1.3.1 START UP AND SHUT DOWN MAIN AND AUXILIARY MACHINERY, INCLUDING ASSOCIATED SYSTEMS 1.3.2 OPERATING LIMITS OF PROPULSION PLANTS 1.3.3 EFFICIENT OPERATION, SURVEILLANCE, PERFORMANCE ASSESSMENT AND MAINTAINING SAFETY OF PROPULSION PLANT AND AUXILIARY MACHINERY 1.3.4 FUNCTIONS AND MECHANISM OF AUTOMATIC CONTROL FOR MAIN ENGINE 1.3.5 FUNCTIONS AND MECHANISM OF AUTOMATIC CONTROL FOR AUXILIARY MACHINERY		STCW Code table A-III/2

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COMPETENCE 1.3	Operation, Surveillance, Performance Assessment and Maintaining Safety of Propulsion Plant and Auxiliary Machinery *Practical knowledge*	IMO Reference

1.3.1 START UP AND SHUT DOWN MAIN AND AUXILIARY MACHINERY, INCLUDING ASSOCIATED SYSTEMS

Textbooks/Bibliography: T2, T5, T6, T7, T8, T9, T10, T11, T12, T13, T14, T15, T20, T21, T22, T23, T31, T32, T38, T39, T40, T41, T42, T45, T46, T47, T48, T49, T50, T51, T52, T55, T56, T61, T62, T63

Teaching aids: A1

Required performance:

1.1 Main machinery and associated systems (7 hours)

- describes precautions to be observed when starting up and shutting down main machinery
- explains the need for authorized and documented procedures/checklist for starting up main machinery
- describes limitations/conditions for starting up and shutting down main machinery depending on types of main machinery
- describes the functions of interlocking and how they work while main machinery is being started up
- explains procedures for starting up and shutting down main machinery in terms of design features of main machinery including associated systems
- describes parameters and factors necessary to develop procedures for starting up and shutting down main machinery including associated systems
- explains that principles of starting up and shutting down procedures of main machinery are the same for any type of main diesel engine, steam turbine and gas turbine
- describes precautions for conducting trial run of main machinery

1.2 Steam boilers and associated systems (6 hours)

- explains the need of developing procedures for starting up and shutting down boilers depending on types and specifications of boilers
- describes precautions to be observed when starting up and shutting down main and auxiliary boilers
- describes the standard procedures of firing up main and auxiliary boilers, and building up steam pressure including the use of bypass functions
- describes the standard procedures of shutting down main and auxiliary boilers
- describes the preparations for associated systems including control systems and drain system for starting up main and auxiliary boilers

1.3 Auxiliary prime mover and associated systems (4 hours)

- explains the general status of auxiliary prime movers and associated systems before starting up depending on types of ships
- describes precautions to be observed when starting up and shutting down prime movers
- describes the functions of interlocking and how they work while auxiliary prime movers are being started up including automatic control systems
- describes the standard procedures of starting up and shutting down auxiliary prime movers in terms of types and specifications of prime movers

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1.4 Other auxiliary machinery (3 hours)

- explains the general status of other auxiliary machinery and associated systems before starting up depending on types of ships
- explains the differences between auxiliary machinery used for ship's propulsion and others in terms of back-up systems and safety systems
- describes the standard procedures of starting up and shutting down auxiliary machinery used for ship's propulsion

1.3.2 OPERATING LIMITS OF PROPULSION PLANTS (8 hours)

Textbooks/Bibliography: T2, T7, T8, T11, T13, T15, T20, T21, T22, T38, T40, T41, T42, T45

Teaching aids: A1

Required performance:

- describes the parameters concerning operating limits of main diesel engine such as mean indicated pressure, maximum indicated pressure, shaft revolution, torque, scavenging air pressure, exhaust gas temperature, cooling water temperature, lubricating oil temperature, turbocharger revolution and others
- describes the parameters concerning operating limits of main steam turbine such as steam inlet pressure and temperature, torque, revolution, vibration and others
- describes the parameters concerning operating limits of main gas turbine such as exhaust gas temperature, torque, revolution, vibration and others
- describes the parameters concerning operating limits of main/auxiliary steam boiler such as properties of boiler water, air/fuel ratio and others
- describes the parameters concerning operating limits of diesel, shaft and steam turbine generator
- describes the design standards of propulsion plants concerning operating limits of plant machinery such as sea water temperature, ambient temperature and fluid velocity

1.3.3 EFFICIENT OPERATION, SURVEILLANCE, PERFORMANCE ASSESSMENT AND MAINTAINING SAFETY OF PROPULSION PLANT AND AUXILIARY MACHINERY

Textbooks/Bibliography: T1, T7, T8, T10, T11, T15, T17, T20, T21, T22, T38, T42, T46, T47

Teaching aids: A1, V1, V3, V5, V7, V8, V9, V10, V11, V12, V53, V69, V70, V74, V77

Required performance:

3.1 Diesel engines (10 hours)

- explains the use of indicator diagrams and draws diagrams to explain:
  - compression pressure, maximum pressure and faults
  - area of indicator diagram
  - calculation of indicated and effective engine power
  - calculating turbocharger efficiency
  - estimation of effective engine power without indicator diagrams
    - fuel index
    - turbocharger speed

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COMPETENCE 1.3	Operation, Surveillance, Performance Assessment and Maintaining Safety of Propulsion Plant and Auxiliary Machinery *Practical knowledge*	IMO Reference

- detects faults from sample indicator diagrams
- discusses engine condition monitoring and evaluation systems with regard to:
  - on line system with automatic sampling of engine parameters supplemented by cylinder pressure measurement
  - engine diagnosis system and computer controlled surveillance

3.2 Engine components (18 hours)

- interprets static and dynamic loads and stresses, identifying service limitations of diesel engine components
- evaluates different fabrication methods of diesel engine components, including:
  - welding
  - forging
  - utilizing composite materials
  - plasma-spraying
  - laser hardening
  - use of ceramics and other special materials
- identifies two and four stroke operating cycle forces, couples, and moments, relating these to design principles of:
  - crankshafts
  - bedplates
  - foundations
  - crossheads
- explains out of balance gas and inertia forces, couples, and moments, and relate these to flywheels, balance weights, and first/second order balancing, and hull vibration
- explains factors contributing to torsional vibration, and identify methods of minimizing or eliminating harmful effects of critical speeds
- evaluates the calibration of:
  - pistons
  - cylinder liners
  - piston rings
  - bearings
  - crankshafts, to identify wear patterns, limits, and means of correction
- specifies alignment and adjustment criteria of:
  - crankshafts
  - chain drives
  - gear drives
  - integral thrust bearings
  - crossheads
- compiles specified working clearances and limits of all bearings, sliding surfaces, and interference fits of a typical diesel engine, using engine builders' manuals

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COMPETENCE 1.3	Operation, Surveillance, Performance Assessment and Maintaining Safety of Propulsion Plant and Auxiliary Machinery *Practical knowledge*	IMO Reference

3.3 Engine lubrication (8 hours)

- identifies diesel engine lubricant types, properties and applications
- outlines principles of diesel engine lubrication
- in relation to contamination and deterioration of diesel engine lubricants:
  - discusses the sources, types and effects of contamination
  - discusses the causes, types and effects of deterioration
  - describes typical testing and treatment methods
  - interprets typical results of testing, giving appropriate actions which should be undertaken
- describes, using diagrams, the distribution of lubricating oil to diesel engines, in particular:
  - guides and crosshead bearings of slow speed diesel engines
  - top end bearings of medium speed engines
  - bottom end bearing
  - main bearings
  - camshaft drives, showing direction of flow, typical clearances, and stating normal operating parameters

3.4 Fuel injection (12 hours)

- explains why atomization and penetration of fuel and the turbulence of air are essential to optimum combustion in a diesel engine
- states typical injection pressures and viscosities for different grades of fuel
- describes how and why fuel pumps, camshafts and injectors are altered for varying fuel types
- describes, with the aid of simple sketches, the difference between constant and variable injection timing of fuel, showing materials, principal parts, methods of operation and adjustments of common types of fuel pump
- compares injection requirements for slow speed, medium speed and high speed diesel engines, including pilot injection and pre-combustion chambers
- identifies common service faults, symptoms and causes of combustion problems, specifying appropriate adjustments, including methods of fuel pump timing
- summarizes occupational health and safety aspects of handling and testing fuel injection systems
- explains, using relevant diagrams and stating normal operating parameters:
  - fuel valve cooling arrangement
  - uni-fuel and dual-fuel systems (for high/medium viscosity fuel types)
- discusses the atmospheric pollution aspects of diesel engine combustion, and give methods which reduce this pollution (especially SOx and NOx reduction)

3.5 Scavenging and supercharging (10 hours)

- evaluates the need for scavenging diesel engines
- compares methods of scavenging diesel engines
- specifies methods of providing pressurized air for combustion in diesel engines

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COMPETENCE 1.3	Operation, Surveillance, Performance Assessment and Maintaining Safety of Propulsion Plant and Auxiliary Machinery *Practical knowledge*	IMO Reference

– assesses pressure charging methods for diesel engines
– examines the working principles of turbochargers
– assesses lubrication and cooling requirements of turbochargers
– analyses typical faults and identify appropriate actions to be undertaken with defective or damaged turbochargers

3.6 Starting and reversing (8 hours)

– describes starting procedures of diesel engines for power generation, propulsion and emergency use
– explains starting and manoeuvring requirements/sequences for direct coupled reversible and geared propulsion diesel engines, for fixed and controllable pitch propeller applications
– describes, with labelled diagrams to indicate major components, typical manoeuvring and reversing systems for propulsion diesel engines
– compares different methods of reversing direct coupled propulsion diesel engines
– identifies common faults and identify appropriate actions to be undertaken with typical diesel engine starting and manoeuvring systems
– compares the different methods of utilizing diesel engines for ship propulsion, including:
  – direct coupled, reversible slow and medium speed engines
  – clutched and geared reversible and unidirectional medium speed engines with a fixed pitch propeller
  – clutched and geared reversible and unidirectional medium speed engines with a controllable pitch propeller
  – diesel electric drive

3.7 Cooling systems (4 hours)

– analyses the problems that may arise in cooling water spaces of diesel engines
– evaluates common methods of diesel engine cooling water treatment
– states the importance of maintaining diesel engine thermal efficiency and evaluate thermal loads on engine components
– justifies cooling media selection and state the advantages and disadvantages of various diesel cooling methods
– evaluates the tests used in the control of diesel engine cooling water treatment
– enumerates the normal operating limits for diesel engine cooling water treatment
– interprets the implications of out of limit readings from water treatment tests and state the corrective procedures which should be undertaken
– itemizes the sources and types of contamination of diesel engine cooling water and explain the effects of these contaminations on the reserves of treatment chemicals
– compares the procedures which may be used to counter contamination of diesel engine cooling water

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COMPETENCE 1.3	**Operation, Surveillance, Performance Assessment and Maintaining Safety of Propulsion Plant and Auxiliary Machinery** ***Practical knowledge***	**IMO Reference**

– explains, using relevant diagrams and stating normal operating parameters, typical methods of cooling:
  – medium and slow speed diesel engine pistons
  – exhaust valves
  – cylinders
  – turbochargers
  – cylinder heads

3.8 Diesel engine control and safety (4 hours)

– with respect to waste heat units:
  – explains the design and operational factors that contribute to fires in waste heat units
  – discusses the generation of soot and hydrogen fires
  – explains the possible consequences of such fires
  – identifies routine cleaning and inspection criteria
  – identifies symptoms of a fire
  – gives appropriate actions to be undertaken upon fire detection in order to contain/extinguish the fire
  – identifies the risks of isolating a waste heat unit
– with respect to scavenge fires:
  – explains the factors that contribute to a fire in the scavenge chamber of a diesel engine
  – explains the possible consequences of such fires
  – specifies detection, protection and extinguishing devices
  – identifies routine cleaning and inspection criteria
  – identifies symptoms of a fire
  – gives appropriate actions to be undertaken upon fire detection in order to contain/extinguish the fire
– with respect to starting air lines:
  – identifies principles of explosive mixtures
  – describes how an air line explosion can occur
  – explains the possible consequences of such an explosion
  – identifies routine evaluation criteria of starting air systems for minimizing/avoiding an explosion, and
  – states how the risk of explosion may be minimized/avoided by protection devices
– with respect to diesel engine crankcases and gearboxes:
  – explains the factors and sequence of occurrences that contribute to generation of explosive oil mist
  – discusses the generation of primary and secondary explosions in these spaces
  – explains the possible consequences of such explosions
  – specifies detection and protection devices

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COMPETENCE 1.3	Operation, Surveillance, Performance Assessment and Maintaining Safety of Propulsion Plant and Auxiliary Machinery *Practical knowledge*	IMO Reference

- states how the risk may be minimized in service
- states indications of hot spots and possible explosive atmospheres
- gives the correct procedure to be undertaken upon indication of a potentially explosive atmosphere, in both diesel and dual fuel engines

– evaluates the causes and consequences of diesel engine overspeed, and give procedures which must be undertaken in the event of such an occurrence

– explains, using diagrams, the operating principles of:
  - oil mist detectors, giving testing procedures
  - explosion relief doors
  - crankcase breathers
  - crankcase extraction fans

3.9 Diesel engine emergency operation (2 hours)

– explains emergency procedures for manoeuvring for diesel engines

– explains emergency procedures which may be undertaken with defective clutches

3.10 Multi-engine propulsion arrangement (2 hours)

– explains the need for changing the output speed of prime movers

– defines gearing concepts, and explain the advantages and disadvantages of:
  - utilizing gearing to change prime mover output speed
  - involute gearing
  - spur and helical gears

– assesses the need for disengaging prime movers from drive lines

– identifies common types of clutches and couplings used with prime movers

– outlines maintenance procedures associated with clutches

3.11 Air compressors and compressed air systems (3 hours)

– examines the functions and operation of all components including fittings and safety devices of air compressors and compressed air systems

– evaluates the effects of common operational faults of single and multi-stage air compressors, including: leaking valves, leaking piston rings, blocked filters, blocked coolers

– explains the reasons and the effects of high levels of oil or water in compressed air

– explains the effects of operating air compressors with synthetic lubricating oils compared to operating with mineral lubricating oils

– describes a procedure for inspecting and maintaining air receivers and their fittings

3.12 Hydraulic power system (6 hours)

– analyses functions and operation of all components including fittings and safety devices of hydraulic power systems

– interprets symptoms, effects and remedial actions for common faults in hydraulic power systems

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3.13 Types of auxiliary boilers (9 hours)

- examines typical boiler types illustrating cross sections, attachments and locations of all fittings, mountings, scantlings and methods of achieving water circulation and gas flow
- distinguishes the material requirements for boiler components
- explains the construction of typical types of boilers
- explains functions and operation of all boiler components including fittings and safety devices
- illustrates a typical boiler fuel system and its components
- examines the operation and maintenance procedures of boiler fuel systems
- analyses the combustion process, its monitoring system, and requirements for proper combustion
- evaluates common types of burners and distinguish how atomization and subsequent combustion is achieved
- identifies the protection devices, alarms and shutdowns used in combustion control and fuel systems, and analyse their importance and methods of operation

3.14 Auxiliary steam system (2 hours)

- illustrates a typical auxiliary steam system, showing the location and purpose of all components
- develops a heat energy balance for an auxiliary steam system
- distinguishes the material requirements for auxiliary steam system components
- examines the construction and operation of typical auxiliary steam system components
- explains the reasons for operating the auxiliary steam plant and its systems at nominated temperatures and pressures, and the effects of departing from these parameters
- analyses the symptoms of faults in steam traps, hot wells, de-aerators and condensers
- analyses the requirements for contamination prevention between systems

3.15 Safety valves (4 hours)

- analyses the requirements for steam safety valves
- analyses the design formulae used for steam safety valves
- differentiates between common types of boiler safety valves in use and explain how they are classified in terms of valve lift
- distinguishes the materials of construction of safety valves
- analyses operational problems that can occur with safety valves
- examines how a safety valve is inspected and overhauled, giving common defects and areas of importance when inspecting
- formulates a procedure for setting safety valves, and examine the precautions necessary when testing safety valves on boilers and waste heat unit

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3.16 Boiler water levels (6 hours)

- discusses requirements for boiler water level indicators
- differentiates between common types of local boiler water level indicator in use, explaining their different methods of construction and operation
- evaluates testing, maintenance and defect rectification procedures for local boiler water level indicators
- differentiates between common types of remote boiler water level indicator in use, explaining their different methods of construction and operation
- evaluates testing, maintenance and defect rectification procedures for remote boiler water level indicators

3.17 Use of 'sea water in boilers' (0.5 hour)

- explains the reasons and the effects of using sea water in boilers

3.18 Use of 'fresh water in boilers' (0.5 hour)

- analyses the different types of impurities present in boiler, feed and make up water
- explains how salts are precipitated from boiler and feed water, and the consequences of this precipitation
- explains how metal is corroded in the boiler and feed system

3.19 Boiler water testing (3 hours)

- defines pH and explain how it is measured and controlled
- evaluates the tests used in the control of boiler and feed water treatment
- interprets the implications of out of limit readings from water treatment tests and state the corrective procedures which should be undertaken

3.20 Boiler water treatment (9 hours)

- evaluates common methods of boiler, feed and make up water treatment
- shows how oxygen is eliminated in boilers
- enumerates the normal and maximum operating limits for boiler and feed water treatment
- itemizes the sources and types of contamination of boiler, feed and make up water and explain the effects of these contaminations on the reserves of treatment chemicals
- compares the procedures which may be used to counter contamination of boiler, feed, and make up water

3.21 Auxiliary steam turbines (9 hours)

- analyses the types, uses and methods of construction of auxiliary steam turbines in use at sea
- examines the typical operating conditions, including temperatures and pressures, of auxiliary steam turbines
- identifies the materials used in auxiliary steam turbines and ancillary equipment
- examines typical operational problems associated with auxiliary steam turbine plants, the symptoms, effects and possible remedies of these faults
- explains the processes of warming through and shutting down auxiliary steam turbine plants

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– outlines the maintenance associated with optimum performance of an auxiliary steam turbine plant

3.22 Boiler defects (3 hours)

– identifies the possible defects which may occur in a boiler, gas and water side, giving their location, nature and effects

– outlines procedures commonly employed to rectify defects in boilers, and explain the limitations of such repairs

– enumerates procedures for leak detection in boilers and other steam system components, and explain the remedial actions which may be undertaken

3.23 Boiler and steam turbine survey and repairs (6 hours)

– examines the need for surveying auxiliary boilers, steam turbines and other components of auxiliary steam systems

– outlines survey requirements for auxiliary boilers, steam turbines and other components of auxiliary steam systems

– outlines the procedures for shutting down, isolating and opening up an auxiliary boiler for inspection or during an emergency

3.24 Evaporators (6 hours)

– compares operation, performance, problems and applications of common fresh water generation plants used at sea

– evaluates the need for treatment of evaporator water, and assess methods of fresh water generation plant water treatment

3.25 Thermal fluid heating system (3 hours)

– examines typical thermal fluid heating systems and explain the advantages and disadvantages of these systems

– explains the locations and functions of all components, fittings and safety devices used in thermal fluid systems

– analyses the properties of thermal fluids used, effects of contamination, and methods of testing the fluid

– compares thermal fluid plants with conventional steam plants

1.3.4 FUNCTIONS AND MECHANISM OF AUTOMATIC CONTROL FOR MAIN ENGINE

Textbooks/Bibliography: T7, T8, T10, T20, T21, T22, T40, T46, T47, T56, T62, T63

Teaching aids: A1

Required performance:

4.1 Diesel engines (4 hours)

– describes system components and configuration for main engine automatic control

– describes the meaning of the following functions used for main engine automatic control including operation/control mechanism:
  – automatic changeover from air running to fuel running
  – start failure
  – start impossible
  – wrong way

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- speed run-up program by revolution, load and/or combination control, including bypass program for critical speed
- crash/emergency astern program
- speed control under rough/calm sea condition
- variable injection timing
- variable exhaust valve timing
- safety (automatic shutdown, automatic slowdown) system

– describes the function and mechanism of the electro-governing system for revolution control

4.2 Steam turbines (3 hours)

– describes system components and configuration for main steam turbine automatic control

– describes the meaning of the following functions used for main steam turbine automatic control, including operation/control mechanisms:

- start impossible
- wrong way
- speed run-up program by revolution, load and/or combination control
- crash/emergency astern program
- automatic rollover
- safety (automatic shutdown, automatic slowdown) system

4.3 Gas turbines (3 hours)

– describes system components and configuration for main gas turbine automatic control

– describes the meaning of the following functions used for main gas turbine automatic control, including operation/control mechanisms:

- start impossible
- wrong way
- speed run-up program by revolution, load and/or combination control
- crash/emergency astern program
- automatic rollover
- safety (automatic shutdown, automatic slowdown) system

1.3.5 FUNCTIONS AND MECHANISM OF AUTOMATIC CONTROL FOR AUXILIARY MACHINERY

Textbooks/Bibliography: T7, T8, T9, T11, T14, T15, T23, T38, T42, T45, T46, T47, T49

Teaching aids: A1, V68, V76, V79, V86

Required performance:

5.1 Generator and distribution system (4 hours)

– describes system components and configuration for generator and distribution system automatic control

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– describes the following functions used for generator and distribution system automatic control, including operation/control mechanisms:
  – full automatic control for generator and distribution system, including automatic starting and stopping prime mover
  – automatic synchronizing
  – automatic load sharing
  – optimum load sharing
  – large motor start blocking
  – preference trip
  – protective/safety functions built in Automatic/Main Circuit Breaker (ACB and VCB)
  – automatic voltage (AVR) and frequency control

5.2 Steam boiler (5 hours)

– describes system components and configuration for steam boiler automatic control
– describes the following functions used for steam boiler automatic control including operation/control mechanisms:
  – Automatic Combustion Control (ACC), including steam pressure control, fuel oil flow control and air flow control
  – automatic feed water control
  – automatic steam temperature control
  – protective/safety functions for steam boiler

5.3 Oil purifier (3 hours)

– explains the automation, monitoring and alarms of oil purifiers:
  – temperature control
  – automatic start
  – automatic desludging
    – partial desludging
    – total desludging
  – monitoring and alarms
    – low/high temperature
    – water content
    – leakage monitoring
  – treated oil flowing into heavy liquid side
  – non-closure of bowl
  – discharge detector for monitoring sludge discharge

5.4 Refrigeration and air conditioning system (3 hours)

– explains the automation, monitoring and alarms in refrigeration systems:
  – if pump down cycle used on board for refrigeration system:
    – automatic shutdown of compressor when all cold rooms attain temperature by shutting off of solenoid valves and low pressure cut out in suction line

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- when one or more cold rooms temperature rises and solenoid valve/s open and suction pressure rises, thereby suction cut in operates and automatic start of compressor
- automatic shutdown and alarm in case of high pressure in discharge line. Manual reset for restarting of compressor
- automatic shutdown of compressor and alarm in case of low pressure of lubricating oil
- timer control for defrosting of evaporator coils of meat room and fish room

– capacity control may be used on board for refrigeration compressor

– automatic control of steam spray for accommodation air conditioning heating system

5.5 Pumping and piping system (1 hour)

– explains the automation, monitoring and alarms of pumping and piping system:

- automatic start of standby pumps
- automatic start/stop of hydrophore pumps
- automatic water level control of boiler by feed pumps
- automatic cargo stripping system onboard tankers
- automatic heeling system

5.6 Steering gear system (2 hours)

– explains the automation, monitoring and alarms of steering systems:

- main and emergency steering systems
- autopilot system
- regaining of steering capability in case of single failure of the hydraulic system

5.7 Cargo handling equipment and deck machinery (1 hour)

– explains the automation, monitoring and alarms of cargo handling equipment and deck machinery:

- self-tensioning mooring winches
- automatic shutdown of cargo pumping on abnormal operating conditions of inert gas system on board tankers
- automatic shutdown of cargo pumping/loading on tankers and gas carriers

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COMPETENCE 1.4	Manage Fuel, Lubrication and Ballast Operations	IMO Reference
TRAINING OUTCOME: Demonstrates a knowledge and understanding of: 1.4.1 OPERATION AND MAINTENANCE OF MACHINERY, INCLUDING PUMPS AND PUMPING SYSTEM		STCW Code table A-III/2

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COMPETENCE 1.4	Manage Fuel, Lubrication and Ballast Operations	IMO Reference

1.4.1 OPERATION AND MAINTENANCE OF MACHINERY, INCLUDING PUMPS AND PUMPING SYSTEM

Textbooks/Bibliography: T7, T11

Teaching aids: A1, V57, V60

Required performance:

1.1 Bilge and ballast (2 hours)

- describes procedures for evaluating pumps, ejectors and pumping systems including ship side valves, explains methods of identifying problems which affect performance, and identify common faults and evaluate methods of assessment
- illustrates the operation of self-priming systems as used on ballast or cargo pumping arrangements
- explains the purpose and procedure for using bilge injection
- explains the main causes of corrosion in sea water systems and the regions most affected
- compares corrosion and marine growth prevention systems used for pumps and pumping systems, including impressed current, sacrificial anodes, chemical injection, special coatings, chlorination and special materials

1.2 Prevention of pollution of the sea by oil (4 hours)

- describes in principle how bilge and ballast water are discharged
- lists the precautions to be taken when transferring or bunkering fuel oil and lubricating oil
- describes the requirements for oily water separators
- explains how the mode and type of pump used affects the contamination of oily water
- explains how the temperature, relative density and size of oil particles affect the separation process
- explains the principles of the operation of a two stage and three stage automatic oily water separator
- explains why and where pressure relief devices are fitted to a separator
- describes the function of a coalescer
- explains the principles and purpose of a separator probe
- describes how the automatic valve is controlled and operated
- lists the safeguards in an oily water separator system
- describes the automatic cleaning of an oily water separator

1.3 Sewage and sludge (4 hours)

- describes a sewage retention system
- explains why vacuum transportation systems are used
- describes the process where a comminutor and treatment with chlorine are used
- describes the processes in a biological treatment plant
- explains how the sludge from a biological treatment plant is disposed of

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COMPETENCE 1.4	Manage Fuel, Lubrication and Ballast Operations	IMO Reference
– explains why biological treatment should be kept working continuously – names the contaminants which would impair the treatment process – describes the operation of chemical treatment plants – lists the waste materials that can be incinerated – explains how liquid and solid waste are prepared for combustion in an incinerator		

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Part D1: Instructor Manual

The following notes are intended to highlight 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 competences concerned with planning and scheduling operations; start up and shut down of main and auxiliary machinery; performance monitoring; safety management and fuel and ballast operations management.

Whilst dealing with theoretical and mathematical subjects, instructors are advised to provide suitable practical examples, related to shipboard applications. This would help the trainees achieve a better and thorough understanding of the principles involved in the theory.

It should be noted that the suggested learning time has been reduced where basic content from operational level training should need only to be refreshed rather than learnt for the first time. Instructors should ensure that trainees have understood the operational level content before introducing the higher level concepts and features that are required at management level.

1.1 MANAGE THE OPERATION OF PROPULSION PLANT MACHINERY

1.1.1 DESIGN FEATURES AND OPERATIVE MECHANISM OF MARINE DIESEL ENGINE AND ASSOCIATED AUXILIARIES

1.1 Design features and operative mechanism of marine diesel engine and associated auxiliaries (15 hours)

Instructors should refer to V5, V12, V70, V78, T10, T15, T20, T21, T22, T40, T41 and T44 for this subject, to deal with topics that

(i) Describe with the aid of sketches/computer aided drawing, material selection and design features of the structure of diesel engine

(ii) Describe with the aid of sketches/computer aided drawing, material selection and design features of the running gear of diesel engine

(iii) Describe with the aid of sketches/computer aided drawing, material selection and design features of the fuel injection equipment of diesel engine

(iv) Describe with the aid of sketches/computer aided drawing, material selection and design features of the combustion chamber components of diesel engine

(v) Describe with the aid of sketches/computer aided drawing, material selection and design features of piston rings, compatibility to cylinder liner and cylinder lubrication employed in a diesel engine

(vi) Describe with the aid of sketches the operative mechanism of diesel engine system.

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1.1.2 DESIGN FEATURES AND OPERATIVE MECHANISM OF MARINE STEAM TURBINE AND ASSOCIATED AUXILIARIES

2.1 Design features and operative mechanism of marine steam turbine and associated auxiliaries (5 hours)

Instructors should refer to V10, V74, T8, T38, T42 and T45 for this subject, to deal with topics that

(i) Describe with the aid of sketches/computer aided drawing, material selection and design features of steam turbines

(ii) Describe with the aid of sketches the operative mechanism of steam turbines.

1.1.3 DESIGN FEATURES AND OPERATIVE MECHANISM OF MARINE GAS TURBINE AND ASSOCIATED AUXILIARIES

3.1 Design features and operative mechanism of marine gas turbine and associated auxiliaries (5 hours)

Instructors should refer to V65, T2, T22, T64 for this subject to deal with topics that

(i) Describe with the aid of sketches/computer aided drawing, material selection and design features of gas turbines and

(ii) Describe with the aid of sketches the operative mechanism of a marine gas turbine.

1.1.4 DESIGN FEATURES AND OPERATIVE MECHANISM OF MARINE STEAM BOILER AND ASSOCIATED AUXILIARIES

4.1 Design features and operative mechanism of marine steam boiler and associated auxiliaries (10 hours)

Instructors should refer to V10, V74, T8, T38, T42 and T45 for this subject to deal with topics that

(i) Describe with the aid of sketches/computer aided drawing, material selection and design features of marine steam boilers and

(ii) Describe with the aid of sketches/computer aided drawing, material selection and design features of marine steam boiler feed water systems.

1.1.5 DESIGN FEATURES AND OPERATIVE MECHANISM OF PROPELLER SHAFT AND ASSOCIATED ANCILLARIES

5.1 Design features and operative mechanism of propeller shaft and associated ancillaries (5 hours)

Instructors should refer to T7, T11, T19, T35 and T36 for this subject to deal with topics *related to*

(i) Establishing the shaft centre line

(ii) Deviation while building

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(iii) Alignment deviation in service
(iv) Fair curve alignment
(v) Shaft checks
(vi) Shaft bearings
(vii) Coupling bolts
(viii) Stern tubes
(ix) Stern tube sealing arrangements
(x) Fixed pitch propellers
(xi) Methods of mounting fixed pitch propellers
(xii) Controllable pitch propellers
(xiii) Gears and clutches
(xiv) Reverse reduction gearbox
(xv) Flexible couplings and
(xvi) Air operated clutches.

1.2 PLAN AND SCHEDULE OPERATIONS *Theoretical knowledge*

1.2.1 THERMODYNAMICS AND HEAT TRANSMISSION

1.1 Gas cycles/engine analysis (12 hours)

Instructors should refer to T2 and T18 for this subject to deal with the topics on

(i) Constant pressure and constant volume air standard cycles
(ii) Reciprocating internal combustion engine performance
(iii) Open and closed gas turbine systems and
(iv) Power, isentropic efficiency and thermal efficiency for gas turbines.

1.2 Properties of vapours (6 hours)

Instructors should refer to T2 and T18 for this subject.

(i) Saturation, dryness fraction and superheat
(ii) T-s, p-h, p-v, h-s diagrams
(iii) Fluid properties using steam tables
(iv) Throttling and separating calorimeters and
(v) Air in condensers.

Trainees should understand that the principles of steam apply to other vapours. Trainees should have used tables of thermodynamic properties in earlier studies and will need to use them in various training outcomes.

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1.3 Steam cycles (9 hours)

Instructors should refer to T2 and T18 for this subject to deal with the topics on

(i) Rankine cycle. Turbine isentropic efficiency
(ii) Feed heating
(iii) Thermal efficiency and
(iv) Cycle on t-s diagram.

1.4 Refrigeration (6 hours)

Instructors should refer to T2 and T18 for this subject to deal with the topics on

(i) Vapour compression cycle
(ii) Refrigerant properties and hazards
(iii) Refrigerant tables
(iv) Cycle on p-h diagram
(v) Coefficient of performance
(vi) Refrigerant mass flow
(vii) Compressor calculations and
(viii) Secondary refrigerants.

1.5 Combustion (6 hours)

Instructors should refer to T2 and T18 for this subject to deal with the topics on

(i) Combustion equations
(ii) Fuel composition
(iii) Air-fuel ratio
(iv) Excess air
(v) Volumetric analysis of combustion products and
(vi) Calorific value.

1.6 Heat transfer (12 hours)

Instructors should refer to T2 and T18 for this subject to deal with the topics on

(i) Conduction, radiation and convection
(ii) Composite walls. Insulation
(iii) Film coefficient
(iv) Interface temperature
(v) Stefan-Boltzmann Law

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(vi) Parallel flow and cross flow heat exchangers and

(vii) Logarithmic mean temperature difference.

1.7 Air conditioning **(3 hours)**

Instructors should refer to T2 and T18 for this subject to deal with the topics on

(i) Comfort conditions

(ii) Psychometric charts

(iii) Wet and dry bulb temperatures

(iv) Humidity

(v) Dewpoint

(vi) Dehumidifying and humidifying processes and

(vii) Air conditioning systems.

1.2.2 MECHANICS AND HYDROMECHANICS

2.1 Balancing **(4 hours)**

Instructors should refer to T1 and T17 for this subject to explain

(i) Primary and secondary forces

(ii) Primary and secondary couples and

(iii) Complete balancing of reciprocating machinery

(iv) Critical speed.

2.2 Simple harmonic motion **(6 hours)**

Instructors should refer to T1 and T17 for this subject to explain

(i) Equation of simple harmonic motion

(ii) Amplitude, frequency and periodic time

(iii) Vibrating spring mass systems

(iv) Springs

(v) Resonance

(vi) Transmissibility and

(vii) Vibrations of flywheels and gearwheels.

2.3 Stress and strain **(10 hours)**

Instructors should refer to T1 and T17 for this subject to explain

(i) Stress and strain relationships in thin cylindrical and spherical shells

(ii) Stress in thin, rotating rims

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(iii) Thermal stress

(iv) Stress in compound bars

(v) Elastic strain energy and

(vi) Stresses due to gradually applied and shock loads.

2.4 Torsion (8 hours)

Instructors should refer to T1 and T17 for this subject to explain

(i) Stress, strain and strain energy due to torsion

(ii) Fundamental torsion equation

(iii) Reciprocating engine crank effort

(iv) Rudder stock turning moment from steering gear

(v) Deflection of helical springs and

(vi) Instructors should relate the theory to components used on board vessels. Highlight the advantages of using a hollow shaft in marine application compared to a solid shaft.

2.5 Combined stress (4 hours)

Instructors should refer to T1 and T17 for this subject to deal with topics on

(i) Stresses on an oblique plane

(ii) Material subjected to two perpendicular stresses

(iii) Axial and bending stress

(iv) Mohr's stress circle. Principal stresses and strains and

(v) Combined bending and twisting.

2.6 Fluid mechanics (12 hours)

Instructors should refer to T1 and T17 for this subject to deal with topics on

(i) Volume and mass flow

(ii) Venturi meter

(iii) Bernouilli's equation

(iv) Jets. Orifice coefficients

(v) Dynamic and kinematic viscosity

(vi) Reynolds' number

(vii) Flow losses in pipes and fittings

(viii) Darcy's formula and

(ix) Centrifugal pumps.

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1.2.3 PROPULSIVE CHARACTERISTICS OF DIESEL ENGINES, STEAM AND GAS TURBINES INCLUDING SPEED, OUTPUT AND FUEL CONSUMPTION (20 hours)

3.1 Propeller and load diagrams

Instructors should refer to T20, T21 and T22 for this subject to deal with the topics on

(i) Propeller curve

(ii) Propeller design point

(iii) Fouled hull, sea margin and heavy propeller

(iv) Constant ship speed lines.

3.2 Propulsion characteristics diesel

(i) Continuous service rating

(ii) Engine margin

(iii) Limits for continuous operation

(iv) Limits for overload operation

(v) Specific fuel oil consumption (SFOC)

(vi) SFOC based on reference ambient conditions stated in ISO 3046/1-1986

(vii) Adjustment of SFOC for lower calorific value of fuels and ambient conditions different from ISO reference conditions

3.3 Propulsion characteristics steam plant

(i) Continuous service rating

(ii) Engine margin

(iii) Constant ship speed lines

(iv) Limits for continuous operation

(v) Specific fuel oil consumption (SFOC)

(vi) SFOC based on reference ambient conditions stated in ISO 3046/1-1986

(vii) Adjustment of SFOC for lower calorific value of fuels and ambient conditions different from ISO reference conditions

3.4 Propulsion characteristics gas turbine

(i) Continuous service rating

(ii) Engine margin

(iii) Limits for continuous operation

(iv) Limits for overload operation

(v) Specific fuel oil consumption (SFOC)

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(vi) SFOC based on reference ambient conditions stated in ISO 3046/1-1986

(vii) Adjustment of SFOC for lower calorific value of fuels and ambient conditions different from ISO reference conditions

1.2.4 HEAT CYCLE, THERMAL EFFICIENCY AND HEAT BALANCE OF THE FOLLOWING

4.1 Marine diesel engine (5 hours)

Instructors should refer to T2 and T18 for this subject

(i) Dual cycle

(ii) Thermal efficiency of dual cycle and

(iii) Heat balance of marine diesel engine

4.2 Marine steam boiler and steam turbine (10 hours)

Instructors should refer to T2 and T18 for this subject

(i) Rankine cycle

(ii) Thermal efficiency of Rankine cycle

(iii) Heat balance of a marine steam plant

(iv) Boiler/turbine performances

(v) Boiler/turbine efficiency

4.3 Marine gas turbine (5 hours)

Instructors should refer to T2 and T18 for this subject

(i) Brayton cycle

(ii) Thermal efficiency of Brayton cycle and

(iii) Heat balance of marine gas turbine plant

1.2.5 REFRIGERATORS AND REFRIGERATION CYCLE

5.1 Refrigeration and air conditioning system (10 hours)

Instructors should refer to V76, T48 and T49 for this subject to

(i) Assess common refrigerants used on board, using factors such as their properties, economics of use, handling, health hazards and environmental impact

(ii) Explain the environmental concerns of traditional refrigerants and the methods used to address these concerns

(iii) Explain correct procedures for the recovery of refrigerants from refrigeration systems

(iv) Analyse functions and operation of all components including fittings and safety devices of refrigeration and air conditioning plants

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(v) Interpret symptoms, effects and remedial actions for common faults in refrigeration and air conditioning systems

(vi) Precautions during cargo operations – re-circulation system of AHU

(vii) Explain the purposes and procedures for pumping down, leak test, refrigerant charging and oil changing

(viii) Record keeping of refrigerant consumption.

1.2.6 PHYSICAL AND CHEMICAL PROPERTIES OF FUELS AND LUBRICANTS

6.1 Shore side and shipboard sampling and testing (1 hour)

Instructors should refer to V10, T7 and T11 for this subject to

(i) Appraise the importance and implications of continual monitoring of quality of fuels and lubricants in efficient operation of machinery and

(ii) Explain the procedures available for testing fuels and lubricants, including viscosity, water in oil, density, pour point, total base number (TBN), microbiological contamination and other contamination.

6.2 Interpretation of test results (1 hour)

Instructors should refer to T7 and T11 for this subject to describe the facilities available for laboratory testing of fuels and lubricants, the properties that can be determined, and how the results can be interpreted and utilized in maintenance programme.

6.3 Contaminants including microbiological infection (2 hours)

Instructors should refer to V6, T7 and T11 for this subject to

(i) Outline procedures for dealing with contamination of oils by water, fuel in lubricating oil, solid debris or other contaminants, including recognition of unacceptable levels and possible consequences and

(ii) Examine the causes, symptoms, effects and methods of treatment of oils that have been infected with microbiological organisms.

6.4 Treatment of fuels and lubricants including storage, centrifuging, blending, pretreatment and handling (4 hours)

Instructors should refer to V67, T7 and T11 for this subject to

(i) Detail bunkering procedures and arrangements, explaining the importance of following correct procedures

(ii) Evaluate the operation of centrifugal separators and analyse the factors that affect optimum separation and

(iii) Explain the function and operation of a shipboard fuel blender and alternative fuel treatments.

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1.2.7 TECHNOLOGY OF MATERIAL

7.1 Engineering processes used in construction and repair (4 hours)

Instructors should refer to T7, T11 and T44 for this subject to

(i) Evaluate common fabrication techniques, including welding, forging and casting and

(ii) Assess common repair techniques.

1.3 OPERATION, SURVEILLANCE, PERFORMANCE ASSESSMENT AND MAINTAINING SAFETY OF PROPULSION PLANT AND AUXILIARY MACHINERY

Practical knowledge

1.3.1 START UP AND SHUT DOWN MAIN AND AUXILIARY MACHINERY, INCLUDING ASSOCIATED SYSTEMS

1.1 Main machinery and associated systems (7 hours)

Instructors should refer to T2, T7, T8, T9, T10, T11, T12, T13, T15, T20, T21, T22, T39, T40, T41, T46, T47 and T63 for this subject to enable trainees to interpret precautions and the need of authorized procedures to start up main machinery, and mechanism and procedures of starting up and shutting down main machinery depending on types of the machinery.

1.2 Steam boilers and associated systems (6 hours)

Instructors should refer to T2, T7, T8, T9, T11, T12, T13, T14, T38, T42, T45, T46 and T47 for this subject to enable trainees to interpret the general procedures of starting up and shutting down steam boiler depending on the types and specifications of the boilers including automatic control systems.

1.3 Auxiliary prime mover and associated systems (4 hours)

Instructors should refer to T2, T7, T8, T9, T10, T11, T12, T13, T15, T20, T21, T22, T40, T41, T46, T47 and T63 for this subject to enable trainees to interpret mechanism and procedures of starting up and shutting down auxiliary prime movers depending on the types of the prime movers including automatic control systems.

1.4 Other auxiliary machinery (3 hours)

Instructors should refer to T5, T6, T7, T8, T9, T11, T12, T13, T14, T15, T23, T31, T32, T46, T47, T48, T49, T50, T51, T52, T55, T56, T61 and T62 for this subject to enable trainees to interpret and identify auxiliary machinery used for ship's propulsion, their starting up and shutting down procedures and how they contribute to safe and continuous operation of main machinery.

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1.3.2 OPERATING LIMITS OF PROPULSION PLANTS (8 hours)

Instructors should refer to T2, T7, T8, T11, T13, T15, T20, T21, T22, T38, T40, T41, T42 and T45 for this subject to enable trainees to examine and interpret running parameters/ factors concerning operating limits of propulsion machinery. Instructors should describe how these running parameters/factors limit the operation range of the machinery including their characteristics. In many cases, instruction manuals say specific operation limits and instructors should also refer to some typical instruction manuals of the machinery.

1.3.3 EFFICIENT OPERATION, SURVEILLANCE, PERFORMANCE ASSESSMENT AND MAINTAINING SAFETY OF PROPULSION PLANT AND AUXILIARY MACHINERY

3.1 Diesel engines (10 hours)

Instructors should refer to V1, V9, V12, T10, T20, T21 and T22 to enable trainees to understand

(i) Indicator and draw diagrams, calculation of power, efficiency estimation of power of engine using engine parameters like fuel index, engine RPM

(ii) Detection of fault from indicator diagrams and

(iii) Engine condition monitoring and evaluation.

Instructors would find considerable benefit from reading a wide range of books on marine engineering and technical papers. Engine manufacturers provide their customers with manuals which give instructions on the operation and maintenance of their engines. Such manuals are of immense value to both instructors and trainees. Every effort should be made to obtain manuals appropriate to the type of machinery which the trainees are likely to experience.

Currently, low-speed diesel engines are built mainly by three manufacturers – MAN B&W, Wartsila Sulzer and Mitsubishi. The former two share the bulk of new tonnage and the latter is largely confined to Japanese-built ships.

3.2 Engine components (18 hours)

Instructors should refer to V12, V70, V74, T1, T7, T11 and T17 for this subject to enable trainees to

(i) Interpret static and dynamic loads and stresses, identifying service limitations, of diesel engine components

(ii) Evaluate different fabrication methods of diesel engine components

(iii) Identify two and four stroke operating cycle forces, couples, and moments, relating these to design principles

(iv) Explain out of balance gas and inertia forces, couples, and moments, and relate these to flywheels, balance weights, and first/second order balancing, and hull vibration

(v) Explain factors contributing to torsional vibration, and identify methods of minimizing or eliminating harmful effects of critical speeds

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(vi) Evaluate the calibration of pistons, cylinder liners, piston rings, bearings and crankshaft

(vii) Specify alignment and adjustment criteria of Crankshafts, Chain drives, Gear drives, Integral thrust bearings and crossheads

(viii) Compile specified working clearances and limits of all bearings, sliding surfaces, and interference fits of a typical diesel engine, using engine builders' manuals.

3.3 Engine lubrication (8 hours)

Instructors should refer to V7, V8, V12, V70, V74, T7 and T11 for this subject to enable trainees to

(i) Identify diesel engine lubricant types, properties and applications

(ii) Outline principles of diesel engine lubrication

(iii) In relation to contamination and deterioration of diesel engine lubricants, discuss the sources, types and effects of contamination, the causes, types and effects of deterioration, typical testing and treatment methods, and interpret typical results of testing, giving appropriate actions which should be undertaken

(iv) Describe, using diagrams, the distribution of lubricating oil to diesel engines, in particular the Guides and crosshead bearings of slow speed diesel engines, Top end bearings of medium speed engines, Bottom end bearing, Main bearings and Camshaft drives, showing direction of flow, typical clearances, and stating normal operating parameters.

3.4 Fuel injection (12 hours)

Instructors should refer to V5, T10, T20, T21 and T22 for this subject to enable trainees to

(i) Explain why atomization and penetration of fuel and the turbulence of air are essential to optimum combustion in a diesel engine

(ii) State typical injection pressures and viscosities for different grades of fuel

(iii) Describe how and why fuel pumps, camshafts and injectors are altered for varying fuel types

(iv) Describe, with the aid of simple sketches, the difference between constant and variable injection timing of fuel, showing materials, principal parts, methods of operation and adjustments of common types of fuel pump

(v) Compare injection requirements for slow speed, medium speed and high speed diesel engines, including pilot injection and pre-combustion chambers

(vi) Identify common service faults, symptoms and causes of combustion problems, specifying appropriate adjustments, including methods of fuel pump timing

(vii) Summarize occupational health and safety aspects of handling and testing fuel injection systems

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(viii) Explain, using relevant diagrams and stating normal operating parameters:

Fuel valve cooling arrangement

Uni-fuel and dual-fuel systems (for high/medium viscosity fuel types)

(ix) Discuss the atmospheric pollution aspects of diesel engine combustion, and give methods which reduce this pollution (especially SOx and NOx reduction).

3.5 Scavenging and supercharging (10 hours)

Instructors should refer to T10, T20, T21 and T22 for this subject to enable trainees to evaluate the need for scavenging in diesel engines, the methods of scavenging, the pressure charging methods, the working principles of turbochargers, cooling and lubrication of turbochargers, assessment of turbocharging, analyse typical faults and appropriate actions to be undertaken with defective or damaged turbochagers.

3.6 Starting and reversing (8 hours)

Instructors should refer to T10, T20, T21 and T22 for starting procedures of diesel engines for power generation, propulsion and emergency use, starting and manoeuvring requirements/ sequences for direct coupled reversible and geared propulsion diesel engines, for fixed and controllable pitch propeller applications, typical manoeuvring and reversing systems for propulsion diesel engines, compare different methods of reversing direct coupled propulsion diesel engines, identify common faults and identify appropriate actions to be undertaken with typical diesel engine starting and manoeuvring systems, compare the different methods of utilizing diesel engines for ship propulsion, including: Direct coupled, reversible slow and medium speed engines, Clutched and geared reversible and unidirectional medium speed engines with a fixed pitch propeller, Clutched and geared reversible and unidirectional medium speed engines with a controllable pitch propeller and Diesel electric drive.

3.7 Cooling systems (4 hours)

Instructors should refer to V69, T10, T20, T21 and T22 for this subject to enable trainees to

(i) Analyse the problems that may arise in cooling water spaces of diesel engines

(ii) Evaluate common methods of diesel engine cooling water treatment

(iii) State the importance of maintaining diesel engine thermal efficiency and evaluate thermal loads on engine components

(iv) Justify cooling media selection and state the advantages and disadvantages of various diesel cooling methods

(v) Evaluate the tests used in the control of diesel engine cooling water treatment

(vi) Enumerate the normal operating limits for diesel engine cooling water treatment

(vii) Interpret the implications of out of limit readings from water treatment tests and state the corrective procedures which should be undertaken

(viii) Itemize the sources and types of contamination of diesel engine cooling water and explain the effects of these contaminations on the reserves of treatment chemicals

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(ix) Compare the procedures which may be used to counter contamination of diesel engine cooling water and

(x) Explain, using relevant diagrams and stating normal operating parameters, typical methods of cooling of Medium and slow speed diesel engine pistons, Exhaust valves, Cylinders, Turbochargers and Cylinder heads.

3.8 Diesel engine control and safety (4 hours)

Instructors should refer to V9, V53, T10, T46 and T47 for this subject to enable trainees to understand the following safety aspects

(i) With respect to waste heat units: explain the design and operational factors that contribute to fires in waste heat units, generation of soot and hydrogen fires, possible consequences of such fires, identify routine cleaning and inspection criteria, identify symptoms of a fire. Appropriate actions to be undertaken upon fire detection in order to contain/extinguish the fire, and identify the risks of isolating a waste heat unit

(ii) With respect to scavenge fires: explain the factors that contribute to a fire in the scavenge chamber of a diesel engine, explain the possible consequences of such fires, specify detection, protection and extinguishing devices, identify routine cleaning and inspection criteria, identify symptoms of a fire, and give appropriate actions to be undertaken upon fire detection in order to contain/extinguish the fire

(iii) With respect to starting air lines: identify principles of explosive mixtures, describe how an air line explosion can occur, explain the possible consequences of such an explosion, identify routine evaluation criteria of starting air systems for minimizing/ avoiding an explosion, and state how the risk of explosion may be minimized/ avoided by protection devices.

(iv) With respect to diesel engine crankcases and gearboxes: evaluate the causes and consequences of diesel engine overspeed, and give procedures which must be undertaken in the event of such an occurrence and explain, using diagrams, the operating principles of oil mist detectors, giving testing procedures, explosion relief doors, crankcase breathers and crankcase extraction fans.

3.9 Diesel engine emergency operation (2 hours)

Instructors should refer to V9, V53, T10, T46 and T47 for this subject to enable trainees to explain emergency procedures for manoeuvring for diesel engines and manoeuvring with defective clutches.

3.10 Multi-engine Propulsion Arrangement (2 hours)

Instructors should refer to T7, T11 and T15 for this subject to enable trainees to

(i) Explain the need for changing the output speed of prime movers

(ii) Define gearing concepts, and explain the advantages and disadvantages of utilizing gearing to change prime mover output speed, involute gearing, spur and helical gears

(iii) Assess the need for disengaging prime movers from drive lines

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(iv) Identify common types of clutches and couplings used with prime movers and

(v) Outline maintenance procedures associated with clutches.

3.11 Air compressors and compressed air systems (3 hours)

Instructors should refer to T7 and T11 for this subject to enable trainees to

(i) Examine the functions and operation of all components including fittings and safety devices of air compressors and compressed air systems

(ii) Evaluate the effects of common operational faults of single and multi-stage air compressors, including: leaking valves, leaking piston rings, blocked filters, blocked coolers

(iii) Explain the reasons and the effects of high levels of oil or water in compressed air

(iv) Explain the effects of operating air compressors with synthetic lubricating oils compared to operating with mineral lubricating oils and

(v) Describe a procedure for inspecting and maintaining air receivers and their fittings.

3.12 Hydraulic power system (6 hours)

Instructors should refer to V11, V77 and T15 for this subject to enable trainee to analyse functions and operation of all components including fittings and safety of devices of hydraulic power systems and interpret symptoms, effects and remedial actions for common faults in hydraulic power systems.

3.13 Types of auxiliary boilers (9 hours)

Instructors should refer to V3, V10, V74, T7, T8, T11, T15, T38 and T42 for this subject to enable trainees to

(i) Examine typical boiler types illustrating cross sections, attachments and locations of all fittings, mountings, scantlings and methods of achieving water circulation and gas flow

(ii) Distinguish the material requirements for boiler components

(iii) Explain the construction of typical types of boilers

(iv) Explain functions and operation of all boiler components including fittings and safety devices

(v) Illustrate a typical boiler fuel system and its components

(vi) Examine the operation and maintenance procedures of boiler fuel systems

(vii) Analyse the combustion process, its monitoring system, and requirements for proper combustion

(viii) Evaluate common types of burners and distinguish how atomization and subsequent combustion is achieved and

(ix) Identify the protection devices, alarms and shutdowns used in combustion control and fuel systems, and analyse their importance and methods of operation.

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3.14 Auxiliary steam system (2 hours)

Instructors should refer to V3, V10, V74, T7, T8, T11, T15, T38 and T42 for this subject to enable trainees to

(i) Illustrate a typical auxiliary steam system, showing the location and purpose of all components

(ii) Develop a heat energy balance for an auxiliary steam system

(iii) Distinguish the material requirements for auxiliary steam system components

(iv) Examine the construction and operation of typical auxiliary steam system components

(v) Explain the reasons for operating the auxiliary steam plant and its systems at nominated temperatures and pressures, and the effects of departing from these parameters

(vi) Analyse the symptoms of faults in steam traps, hot wells, de-aerators and condensers and

(vii) Analyse the requirements for contamination prevention between systems.

3.15 Safety valves (4 hours)

Instructors should refer to V3, V10, V74, T7,T8, T11, T15, T38 and T42 for this subject to enable trainees to

(i) Analyse the requirements for steam safety valves

(ii) Analyse the design formulae used for steam safety valves

(iii) Differentiate between common types of boiler safety valves in use and explain how they are classified in terms of valve lift

(iv) Distinguish the materials of construction of safety valves

(v) Analyse operational problems that can occur with safety valves

(vi) Examine how a safety valve is inspected and overhauled, giving common defects and areas of importance when inspecting

(vii) Formulate a procedure for setting safety valves, and examine the precautions necessary when testing safety valves on boilers and waste heat unit.

3.16 Boiler water levels (6 hours)

Instructors should refer to V3, V10, V74, T7, T8, T11, T15, T38 and T42 for this subject to enable trainees to

(i) Discuss requirements for boiler water level indicators

(ii) Differentiate between common types of local boiler water level indicator in use, explaining their different methods of construction and operation

(iii) Evaluate testing, maintenance and defect rectification procedures for local boiler water level indicators

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(iv) Differentiate between common types of remote boiler water level indicator in use, explaining their different methods of construction and operation and

(v) Evaluate testing, maintenance and defect rectification procedures for remote boiler water level indicators.

3.17 Use of sea water in boilers (0.5 hour)

Instructors should refer to V3, V10, V74, T7, T8, T11, T15, T38 and T42 for this subject to enable trainees to explain the reasons and the effects of using sea water in boilers.

3.18 Use of fresh water in boilers (0.5 hour)

Instructors should refer to V3, V10, V74, T7, T8, T11, T15, T38 and T42 for this subject to enable trainees to

(i) Analyse the different types of impurities present in boiler, feed and make up water

(ii) Explain how salts are precipitated from boiler and feed water, and the consequences of this precipitation and

(iii) Explain how metal is corroded in the boiler and feed system.

3.19 Boiler water testing (3 hours)

Instructors should refer to V3, V10, V74, T7, T8, T11, T15, T38 and T42 for this subject to enable trainees to

(i) Define pH and explain how it is measured and controlled

(ii) Evaluate the tests used in the control of boiler and feed water treatment and

(iii) Interpret the implications of out of limit readings from water treatment tests and state the corrective procedures which should be undertaken.

3.20 Boiler water treatment (9 hours)

Instructors should refer to V3, V10, V74, T7, T8, T11, T15, T38 and T42 for this subject to enable trainees to

(i) Evaluate common methods of boiler feed and make up water treatment

(ii) Show how oxygen is eliminated in high pressure boilers

(iii) Enumerate the normal and maximum operating limits for boiler and feed water treatment

(iv) Itemize the sources and types of contamination of boiler, feed and make up water and explain the effects of these contaminations on the reserves of treatment chemicals and

(v) Compare the procedures which may be used to counter contamination of boiler, feed and make up water.

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3.21 Auxiliary steam turbines (9 hours)

Instructors should refer to V3, V10, V74, T7, T8, T11, T15, T38 and T42 for this subject to enable trainees to

(i) Analyse the types, uses and methods of construction of auxiliary steam turbines in use at sea

(ii) Examine the typical operating conditions, including temperatures and pressures, of auxiliary steam turbines

(iii) Identify the materials used in auxiliary steam turbines and ancillary equipment

(iv) Examine typical operational problems associated with auxiliary steam turbine plants, the symptoms, effects and possible remedies of these faults

(v) Explain the processes of warming through and shutting down auxiliary steam turbine plants and

(vi) Outline the maintenance associated with optimum performance of an auxiliary steam turbine plant.

3.22 Boiler defects (3 hours)

Instructors should refer to V3, V10, V74, T7, T8, T11, T15, T38 and T42 for this subject to enable trainees to

(i) Identify the possible defects which may occur in a boiler, gas and water side, giving their location, nature and effects

(ii) Outline procedures commonly employed to rectify defects in boilers, and explain the limitations of such repairs and

(iii) Enumerate procedures for leak detection in boilers and other steam system components, and explain the remedial actions which may be undertaken.

3.23 Boiler and steam turbine survey and repairs (6 hours)

Instructors should refer to V3, V10, V74, T7, T8, T11, T15, T38 and T42 for this subject to enable trainees to

(i) Examine the need for surveying auxiliary boilers, steam turbines and other components of auxiliary steam systems

(ii) Outline survey requirements for auxiliary boilers, steam turbines and other components of auxiliary steam systems and

(iii) Outline the procedures for shutting down, isolating and opening up an auxiliary boiler for inspection or during an emergency.

3.24 Evaporators (6 hours)

Instructors should refer to V3, V10, V74, T7, T8, T11, T15, T38 and T42 for this subject to enable trainees to compare operation, performance, problems and applications of common fresh water generation plants used at sea and evaluate the need for treatment of evaporator water, and assess methods of fresh water generation plant water treatment.

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3.25 Thermal fluid heating system (3 hours)

Instructors should refer to V3, V10, V74, T7, T8, T11, T15, T38 and T42 for this subject to enable trainees to examine typical thermal fluid heating systems and explain the advantages and disadvantages of these systems, compare with conventional steam plant, explain the locations and functions of all components, fittings and safety devices used in thermal fluid systems and analyse the properties of thermal fluids used, effects of contamination, and methods of testing the fluid.

1.3.4 FUNCTIONS AND MECHANISM OF AUTOMATIC CONTROL FOR MAIN ENGINE

4.1 Diesel engines (4 hours)

Instructors should refer to T7, T10, T20, T21, T22, T40, T46, T47, T56, T62 and some typical instruction manuals for this subject to enable trainees to interpret what components are comprised to control main diesel engines and their operation mechanism. Functions for controlling the main diesel engines must differ according to the engine types, specifications and other factors; however, instructors should describe how the functions contribute/work to the automatic control of the main diesel engines taking up the functions listed in the detailed teaching syllabus.

4.2 Steam turbines (3 hours)

Instructors should refer to T8, T46, T47, T56, T62, T63 and some typical instruction manuals for this subject to enable trainees to interpret what components are comprised to control main steam turbines and their operation mechanism. Functions for controlling main steam turbines must differ according to the engine types, specifications and other factors; however, instructors should describe how the functions contribute/work to the automatic control of main steam turbines taking up the functions listed in the detailed teaching syllabus

4.3 Gas turbines (3 hours)

Instructors should refer to T8, T46, T47, T56, T62, T63 and some typical instruction manuals for this subject to enable trainees to interpret what components are comprised to control main gas turbines and their operation mechanism. Functions for controlling main gas turbines must differ according to the engine types, specifications and other factors; however, instructors should describe how the functions contribute/work to the automatic control of main gas turbines taking up the functions listed in the detailed teaching syllabus

1.3.5 FUNCTIONS AND MECHANISM OF AUTOMATIC CONTROL FOR AUXILIARY MACHINERY

5.1 Generator and distribution system (4 hours)

Instructors should refer to T14, T23, T55 and T62 for this subject to enable trainees to interpret what components are generally comprised in the system to control the generator and distribution system. Instructors should describe the meaning/aims of functions listed in the detailed teaching syllabus and how the functions work

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5.2 Steam boiler (5 hours)

Instructors should refer to T8, T9, T11, T38, T42, T45 and T47 for this subject to enable trainees to interpret what components/devices are generally comprised in the system to control the steam boiler and how the components work. Instructors should describe the meaning/aims of functions listed in the detailed teaching syllabus. With regard to ACC for main boilers, as control methodologies must include higher level of control engineering so that instructors should arrange suitable limitations to teach and should focus on operation principles of the components.

5.3 Oil purifier (3 hours)

Instructors should refer to V87, T9 and T46 for this subject to enable trainees to understand automation, monitoring and alarms, temperature control, automatic start and desludging, detection of water content.

5.4 Refrigeration and air conditioning system (3 hours)

Instructors should refer to V76, T7, T11 and T49 for this subject to enable trainees to understand

(i) Automation, monitoring and alarms in refrigeration system

(ii) Capacity control may be used on board for refrigeration compressor and

(iii) Automatic control of steam spray for accommodation air conditioning heating system.

5.5 Pumping and piping system (1 hour)

Instructors should refer to V79, T7 and T11 for this subject to deal with pumping and piping system. Explain with examples of piping system on different types of vessels such as bulk carriers, tankers and other vessels.

5.6 Steering gear system (2 hours)

Instructors should refer to V68, V86, T7 and T11 for this subject to deal with topics on autopilot system and regaining of steering capability in case of single failure of the hydraulic system.

5.7 Cargo handling equipment and deck machinery (1 hour)

Instructors should refer to T7, T11 and T15 for this subject to deal with topics on

(i) Self-tensioning mooring winches

(ii) Automatic shutdown of cargo pumping on abnormal operating conditions of inert gas system on board tankers and

(iii) Automatic shutdown of cargo pumping/loading on tankers and gas carriers.

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1.4 MANAGE FUEL, LUBRICATION AND BALLAST OPERATIONS

1.4.1 OPERATION AND MAINTENANCE OF MACHINERY, INCLUDING PUMPS AND PUMPING SYSTEM

1.1 Ballast (2 hours)

Instructors should refer to V57, V60, R39, R40, T7 and T11 for this subject to

(i) Describe procedures for evaluating pumps, ejectors and pumping systems including ship side valves, explain methods of identifying problems which affect performance, and identify common faults and evaluate methods of assessment

(ii) Illustrate the operation of self-priming systems as used on ballast or cargo pumping arrangements

(iii) Explain the main causes of corrosion in sea water systems and the region's most affected and

(iv) Compare corrosion and marine growth prevention systems used for pumps and pumping systems, including impressed current, sacrificial anodes, chemical injection, special coatings, chlorination and special materials.

Instructors should also explain to the trainees

International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM)

The Convention aims to prevent the potentially devastating effects of the spread of harmful aquatic organisms carried by ships' ballast water from one region to another.

The Convention will require all ships to implement a Ballast Water and Sediments Management Plan. All ships will have to carry a Ballast Water Record Book and will be required to carry out ballast water management procedures to a given standard. Existing ships will be required to do the same, but after a phase-in period.

Instructors are advised to refer to the IMO website: *www.imo.org* for details.

1.2 Prevention of pollution of the sea by oil (4 hours)

Instructors should refer to T7 and T11 for this subject which

(i) Describes in principle how bilge and ballast water are discharged

(ii) Lists the precautions to be taken when bunkering fuel oil and lubricating oil

(iii) Describes the requirements for oily water separators

(iv) Explains how the mode and type of pump used affects the contamination of oily water

(v) Explains how the temperature, relative density and size of oil particles affect the separation process

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(vi) Explains the principles of the operation of a two stage and three stage automatic oily water separator

(vii) Explains why and where pressure relief devices are fitted to a separator

(viii) Describes the function of a coalesce

(ix) Explains the principles and purpose of a separator probe

(x) Describes how the automatic valve is controlled and operated

(xi) Lists the safeguards in an oily water separator system and

(xii) Describes the automatic cleaning of an oily water separator.

1.3 Sewage and sludge (4 hours)

Instructors should refer to T7 and T11 for this subject which

(i) Describes a sewage retention system

(ii) Explains why vacuum transportation systems are used

(iii) Describes the process where a comminutor and treatment with chlorine are used

(iv) Describes the processes in a biological treatment plant

(v) Explains how the sludge from a biological treatment plant is disposed of

(vi) Explains why biological treatment should be kept working continuously

(vii) Names the contaminants which would impair the treatment process

(viii) Describes the operation of chemical treatment plants

(ix) Lists the waste materials that can be incinerated and

(x) Explains how liquid and solid waste are prepared for combustion in an incinerator.

Reference to this training outcome is MARPOL Annex IV, which has entered into force and many ships are equipped to comply in order to satisfy port regulations.

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Function 2:
Electrical, Electronic and Control Engineering at the Management Level

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Function 2: Electrical, Electronic and Control Engineering at the Management Level

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Part D2: Instructor Manual **109**

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Part B2: Course Outline

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
Competence:		
2.1 MANAGE OPERATION OF ELECTRICAL AND ELECTRONIC CONTROL EQUIPMENT *Theoretical knowledge*		
2.1.1 MARINE ELECTROTECHNOLOGY, ELECTRONICS, POWER ELECTRONICS, AUTOMATIC CONTROL ENGINEERING AND SAFETY DEVICES		
.1 Marine electrotechnology	10	
.2 Electronics, power electronics	30	
.3 Automatic control engineering and safety devices	40	80
2.1.2 DESIGN FEATURES AND SYSTEM CONFIGURATION OF AUTOMATIC CONTROL EQUIPMENT AND SAFETY DEVICES FOR THE FOLLOWING:		
.1 General requirements	2	
.2 Main engine	20	
.3 Generator and distribution system	2	
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2.1.3 DESIGN FEATURES AND SYSTEM CONFIGURATION OF OPERATIONAL CONTROL EQUIPMENT FOR ELECTRICAL MOTORS		
.1 Three phase A.C. motor	6	
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.5 Insulated gate bipolar transistor (IGBT) motor speed control	4	
.6 Motor speed control by thyristors	2	
.7 Three phase generators	7	
.8 Three phase transformers	3	
.9 Distribution	4	
.10 Emergency power	3	40
2.1.4 DESIGN FEATURES OF HIGH-VOLTAGE INSTALLATIONS		
.1 Design features of high-voltage installations	20	
.2 Operational safety of high-voltage installations	2	22
2.1.5 FEATURES OF PNEUMATIC AND HYDRAULIC CONTROL EQUIPMENT		
.1 Hydraulic control equipment	5	
.2 Pneumatic control equipment	5	10

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Knowledge, understanding and proficiency			Total hours for each topic	Total hours for each subject area of Required performance
2.2	**MANAGE TROUBLESHOOTING AND RESTORATION OF ELECTRICAL AND ELECTRONIC CONTROL EQUIPMENT TO OPERATING CONDITION *Practical knowledge***			
2.2.1	TROUBLESHOOTING OF ELECTRICAL AND ELECTRONIC CONTROL EQUIPMENT			
	.1	Electrical safety	2	
	.2	Test equipment	12	
	.3	Interpretation of circuit symbols	12	
	.4	Logical six step troubleshooting procedure	8	
	.5	Generation	6	
	.6	Prime mover electrical controls	3	
	.7	Main air circuit breaker	3	
	.8	Protection of generators	4	
	.9	Electrical distribution systems	2	
	.10	Motors	4	
	.11	Electrical survey requirements	4	
	.12	Calibrate and adjust transmitters and controllers	3	
	.13	Control system fault finding	3	66
2.2.2	FUNCTION TEST OF ELECTRICAL, ELECTRONIC CONTROL EQUIPMENT AND SAFETY DEVICES			
	.1	Function test of electrical, electronic control equipment and safety devices	12	12
2.2.3	TROUBLESHOOTING OF MONITORING SYSTEMS			
	.1	Test and calibration of sensors and transducers of monitoring system	12	12
2.2.4	SOFTWARE VERSION CONTROL			
	.1	Programmable logic controllers (PLC)	6	
	.2	Microcontrollers	6	
	.3	Digital techniques	8	20
Total for Function 2: Electrical, Electronic and Control Engineering at the Management Level				**288 hours**

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Part C2: Detailed Teaching Syllabus

COMPETENCE 2.1	Manage Operation of Electrical and Electronic Control Equipment *Theoretical knowledge*	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 2.1.1 MARINE ELECTROTECHNOLOGY, ELECTRONICS, POWER ELECTRONICS, AUTOMATIC CONTROL ENGINEERING AND SAFETY DEVICES 2.1.2 DESIGN FEATURES AND SYSTEM CONFIGURATION OF AUTOMATIC CONTROL EQUIPMENT AND SAFETY DEVICES 2.1.3 DESIGN FEATURES AND SYSTEM CONFIGURATION OF OPERATIONAL CONTROL EQUIPMENT FOR ELECTRICAL MOTORS 2.1.4 DESIGN FEATURES OF HIGH-VOLTAGE INSTALLATIONS 2.1.5 FEATURES OF PNEUMATIC AND HYDRAULIC CONTROL EQUIPMENT		STCW Code table A-III/2

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COMPETENCE 2.1	Manage Operation of Electrical and Electronic Control Equipment *Theoretical knowledge*	IMO Reference

2.1.1 MARINE ELECTROTECHNOLOGY, ELECTRONICS, POWER ELECTRONICS, AUTOMATIC CONTROL ENGINEERING AND SAFETY DEVICES

Textbooks/Bibliography: T5, T6, T9, T10, T14, T15, T22, T31, T32, T46, T47, T51, T58, B114

Teaching aids: A1

Required performance:

1.1 Marine electrotechnology (10 hours)

- discusses the following in terms of electrical practice in ships
  - materials of conductors – single wire and multi-stranded
  - commonly used insulation material
  - effect of temperature, oxidation, fire, oil, seawater, acids and solvents on insulation materials
  - sheathing of electric cables
  - cable runs in machinery spaces, cargo holds and cold-storage chambers
  - passing of cables through bulkheads and decks
  - deck machinery
  - fail safe brake
  - coil operated brake
  - deck winches and capstans, windlass and deck cranes
  - electrical interference
  - equipment susceptible to electric interference
  - common sources of interference
  - method of suppression of interference

1.2 Electronics, power electronics (30 hours)

- discusses the operation of semiconductor devices
  - uni-junction transistor
  - bipolar transistor, operation and characteristics, bias circuits, ac and dc current gain, data sheets
  - field effect transistors, operation
  - thyristors, SCRs, GTOs, DIACs and TRIACs operation and characteristics
  - insulated gate bipolar transistor (IGBT)
  - snubber circuits, commutation, data sheets
  - device applications in electronic control, surveillance and recording systems, power supplies, rectification, smoothing circuits, stabilization, switching, amplification, pulse shaping, clipping and clamping
- explains integrated circuits
  - ideal operational amplifier, characteristics, types, mounting methods and markings, advantages of ICs
  - practical operational amplifier, circuit configurations
  - CMRR, instrumentation amplifier, 4-20mA circuit
  - voltage regulators, multivibrators
  - IC applications and common circuits. Data sheets

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COMPETENCE 2.1	Manage Operation of Electrical and Electronic Control Equipment *Theoretical knowledge*	IMO Reference

- explains electronic fault diagnosis on board ship
  - interpretation and use of electronic systems and subsystem circuit diagrams, operation and maintenance manuals
  - electronic test equipment, method of dmm display
  - use of CRO as a testing and display instrument
  - analysis of measurement and test result on components and circuits
  - methods of fault detection

1.3 Automatic control engineering and safety devices (40 hours)

- explains the basic concepts of:
  - open and closed control loops
  - process control
  - essential components in process control loops
- explains the operation and use of sensors and transmitters in shipboard systems
  - resistance temperature devices
  - thermocouples
  - flow and pressure measurement
  - level measurement
  - ambient temperature compensation
  - viscosity measurement
  - torque measurement
  - force balance transmitters
  - oil/water interface and oil in water monitoring
  - the pneumatic flapper/nozzle system
  - pneumatic 20 – 100 kPa, analog 4 to 20 mA signals, pneumatic pilot relays
  - control air supply
  - operational amplifiers
  - electrical supply
- discusses controllers and basic control theory
  - disturbances and time delays and means to reduce them
  - two step, proportional, integral, and derivative control actions
- identifies the operation and use of final control elements
  - diaphragm operated control valves
  - flow/lift characteristics of control valves
  - control valve actuators and positioners
  - “fail – safe”, “fail – set” strategies
  - wax element valves
  - electrically operated valves
- control loop analysis
  - temperature control systems
  - level control systems
  - pressure control systems

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COMPETENCE 2.1	Manage Operation of Electrical and Electronic Control Equipment *Theoretical knowledge*	IMO Reference

- split range and cascade control
- single, two and three element control

– explains the operation and use of governors
- need for governors
- governor terms, concepts and operation
- hydraulic governors
- digital governors, power sharing
- governing systems

2.1.2 DESIGN FEATURES AND SYSTEM CONFIGURATION OF AUTOMATIC CONTROL EQUIPMENT AND SAFETY DEVICES FOR THE FOLLOWING:

Textbooks/Bibliography: T7, T8, T9, T11, T14, T15, T47

Teaching aids: A1, V14, V15, V62

Required performance:

2.1 General requirements (2 hours)

– explains that electrical equipment designed for land use is often not suitable for use in ships

– explains that as far as possible, all materials should be non-flammable; explains where flame retardant materials may be used

– explains the meaning of the term flame retardant

– states the angles of heel and trim at which machinery should be capable of operating

– explains the effect of temperature changes on:
- electromagnetic devices
- generator voltage

– discusses common maximum temperatures of air and sea water used for design purposes

– explains that the axis of a rotating machine should not be placed athwart ships unless so designed

– discusses the need to periodically check the security of all electrical connections

– discusses requirements regarding the provision of electrical power and lighting for normal operation and for an emergency

2.2 Main engine (20 hours)

– control theory
- changing set points
- basic control system design
- first order and second order systems
- transfer functions
- control system stability
- natural frequency and control systems
- time lag and time constant
- system response

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COMPETENCE 2.1	Manage Operation of Electrical and Electronic Control Equipment *Theoretical knowledge*	IMO Reference

- tuning
  - system response
  - control loop tuning
  - Ziegler-Nichols, Cohen-Coon tuning methods
- signal transmission systems
  - digital communication bus and fibre optic signal transmission systems
- final control elements
  - control valve trim
  - selecting control valves and their actuators
  - valve sizing
- electronic PID Controllers
  - single loop digital controllers
  - manual and automatic tuning of electronic controllers
- monitoring and control systems
  - boiler water level control
  - advanced boiler combustion control
  - diesel engine cooling control
  - main engine control for FP and CP propellers
  - alarm and monitoring systems
- general requirements of automatic control equipment and safety devices
  - monitoring system
  - safety system
  - system independence
  - local control
  - failure mode and effect analysis
  - power supply
- remote control – diesel propulsion
  - control – electronic, electro-pneumatic, electro-hydraulic or pneumatic
  - malfunctions – alarm, engine slow down, engine stop
- UMS systems
  - concept of unattended machinery spaces (UMS)
  - requirements of UMS
  - bridge control
  - testing regime for UMS

2.3 Generator and distribution system (2 hours)

- instrumentation and safety in generator and distribution system
- auxiliary diesel generator alarm and shutdown
- automatic starting of propulsion auxiliaries

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COMPETENCE 2.1	Manage Operation of Electrical and Electronic Control Equipment *Theoretical knowledge*	IMO Reference

2.4 Steam boiler (2 hours)

– following failures will have alarms and display – feedwater high salinity, high water level, boiler pressure high and low, superheater outlet temperature high, fuel pump low outlet pressure, heavy fuel temperature high and low (or high and low viscosity), uptake high gas temperature, control system power failure, atomization steam/air pressure low

– following failures will have alarms, display and automatic shutdown of boiler – low water level, supply air pressure failure, ignition or flame failure

2.1.3 DESIGN FEATURES AND SYSTEM CONFIGURATION OF OPERATIONAL CONTROL EQUIPMENT FOR ELECTRICAL MOTORS

Textbooks/Bibliography: T5, T6, T14, T58, T60

Teaching aids: A1, V13, V15, V16

Required performance:

3.1 Three phase A.C. motors (6 hours)

– construction, principle of operation of 3-phase induction motors
– design features of star and delta motors
– starting, speed controlling and braking methods of 3-phase induction motors
– load-torque characteristics and protection

3.2 Three phase synchronous motors (4 hours)

– construction
– principle of operation
– load characteristics
– power factor improvement with synchronous motors

3.3 Effect of varying frequency and voltage of A.C. motors (4 hours)

– speed
– temperature
– torque
– power output
– starting time, current

3.4 Motor control and protection (3 hours)

– D.C. motors
– A.C. motors

3.5 Insulated Gate Bipolar Transistor (IGBT) motor speed control (4 hours)

– gate driving characteristics with high current
– high frequency, high current switch
– advantages of IGBT in varying motor speed control

3.6 Motor speed control by thyristors (2 hours)

– application of thyristors in motor speed control

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COMPETENCE 2.1	Manage Operation of Electrical and Electronic Control Equipment *Theoretical knowledge*	IMO Reference

3.7 Three phase generators (7 hours)

- construction
- salient and cylindrical rotor types
- shaft generators
- excitation methods
- automatic voltage regulation
- synchronization
- parallel operation
- generator troubleshooting

3.8 Three phase transformers (3 hours)

- construction
- polarity
- configurations in star and delta combinations
- open delta configuration

3.9 Distribution (4 hours)

- main switchboard construction and configuration
- short circuit protection – fuses, main circuit breakers
- generator air circuit breaker
- protection coordination
- distribution configuration
- electrical equipment for tankers and hazardous areas and safety systems

3.10 Emergency power (3 hours)

- automatic starting arrangements for the emergency generator
- emergency power requirements
- essential and non essential circuits
- batteries

2.1.4 DESIGN FEATURES OF HIGH-VOLTAGE INSTALLATIONS

Textbooks/Bibliography: T14, T58

Teaching aids: A1, V20

Required performance:

4.1 Design features of high-voltage installations (20 hours)

- generation and distribution of high voltage on ships
- electric propulsion system
- synchro-convertors and cyclo-convertors
- functional, operational and safety requirements for a marine high-voltage system
- assigning qualified personnel to carry out maintenance and repair of high-voltage switchgear of various types
- high-voltage system advantages
- advantages of an insulated system
- high-voltage circuit breakers

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COMPETENCE 2.1	Manage Operation of Electrical and Electronic Control Equipment *Theoretical knowledge*	IMO Reference

– high-voltage cable
– high-voltage fuses
– remedial action necessary during faults in a high-voltage system
– switching strategy for isolating components of a high-voltage system
– selection of suitable apparatus for isolation and testing of high-voltage equipment
– switching and isolation procedure on a marine high-voltage system, complete with safety documentation
– performance of insulation resistance and polarization index on high-voltage equipment

4.2 Operational safety of high voltage installations (2 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 coordination of HV works
  – information, warnings and protection against unauthorized influence on safety
  – assistance during HV work
  – checking for voltage presence before any work starts

2.1.5 FEATURES OF HYDRAULIC AND PNEUMATIC CONTROL EQUIPMENT

Textbooks/Bibliography: T50

Teaching aids: A1, V11, V77

Required performance:

5.1 Hydraulic control equipment (5 hours)

– system components, hydraulic circuits, hydraulic system fitting and maintenance

5.2 Pneumatic control equipment (5 hours)

– fluids, pneumatic circuits, pneumatic system fitting and maintenance components and troubleshooting

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COMPETENCE 2.2	**Manage Troubleshooting and Restoration of Electrical and Electronic Control Equipment to Operating Condition *Practical knowledge***	**IMO Reference**
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 2.2.1 TROUBLESHOOTING OF ELECTRICAL AND ELECTRONIC CONTROL EQUIPMENT 2.2.2 FUNCTION TEST OF ELECTRICAL, ELECTRONIC CONTROL EQUIPMENT AND SAFETY DEVICES 2.2.3 TROUBLESHOOTING OF MONITORING SYSTEMS 2.2.4 SOFTWARE VERSION CONTROL		STCW Code table A-III/2

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COMPETENCE 2.2	Manage Troubleshooting and Restoration of Electrical and Electronic Control Equipment to Operating Condition *Practical knowledge*	IMO Reference

2.2.1 TROUBLESHOOTING OF ELECTRICAL AND ELECTRONIC CONTROL EQUIPMENT

Textbooks/Bibliography: T5, T6, T9, T14, T55, T56

Teaching aids: A1, V13, V14, V15, V17, V18, V19, V62

Required performance:

1.1 Electrical safety (2 hours)

- safety procedures to be adopted when working on electrical installations
- effects of electric current on the human body

1.2 Test equipment (12 hours)

- practical use of Meggers, multimeters and CRO
- care and precautions for carrying out open, short and insulation measurement test

1.3 Interpretation of circuit symbols (12 hours)

- circuit components, functional description
- construction of simple electrical circuits using relays, timers, contactors and other components

1.4 Logical six step troubleshooting procedure (8 hours)

- symptom identification
- symptom analysis
- listing of probable faulty function
- localizing of faulty function
- localizing trouble to circuit
- failure analysis

1.5 Generation (6 hours)

- alternators, excitation methods, AVR and auto-synchronizing equipment
- manual load sharing and modern load sharing equipment

1.6 Prime mover electrical controls (3 hours)

- description, identification and operation of control components of the prime mover for the alternator

1.7 Main air circuit breaker (3 hours)

- operating and servicing

1.8 Protection of generators (4 hours)

- instrumentation and control associated with the electrical protection of the generating plant
- routine maintenance

1.9 Electrical distribution systems (2 hours)

- general layout, problems encountered using neutral configuration
- fault tracing in distribution circuits

1.10 Motors (4 hours)

- review of motor features and starting arrangements
- troubleshooting
- speed control of A.C. motors using solid state devices
- soft starters

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COMPETENCE 2.2	Manage Troubleshooting and Restoration of Electrical and Electronic Control Equipment to Operating Condition *Practical knowledge*	IMO Reference

1.11 Electrical survey requirements (4 hours)

– conducting tests to the requirements of survey

1.12 Calibrate and adjust transmitters and controllers (3 hours)

– differential pressure transmitter calibration
– electronic temperature transmitter calibration
– operation of a PID controller
– tuning a PID controller
– governors and controllable pitch propeller control
– tests, faults, and solutions

1.13 Control system fault finding (3 hours)

– fault finding methods
– governor faults
– evaluation and rectification of common control systems
– testing alarm and monitoring systems
– electric power supply for control systems

2.2.2 FUNCTION TEST OF ELECTRICAL, ELECTRONIC CONTROL EQUIPMENT AND SAFETY DEVICES

Textbooks/Bibliography: T14, T23, T55, T56

Teaching aids: A1

Required performance:

2.1 **Function test of electrical, electronic control equipment and safety devices (12 hours)**

– function test Over Current Relay (OCR)
– function test relays and magnetic contactors
– function test timers
– function test fuses
– function test MCCB
– function test ACB
– function test diodes
– function test Silicon Controlled Rectifier (SCR)
– function test temperature, pressure and level transmitters
– function test overspeed protection devices
– function test flame scanners
– function test fire detecting system

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COMPETENCE 2.2	Manage Troubleshooting and Restoration of Electrical and Electronic Control Equipment to Operating Condition *Practical knowledge*	IMO Reference

2.2.3 TROUBLESHOOTING OF MONITORING SYSTEMS

Textbooks/Bibliography: T61

Teaching aids: A1

Required performance:

3.1 Test and calibration of sensors and transducers of monitoring system (12 hours)

- testing and calibration of pressure sensor and transducer
- testing and calibration of temperature sensor and transducer
- testing and calibration of flow sensor and transducer
- testing and calibration of level sensor and transducer
- testing and calibration of tachometer sensor and transducer
- testing and calibration of viscometer sensor and transducer

2.2.4 SOFTWARE VERSION CONTROL

Textbooks/Bibliography: T52, T31, T51, T52, T62

Teaching aids: A1

Required performance:

4.1 Programmable logic controllers (PLC) (6 hours)

- basics of PLC operation
- comparison between hard-wired and programmable control operation
- advantages of PLCs
- binary number conversion
- digital logic gates and its practical application
- inputs and output modules and configuration of PLCs
- understanding of ladder logic and PLCs programming
- Human Machine Interface (HMI) and alteration of parameters in the programme
- basic software version and control of access
- maintenance of electronic control equipment and PLC controlled processes
- checking the programme validity and faultfinding and restoration of process with the help of PLCs

4.2 Microcontrollers (6 hours)

- introduction to microcontroller
- basics of microcontroller
- analog to digital convertor
- digital interfaces
- serial peripheral interface
- communication with PC
- code integration

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COMPETENCE 2.2	Manage Troubleshooting and Restoration of Electrical and Electronic Control Equipment to Operating Condition *Practical knowledge*	IMO Reference
4.3 Digital techniques (8 hours) – basic logic gates and derived logic gates – boolean algebra – principles and operation of digital integrated circuits (TTL and CMOS), adders, flip flops, registers, counters, multiplexers, encoders and decoders – memories, RAM, ROM, PROM, EPROM, UVPROM – microprocessors, principles of operation, input/output functions, application in marine control systems, programs, alteration of values – single integrated circuit containing a processor core, memory and programmable input/output peripherals – program memory in the form of NOR flash or OTP ROM is also often included on chip and RAM – microcontrollers – designed for embedded applications and real time response to events – typical input and output devices – switches, relays, solenoids, LEDs, radio frequency devices, and sensors for data such as temperature, humidity, light level, etc. – description and use of General Purpose Input/Output pins (GPIO) – analog to digital converter (ADC) – digital to analog converter (DAC)		

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Part D2: Instructor Manual

The instructor manual is included to provide additional information to instructors and teachers. It is designed to help in structuring and organizing this model course. It gives guidance on the material that is to be presented and the workshops that should be conducted during the course for marine environmental awareness. This manual reflects the views of the course developers with respect to methodology and organization as well as what they consider important in light of their experience as instructors of this course.

The guidance given is intended to give the instructor an operational baseline to develop a course that will meet the particular local requirements and to use the instructor's own experience and ideas.

Guidance is also provided in a booklet titled 'Guidance on the implementation of IMO model courses' which includes a checklist for preparation of courses.

■ Theory

Theory can be taught as classroom lectures, preferably supported by videos, pictures and visual presentations.

Tips to present theory:

- Relate subjects to situations, which are familiar to participants
- Use enthusiastic presenters
- Ask questions, as this makes trainees think about the issue
- Encourage trainees to ask questions themselves and to interact during the lectures. Some points are more important than others and should be emphasized. To ensure that such points are remembered, they must be restated a number of times preferably in different words
- Reiterate things that are complex – don't worry about repeating information. Find more than one way to get a point across. If someone doesn't understand the first time, you can word it differently and it might be clear the second time (or the third time). Simple analogies are good. Ask if the audience understood the principle.

2.1 MANAGE OPERATION OF ELECTRICAL AND ELECTRONIC CONTROL EQUIPMENT *Theoretical knowledge*

2.1.1 MARINE ELECTROTECHNOLOGY, ELECTRONICS, POWER ELECTRONICS, AUTOMATIC CONTROL ENGINEERING AND SAFETY DEVICES

1.1 Marine Electrotechnology (10 hours)

Instructors should consult T14 for

(i) Materials of conductors – single wire and multi-stranded

(ii) Commonly used insulation material

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(iii) Effect of temperature, oxidation, fire, oil, seawater, acids and solvents on insulation materials

(iv) Sheathing of electric cables

(v) Cable runs in machinery spaces, cargo holds and cold-storage chambers

(vi) Passing of cables through bulkheads and decks

(vii) Deck Machinery

(viii) Fail safe brake

(ix) Coil operated brake

(x) Deck winches and capstans, windlass and deck cranes.

Instructors should consult T58 for

(i) Electrical Interference

(ii) Equipment susceptible to electric interference

(iii) Common sources of interference

(iv) Method of suppression of interference.

1.2 Electronics, Power Electronics (30 hours)

Instructors should consult T5, T6, T31, T32 and T51 for

(i) Semiconductor Devices

(ii) Uni-junction transistor

(iii) Bipolar transistor, operation and characteristics, bias circuits, AC and DC current gain, data sheets

(iv) Field Effect Transistors, operation

(v) Thyristors, SCRs, GTOs, DIACs and TRIACs operation and characteristics

(vi) Insulated gate bipolar transistor (IGBT)

(vii) Snubber circuits, commutation, data sheets

(viii) Device applications in electronic control, surveillance and recording systems, power supplies, rectification, smoothing circuits, stabilization, switching, amplification, pulse shaping, clipping and clamping

(ix) Integrated Circuits

(x) Ideal operational amplifier, characteristics, types, mounting methods and markings, advantages of ICs

(xi) Practical operational amplifier, circuit configurations

(xii) CMRR, instrumentation amplifier, 4-20mA circuit

(xiii) Voltage regulators, multivibrators

(xiv) IC applications and common circuits. Data sheets

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(xv) Electronic Fault Diagnosis

(xvi) Interpretation and use of electronic systems and subsystem circuit diagrams, operation and maintenance manuals

(xvii) Electronic test equipment, method of DMM display

(xviii) Use of CRO as a testing and display instrument

(xix) Analysis of measurement and test result on components and circuits

(xx) Methods of fault detection.

1.3 Automatic Control Engineering and safety devices (40 hours)

Instructors should consult T9, T46, T47 for

(i) Introduction

(ii) Sensors and transmitters

(iii) Controllers and Basic Control Theory

(iv) Final Control Elements

(v) Control Loop Analysis.

Instructors should consult T10, T15, T22 and B114 for Governors.

2.1.2 DESIGN FEATURES AND SYSTEM CONFIGURATION OF AUTOMATIC CONTROL EQUIPMENT AND SAFETY DEVICES

2.1 General Requirements (2 hours)

Instructors should consult the website of a classification society for following:

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

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2.2 Main Engine (20 hours)

Instructors should consult T60, T46 and V9 for

(i) Control Theory

(ii) Tuning

(iii) Signal Transmission Systems

(iv) Digital communication bus and fibre optic signal transmission systems

(v) Final Control Elements

(vi) Electronic PID Controllers

(vii) Monitoring & Control Systems.

Instructors should consult the website of a Classification society for:

(i) General requirements of automatic control equipment and safety devices

(ii) Remote control – Diesel propulsion and

(iii) UMS Systems.

2.3 Generator and distribution system (2 hours)

Instructors should refer to T14, V14, V15 and V62 for following:

- Instrumentation and Safety in Generator and Distribution system
- Auxiliary Diesel Generator Alarm and Shutdown
- Automatic Starting of Propulsion Auxiliaries

2.4 Steam boiler (2 hours)

Instructors should refer to T7, T8, T9, T11, T15 and T47 for following:

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

2.1.3 DESIGN FEATURES AND SYSTEM CONFIGURATION OF OPERATIONAL CONTROL EQUIPMENT FOR ELECTRICAL MOTORS

3.1 Three Phase A.C. Motors (6 hours)

Instructors should consult T5, T6 and T14 for

(i) Construction, principle of operation of 3-phase induction motors

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(ii) Design features of star and delta motors
(iii) Starting, speed controlling and braking methods of 3-phase induction motors
(iv) Load-torque characteristics and protection.

3.2 Three Phase Synchronous Motors (4 hours)

Instructors should consult T5, T6 and V16 for

(i) Construction, Load characteristics
(ii) Principle of operation
(iii) Power factor improvement with synchronous motors.

3.3 Effect of varying frequency and voltage of A.C. Motors (4 hours)

Instructors should consult T58 for

(i) Speed
(ii) Temperature
(iii) Torque
(iv) Power output and
(v) Starting time, current.

3.4 Motor control and protection (3 hours)

Instructors should consult T5, T6 and T14 for

(i) D.C. motors and
(ii) A.C. motors.

3.5 Insulated Gate Bipolar Transistor (IGBT) motor speed control (4 hours)

Instructors should consult T60 for

(i) Gate driving characteristics with high current
(ii) High frequency, high current switch and
(iii) Advantages of IGBT in varying motor speed control.

3.6 Motor speed control by Thyristors (2 hours)

Instructors should consult T58 for Application of thyristors in motor speed control.

3.7 Three Phase generators (7 hours)

Instructors should consult T5, T6 and T14 for

(i) Construction.
(ii) Salient and cylindrical rotor types

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(iii) Shaft generators
(iii) Excitation methods
(iv) Automatic voltage regulation
(v) Synchronization
(vi) Parallel operation and
(vii) Generator troubleshooting.

3.8 Three Phase Transformers (3 hours)

Instructors should consult T14 for

(i) Construction
(ii) Polarity
(iii) Configurations in Star and Delta combinations and
(iv) Open delta configuration.

3.9 Distribution (4 hours)

Instructors should consult T14 and V15 for

(i) Main switchboard construction and configuration
(ii) Short circuit protection – fuses, main circuit breakers
(iii) Generator air circuit breaker
(iv) Protection coordination
(v) Distribution configuration
(vi) Electrical equipment for tankers and hazardous areas and safety systems.

3.10 Emergency Power (3 hours)

Instructors should consult T14 and V13 for

(i) Automatic starting arrangements for the emergency generator
(ii) Emergency power requirements
(ii) Essential and non essential circuits and
(iii) Batteries.

2.1.4 DESIGN FEATURES OF HIGH-VOLTAGE INSTALLATIONS

4.1 Design features of high-voltage installations (20 hours)

Instructors should consult T14, T58 and V20 for

(i) Generation and distribution of high voltage on ships

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(ii) Electric propulsion system

(iii) Synchro-convertors and cyclo-convertors

(iv) Functional, operational and safety requirements for a marine high-voltage system

(v) Assigning qualified personnel to carry out maintenance and repair of high-voltage switchgear of various types

(vi) High-voltage system advantages

(vii) Advantages of an insulated system

(viii) High-voltage circuit breakers

(ix) High-voltage cable

(x) High-voltage fuses

(xi) Remedial action necessary during faults in a high-voltage system

(xii) Switching strategy for isolating components of a high-voltage system

(xiii) Selection of suitable apparatus for isolation and testing of high-voltage equipment

(xiv) Switching and isolation procedure on a marine high-voltage system, complete with safety documentation

(xv) Performance of insulation resistance and polarization index on high-voltage equipment.

4.2 Operational Safety of High Voltage Installations (2 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 organized by specialized training centres which must adhere to relevant national legislation.

2.1.5 FEATURES OF PNEUMATIC AND HYDRAULIC CONTROL EQUIPMENT

5.1 Hydraulic Control Equipment (5 hours)

Instructors should consult T50, V11 and V77 for hydraulic control equipment. Directional control valves, control equipment, filter, regulators, lubricators should be adequately covered with reference to position control and velocity control systems.

5.2 Pneumatic Control Equipment (5 hours)

Instructors should consult T50 for pneumatic control equipment. Directional control valves, control equipment, filter, regulators, lubricators should be adequately covered with reference to position control and velocity control systems.

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2.2 MANAGE TROUBLESHOOTING AND RESTORATION OF ELECTRICAL AND ELECTRONIC CONTROL EQUIPMENT TO OPERATING CONDITION
Practical knowledge

2.2.1 TROUBLESHOOTING OF ELECTRICAL AND ELECTRONIC CONTROL EQUIPMENT

1.1 Electrical Safety (2 hours)

Instructors should consult T5, T6, T14 and V13 for

(i) Safety procedures to be adopted when working on electrical installations and

(ii) Effects of electric current on the human body.

1.2 Test Equipment (12 hours)

Instructors should consult T14, V17 and V19 for

(i) Practical use of Meggers, multimeters and CRO and

(ii) Care and precautions for carrying out open, short and insulation measurement test.

1.3 Interpretation of Circuit Symbols (12 hours)

Instructors should consult T56 for

(i) Circuit components and

(ii) Construction of simple circuits. Practicals shall include numerous diagrams and interpretation by the candidates.

1.4 Logical six step troubleshooting procedure (8 hours)

Instructors should consult T55 for troubleshooting. Instructors should explain the six steps troubleshooting procedures

(i) Symptom identification

(ii) Symptom analysis

(iii) Listing of probable faulty function

(iv) Localizing of faulty function

(v) Localizing trouble to circuit and

(vi) Failure analysis.

1.5 Generation (6 hours)

Instructors should consult T5, T6, T14 and V62 for Generation. AVR, Reactive loading of Alternators in parallel, excitation schemes, pilot excitation, residual excitation, 'flashing up' the alternator are topics that are covered in this section. Particular attention is paid to the alternators, the manner in which power is shared and the roles of the governor and the AVR in parallel operation. Power factor relation and some charts as follows may be made use

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of. The relation between KVA, KVAR, power factor should be explained by varying electrical loads on the system.

1.6 Prime Mover Electrical Controls (3 hours)

The electrical controls of prime movers include monitoring equipments viz. luboil pressure, cooling freshwater temperature, RPM, etc.

1.7 Main Air Circuit Breaker (3 hours)

Instructors should consult T14 and V15 for Main Air Circuit Breaker (ACB). The testing of ACB functions except the OCR can be done by ship's staff because current injectors are normally not available on board ships. Inspections of the ACB's shutdown circuits, reverse power etc. are carried out by ship staff. The 'drawout' position of the ACB and the subsequent testing should be explained. SF6 breakers and Vacuum breakers are used in High-Voltage installations.

1.8 Protection of Generators (4 hours)

The basic plant protection include

- Lubricating oil pressure low pressure
- Cooling Fresh water high temperature
- Overspeed
- Fuel oil leak off

Instructors should discuss that plant installation may have more than one sensor for the purpose of monitoring the above mentioned parameters. The difference between the alarm monitoring system and the shutdown system is to be adequately highlighted. Calibration and testing routines are also to be explained.

1.9 Electrical Distribution Systems (2 hours)

Instructors should consult T14, V14 and V18 for Electrical distribution Systems. The need for 3 phase, three wire and insulated neutral system to be explained. Monitoring earth fault in 440V AC and lighting circuits to be explained. Earth lamp and insulation monitoring device for earth faults to be explained.

Need for early elimination of earth fault in 440V AC should be explained. Method of testing and removal of earth fault in 440V AC and lighting circuit to be explained. If it is possible, then a practical demonstration of above may be carried out.

1.10 Motors (4 hours)

Instructors should consult T58 for this subject.

1.11 Electrical Survey Requirements (4 hours)

Instructors to consult T14 and V19 for this subject.

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1.12 Calibrate and Adjust Transmitters and Controllers (3 hours)

Instructors should consult T9 for this subject.

1.13 Control System Fault Finding (3 hours)

Instructors should consult T9 for this subject.

2.2.2 FUNCTION TEST OF ELECTRICAL, ELECTRONIC CONTROL EQUIPMENT AND SAFETY DEVICES

2.1 Function test of electrical, electronic control equipment and safety devices (12 hours)

Instructors should consult T14, T23, T55 and T56 for this subject.

2.2.3 TROUBLESHOOTING OF MONITORING SYSTEMS

3.1 Test and calibration of sensors and transducers of monitoring system (12 hours)

Instructors should consult T61 for this subject. Testing of sensors and calibration of instrumentation systems should be covered in extensive detail permitting demonstration and practical involvement.

The sensor testing should be realistic such as temperature baths for PT100s, thermocouples, thermistors and other heat sensing elements. The nature of the response is to be studied in accordance with the 'upstream requirements'.

Note: This has a direct bearing on the understanding of Control systems (electronic type)

Calibration is a function of procedure. The procedure for each instrumentation loop or system will be less or more extensive based on the hardware. The elements in the instrumentation loop need to be identified and then the element has to be calibrated.

E.g. Oxygen Monitor for IG systems – While the calibration procedure for a NGK or a Servomex would be explicitly mentioned in the manuals, it is actually a calibration of the functional electronics and the instrumentation amplifier. The primary sensor in this case cannot be accessed at all. The indicators in the loop for the CCR, bridge and other remote indications are however on a different loop.

2.2.4 SOFTWARE VERSION CONTROL

4.1 Programmable logic controllers (PLC) (6 hours)

Instructors should consult T52 for this subject.

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Basics of PLC operation

While covering the basics of PLC based systems operations a categorical division between what the PLC controls and what the rest of the hardware in a system independently manages shall be distinguished. Very often the PLC does not control various continuous control or analog parameters of the system and these are managed by discrete circuits or units.

Comparison between hard-wired and programmable control operation

The instructor must draw parallels and point out the differences and similarities between these two types of systems. Relay based systems allow for 'familiar' though not 'easy' troubleshooting. The concept of hardwiring to a PLC based system to peripheral devices and their control actions being governed by program or parametric changes needs to be covered in detail. This introduces the use and functions of registers, counters, times and the necessary API's.

Inputs and output modules and configuration of PLCs

Various types of modules in a PLC based system are to be introduced. The analog modules are to be covered in reasonable detail covering the sections that lead to the various types of inputs and standard outputs that the system is capable of addressing/generating.

Methods of Programming

Amongst the various methods of programming the 'Ladder logic' diagrams though increasingly popular, Human Machine Interface (HMI) and alteration of parameters in the programme is an important segment of this section. It is to be distinguished from upward network systems in the initial stages before the candidates are exposed to multi-drop systems with more than one 'Master' on the same system bus.

4.2 Microcontrollers (6 hours)

Instructors should consult T62 for this subject. While the working knowledge of microcontrollers varies from that of digital techniques or microprocessors applied to computational machines, the candidates must understand the implications of working with microcontrollers. The Motorolla, Atmel, Philips and other derivatives of the 8051 or similar should be demonstrated with application areas, ranging from control system for supervision of machinery to embedded systems.

Communication related to microcontrollers shall be explained and the difference between the physical standard and the overlying protocol aptly communicated. Due diligence must be paid so as not to generalize the communication interfaces between higher level platforms such as PLC and computers and the embedded system.

Noise immunity, crystal frequencies, buffer circuits, current drivers are within the gamut of this section.

4.3 Digital Techniques (8 hours)

Instructors should consult T31, T51 and T52 for this subject.

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Logic Gates – Instructors should demonstrate electronic gates and Boolean logic. Whilst this is done the need to co-relate 'gates' to analysis of pneumatic, hydraulic or electrical systems should be referenced. (E.g. valves in series, parallel, etc.)

Boolean Algebra should be limited to equations and product of multiples should not be included nor Karnaugh maps.

The following gates should have been covered – NOT, AND, OR, NAND, EX-OR. The logical expression of the gate in terms of I/O relation should be covered. (E.g. Y = A.B [Y = A AND B)

The use of **counters** should be demonstrated through the use of a pulse generator and with a binary or decimal output. Co-relation between the counter and the pulse counter for rpm of the flywheel is a good starting point.

Flip – Flops with clock (JK) shall be included for demonstration. Due reference to standby pump monitoring systems may be made and the conceptual building block be demonstrated by means of a bi-stable pneumatic directional control valve.

Memories – While the various types of memories covered in this section are relevant, trainees should be exposed to the awareness and develop an ability to recognize volatile & non-volatile memory elements. Genuine usage of this would reflect in the PLC or Industrial automation segment where the configuration settings are volatile. The use of a CMOS battery or backup battery should be duly covered in this section for the sake of completeness.

Microprocessors – The scope of the course should be taken into account and the depth of the subject should be limited to functional descriptions, working principles and interface to the real world. Similar techniques should be applied for **Microcontrollers.**

ADC & DAC – The principles of ADC (analog to digital conversion) having been covered, the methods and circuit diagrams are unnecessary. The application of the ADC, the difference between analog instrumentation and ADC and multiplexers should be covered as a whole to orient the candidature towards automation and monitoring systems.

I/O – While real world interfacing is covered, the intelligent CPU's covered in the microprocessors or microcontrollers section should be used to connect to hardware peripheral analog and digital loads such as lamps, switches, solenoids, meters, potentiometers. Due diligence must be paid to ensure that the candidate has an understanding of power sourced and the enhancement of power levels through galvanic isolation (relays, solid state power devices, etc.)

Electronic troubleshooting shall include storing or referencing the volatile configuration settings of universal devices that may be used in various applications but are made specific for task by setting the configuration settings.

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Chief Engineer Officer and Second Engineer Officer

Function 3:
Maintenance and Repair at the Management Level

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Chief Engineer Officer and Second Engineer Officer

Function 3: Maintenance and Repair at the Management Level

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3.3 Ensure safe working practices *Practical knowledge*

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Part B3: Course Outline

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
Competence:		
3.1 MANAGE SAFE AND EFFECTIVE MAINTENANCE AND REPAIR PROCEDURES		
3.1.1 MARINE ENGINEERING PRACTICE		
Theoretical knowledge		
.1 Planned maintenance system as per ISM Code	5	
3.1.2 MANAGE SAFE AND EFFECTIVE MAINTENANCE AND REPAIR PROCEDURES		
Practical knowledge		
.1 Manage safe and effective maintenance and repair procedures relevant to 3.1.1	10	
3.1.3 PLANNING MAINTENANCE, INCLUDING STATUTORY AND CLASS VERIFICATIONS		
Practical knowledge		
.1 Planning maintenance, including statutory and class verifications relevant to 3.1.1	5	
3.1.4 PLANNING REPAIRS		
Practical knowledge		
.1 Planning repairs relevant to 3.1.1	5	25
3.2 DETECT AND IDENTIFY THE CAUSE OF MACHINERY MALFUNCTIONS AND CORRECT FAULTS		
Practical knowledge		
3.2.1 DETECTION OF MACHINERY MALFUNCTIONS, LOCATION OF FAULTS AND ACTION TO PREVENT DAMAGE		
.1 Unplanned maintenance	5	
3.2.2 INSPECTION AND ADJUSTMENT OF EQUIPMENT		
.1 Inspection and adjustment of equipment relevant to 3.1.1	5	
3.2.3 NON-DESTRUCTIVE EXAMINATION		
.1 Different types of non-destructive examination	10	20

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Knowledge, understanding and proficiency		Total hours for each topic	Total hours for each subject area of Required performance
3.3	**ENSURE SAFE WORKING PRACTICES**		
	Practical knowledge		
3.3.1	SAFE WORKING PRACTICES		
	.1 Risk assessment	1	
	.2 Safety officials	1	
	.3 Personal protective equipment	1	
	.4 Work equipment	1	
	.5 Safety induction	1	
	.6 Fire precautions	1	
	.7 Emergency procedures	1	
	.8 Safe movement	1	
	.9 Safe system of works	1	
	.10 Entering enclosed or confined spaces	2	
	.11 Permit to work systems	2	
	.12 Manual handling	1	
	.13 Use of work equipment	1	
	.14 Lifting plant	1	
	.15 Maintenance of machineries	1	
	.16 Hot work	1	
	.17 Painting	1	
	.18 Hazardous substances	1	
	.19 Noise and vibrations	1	21
Total for Function 3: Maintenance and Repair at the Management Level			**66 hours**

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Part C3: Detailed Teaching Syllabus

COMPETENCE 3.1	Manage Safe and Effective Maintenance and Repair Procedures	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 3.1.1 MARINE ENGINEERING PRACTICE *Theoretical knowledge* 3.1.2 MANAGE SAFE AND EFFECTIVE MAINTENANCE AND REPAIR PROCEDURES *Practical knowledge* 3.1.3 PLANNING MAINTENANCE, INCLUDING STATUTORY AND CLASS VERIFICATIONS *Practical knowledge* 3.1.4 PLANNING REPAIRS *Practical knowledge*		STCW Code table A-III/2

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COMPETENCE 3.1	Manage Safe and Effective Maintenance and Repair Procedures	IMO Reference
3.1.1 MARINE ENGINEERING PRACTICE *Theoretical* knowledge		R1, R4
Textbooks/Bibliography:		
Teaching aids: A1, V25, V40		
Required performance:		
1.1 Discusses the preparation and use of planned maintenance systems (PMS) as per ISM Code (5 hours) – objective of PMS – equipment covered under PMS – critical equipment – preparation of vessel specific PMS – maintenance schedule and job procedures – updating of maintenance schedule – spare parts inventory – recording of defects		
3.1.2 MANAGE SAFE AND EFFECTIVE MAINTENANCE AND REPAIR PROCEDURE *Practical knowledge*		
Textbooks/Bibliography: T36		R1
Teaching aids: A1		
Required performance:		
2.1 Manage safe and effective maintenance and repair procedures relevant to 3.1.1 (10 hours) – discusses the preparation and practice of dry-docking, in-water survey and lay up – dry-dock repair file – preparation of dry-dock repair specification – dry-docking and in-water survey – initial and final dry-dock inspection – supporting the vessel in dry-dock – preparations for dry-docking and undocking – survey work and maintenance during dry-dock – typical arrangements for the supply of electrical power, fresh water and sanitation facilities while the vessel is in dry-dock – special arrangements during dry-dock for the prevention of fires and explosions – management of oil and water tanks during dry-dock. Testing of tanks by hydrostatic and pneumatic means – describe the preparations, inspections, records, planning, maintenance and events which occur with dry-docking and in-water hull surveys – lay ups. Plan aspects of dry-docking, in water hull cleaning and vessel layup/reactivation		

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COMPETENCE 3.1	Manage Safe and Effective Maintenance and Repair Procedures	IMO Reference

3.1.3 MANAGE SAFE AND EFFECTIVE MAINTENANCE AND REPAIR PROCEDURE
Practical knowledge

Textbooks/Bibliography:

Teaching aids: A1

Required performance:

3.1 Planning maintenance, including statutory and class verifications relevant to 3.1.1 (5 hours)

- discusses procedures for planned maintenance that requires dismantling and inspection/calibrations
  - dismantled in sequential order as per manufacturer's instruction manual
  - cleaned prior to inspection
  - inspected and/or calibrated as appropriate
  - items are assessed to determine whether can be reused or need to be replaced/repaired/reconditioned
  - above information recorded in maintenance record of equipment/machines
  - entry completed in spare parts inventory

3.1.4 PLANNING REPAIRS
Practical knowledge

Textbooks/Bibliography: R1

Teaching aids: A1

Required performance:

4.1 Planning repairs relevant to 3.1.1 (5 hours)

- conducts planned maintenance that involves assembly and testing
  - individual parts are tested as per manufacturer's instruction manual
  - parts are assembled in sequential order as per manufacturer's instruction manual
  - pre-start checks are carried out in accordance with manufacturer's instruction manual
  - equipment/machinery is run up and relevant performance criteria are compared and recorded
  - updating of maintenance schedule records

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COMPETENCE 3.2	Detect and Identify the Cause of Machinery Malfunctions and Correct Faults	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 3.2.1 DETECTION OF MACHINERY MALFUNCTIONS, LOCATION OF FAULTS AND ACTION TO PREVENT DAMAGE 3.2.2 INSPECTION AND ADJUSTMENT OF EQUIPMENT 3.2.3 NON-DESTRUCTIVE EXAMINATION		STCW Code table A-III/2

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COMPETENCE 3.2	Detect and Identify the Cause of Machinery Malfunctions and Correct Faults	IMO Reference

3.2.1 DETECTION OF MACHINERY MALFUNCTIONS, LOCATION OF FAULTS AND ACTION TO PREVENT DAMAGE

Textbooks/Bibliography:

Teaching aids: A1

Required performance:

1.1 Unplanned maintenance (5 hours)

- discusses the initial action taken when fault is first identified, considering vessel's safety
- notifies the bridge potential problems in good time
- re-assesses priorities and scheduled work in light of identified fault
- errors are acknowledged, reported, recorded and corrective action taken

3.2.2 INSPECTION AND ADJUSTMENT OF EQUIPMENT

Textbooks/Bibliography:

Teaching aids: A1

Required performance:

2.1 Inspection and adjustment of equipment relevant to 3.1.1 (5 hours)

- discusses daily, weekly, monthly and routine inspection as per manufacturer's instruction manual
- identifies inspection of equipment as per class and statutory requirements
- completes adjustment of equipment as per manufacturer's instruction manual
- identifies the special tools for adjustment of equipment

3.2.3 NON-DESTRUCTIVE EXAMINATION

Textbooks/Bibliography: T57

Teaching aids: A1

Required performance:

3.1 Different types of non-destructive examination (10 hours)

- discusses the practice and limitations of visual inspection
  - unaided visual inspection
  - use of optical aids
  - application of visual inspection on board ship
- discusses the use of dye penetrant testing
  - use of cleaner, penetrant and developer
  - inspection and evaluation
- discusses the use of magnetic particle testing
  - principle of magnetic particle testing
  - magnetizing using electromagnet
  - use of premixed aerosol cans of wet fluorescent iron oxide visible in ultraviolet rays
  - used for crack detection of tail end shaft taper

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COMPETENCE 3.2	Detect and Identify the Cause of Machinery Malfunctions and Correct Faults	IMO Reference

	– discusses the use of radiography
	  – use of radiography in testing welds
	– discusses the use of portable hardness measurement
	  – measurement of hardness by portable instrument
	  – used on board to check harness of turbocharger compressor impeller
	– discusses the use of thermography
	  – use of thermographic camera using infrared imaging
	  – used on board for measurement of temperature variations	

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COMPETENCE 3.3	Ensure Safe Working Practices	IMO Reference
TRAINING OUTCOME: Demonstrates a knowledge and understanding of: 3.3.1 SAFE WORKING PRACTICES		STCW Code table A-III/2

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COMPETENCE 3.3	Ensure Safe Working Practices	IMO Reference

3.3.1 SAFE WORKING PRACTICES

Textbooks/Bibliography: T13, T24, B35

R50

Teaching aids: A1, V24, V29, V30, V31, V32, V33, V34, V35, V36, V38, V42, V49, V53, V55, V94, V95, V96, V98

Required performance:

1.1 Explains risk assessment practices and their use on board ship (1 hour)

- elements of risk assessment
- identify hazards
- identify risk controls
- estimate risks
- determine tolerability of risks
- prepare risk control action plan

1.2 Discusses the role of safety officials on board ship (1 hour)

- safety officer
- safety committee
- safety inspections
- investigation of accidents and dangerous occurrences

1.3 Discusses the use of personal protective equipment (1 hour)

- types of personal protective equipment

1.4 Explains the requirements to ensure that work equipment is safe (1 hour)

- maintenance
- inspection
- training
- electrical equipment

1.5 Discusses the use of safety induction procedures (1 hour)

- emergency procedures and fire precautions
- accidents and medical emergencies
- health and hygiene
- good housekeeping
- environmental responsibilities
- occupational health and safety

1.6 Explains the precautions required to minimize the risk of fire (1 hour)

- smoking
- electrical fittings
- spontaneous combustion
- precautions in machinery spaces

1.7 Explains typical shipboard emergency procedures (1 hour)

- action in the event of fire
- muster and drills

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COMPETENCE 3.3	Ensure Safe Working Practices	IMO Reference

1.8 Discusses the requirements to ensure the safe movement of personnel (1 hour)

- lighting
- guarding of openings
- watertight doors

1.9 Discusses safe work practices when (1 hour)

- working aloft
- portable ladders
- lagging of steam and exhaust pipes
- unmanned machinery spaces
- refrigeration machinery

1.10 Identifies the risks and the safety precautions and procedures for entering enclosed or confined spaces (2 hours)

- identifying hazards
  - oxygen deficiencies
  - toxicity of oil and other substances
  - flammability
  - other hazards
- breathing apparatus and resuscitation equipment
- preparing the space for entry
- testing atmosphere of the space
- procedures and arrangements before entry
- procedures and arrangements during entry
- procedures on completion

1.11 Discusses the use of permit to work systems (2 hours)

- work in unmanned machinery spaces
- entry into enclosed or confined spaces
- hot work
- working aloft
- electrical system for other than electrical officer

1.12 Identifies safe practices for manual handling (1 hour)

- musculo-skeletal injuries due to an unsatisfactory working method
- appropriate steps to reduce risk of injury

1.13 Discusses the safe use of common shipboard equipment (1 hour)

- use of tools and equipment
- abrasive wheels
- high pressure hydraulic and pneumatic equipment
- ropes

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COMPETENCE 3.3	Ensure Safe Working Practices	IMO Reference
1.14	**Explains procedures for the safe use of lifting plant (1 hour)** – safe working load (SWL) – register of lifting appliances, markings and certificates – regular maintenance – examination, inspection and testing – safety measures	
1.15	**Discusses procedures for the maintenance of machinery (1 hour)** – precautions before maintenance – warning notices not to start machines – securing heavy parts during maintenance	
1.16	**Discusses procedures for undertaking hot work on board ship (1 hour)** – pre-use equipment test – precautions against fire and explosion – precautions during use of electric arc welding – compressed gas cylinders – gas welding and cutting	
1.17	**Explains the preparation and use of paint systems on board ship (1 hour)** – preparation and precautions	
1.18	**Discusses procedures for working safely with hazardous substances (1 hour)** – carcinogens and mutagens – asbestos dust – use of chemical agents – safety data sheet	
1.19	**Discusses procedures for minimizing adverse effects of noise and vibrations (1 hour)** – assessing exposure to noise – types of vibration and their effects – prevention and control of exposure to noise and vibrations	

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Part D3: Instructor Manual

The following notes are intended to highlight 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.

Function 3: Maintenance and Repair at the Management Level

3.1 MANAGE SAFE AND EFFECTIVE MAINTENANCE AND REPAIR PROCEDURES

3.1.1 MARINE ENGINEERING PRACTICE *Theoretical knowledge*

1.1 Planned maintenance system (PMS) as per ISM Code (5 hours)

The ship's safety management system (R4) as required by SOLAS (R1) chapter VIII, should be consulted when planning maintenance and repair work. Refer also to V25 and V40.

Objective of PMS are

- Equipment covered under PMS
- Critical equipment
- Preparation of vessel specific PMS
- Maintenance schedule and job procedures
- Updating of maintenance schedule
- Spare parts inventory
- Recording of defects

Every Vessel must have a Vessel Specific Planned Maintenance System – PMS. The primary objective of the PMS is to improve the effectiveness of maintenance and ensure that machinery and equipment function in a safe, reliable and efficient manner.

The PMS, preferably computerized, should consist of:

- Maintenance Schedules
- Spare Part Inventory
- Records of defects and breakdowns of the machinery and equipment.

The Chief Engineer and Chief Officer in consultation with the Superintendent are responsible for preparing the Vessel Specific PMS.

The PMS must cover the equipment as listed below:

- Critical Equipment
- Hull, Deck Machinery and Equipment
- Cargo Machinery, Equipment and Automation

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- Life-Saving and Firefighting equipment
- Navigational and Radio Equipment
- Main Engine, Auxiliary Engines, Auxiliary and Ancillary Machinery
- Electrical Machinery and Equipment
- Automation Equipment including Alarm and Cut-outs
- Calibration Equipment and Instruments
- Equipment supplied by charterer, owner or others, such as cargo handling equipment

Additionally the PMS can also be utilized to monitor Statutory and Class Surveys.

MAINTENANCE SCHEDULE – INTERVALS

The following factors should be considered:

- Equipment Manufacturers Recommendations and Specifications.
- Company, Industry, Flag Administration standards and guidelines.
- Condition Monitoring and Predictive Maintenance techniques – i.e. vibration analysis.
- Practical experience and Historical trends in the results of routine inspections, and in the nature and rates of failures.
- The usage of the equipment – Continuous, Intermittent, Stand-by or Emergency.
- Practical or Operational restrictions, e.g. maintenance that can be performed only in dry-dock.

MAINTENANCE SCHEDULE – TASK

The Job procedure of each Maintenance Schedule Task must be included in Planned Maintenance System and should be in accordance with the Maker's Specific Instructions, Drawings and Service Notes. The Job Procedure should preferably include reference to the Instruction Manual, i.e. Page or Drawing number.

ISSUING PMS MAINTENANCE SCHEDULES

Chief Engineer and **Chief Officer** must ensure that the Maintenance schedules are extracted from the PMS every week. The jobs schedules should be given to the Person in charge of the maintenance. A record is to be maintained on board.

If for any reason the Maintenance cannot be carried out, then the job should be postponed and reason for same should be recorded.

RESPONSIBILITIES FOR PERFORMING VARIOUS TASKS

The job responsibilities for all personnel are listed in the Main Shipboard Manual, with detailed inspection responsibilities and Maintenance schedules included in various sections of the

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MTM. In event of absence of any personnel, the Master or the Chief Engineer may reassign the duties as deemed necessary, after making due consideration for competence and rest hours.

UPDATING COMPUTER BASED PMS MAINTENANCE SCHEDULE

Officer in charge of the maintenance must ensure that the schedule is updated upon completion. The actual work carried out, condition of the equipment in particular critical parts and parts renewed must be entered in the PMS rather than just entering “Done” while updating the schedule. Where relevant, the exact values/readings/measurements observed at the time of overhaul/inspection must be stated in the records. Remarks are to be made if any part would need particular attention or renewal during the next overhaul. Unscheduled Inspections, Routine and Breakdown maintenance must be recorded in the PMS.

SPARE PARTS INVENTORY

An up-to-date Spare Parts Inventory is extremely important as it prevents shortfalls and overstocking. Shortfalls lead to last minute orders resulting in expensive airfreight, postponed maintenance, possible non-compliance in third party inspections and occasionally an incident. Overstocking is blocking money unnecessarily and could lead to loss to the Owners. If the vessel is sold these will be generously donated, for no appreciable value, to the next owner. The Inventory must be maintained within the PMS.

The Chief Engineer and Chief Officer in consultation with the Superintendent must prepare a Vessel specific List of Minimum spares to be maintained for Critical Equipment and Other Machinery/Equipment. The list of Minimum Spares should be prepared on the basis of a) Trading area of the Vessel b) Duration of Voyages c) Availability of Spares from Manufacturers and d) Age of vessels.

The minimum spare parts list should be reviewed if the trading pattern of the vessel changes to areas where supplies are difficult to connect.

DEFECTS

All Defects/Observations as observed on board must be recorded in the appropriate section of the PMS. The complete list of all such defects should be maintained by Chief Engineer and Chief Officer for their respective departments.

The Master and the Chief Engineer, within one month of joining, must send the update on the defect list to the vessel’s Superintendent, making additions, if any.

The defects requiring shore assistance should be followed up separately on the Repair Order Forms. In case permanent repairs cannot be undertaken whilst the vessel is in service, then a Dry-Dock Job Specification/Order should be raised. Computerized PMS that have the Defect Reporting feature may have a provision for raising Dry-Dock Specifications.

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CRITICAL EQUIPMENT

Critical Equipment is defined as Machinery and Equipment on a Vessel including Alarms and Trips, the sudden failure of which may result in a hazardous situation thereby placing the personnel and/or vessel at risk.

Equipment with redundancy does not fall into the Critical Equipment category, e.g. Fire and GS Pumps.

Critical equipment must be clearly identified in the PMS.

RESPONSIBILITY

No critical systems, alarms, control or shutdown may be by-passed, inhibited or taken out of service without the permission of the Master. The Chief Engineer must approve any changes to critical alarms, control or shutdown set points. The Chief Engineer is responsible for communicating any temporary deactivation of a critical alarm or system to the duty personnel. Only those personnel designated by the Chief Engineer are to work on any such critical systems.

INOPERATIVE – CRITICAL EQUIPMENT

Any Critical Equipment found inoperative/defective must be reported immediately by a Non Routine Message to the Office and a Telephone call to the Technical Superintendent. An onboard Risk Assessment will have to be carried out, controls to mitigate any risk posed as a result of the defect will have to be established and put in place. If the Vessel is in Port, attempts should be made to have the Equipment repaired prior departure.

CRITICAL EQUIPMENT – MAINTENANCE

If routine maintenance is required to be carried out on Critical Equipment, the Staff must carry out a Risk Assessment and forward the assessment to the Office. Only on approval from the Office can the Equipment be taken “Out of Service”. If approval is received on phone, a confirmatory email must be sent. ‘Out of service’ with respect to critical equipment may be defined as equipment that may be ‘immobilized’ either to carry out ‘routine maintenance’ or ‘breakdown maintenance’. In either case a thorough risk assessment shall be carried out on board by the senior management identifying all hazards and with a backup plan to mitigate any eventuality. The senior management on board after quantifying the level of risk, whether low, medium or high, will inform office accordingly. Permission to carry out high risk maintenance activities on critical machinery shall be given by appropriate levels of management.

3.1.2 MANAGE SAFE AND EFFECTIVE MAINTENANCE AND REPAIR PROCEDURES
Practical knowledge

2.1 Manage safe and effective maintenance and repair procedures relevant to 3.1.1 (10 hours)

Ship’s safety management system, as required by SOLAS (R1) chapter VIII, should be consulted when carrying out maintenance and repair work. Manufacturer’s Instruction and

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Operation Manual give guidance on maintenance. Spare parts availability should be checked before starting maintenance procedures. Availability of specific tools and lifting equipment safe should be determined.

Instructors should consult T36 for dry-docking.

3.1.3 PLANNING MAINTENANCE, INCLUDING STATUTORY AND CLASS VERIFICATIONS
Practical knowledge

3.1 Planning maintenance, including statutory and class verifications relevant to 3.1.1 (5 hours)

For Machinery Surveys, Classification Societies offer four arrangements for Class follow-up of the components in the Machinery list. The best suited survey arrangement for the Manager depends on the company's maintenance strategy and operation.

The components covered by the four survey arrangements are listed in the Classification Society's machinery list. The components are given specific codes for easy identification.

.1 Survey arrangement Machinery Renewal

Machinery Renewal is Classification Society's default survey arrangement. This survey arrangement is suitable for vessels which carry out most of the maintenance in dock.

Rules and Requirements:

All machinery is to be opened up and/or function tested at each Main Class Renewal Survey (5 yearly). The time window for crediting: -/+ 15/0 months, no flexibility.

Preparations for survey:

As all Machinery Components are to be opened up and/or tested at the end of the Renewal Class period, the crew and the Chief Engineer must be prepared for an extensive machinery inspection during Renewal survey. An important point is that even though a component has not achieved the maker's recommended running hours for overhaul, it must be opened up or tested during survey.

.2 Survey Arrangement Machinery Continuous

When operating with survey arrangement Machinery Continuous, the Manager is given more flexibility. Components are credited by Classification Society on a continuous basis, either during the annual surveys or when requested by the Manager.

Class involvement

A Classification Society's Surveyor shall be called in every time a main overhaul is carried out for crediting of Class machinery. Half of all identical components of which there are more than one (e.g. fuel oil booster pumps for the main engine) in the Machinery list, can be credited by the Chief Engineer on behalf of Classification Society every second time overhaul

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is carried out. Postponement of components may be granted given that a sighting survey is carried out, and with a maximum period of 3 months.

Surveys/Preparations

No specific survey interval is required, but all components have to be surveyed with a maximum interval of 5 years. In the Classification Society's quarterly listing, the Machinery List will for each component show both the last survey date and the due date for the next survey.

.3 Survey Arrangement Machinery PMS (Planned Maintenance System)

Crediting of Machinery Components when on Machinery PMS is based on annual surveys and audits of the reported maintenance history in the vessel's computer based planned maintenance system.

All components in the Machinery List can be surveyed by the chief engineer at the time of overhaul. The component may then be credited by the discretion of the attending surveyor during the next annual survey based on the reported maintenance history for the component.

Conditions/Requirements for PMS

The approval of the survey arrangement Machinery PMS is directly connected to the technical management of the vessel. The Manager is given more flexibility and responsibility, and Classification Society performs audits of the planned maintenance programme rather than performing the actual component survey. In order to ensure that Class related Machinery components are given adequate follow up, the approval of the system itself and the on board system is connected to the Management of the vessel.

Machinery PMS will be deleted upon change of management or change of system. Please note that upon deletion of Machinery PMS, components with more than 5 years since last overhaul will be given a due date 6 months from the date that Machinery PMS was deleted. The vessel will then be assigned to survey arrangement Machinery Continuous unless otherwise requested.

If a vessel changes Management, and the new Management wants to reinstall Machinery PMS, a new initial survey is required to be carried out. Unless the new Manager has a system approval for the on board planned maintenance system, a system approval must be obtained before an initial survey can be carried out on board.

Prior to initial survey on board, the approval of the Manager to use the planned maintenance system must be in order.

Survey/Preparations: Machinery PMS Initial Survey

An initial survey is required on board each vessel in order to obtain the survey arrangement Machinery PMS. The Chief Engineer's attendance is required throughout the entire duration

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of the survey, normally 5-8 hours. During the initial PMS Survey, the system will be audited with respect to the Classification Society's requirements. Main focus areas will be:

- Work/job descriptions are to be in accordance with maker's requirements and shall cover the Classification Society's requirements for class components.
- Classification Society's Machinery Component in the Machinery list included in the maintenance system on board with correct codes.
- All jobs for components with Class scope "main overhaul" shall be identified as Class jobs, with intervals according to maker's recommendations. No duplicate Class job in the system.
- Continuous improvement of the system. It is required to have a system for review of the planned maintenance system to further increase the focus on continuously improving the efficiency and the input quality of your system. All corrective jobs are to be identified and reviewed in an annual job. If many corrective jobs are identified on a specific component, the maintenance interval may be considered reduced. If intervals are to be increased beyond maker's recommended intervals, this shall be approved by the management's organization ashore in agreement with maker, and may be accepted by the attending surveyor during the next annual survey.
- Circulating components. Components being re-used in several positions (cylinder covers, pistons, etc.) must have a traceable maintenance history. This can either be part of the maintenance system, or kept as a separate system.
- If the vessel has class notation Unmanned Machinery Space (UMS), the UMS Class jobs have to be included and especially identified in the PMS.

If the requirements for Machinery PMS are not fulfilled, the survey arrangement will not be granted, or can be deleted if already in operation.

Survey/Preparations: Machinery PMS Annual Survey

At the annual survey, the use of the system including the Chief Engineer's familiarity with it will be audited. In addition, the surveyor will review the machinery maintenance history in the PMS on board and perform a general inspection of the engine room.

The Chief Engineer has to prepare the printouts of the following reports before or during the survey:

- All main overhauls (Class linked jobs) carried out since last annual survey
- Overdue list.

If the requirements for the Machinery PMS are not fulfilled, a condition of class will be issued, and the survey arrangement may be deleted upon consideration.

Changing to Survey Arrangement Machinery PMS

When planning a change to the survey arrangement Machinery PMS it is required that the software used for planned maintenance is approved by Classification Society. Additionally, the Manager needs to hold a company approval for the maintenance system itself and an approval for each applicable vessel. It is important to bear in mind that an installed Planned

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Maintenance System onboard, is not the same as having the survey arrangement Machinery PMS. Before changing to the Survey Arrangement Machinery PMS a successful initial survey must be carried out on each vessel. The maintenance system should have been in use for approximately 6 months before an initial survey is requested.

System requirements

Several requirements apply to the maintenance system in use on board:

The planned maintenance system shall be computer based

- The system shall be able to produce a maintenance history report of all main overhauls carried out on class related machinery components during a specific period of time
- The system shall be able to identify all Class machinery with corresponding Classification Society's codes
- All corrective actions shall be especially identified in the system
- The job descriptions and maintenance history shall be in English
- A system for tracing circulating components should be in place (either included in the system or as a separate system)

Vessel Approval

A vessel approval has to be granted to each vessel which the Manager wants to have on Survey Arrangement Machinery PMS. After completion of an initial survey, the survey report is evaluated by the Classification Society's Head Office. Upon the successful review, a certificate is issued and the vessel is transferred to survey arrangement Machinery PMS.

.4 Survey Arrangement Machinery CM (Condition Monitoring)

Classification Society has developed Machinery CM, intended for Managers with an implemented Condition Based Maintenance (CBM) strategy. Machinery CM allows the manager to adjust maintenance intervals based on the monitored condition of applicable components, which gives the manager optimized maintenance with significant flexibility. Machinery CM requires that Machinery PMS is already granted.

Rules and Requirements:

The operator must submit a CM programme for approval. The CBM must be a well established maintenance philosophy and strategy within the management before the process of Class approval can be initiated.

3.1.4 PLANNING REPAIRS *Practical knowledge*

4.1 Planning repairs relevant to 3.1.1 (5 hours)

Ship's safety management system, as required by SOLAS (R1) chapter VIII, should be consulted when carrying out repair work. Manufacturer's Instruction and Operation Manual

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give guidance on repairs. Spare parts availability should be checked before starting repair procedures. Availability of specific tools and lifting equipment safe should be determined. Individual parts are to be tested as per manufacturer's instruction manual.

3.2 DETECT AND IDENTIFY THE CAUSE OF MACHINERY MALFUNCTIONS AND CORRECT FAULTS *Practical knowledge*

3.2.1 DETECTION OF MACHINERY MALFUNCTIONS, LOCATION OF FAULTS AND ACTION TO PREVENT DAMAGE

1.1 Unplanned maintenance (5 hours)

Comparison is made with normal operating values and abnormal operating conditions. Observation of physical parameters viz. vibrations, noise, temperature, pressures, levels, flow, etc., indicate abnormal conditions. Initial action taken when fault is first identified, considering vessel's safety. Bridge is notified of potential problems in good time. Senior engineers are advised when appropriate and advice sought in all cases of doubt. Priorities and scheduled work are re-assessed in light of identified fault. Errors are acknowledged, reported, recorded and corrective action taken.

3.2.2 INSPECTION AND ADJUSTMENT OF EQUIPMENT

2.1 Inspection and adjustment of equipment relevant to 3.1.1 (5 hours)

Inspection and adjustment of equipment to be carried out as per relevant data provided by the manufacturer's operating manual.

3.2.3 NON-DESTRUCTIVE EXAMINATION

3.1 Different types of non-destructive examination (10 hours)

Instructors should consult T57 for

(i) Visual Inspection

(ii) Dye penetrant test

(iii) Magnetic Particle Testing

(iv) Radiography

(v) Portable Hardness

(vi) Thermography.

3.3 ENSURE SAFE WORKING PRACTICES *Practical knowledge*

3.3.1 SAFE WORKING PRACTICES

1.1 Risk assessment (1 hour)

Extensive guidance is available in T24. Refer also to V42 and V94.

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1.2 Safety officials (1 hour)

Extensive guidance is available in T24.

1.3 Personal protective equipment (1 hour)

Extensive guidance is available in T24. Refer also to V49.

1.4 Work equipment (1 hour)

Extensive guidance is available in T24.

1.5 Safety induction (1 hour)

Extensive guidance is available in T24. Refer also to V29, V30, V31, V32, V33, V34, V35, V36 V38 and V39.

1.6 Fire precautions (1 hour)

Extensive guidance is available in T24. Refer also to V24 and V53.

1.7 Emergency procedures (1 hour)

Extensive guidance is available in T24.

1.8 Safe movement (1 hour)

Extensive guidance is available in T24.

1.9 Safe system of works (1 hour)

Extensive guidance is available in T24.

1.10 Entering enclosed or confined spaces (2 hour)

Extensive guidance is available in T24. Refer also to V55, V96 and V98.

1.11 Permit to work systems (2 hour)

Extensive guidance is available in T24. Refer also to V49.

1.12 Manual handling (1 hour)

Extensive guidance is available in T24.

1.13 Use of work equipment (1 hour)

Extensive guidance is available in T24.

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1.14 Lifting plant (1 hour)

Extensive guidance is available in T24.

1.15 Maintenance of machineries (1 hour)

Extensive guidance is available in T24.

1.16 Hot work (1 hour)

Extensive guidance is available in T24. Refer also to V95.

1.17 Painting (1 hour)

Extensive guidance is available in T24. Refer also to B35.

1.18 Hazardous substances (1 hour)

Extensive guidance is available in T24.

1.19 Noise and vibrations (1 hour)

Extensive guidance is available in T24. Refer to R50 for noise and T13 for vibrations. Also Guidance on vibrations is available on websites of Classification Societies, e.g. following: http://www.eagle.org/eagleExternalPortalWEB/ShowProperty/BEA%20Repository/Rules&Guides/Current/147_ShipVibration/Pub147_ShipVib

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Chief Engineer Officer and Second Engineer Officer

Function 4:
Controlling the Operation of the Ship and Care for Persons on Board at the Management Level

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Chief Engineer Officer and Second Engineer Officer

Function 4: Controlling the Operation of the Ship and Care for Persons on Board at the Management Level

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Lectures
Course outline

Part C4: Detailed Teaching Syllabus **153**
Introduction
Explanation of information contained in the syllabus tables
4.1 Control trim, stability and stress
4.2 Monitor and control compliance with legislative requirements and measures to ensure safety of life at sea and the protection of the marine environment
4.3 Maintain safety and security of crew and passengers and the operational condition of safety systems
4.4 Develop emergency and damage control plans and handle emergency situations
4.5 Use of leadership and managerial skills

Part D4: Instructor Manual **216**

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Part B4: Course Outline

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
Competence:		
4.1 Control trim, stability and stress		
4.1.1 FUNDAMENTAL PRINCIPLES OF SHIP CONSTRUCTION, TRIM AND STABILITY		
.1 Stress	4	
.2 Construction arrangements	27	
.3 Watertight and weathertight doors	3	
.4 Ship dynamics	2	
.5 Corrosion and its prevention	4	
.6 Surveys and dry-docking	2	
.7 Stability	42	
.8 Resistance and fuel consumption	5	
.9 Rudders	1	90
4.1.2 EFFECT ON TRIM AND STABILITY IN THE EVENT OF DAMAGE AND FLOODING		
.1 Effect of flooding on Transverse Stability and Trim	9	
.2 Theories affecting trim and stability	2	11
4.1.3 KNOWLEDGE OF IMO RECOMMENDATIONS CONCERNING SHIP STABILITY		
.1 Responsibilities under the relevant requirements of the International Conventions and Codes	2	2
4.2 Monitor and control compliance with legislative requirements and measures to ensure safety of life at sea and the protection of the marine environment		
4.2.1 INTERNATIONAL MARITIME LAW EMBODIED IN INTERNATIONAL AGREEMENTS AND CONVENTIONS		
.1 Certificates and other documents required to be carried on board ships by international conventions	1	
.2 Responsibilities under the relevant requirements of the International Convention on Load Lines	1	
.3 Responsibilities under the relevant requirements of the International Convention for the Safety of Life at Sea	1	
.4 Responsibilities under the International Convention for the Prevention of Pollution From Ships	3	
.5 Maritime declarations of health and the requirements of the International Health Regulations	1	
.6 Responsibilities under other international maritime law embodied in international agreements and conventions that impact on the role of management level officers	11	
.7 Responsibilities under international instruments affecting the safety of the ship, passengers, crew and cargo	3	

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Knowledge, understanding and proficiency			Total hours for each topic	Total hours for each subject area of Required performance
	.8	Methods and aids to prevent pollution of the marine environment by ships	2	
	.9	National legislation for implementing international agreements and conventions	1	24
4.3	**Maintain safety and security of crew and passengers and the operational condition of safety systems**			
4.3.1	KNOWLEDGE OF LIFE-SAVING APPLIANCE REGULATIONS		2	2
4.3.2	ORGANIZATION OF FIRE DRILLS AND ABANDON SHIP DRILLS		-	-
	See IMO model courses 2.03 and 1.23 and STCW Code sections A-V1/3 and A-V1/2			
4.3.3	MAINTENANCE OF OPERATIONAL CONDITION OF LIFE-SAVING, FIREFIGHTING AND OTHER SAFETY SYSTEMS		-	-
	See IMO model courses 2.03 and 1.23 and STCW Code sections A-V1/3 and A-V1/2			
4.3.4	ACTIONS TO BE TAKEN TO PROTECT AND SAFEGUARD ALL PERSONS ON BOARD IN EMERGENCIES		4	4
4.3.5	ACTIONS TO LIMIT DAMAGE AND SALVE THE SHIP FOLLOWING A FIRE, EXPLOSION, COLLISION OR GROUNDING		4	4
4.4	**Develop emergency and damage control plans and handle emergency situations**			
4.4.1	PREPARATION OF CONTINGENCY PLANS FOR RESPONSE TO EMERGENCIES		9	9
4.4.2	SHIP CONSTRUCTION INCLUDING DAMAGE CONTROL		4	4
4.4.3	METHODS AND AIDS FOR FIRE PREVENTION, DETECTION AND EXTINCTION		-	-
	See IMO model course 2.03 and STCW Code section A-V1/3			
4.4.4	FUNCTIONS AND USE OF LIFE SAVING APPLIANCES		-	-
	See IMO model course 1.23 and STCW Code section A-V1/2-1			
4.5	**Use of leadership and managerial skills**			
4.5.1	SHIPBOARD PERSONNEL MANAGEMENT AND TRAINING			
	.1	Shipboard Personnel Management	10	
	.2	Training on board ships	6	16
4.5.2	RELATED INTERNATIONAL MARITIME CONVENTIONS AND RECOMMENDATIONS, AND NATIONAL LEGISLATION			
	.1	Related international maritime conventions, recommendations and national legislation	4	4
4.5.3	APPLICATION OF TASK AND WORKLOAD MANAGEMENT			
	.1	Task and Workload Management	8	8
4.5.4	EFFECTIVE RESOURCE MANAGEMENT			
	.1	Application of effective resource management at a management level	10	10

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Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
4.5.5 DECISION-MAKING TECHNIQUES		
.1 Situation and risk assessment	2	
.2 Identify and generate options	2	
.3 Selecting course of action	2	
.4 Evaluation of outcome effectiveness	1	7
4.5.6 DEVELOPMENT, IMPLEMENTATION AND OVERSIGHT OF STANDARD OPERATING PROCEDURES	1	1
Total for Function 4: Controlling the Operation of the Ship and Care for Persons on Board at the Management Level		**196 hours**

Teaching staff and Administrations 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.

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Part C4: Detailed Teaching Syllabus

COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of 4.1.1 FUNDAMENTAL PRINCIPLES OF SHIP CONSTRUCTION, TRIM AND STABILITY 4.1.2 EFFECT ON TRIM AND STABILITY IN THE EVENT OF DAMAGE AND FLOODING 4.1.3 KNOWLEDGE OF IMO RECOMMENDATIONS CONCERNING SHIP STABILITY		STCW Code table A-III/2

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference
4.1.1 FUNDAMENTAL PRINCIPLES OF SHIP CONSTRUCTION, TRIM AND STABILITY **Textbooks/Bibliography:** T3, T4, T19, T25, T33, T34, T35, B97 **Teaching aids:** A1 Required performance: *Note that trainees must be familiar with the content and application of the basic knowledge of ship construction and stability from IMO model course 7.04. This knowledge is considered so fundamental for much of the management level content within this course that there is merit in reviewing the operational level content quickly before covering the additional elements required at management level. The learning time has been reduced for many elements on the basis that trainees will be reviewing rather than learning much of this content at this level. It may be necessary for some trainees to refresh their knowledge of this content before undertaking this management level content* **Ship Construction** **1.1 Ship stresses (4 hours)** explains: – stresses in ship structures: longitudinal bending, still water bending, load diagram, shear force diagram, bending moment diagram, hogging, sagging, wave bending, transverse bending – docking, grounding – pounding, panting **1.2 Ship construction arrangements (27 hours)** describes common arrangements for: – double bottom construction – safety features for duct keels – forward and after peak structures – anchor cable termination details – longitudinal, transverse and combined framed vessels – decks – hatch covers – bulwarks – deep frames – design consideration for discontinuities in the vessel structure – bilge keel consideration – strakes for the hull – fittings through the hull – engine, deck machinery and stabilizer strength members – bulkhead construction and their position – maintenance of strength and watertight integrity when bulkheads are pierced for normal operation – rudder and its support arrangements – stern frame – design criteria for specialized ships	R1

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference
	– structural fire protection – ship's general arrangement drawing – shell expansion – deck plan – midship section	
1.3	**Watertight integrity and weathertight doors (3 hours)**	R1
.1	**Explains the general design and construction features of SOLAS compliant vessels in terms of watertight integrity**	
	– explains the possible effects of sustaining damage when in a less favourable condition	
	– states that the number of openings in watertight bulkheads of passenger ships should be reduced to the minimum compatible with the design and working of the ship	R2
	– categorizes watertight doors as: class 1 — hinged doors class 2 — hand-opened sliding doors class 3 — sliding doors which are power-operated as well as hand-operated	
	– states that all types of watertight doors should be capable of being closed with the ship listed to 15° either way	
	– describes with sketches the arrangement of a power-operated sliding watertight door	
	– describes with sketches a hinged watertight door, showing the means of securing it	
	– states that hinged watertight doors are only permitted above a deck at least 2.0 metres above the deepest subdivision load line	
	Cargo vessels	
	– distinguishes between ships of Type A and Type B for the purposes of computation of freeboard	
	– describes the extent of damage which a Type A ship of over 150 metres length should withstand	
	– explains that a Type A ship of over 150 metres length is described as a 'one-compartment ship'	
	– describes the requirements for survivability of Type B ships with reduced freeboard assigned	
	– summarizes the equilibrium conditions regarded as satisfactory after flooding	
	All ships	
	– states that openings in watertight bulkheads must be fitted with watertight doors	
	– explains that weathertight doors in superstructure openings are similar to hinged watertight doors	
	– states that drills for the operating of watertight doors, side scuttles, valves and other closing mechanisms must be held weekly	

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference
	– states the requirements for watertight openings to be closed at sea – discusses procedures for ensuring that all watertight openings are closed – states that all watertight doors in main transverse bulkheads, in use at sea, must be operated daily – states that watertight doors and their mechanisms and indicators, all valves the closing of which is necessary to make a compartment watertight and all valves for damage-control cross-connections must be inspected at sea at least once per week – states that records of drills and inspections are to be entered in the log, with a record of any defects found	
1.4	**Ship dynamics (2 hours)** explains – rolling – period of roll and isochronous rolling – pitching – heaving – bilge keels – fin stabilizers – passive and active anti-roll tanks – vibration	

1.5	**Corrosion and its prevention (4 hours)**
	– explains what is meant by corrosion
	– explains what is meant by erosion of metals and gives examples of where this is likely to occur
	– describes the formation of a corrosion cell and defines anode, cathode and electrolyte
	– states that corrosion takes place at the anode while the cathode remains unaffected
	– describes the galvanic series of metals in seawater
	– given the galvanic series, states which of two metals will form the anode in a corrosion cell
	– explains the differences in surface condition or in stress concentration can give rise to corrosion cells between two areas of the same metal
	– states that corrosion can be controlled by:
	  – applying a protective coating to isolate the steel from the air or from seawater electrolyte
	  – using cathodic protection to prevent steel from forming the anode of a corrosion cell
	– explains that cathodic protection can only be used to protect the underwater hull or ballasted tanks
	– states that both of the methods mentioned above are normally used together
	– explains what mill scale is and states that it is cathodic to mild steel
	– describes the treatment of steel in a shipyard and the use of holding primers (shop primers)
		R1

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference

- explains that the required preparation of steelwork depends upon the type of paint to be applied
- states that many modern paints, such as epoxy and polyurethane, need to be applied to a very clean shot-blasted surface
- states that paints consist mainly of a vehicle, a pigment and a solvent, and explains the purpose of each
- explains the suitability of the following paint types for various applications as:
  - drying oils
  - oleo-resins
  - alkyd resins
  - polymerizing chemicals
  - bitumen
- describes the action of anti-fouling paint
- describes the use of self-polishing anti-fouling paint
- explains the ban on harmful types of anti-fouling paint
- describes typical paint schemes for:
  - underwater areas
  - boot topping
  - topsides
  - weather decks
  - superstructures
  - tank interiors
- states the safety precautions to take when using paints
- describes the system of cathodic protection using sacrificial anodes
- lists the metals and alloys which may be used as anodes
- explains why anodes of magnesium and of magnesium alloy are not permitted in cargo/ballast tanks and in adjacent tanks in tankers
- states that good electrical contact between the anode and the hull or tank is essential
- explains why the anodes are insulated from the hull
- describes the impressed-current system of hull protection
- explains that the system is adjusted for optimum protection, often automatically, by use of a reference cell
- states that electrical connection with the hull via slip rings and brushes on the rudder stock and propeller shaft ensures protection of the rudder and propeller
- explains that, as the underwater paintwork deteriorates, higher currents are required for protection
- states that too high a current can result in damage to paintwork and a chalky deposit on areas of bare metal, which has to be removed before repainting can be carried out
- states that a protective shield of epoxy resin is applied for about 1 metre around the anodes to withstand the alkaline conditions there

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference

1.6 Surveys and dry-docking (2 hours) — R1

- states the frequency of classification society surveys
- states that intervals between dry-dockings may be extended up to 2.5 years where a ship has high-resistance paint and an approved automatic impressed-current cathodic protection system
- states that continuous hull survey, in which all compartments are examined over a 5-year period, may replace the special surveys
- explains all types of survey a ship is subjected to, including but limiting to: Initial Survey, Renewal Survey, Periodical Survey, Intermediate Survey, Annual Survey, Inspection of the outside of the ship's bottom, Additional Survey
- explains the harmonized system of ship survey and certification
- explains Condition Assessment Scheme (CAS) for oil tankers and Condition Assessment Programme (CAP)
- lists the items inspected at annual survey as:
  - protection of openings: hatches, ventilators, cargo doors, side scuttles, overside discharges and any other openings through which water might enter
  - guardrails
  - water-clearing arrangements, freeing ports, scuppers
  - means of access to crews quarters and working areas
- states that the inspections listed above are also required for the annual inspection under the International Convention on Load Lines
- lists the items to examine in dry-dock as:
  - shell plating
  - cathodic protection fittings
  - rudder
  - stem frame
  - propeller
  - anchors and chain cable
- describes the examinations to be made of the items listed above
- describes the cleaning, preparation and painting of the hull in dry-dock
- calculates paint quantities, given the formula for wetted surface area as:

  $S = 2.58 \sqrt{\Delta} L$

  where S = surface area in m^2

  Δ = displacement in tonnes

  L = length of ship in metres

1.7 Stability (42 hours)

Approximate calculation of areas and volumes

- states the trapezoidal rule for the area under a curve in terms of the number of ordinates, the interval and the ordinate values
- uses the trapezoidal rule to find the area under a curve defined by given ordinates

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference

– states Simpson's first rule as

$A = h (y_1 + 4y_2 + y_3) / 3$

where: A = area under curve

h = interval length

y_1, y_2, y_3 are ordinates

– writes down the repeated first rule for any odd number of ordinates

– uses Simpson's first rule to find the area under a curve defined by an odd number of ordinates

– states that the area is exact for a linear, quadratic or cubic curve but an approximation otherwise

– states Simpson's second rule as

$A = 3h (y_1 + 3y_2 + 3y_3 + y_4) / 8$

where: A = area

h = interval length

y_1, y_2, y_3, y_4 are ordinates

– writes down the repeated second rule for 7, 10, 13, etc., ordinates

– uses Simpson's second rule to find the area under a curve defined by a suitable number of given ordinates

– states that the area is exact for linear, quadratic or cubic curves

– states that the first rule has smaller errors than the second and should be used in preference where possible

– states that errors can be reduced by using a smaller interval

– states the 5, 8, -1 rule as $A = h (5y_1 + 8y_2 – y_3) / 12$

where: A = area between first and second ordinates

h = interval length

y_1, y_2, y_3, are ordinates

– uses Simpson's rules to find the area under a curve defined by any number of ordinates

– explains that the volume of a body may be calculated by using Simpson's rules with cross-sectional areas as ordinates

– calculates the volume of a ship to a stated draught by applying Simpson's rules to given cross-sectional areas or waterplane areas

– uses Simpson's first, second and 5/8-1 Rules to approximate areas and volumes of ship structure and GZ curves with any number of ordinates and intermediate ordinates

– uses Simpson's 1st and 2nd Rules for 1st moments and centroids

– applies Simpson's Rules to find centroids

– uses Simpson's Rules to find common areas such as, waterplanes, sections and bulkheads

– calculates Vertical Centre of Buoyancy, VCB; Longitudinal Centre of Buoyancy, LCB of ship shapes

– applies Simpson's 1st and 2nd Rules for 2nd moments of area

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference

- calculates transverse moment of inertia, IT; Longitudinal moment of inertia, IL of ship shapes
- explains why the density of the water in the dock should be taken at the same time as the draughts are read
- describes the statical and dynamic effects on stability of the movement of liquids with a free surface
- calculates the virtual reduction in GM for liquids with a free surface in spaces with rectangular and triangular waterplanes
- deduces from the above objective that halving the breadth of a tank reduces the free surface effect to one eighth of its original value
- deduces that the subdividing a tank at the centre reduces its free surface effect to one quarter of that of the undivided tank
- states that the quantity 'inertia x density of liquid' is called the 'free surface moment' of the tank, in tonne-metres
- states that information for calculating free surface effect is included in tank capacity tables
- states that the information may be given in one of the following ways:
  - inertia in metre^4
  - free surface moments for a stated density of liquid in the tank
  - as a loss of GM, in tabulated form for a range of draughts (displacements) for a stated density of liquid in the tank
- corrects free surface moments when a tank contains a liquid of different density from that stated in the capacity table
- given a ship's displacement and the contents of its tanks, uses the information from ship's stability information to calculate the loss of GM due to slack tanks
- given a ship's departure conditions and the daily consumption of fuel, water and stores, calculates the GM allowing for free surfaces on arrival at destination

Stability at moderate and large angles of heel

- states that the formula GZ = GM sin θ does not hold for angles in excess of about 10°
- states that the initial KM is calculated from

  KM = KB + BM
- uses a metacentric diagram to obtain values of KM, KB and BM for given draughts
- states that the transverse BM = I / V

  where: I = second moment of area of the waterplane about the centre line;
  V = underwater volume of the ship
- states that for a rectangular waterplane I = LB^3 / 12

  where: L is the length of the waterplane;
  B is the breadth of the waterplane
- shows that, for a box-shaped vessel,

  KM = (B^2 /12d) + (d / 2)

  where: d = draught

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference

- states that, for moderate and large angles of heel, values of GZ found by calculating the position of the centre of buoyancy are provided by the shipbuilder for a range of displacements and angles of heel for an assumed position of the centre of gravity
- uses cross-curves of stability and KN curves to construct a curve of statical stability for a given displacement and value of KG, making correction for any free surface moments
- explains how to use the initial metacentric height as an aid to drawing the curve
- identifies from the curve the approximate angle at which the deck edge immerses
- describes the effect of increased freeboard on the curve of statical stability for a ship with the same initial GM
- states that the righting lever, GZ, may be found from the wall-sided formula up to the angle at which the deck edge is immersed
- given the wall-sided formula:

  $GZ = (GM + BM / 2 \tan^2\theta) \sin \theta$

  and other relevant data, calculates the value of GZ for a stated angle of heel
- shows that, for small angles of heel, the term

  $BM / 2 \tan^2\theta$ is negligible, leading to the usual expression for GZ at small angles of heel
- uses the wall-sided formula for calculating the angle of loll of an initially unstable ship
- compares the result in the above objective with that obtained by connecting a curve of statical stability
- states that cross-curves and KN curves are drawn for the ship with its centre of gravity on the centre line
- demonstrates how to adjust the curve of statical stability for a ship with a list
- describes the effect when heeled to the listed side on:
  - the maximum righting moment
  - the angle of vanishing stability
  - the range of stability
- states that cross-curves and KN curves are drawn for the ship at the designed trim when upright
- states that righting levers may differ from those shown if the ship has a large trim when upright

Simplified stability data

- states that stability information may be supplied in a simplified form, consisting of:
  - a diagram or table of maximum deadweight moment
  - a diagram or table of minimum permissible GM
  - a diagram or table of maximum permissible KG all related to the displacement or draught in salt water

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference
	– states that a deadweight moment is mass in tonnes x vertical height of the mass above the keel	
	– states that free surface moments are to be added to the deadweight moments when using the diagram of maximum deadweight moment	
	– states that if, for a stated displacement or draught, the total deadweight moment or KG is less than the maximum permissible value, the ship will have adequate stability	
	– reads the maximum permissible deadweight moment from a curve of deadweight moment for a given displacement	
	– given the masses loaded, their heights above the keel and the free surface moments of slack tanks, calculates the deadweight moment and uses the result with the diagram of deadweight moment to determine if the stability is adequate	
	– uses the diagram of deadweight moment to calculate the maximum mass that can be loaded in a given position to ensure adequate stability during a voyage, making allowance for the fuel, water and stores consumed and for any resulting free surface	
	– states that curves of maximum KG or minimum GM to ensure adequate stability in the event of partial loss of intact buoyancy are provided in passenger ships	R1, R2
	Trim and list	
	– defines longitudinal centre of gravity (LCG) and longitudinal centre of buoyancy (LCB)	R1
	– states that a ship trims about the centre of flotation until LCG and LCB are in the same vertical line	
	– states that the distance of the LOB from amidships or from the after perpendicular is given in a ship's hydrostatic data for the ship on an even keel	
	– explains that the LCG must be at the same distance from amidships as LCB when the ship floats on an even keel	
	– shows on a diagram of a ship constrained to an even keel the couple that is formed by the weight and buoyancy forces when LCG is not the same distance from amidships as LCB	
	– states that the trimming moment = displacement x the horizontal distance between LCB (tabulated) and LCG (actual) = Δ x GG_1 where GG^1 is the horizontal distance between the position of LCG for the even-keel condition and the actual LCG	
	– states that trim = (Δ x GG_1) / MCT 1cm	
	– states that if the actual LCG is abaft the tabulated position of LCB, then the trim will be by the stern, and vice versa	
	– given the initial displacement, initial position of LCG, masses loaded or discharged and their LCGs, calculates the final position of LCG	
	– using a ship's hydrostatic data and a given disposition of cargo, fuel, water and stores, determines the trim, the mean draught and the draughts at each end	
	– calculates the mass to move between given positions to produce a required trim or draught at one end	

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference

- calculates where to load a given mass to produce a required trim or draught at one end
- calculates how to divide a loaded or discharged mass between two positions to produce a required trim or draught at one end
- calculates where to load a mass so as to keep the after draught constant
- states that calculated draughts refer to draughts at the perpendiculars
- given the distance of draught marks from the perpendiculars and the length between perpendiculars, corrects the draughts indicated by the marks
- given draughts forward, aft and amidships, states whether or not the ship is hogged or sagged and the amount
- corrects the draught amidships for hog or sag
- given the forward and after draughts, the length between perpendiculars and hydrostatic data, calculates the correction for trim to apply to the displacement corresponding to the draught amidships
- states that a second correction for trim, using Nemoto's formula, may be applied to the displacement
- given Nemoto's formula, calculates the second correction to displacement
- calculates the maximum list during loading or discharging a heavy lift, using a ship's derrick, given the relevant stability information and the dimensions of the derrick
- calculates the minimum GM required to restrict the list to a stated maximum when loading or discharging a heavy lift
- calculates the quantities of fuel oil or ballast to move between given locations to simultaneously correct a list and achieve a desired trim
- explains how to distinguish between list and loll and describes how to return the ship to the upright in each case
- by making use of curves of statical stability, including those for ships with zero or negative initial GM, determines the equilibrium angle of heel resulting from a transverse moment of mass

Dynamical stability

- defines dynamical stability at any angle of heel as the work done in inclining the ship to that angle
- states that the dynamical stability at any angle is given by the product of displacement and the area under the curve of statical stability up to that angle
- given a curve of statical stability, uses Simpson's rules to find the area in metre-radians up to a stated angle
- states that dynamical stability is usually expressed in tonne-metres
- explains that the dynamical stability at a given angle of heel represents the potential energy of the ship
- states that the potential energy is used partly in overcoming resistance to rolling and partly in producing rotational energy as the ship returns to the upright
- states that the rotational energy when the ship is upright causes it to continue rolling

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference
	– states that, in the absence of other disturbing forces, the ship will roll to an angle where the sum of the energy used in overcoming resistance to rolling and the dynamical stability are equal to the rotational energy when upright – states that a beam wind exerts a force equal to the wind pressure multiplied by the projected lateral area of the portion of the ship and deck cargo above the waterline – explains that a heeling moment is formed, equal to the force of the wind multiplied by the vertical separation between the centres of the lateral areas of the portions of the ship above and below the waterline – states that the heeling lever equals the heeling moment divided by the ship's displacement – states that a steady wind will cause a ship to heel to an angle at which the righting lever is equal to the heeling over – states that a ship under the action of a steady wind would roll about the resulting angle of heel – on a curve of righting levers, indicates the angle of equilibrium under the action of a steady wind and the areas which represent the dynamical stability at angles of roll to each side of the equilibrium position – by reference to dynamical stability, describes the effect of an increase in wind pressure when a vessel is at its maximum angle of roll to windward – summarizes the recommendation on severe wind and rolling criterion for the intact stability of passenger and cargo ships – by reference to a curve of righting levers and dynamical stability, describes the effect of a listing moment on the rolling of the ship about the equilibrium position	
	Approximate GM by means of rolling period tests – states that, for ships up to 70m in length, the GM can be verified in still water by causing the ship to roll and noting the rolling period – defines the rolling period as the time taken for one complete oscillation from the extreme end of a roll to one side, right across to the extreme on the other side and back to the original position – states that for small angles of roll in still water, the initial metacentric height, GM_o is given by: $GM_o = [fB / Tr]^2$ where: f = rolling factor B = breadth of the ship Tr = rolling period in seconds – states that the formula may be given as: $GM_o = F / Tr^2$ where the F-value is provided by the Administration – summarizes the procedures for determining a ship's stability by means of the rolling period test – given values of F and T and the equation $GM_o = F / T^2$, calculates GM_o – states the limitations of the method – states that when construction is completed, a ship undergoes an inclining test to determine the displacement and position of the centre of gravity, KG and LCG, in the light ship condition	R1

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference
	– states that the displacement and KM are calculated from the observed draughts and the ship's lines plans, making allowance for density of water and trim	
	– states that the position of the centre of buoyancy is calculated to enable the LCG for the light ship to be determined	
	– describes how an inclining test is carried out	
	– given the mass and the distance through which it was moved, the displacement, length of the plumb line and the deflection, calculates the KG	
	– states that the values obtained in a test are corrected for masses to be removed and added to obtain the KG and LCG for the light ship	
	– states that, at periodical intervals not exceeding five years, a light ship survey must be carried out on all passenger ships to verify any changes in light ship displacement and longitudinal centre of gravity	
	– states that the ship must be re-inclined whenever, in comparison with the approved stability information, a deviation from the light ship displacement exceeding 2% or a deviation of the longitudinal centre of gravity exceeding 1% of L is found or anticipated	R2
	Intact stability code	R1
	– describes the general precautions to be taken against capsizing	
	– states the recommended criteria for passenger and cargo ships of all types	
	– given the initial metacentric height and the GZ curve, determines whether the ship meets the recommended criteria	
	– states that stability information should comprise:	
	– stability characteristics of typical loading conditions	
	– information to enable the assessment of the stability of the ship in all loading conditions differing from the standard ones	
	– information on the proper use of anti-rolling devices, if fitted	
	– information to enable the GM_o to be determined by means of a rolling test corrections to be made to GM_o for free surface liquids	
	– for ships carrying timber deck cargoes information setting out changes in deck cargo from that shown in the loading conditions, when the permeability of the deck cargo is significantly different from 25%	
	– for ships carrying timber deck cargoes, indications of the maximum permissible amount of deck cargo	
	– states that criteria are laid down for ships carrying timber deck cargoes	
	– discusses the use of the weather criterion and how to assess whether a vessel complies with this	
	– states the additional criteria recommended for passenger ships	
	– states that the information includes a curve or table giving, as a function of the draught, the required initial GM which ensures compliance with the recommendations on intact stability	
	Rolling of ships	R1
	– describes the effect on GM of rolling	
	– explains how increase of draught and of displacement influence rolling	
	– describes how the distribution of mass within the ship affects the rolling period	

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference

– explains what synchronization is and the circumstances in which it is most likely to occur
– describes the actions to take if synchronization is experienced
– describes how bilge keels, anti-rolling tanks and stabilizer fins reduce the amplitude of rolling
– states that a ship generally heels when turning
– states that, while turning, the ship is subject to an acceleration towards the centre of the turn
– states that the force producing the acceleration acts at the underwater centre of lateral resistance, which is situated at about half-draught above the keel
– states that the force in the above objective is called the centripetal force, given by $F = Mv^2 / r$

where: M = mass of the ship in tonnes
v = speed in metres per second
r = radius of turn in metres
F = centripetal force in kilonewtons

– states that the ship will heel until the resulting righting moment equals the heeling couple, i.e

$$M \times g \times GM \sin\theta = \frac{Mv^2}{r}\left[KG - \frac{d}{2}\right]\cos\theta$$

where: g = acceleration due to gravity
θ = angle of heel

– given the relevant data, calculates the angle of heel from

$$\tan\theta = \frac{v^2 \times \left[KG - \frac{d}{2}\right]}{g \times GM \times r}$$

Dry-docking and grounding R1

– states that for dry-docking a ship should:
  – have adequate initial metacentric height
  – be upright
  – have a small or moderate trim, normally by the stern
– states that part of the weight is taken by the blocks as soon as the ship touches, reducing the buoyancy force by the same amount
– states that the upthrust at the stern causes a virtual loss of metacentric height
– explains why the GM must remain positive until the critical instant at which the ship takes the blocks overall
– derives the formula for the upthrust at the stern

$$P = \frac{(MCT \times t)}{L}$$

where: P = upthrust at the stern in tonnes
t = change of trim in cm
L = distance of the centre of flotation from aft

– explains that a ship with a large trim will develop a large upthrust, which may damage the stern frame, trip the blocks or lead to an unstable condition before taking the blocks overall

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference
	– by taking moments about the centre of buoyancy, shows that, for a small angle of heel, θ,	
	righting moment = Δ x GM sin θ – P x KM sin θ	
	where GM is the initial metacentric height when afloat	
	– shows that the righting lever is that for the ship with its metacentric height reduced by (P x KM) / Δ	
	– by using the equation in the above objective and KM + KG + GM, shows that righting moment = (Δ – P) x GM sin θ – P x KG sin θ	
	– shows that the righting lever is that for a ship of displacement (Δ – P) and with metacentric height reduced by (P x KG) / Δ – P	
	– explains that the righting moment remains positive providing Δ x GM is greater than P x KM or equivalently, (Δ – P) x GM is greater than P x KG	
	– calculates the minimum GM to ensure that the ship remains stable at the point of taking the blocks overall	
	– calculates the maximum trim to ensure that the ship remains stable on taking the blocks overall for a given GM	
	– calculates the virtual loss of GM and the draughts of the ship after the after level has fallen by a stated amount	
	– calculates the draughts on taking the blocks overall	
	– explains that the stability of a ship aground at one point on the centre line is reduced in the same way as in dry-docking	
	– states that when grounding occurs at an off-centre point, the upthrust causes heel as well as trim and reduction of GM	
	– explains that the increase in upthrust as the tide falls increases the heeling moment and reduces the stability	
	Shear force, bending moments and torsional stress	R1
	– explains what is meant by shearing stress	
	– states that the shear force at a given point of a simply supported beam is equal to the algebraic sum of the forces to one side of that point	
	– explains that, for a beam in equilibrium, the sum of forces to one side of a point is equal to the sum of the forces on the other side with the sign reversed	
	– explains what is meant by a bending moment	
	– states that the bending moment at a given point of a beam is the algebraic sum of the moment of force acting to one side of that point	
	– states that the bending moment measured to opposite sides of a point are numerically equal but opposite in sense	
	– draws a diagram of shear force and bending moment for simply supported beams	
	– states that the bending moment at any given point is equal to the area under the shear-force curve to that point	
	– uses the above objective to show that the bending-moment curve has a turning point where the shear force has zero value	
	– explains that shear forces and bending moments arise from differences between weight and buoyancy per unit length of the ship	
	– states that the differences between buoyancy and weight is called the load	
	– draws a load curve from a given buoyancy curve and weight curve	

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference

- states that the shear force at any given point is equal to the area under the load curve between the origin and that point
- draws a diagram of shear force and bending moment for a given distribution of weight for a box-shaped vessel
- explains how wave profile affects the shear-force curve and bending-moment curve
- states that each ship above a specified length is required to carry a loading manual, in which are set out acceptable loading patterns to keep shear forces and bending moments within acceptable limits
- states that the classification society may also require a ship to carry an approved means of calculating shear forces and bending moment at stipulated stations
- demonstrates the use of a loading instrument
- states that the loading manual and instrument, where provided, should be used to ensure that shear forces and bending moments do not exceed the permissible limits in still water during cargo and ballast handling
- explains what is meant by a torsional stress
- describes how torsional stresses in the hull are set up
- states that wave-induced torsional stresses are allowed for in the design of the ship
- states that cargo-induced torsional stresses are a problem mainly in container ships
- states that classification societies specify maximum permissible torsional moments at a number of specified cargo bays
- given details of loading, calculates cumulative torsional moments for stated positions
- describes the likelihood of overstressing the hull structure when loading certain bulk cargoes

1.8 Resistance and fuel consumption (5 hours)

explains and completes calculations involving:

- Frictional resistance
- REYNOLDS' number
- Residuary resistance
- Froude number
- Speed length ratio
- Effective power
- Admiralty coefficient
- Fuel coefficient and fuel consumption

1.9 Rudders (1 hour)

explains and completes calculations on:

- Force on a rudder
- Torque on a rudder stock

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference

4.1.2 EFFECT ON TRIM AND STABILITY IN THE EVENT OF DAMAGE AND FLOODING

Textbooks: T4

Bibliography:

Teaching aids: A1

Required performance:

2.1 Effect of flooding on transverse stability and trim (9 hours) — R1

Passenger vessels

- explains what is meant by 'floodable length'
- defines:
  - margin line
  - bulkhead deck
  - permeability of a space
- explains what is meant by 'permissible length of compartments' in passenger ships
- describes briefly the significance of the Criterion of Service Numeral
- explains the significance of the factor of subdivision
- states the assumed extent of damage used in assessing the stability of passenger ships in damaged condition
- summarizes, with reference to the factor of subdivision, the extent of damage which a passenger ship should withstand
- describes the provisions for dealing with asymmetrical flooding
- states the requirements for the final condition of the ship after assumed damage and, where applicable, equalization of flooding
- states that the vessel is supplied with data necessary to maintain sufficient intact stability to withstand the critical damage
- explains the minimum residual stability requirements in the damaged condition with the required number of compartments flooded
- discusses the use of the damaged stability information required to be provided to a passenger vessel

Cargo ships

- distinguishes between ships of Type A and Type B for the purpose of computation of freeboard
- describes the extent of damage that a Type A ship of over 150m in length should be able to withstand
- explains that a Type A ship of over 150m in length is described as a one compartment ship
- describes the requirements for the survivability of Type B ships with reduced assigned freeboard
- summarizes the equilibrium conditions regarded as satisfactory after flooding

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference

– states that damage to compartments may cause a ship to sink as a result of:
  – insufficient reserve buoyancy leading to progressive flooding
  – progressive flooding due to excessive list or trim
  – capsizing due to a loss of stability
  – structural failure

Calculation of vessel condition after flooding

– states that, in the absence of hull damage, the stability is calculated in the usual way using the added mass and making allowance for free surface liquid

– states that free surface moments for any rectangular compartment that is flooded by salt water can be approximated by
  moment = length x $(\text{breadth})^3$ x 1.025 / 12

– states that virtual loss of GM = $\dfrac{\text{moment}}{\text{flooded displacement}}$

– states that when a compartment is holed the ship will sink deeper in the water until the intact volume displaces water equivalent to the mass of the ship and its contents

– explains that the loss of buoyancy of a holed compartment is equal to the mass of water which enters the compartment up to the original waterline

– states that the volume of lost buoyancy for a loaded compartment is equal to the volume of the compartment x the permeability of the compartment

– calculates the permeability of cargo, given its density and its stowage factor

– states that if the lost buoyancy is greater than the reserve buoyancy the ship will sink

– states that the centre of buoyancy moves to the centre of immersed volume of the intact portion of the ship

– states that when a compartment is holed the ship's displacement and its centre of gravity are unchanged

– explains that a heeling arm is produced, equal to the transverse separation of G and the new position of B for the upright ship

– states that the area of intact waterplane is reduced by the area of the flooded spaces at the level of the flooded waterline multiplied by the permeability of the space

– states that if the flooded space is entirely below the waterline there is no reduction in intact waterplane

– calculates the increase in mean draught of a ship, given the TPC and the dimensions of the flooded space, using increase in draught
  = $\dfrac{\text{volume of lost buoyancy}}{\text{area of intact waterplane}}$

– states that the height of the centre of buoyancy above the keel increases by about half the increase in draught due to flooding

– states that a reduction in waterplane area leads to a reduction in the second moment of area (I)

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference

– uses the formula BM = I / V to explain why the BM of a ship is generally less when bilged than when intact

– states that change in GM is the net result of changes in KB and BM

– explains why the GM usually decreases where:
  – there is a large loss of intact waterplane
  – there is intact buoyancy below the flooded space
  – the flooded surface has a high permeability

– explains why the bilging of empty double-bottom tanks or of deep tanks that are wholly below the waterline leads to an increase in GM

– calculates the reduction in BM resulting from lost area of the waterplane, given the following corrections:

  second moment of lost area about its centroid / displaced volume;

  this is $\frac{lb^3}{12\ V}$ for a rectangular surface

  where: L is length of the lost area

  b is breadth of the lost area

  V is displaced volume = $\frac{\text{displacement}}{\text{density of water}}$

  original waterplane area / intact waterplane area x lost area x (distance from centreline)^2 / displaced volume

  this is original $\frac{\text{waterplane area}}{\text{intact waterplane area x } I.b.d^2 / V}$

  for a rectangular surface, where d is the distance of the centre of the area from the centreline

– deduces that the second correction applies only in the case of asymmetrical flooding

– calculates the shift (F) of the centre of flotation (CE) from the centreline, using

  $F = \frac{a \times d}{A - a}$

  where: a is the lost area of waterplane

  A is the original waterplane area

  d is the distance of the centre of lost area of waterplane from the centreline

– shows that the heeling arm is given by

  heeling arm = lost buoyancy (tonnes) / displacement x transverse distance from new CF

– constructs a GZ curve for the estimated GM and superimposes the heeling-arm curve to determine the approximate angle of heel

– uses wall-sided formula to determine GZ values

– uses wall-sided formula to calculate angle of heel

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference

– states that, for small angles of heel, θ,

$$\tan\theta = \frac{\text{heeling arm}}{\text{GM}}$$

– explains how lost area of waterplane affects the position of the centre of flotation

Effect of flooding on trim

– calculates the movement of the centre of flotation (CF), given:
  – movement of CF = moment of lost area about original CF / intact waterplane area

– explains how the reduction in intact waterplane reduces the MCT 1cm

– calculates the reduction of BML, given the following corrections:
  second moment of lost area about its centroids / displaced volume;
  this is $\frac{bL^3}{12\,V}$ for a rectangular surface
  where: L is length of lost area
  b is breadth of lost area
  V is displaced volume = $\frac{\text{displacement}}{\text{density of water}}$
  Original waterplane area / intact waterplane area x lost area x (distance from CF) ^{2} / displaced volume
  This is original waterplane area / intact waterplane area x bld^2 / v for a rectangular surface, where d is the distance of the centre of area from the original centre of flotation

– calculates the reduction of MCT 1cm, given,
  reduction of MCT 1cm = (displacement x reduction of GM) / 100 x ship's length

– states that the trimming moment is calculated from:
  trimming moment = lost buoyancy x distance from new CF
  where the lost buoyancy is measured in tonnes

– given the dimensions of a bilged space and the ship's hydrostatic data, calculates the draughts in the damaged condition

– describes measures which may be taken to improve the stability or trim of a damaged ship

2.2 Theories affecting trim and stability (2 hours) — R1

– describes the static and dynamic effects on stability of liquids with a free surface

– identifies free surface moments and shows its application to dead-weight moment curves

– interprets changes in stability which take place during a voyage

– describes effect on stability of ice formation on superstructure

– describes the effect of water absorption by deck cargo and retention of water on deck

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COMPETENCE 4.1	Control Trim, Stability and Stress	IMO Reference
– describes stability requirements for dry-docking – demonstrates understanding of angle of loll – states precautions to be observed in correction of angle of loll – explains the dangers to a vessel at an angle of loll – describes effects of wind and waves on ship's stability – lists the main factors which affect the rolling period of a vessel – explains the terms synchronous and parametric rolling and pitching and describes the dangers associated with it – describes the actions that can be taken to stop synchronous and parametric effects		
4.1.3 KNOWLEDGE OF IMO RECOMMENDATIONS CONCERNING SHIP STABILITY **Textbooks:** **Bibliography:** **Teaching aids:** A1 Required performance: **3.1 Responsibilities under the international conventions and codes (2 hours)**		
– states minimum stability requirements required by Load Line Rules 1966 – states the minimum stability requirements and recommendations of the Intact Stability Code – explains the use of the weather criterion – demonstrates the use of IMO grain regulations – describes the requirements for passenger ship stability after damage		R1

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COMPETENCE 4.2	**Monitor and Control Compliance with Legislative Requirements and Measures to Ensure Safety of Life at Sea and the Protection of the Marine Environment**	**IMO Reference**
TRAINING OUTCOME: Demonstrates a knowledge and understanding of 4.2.1 INTERNATIONAL MARITIME LAW EMBODIED IN INTERNATIONAL AGREEMENTS AND CONVENTIONS		STCW Code table A-III/2

INTERNATIONAL MARITIME ORGANIZATION PUBLISHING

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COMPETENCE 4.2	Monitor and Control Compliance with Legislative Requirements and Measures to Ensure Safety of Life at Sea and the Protection of the Marine Environment	IMO Reference
4.2.1 INTERNATIONAL MARITIME LAW EMBODIED IN VARIOUS CONVENTIONS **Textbooks/Bibliography:** **Teaching aids:** A1, V2, V79 Required performance:		
1.1	**Certificates and other documents required to be carried on board ships by international conventions (1 hour)**	R1
	– states that IMO publishes a list of certificates and documents required to be carried on board ship	R1
	– states how a current version of the IMO list of certificates and documents required to be carried on board ship may be obtained	
	– identifies the certificates required by MLC (2006) to be carried on board ship	
	– identifies the certificates and documents that are required to be carried on board a ship of any type using the IMO information	
	– states the period of validity for each of the above certificates and explains the requirements for renewing or maintaining the validity of each	
	– explains how each of the certificates and documents required to be carried on board ships are obtained	
	– explains the proof of validity that may be required by authorities for the certificates and documents above	
1.2	**Responsibilities under the relevant requirements of the international convention on load lines (1 hour)**	
	– states that a ship to which the Convention applies must comply with the requirements for that ship	
	– explains the general requirements of the Conditions of Assignment to be met before any vessel can be assigned a load line	
	– describes the factors that determine the freeboards assigned to a vessel	
	– describes the requirements and coverage of initial, renewal and annual surveys	
	– describes the contents of the record of particulars which should be supplied to the ship	
	– explains the documentation and records that must be maintained on the ship in terms of – certificates – record of particulars – record of freeboards – information relating to the stability and loading of the ship	
	– states that after any survey has been completed no change should be made in the structure, equipment or other matters covered by the survey without the sanction of the Administration	
	– states that, after repairs or alterations, a ship should comply with at least the requirements previously applicable and that, after major repairs or alterations, ships should comply with the requirements for a new ship in so far as the Administration deems reasonable and practicable	
	– describes the preparation required for renewal and annual load line surveys	

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COMPETENCE 4.2	Monitor and Control Compliance with Legislative Requirements and Measures to Ensure Safety of Life at Sea and the Protection of the Marine Environment	IMO Reference
	– states that the appropriate load lines on the sides of the ship corresponding to the season and to the zone or area in which the ship may be must not be submerged at any time when the ship puts to sea, during the voyage or on arrival – states that when a ship is in fresh water of unit density the appropriate load line may be submerged by the amount of the fresh water allowance shown on the International Load Line Certificate (1966) – states that when a ship departs from port situated on a river or inland waters, deeper loading is permitted corresponding to the weight of fuel and all other materials required for consumption between the point of departure and the sea – explains the treatment of a port lying on the boundary between two zones or areas – explains the circumstances in which an International Load Line Certificate (1966) would be cancelled by the Administration	
1.3	**Responsibilities under the relevant requirements of the international convention for the safety of life at sea (1 hour)** – states the obligations of the master of a ship at sea on receiving a signal from any source that a ship or aircraft or a survival craft thereof is in distress – explains the rights of the master of a ship in distress to requisition one or more ships which have answered his call for assistance – explains when the master of a ship is released from the obligation to render assistance – states that all equipment fitted in compliance with regulation V/12 must be of a type approved by the Administration – states that all ships should be sufficiently and efficiently manned – states that manning is subject to Port State Control inspection – lists the contents of the minimum safe manning document referred to in Assembly resolution A481(XII), Principles of safe manning – describes the procedure for the testing of the ship's steering gear before departure – describes the requirements for the display of operating instructions and change-over procedures for remote steering gear control and steering gear power units – describes the requirements for emergency steering drills – lists the entries which should be made in the logbook regarding the checks and tests of the steering gear and the holding of emergency drills – explains the basic requirements for the carriage of dangerous goods in packaged form and IMDG Code – explains the basic requirements for the carriage of dangerous goods in solid form in bulk	R1
1.4	**Responsibilities under the international convention for the Prevention of Pollution from Ships, 1973, and the protocol of 1978 relating thereto (MARPOL 73/78) (3 hours)** – explains who may cause proceedings to be taken when a violation occurs within the jurisdiction of a Party to the Convention	

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– explains the Parties to the Convention must apply the requirements of the Convention to ships of non-Parties to ensure that no more favourable treatment is given to such ships

Annex I — Oil

– states that, after survey has been completed, no change should be made in the structure, equipment, fittings, arrangements or materials without the sanction of the Administration, except the direct replacement of equipment and fittings
– explains the master's duty to report when an accident occurs or a defect is discovered which substantially affects the integrity of the ship or the efficiency or completeness of its equipment covered by this Annex
– states that the dates of intermediate and annual surveys are endorsed on the IOPP Certificate
– states that a record of construction and equipment is attached as a supplement to the IOPP Certificate
– explains the duration of validity of the IOPP Certificate and the circumstances in which the IOPP Certificate will cease to be valid
– states that all new crude oil tankers of 20,000 tonnes deadweight and above must be fitted with a crude oil washing system
– states that the competent authority of the Government of a Party to the Convention may inspect the Oil Record Book while the ship is in its port or offshore terminals and may make a copy of any entry and may require the master to certify that the copy is a true copy of such entry
– states that a copy certified by the master is admissible in any judicial proceedings as evidence of the facts stated in the entry
– states that the master should be provided with information relative to loading and distribution of cargo necessary to ensure compliance with the regulation on subdivision and stability and the ability of the ship to comply with the damage stability criteria
– states all ships of 400gt or more must carry an approved shipboard oil pollution emergency plan (SOPEP)

Annex II — Noxious Liquid Substances in Bulk

– states the duration of validity of the certificate
– explains the nature and purpose of the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code), the Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (BCH Code) and the Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)
– explains that ships which have been surveyed and certified in accordance with the International Bulk Chemical Code (IBC Code) or the Bulk Chemical Code (BCH Code), as applicable, are deemed to have complied with the regulations regarding survey and certification and do not require to have an International Pollution Prevention Certificate for the Carriage of Noxious Liquid Substances in Bulk

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COMPETENCE 4.2	Monitor and Control Compliance with Legislative Requirements and Measures to Ensure Safety of Life at Sea and the Protection of the Marine Environment	IMO Reference

Annex III — Harmful Substances Carried by Sea in Packaged Forms, or in Freight Containers, Portable Tanks or Tank Wagons

- states that the master of the ship, or his representative, should notify the appropriate port authority of the intention to load or unload certain harmful substances at least 24 hours in advance

Annex IV — Sewage

- defines, for the purposes of Annex IV:

  holding tank, sewage and nearest land
- states the ships to which the provisions apply
- states that ships to which the regulations apply are subject to surveys for the issue of an International Sewage Pollution Prevention Certificate (1973)
- states the duration of validity of the certificate

Annex V — Garbage

- explains that when garbage is mixed with other discharges having different disposal requirements, the more stringent requirements apply
- describes the provisions for disposal of garbage from off-shore platforms and from ships alongside or within 500 metres from them
- lists the special areas for the purposes of this annex
- explains the requirements for disposal of garbage within special areas
- describes the exceptions to regulations 3, 4 and 5
- describes the form of record keeping required
- states records are subject to scrutiny by port State control officers

Annex VI — (Regulations for the Prevention of Air Pollution from Ships) of the MARPOL Convention

- states that MARPOL 73/78 Annex VI Regulations for the Prevention of Air Pollution from Ships entered into force on 19 May 2005
- states that MARPOL Annex VI sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone-depleting substances
- explains that Annex VI emission control requirements are in accordance with the 1987 Montreal Protocol (a UN international environmental treaty), as amended in London in 1990
- states that MARPOL Annex VI applies to all ships, fixed and floating drilling rigs and other platforms, but the certification requirements are depending on size of the vessel and when it is constructed
- explains the requirements for shipboard energy efficiency plans under MARPOL Annex VI
- explains that regulation 16 sets out requirements for shipboard incineration and as per 16(4) bans the incineration of:
  - MARPOL Annex I, II and III cargo residues and related contaminated packing materials;

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COMPETENCE 4.2	Monitor and Control Compliance with Legislative Requirements and Measures to Ensure Safety of Life at Sea and the Protection of the Marine Environment	IMO Reference

- polychlorinated biphenyls (PCBs);
- garbage, as defined in MARPOL Annex V, containing more than traces of heavy metals; and
- refined petroleum products containing halogen compounds

– explains that under regulation 16(5) incineration of sewage sludge and sludge oil generated during the normal operation of a ship may take place in the main or auxiliary power plant or boilers (as well as in an incinerator), but in those cases, must not take place inside ports, harbours and estuaries

– explains that regulation 16(6) prohibits the shipboard incineration of polyvinyl chlorides (PVCs), except in incinerators for which IMO Type Approval Certificates have been issued

– explains that under regulation 16(7) all ships with incinerators subject to regulation 16 must possess a manufacturer's operating manual which must specify how to operate the incinerator within the limits described in paragraph 2 of appendix IV to Annex VI

– explains that under regulation 16(8) personnel responsible for operation of any incinerator must be trained and capable of implementing the guidance in the manufacturer's operating manual

– explains that regulation 3 provides that the regulations of Annex VI will not apply to any emission necessary for the purpose of securing the safety of a ship or saving life at sea, or any emission resulting from damage to a ship or its equipment, subject to certain conditions

– states that regulation 15 provides that in ports or terminals in Party States any regulation of emissions of Volatile Organic Compounds (VOCs) from tankers must be in accordance with Annex VI

– states that as per regulation 15 a tanker carrying crude oil is required to have a "VOC Management Plan" approved by the Administration on board

– states that ships of 400 gross tons and above engaged in international voyages involving countries that have ratified the conventions, or ships flying the flag of those countries, are required to have an International Air Pollution Prevention Certificate (IAPP Certificate)

– states that the IAPP certificate will be issued following an initial survey carried out by the flag Administration or by a recognized organization on behalf of the flag Administration, confirming compliance with MARPOL Annex VI. For ships with the flag of an Administration that have not yet ratified Annex VI, a Certificate of Compliance with Annex VI may be issued

– states that Annex VI also requires diesel engines with a power output of more than 130 kW which is installed on a ship constructed on or after 1 January 2000 or with a power output of more than 130 kW which undergoes a major conversion on or after 1 January 2000 or with a power output of more than 5000 kW and a per cylinder displacement at or above 90 litres which is installed on a ship constructed on or after 1 January 1990 but prior to 1 January 2000, to carry individual certificates with regard to NOx emissions, named Engine International Air Pollution Prevention (EIAPP) Certificates

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COMPETENCE 4.2	Monitor and Control Compliance with Legislative Requirements and Measures to Ensure Safety of Life at Sea and the Protection of the Marine Environment	IMO Reference

- states that Annex VI requires that every ship of 400 gross tonnage or above and every fixed and floating drilling rig and other platforms shall be subject to a schedule of surveys that occur throughout the life of a vessel
- states that the schedule of surveys include:
  - Initial survey: This survey occurs before the ship is put into service or before a vessel certificate is issued for the first time. This survey ensures that the equipment, systems, fitting, arrangements and material used on board fully comply with the requirements of Annex VI. The vessel's International Air Pollution Prevention certificate (IAPP) will be issued to the vessel by an organization authorized to act on behalf of the State, after this survey
  - Periodic surveys: These surveys occur at least every five years after the initial survey. These surveys confirm that nothing has been done to the ship's equipment that would take it out of compliance. The vessel's IAPP certificate will be re-issued by an organization authorized to act on behalf of the State, after this survey
  - Intermediate surveys: These surveys occur at least once during the period between issuance of an IAPP and the periodic surveys. They also confirm that all of the ship's equipment remains in compliance
- states that chapter III of Annex VI (regulations 12 to 19) contains requirements for control of emissions from ships, but the following regulations directly impact Vessel operation:
  - regulation 12 – Ozone-depleting Substances
  - regulation 13 – NOx emissions
  - regulation 14 – Sulphur Oxide emissions
  - regulation 15 – VOC emissions
  - regulation 16 – Shipboard Incinerators
  - regulation 18 – Fuel Oil Quality control
- states that regulation 12(1) prohibits deliberate emissions of ozone-depleting substances, except where necessary for the purpose of securing the safety of a ship or saving life, as provided in regulation 3
- states that regulation 12(2) prohibits, on all ships, new installations containing ozone-depleting substances, except that new installations containing hydrochlorofluorocarbons (HCFCs) are permitted until 1 January 2020
- states that all the ships subject to the requirements of Annex VI are required to maintain a list of equipment containing ozone-depleting substances and in the case of a ship which has rechargeable systems containing ozone-depleting substances, an Ozone-depleting Substances Record Book is to be maintained on board
- states that regulation 13 sets NOx emission limits for diesel engines with a power output of more than 130kW installed on ships built on or after 1 January 2000, and diesel engines of similar power undergoing a major conversion on or after 1 January 2000

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- states that regulation 13 does not apply to emergency diesel engines, engines installed in lifeboats and any device or equipment intended to be used solely in case of emergency, or engines installed on ships solely engaged in voyages within waters subject to the sovereignty or jurisdiction of the flag State, provided that such engines are subject to an alternative NOx control measure established by the Administration
- explains that regulation 13 further contains a 3-Tier approach:
  - Tier I (current limits)
    - For diesel engines installed on ships constructed from 1 January 2000 to 1 January 2011
  - Tier II
    - For diesel engines installed on ships constructed on or after 1 January 2011
  - Tier III
    - Ships constructed on or after 1 January 2016
- states that Engine surveys are described in chapter 2 of the NOx Technical Code, a supporting document to Annex VI
- states that the four kinds of engine surveys are:
  - Pre-certification survey: This survey occurs before an engine is installed on board a vessel, to ensure the engine meets the NOx limits. The Engine International Air Pollution Prevention certificate (EIAPP) is issued after this survey for each applicable engine, engine family, or engine group
  - Initial certification survey: This survey occurs after the engine is installed on board the ship, but before the ship is placed into service. It ensures that the engine meets the NOx limits as installed. If an engine has an EIAPP, the initial certification survey will primarily ensure that any modifications to the engine's settings are within the allowable adjustment limits specified in the EIAPP
  - Periodic and intermediate surveys: These surveys occur as part of the ship's surveys described above. They ensure that the engine continues to comply fully with the NOx limits
  - Modification survey: This survey occurs when an engine overhaul meets the criteria for a major conversion. It ensures that the modified engine complies with the NOx limits
- states that there are three documents that are essential for completing the engine and vessel surveys. These are the EIAPP or Statement of Compliance, the Technical File, and the Record Book of Engine Parameters
- states that regulation 14 provides for adoption of "SOx Emission Control Areas"- "SECA" where the adoption of special mandatory measures for SOx emissions from ships is required to prevent, reduce and control air pollution from SOx and its attendant adverse impacts on land and sea areas with more stringent control on sulphur emissions
- states for the purpose of the regulation, Emission Control Areas (ECA) includes:
  - The Baltic Sea area as defined in regulation 1.11.2 of Annex I, the North Sea as defined in regulation 5(1)(f) of Annex V

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- states that in these areas the sulphur content of fuel oil used on ships must not exceed 1.5% m/m. Alternatively, ships in these areas must fit an exhaust gas cleaning system or use any other technological method to limit SOx emissions
- states that regulation 15 provides that in ports or terminals in Party States any regulation of emissions of Volatile Organic Compounds (VOCs) from tankers must be in accordance with Annex VI

– explains that regulation 16 sets out requirements for shipboard incineration and as per 16(4) bans the incineration of:
- MARPOL Annex I, II and III cargo residues and related contaminated packing materials;
- polychlorinated biphenyls (PCBs);
- garbage, as defined in MARPOL Annex V, containing more than traces of heavy metals; and
- refined petroleum products containing halogen compounds

– explains that under regulation 16(5) incineration of sewage sludge and sludge oil generated during the normal operation of a ship may take place in the main or auxiliary power plant or boilers (as well as in an incinerator), but in those cases, must not take place inside ports, harbours and estuaries

– explains that regulation 16(6) prohibits the shipboard incineration of polyvinyl chlorides (PVCs), except in incinerators for which IMO Type Approval Certificates have been issued

– explains that under regulation 16(7) all ships with incinerators subject to regulation 16 must possess a manufacturer's operating manual which must specify how to operate the incinerator within the limits described in paragraph 2 of appendix IV to Annex VI

– explains that under regulation 16(8) personnel responsible for operation of any incinerator must be trained and capable of implementing the guidance in the manufacturer's operating manual

– states that as per regulation 15 a tanker carrying crude oil is required to have a "VOC Management Plan" approved by the Administration on board

– explains that regulation 3 provides that the regulations of Annex VI will not apply to any emission necessary for the purpose of securing the safety of a ship or saving life at sea, or any emission resulting from damage to a ship or its equipment, subject to certain conditions

1.5 Maritime declarations of health and the requirements of the international health regulations

Arrival documents and procedures (1 hour)

International Health Regulations (1969) as amended

– defines for the purposes of these regulations:
- arrival of a ship
- baggage
- container or freight container

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- crew
- diseases subject to the regulations
- disinsecting
- epidemic
- free pratique
- health administration
- health authority
- infected person
- in quarantine
- international voyage
- isolation
- medical examination
- ship
- suspect
- valid certificate

– states that a health authority should, if requested, issue, free of charge to the carrier, a certificate specifying the measures applied to a ship or container, the parts treated, methods used and the reasons why they have been applied

– states that, except in an emergency constituting a grave danger to public health, a ship which is not infected or suspected of being infected with a disease subject to the regulations should not be refused free pratique on account of any other epidemic disease and should not be prevented from discharging or loading cargo or stores, or taking on fuel or water

– states that a health authority may take all practicable measures to control the discharge from any ship of sewage and refuse which might contaminate the waters of a port, river or canal

– describes the measures which the health authority of a port may take with respect to departing travellers

– states that no health measures should be applied by a State to any ship which passes through waters within its jurisdiction without calling at a port or on the coast

– describes the measures which may be applied to a ship which passes through a canal or waterway in a territory of a State on its way to a port in the territory of another State

– states that, whenever possible, States should authorize granting of free pratique by radio

– explains that the master should make known to port authorities, as long as possible before arrival, any case of illness on board, in the interests of the patient and the health authorities and to facilitate clearance of the ship

– states that, on arrival of a ship, an infected person may be removed and isolated and that such removal should be compulsory if required by the master

– states that a ship should not be prevented for health reasons from calling at any port, but if the port is not equipped for applying the health measures which in the opinion of the health authority of the port are required, the ship may be ordered to proceed at its own risk to the nearest suitable port convenient to it

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– explains the actions open to a ship which is unwilling to submit to the measures required by the health authority of a port
– describes the measures concerning cargo and goods
– describes the measures concerning baggage

Plague

– states that, for the purposes of the regulations, the incubation period of plague is six days
– states that vaccination against plague should not be required as a condition of admission of any person to a territory
– states that during the stay of a ship in a port infected by plague, special care should be taken to prevent the introduction of rodents on board
– states that ships should be permanently kept free of rodents and the plague vector or be periodically derailed
– describes the requirements for the issue of a Ship Sanitation Control Certificate or a Ship Sanitation Control Exemption Certificate and states their periods of validity
– states the conditions in which a ship on arrival is to be regarded as infected, suspected or healthy
– describes the measures which may be applied by a health authority on the arrival of an infected or suspected ship

Cholera

– describes the measures which may be applied by a health authority on the arrival of a healthy ship from an infected area
– states that, for the purposes of the regulations, the incubation period of cholera is five days
– describes the measures to be taken by the health authority if a case of cholera is discovered upon arrival or a case has occurred on board

Yellow fever

– states that, for the purposes of the regulations, the incubation period of yellow fever is six days
– states that vaccination against yellow fever may be required of any person leaving an infected area on an international voyage
– states that every member of the crew of a ship using a port in an infected area must be in possession of a valid certificate of vaccination against yellow fever
– states the conditions in which a ship on arrival is to be regarded as infected, suspected or healthy
– describes the measures which may be applied by a health authority on the arrival of an infected or suspected ship

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Documents

- states that bills of health or any other certificates concerning health conditions of a port are not required from any ship
- describes the master's obligations concerning a Maritime Declaration of Health
- states that the master and the ship's surgeon, if one is carried, must supply any information required by the health authority as to health conditions on board during the voyage
- states that no health document, other than those provided for in the regulations, should be required in international traffic

1.6 Responsibilities under other international maritime law embodied in international agreements and conventions that impact on the role of management level engineering officers

1.6.1 United Nations Convention on the Law of the Sea (UNCLOS) (1 hour)

- explains that the outcome of UNCLOS III conference convened at Geneva in 1974 was the United Nations Convention on the Law of the Sea commonly known as "UNCLOS"
- explains that UNCLOS attempts to codify the international law of the sea
- states that UNCLOS defines the legal status of the high seas and establishes regulations for the control of marine pollution
- states that UNCLOS is a treaty document of 320 articles and 9 annexes, governing all aspects of ocean space, such as delimitation, environmental control, marine scientific research, economic and commercial activities, transfer of technology and the settlement of disputes relating to ocean matters
- states that UNCLOS came into force internationally on 16 November 1994
- states that UNCLOS sets the width of the territorial sea at 12 nautical miles, with a contiguous zone at 24 nautical miles from the baseline
- states that UNCLOS defines innocent passage through the territorial sea and defines transit passage through international straits
- states that UNCLOS defines archipelagic States and allows for passage through archipelagic waters
- states that UNCLOS establishes exclusive economic zones (EEZs) extending to 200 nautical miles from baselines
- explains that it defines the continental shelf and extends jurisdiction over the resources of the shelf beyond 200 miles where appropriate
- explains that States in dispute about their interpretation of UNCLOS may submit their disagreements to competent courts such as the International Court of Justice (in The Hague), or the Law of the Sea Tribunal (in Hamburg)
- states that the responsibility for enforcement of regulations rests mainly with flag States, but as vessels enter zones closer to the coast the influence of coastal State jurisdiction and, ultimately, port State jurisdiction, gradually increases

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- states that Article 94 of the UNCLOS deals with duties of the flag State, while Article 217 deals with enforcement by flag States
- states that Article 218 of the UNCLOS deals with port State jurisdiction
- explains when a vessel is voluntarily within a port or at an offshore terminal, the port State may, where the evidence warrants, begin proceedings in respect of discharges in violation of international rules (i.e. regulations in MARPOL 73/78)
- states that another State in which a discharge violation has occurred, or the flag State, may request the port State to investigate the violation
- states that Article 200 of the UNCLOS deals with coastal State jurisdiction as applied in relation to pollution provisions
- states that where there are clear grounds for believing that a vessel navigating in the territorial sea of a State has violated laws and regulations of the coastal State adopted in accordance with UNCLOS or applicable international pollution regulations, the coastal State may inspect the vessel and, where evidence warrants, institute proceedings including detention of the vessel
- states that vessels believed to have violated pollution laws in an EEZ may be required to give identification and voyage information to the coastal State
- explains that as per UNCLOS, States must agree international rules and standards to prevent pollution from vessels (Article 211). (This obligation is currently met by MARPOL 73/78)
- explains that coastal States may also promulgate and enforce pollution regulations in their own EEZs which may, in some circumstances, include imposition of routeing restrictions
- states that in the territorial sea additional navigational restraints (e.g. traffic separation schemes and sea lanes) may be imposed on vessels with dangerous and hazardous cargoes
- explains that coastal States and ports may make entry to internal waters and harbours conditional on meeting additional pollution regulations

1.6.2 Maritime Labour Convention (MLC 2006) (6 hours)

- explains that the Maritime Labour Convention, 2006, is an important new international labour Convention that was adopted by the International Labour Conference of the International Labour Organization (ILO), under article 19 of its Constitution at a maritime session in February 2006 in Geneva, Switzerland
- explains that it sets out seafarers' rights to decent conditions of work and helps to create conditions of fair competition for shipowners
- explains that it is intended to be globally applicable, easily understandable, readily updatable and uniformly enforced
- explains that the MLC 2006, complementing other major international conventions, reflects international agreement on the minimum requirements for working and living conditions for seafarers

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- explains that the Maritime Labour Convention, 2006, has two primary purposes:
  - to bring the system of protection contained in existing labour standards closer to the workers concerned, in a form consistent with the rapidly developing, globalized sector (ensuring "decent work");
  - to improve the applicability of the system so that shipowners and governments interested in providing decent conditions of work do not have to bear an unequal burden in ensuring protection ("level playing field" fair competition)
- explains that the Maritime Labour Convention, 2006, has been designed to become a global legal instrument that, once it enters into force, will be the "fourth pillar" of the international regulatory regime for quality shipping, complementing the key Conventions of the International Maritime Organization (IMO) such as the International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS), the International Convention on Standards of Training, Certification and Watchkeeping, 1978, as amended (STCW) and the International Convention for the Prevention of Pollution from Ships, 73/78 (MARPOL)
- states that it is sometimes called the consolidated Maritime Labour Convention, 2006, as it contains a comprehensive set of global standards, based on those that are already found in 68 maritime labour instruments (Conventions and Recommendations), adopted by the ILO since 1920
- states that the new Convention brings almost all of the existing maritime labour instruments together in a single new Convention that uses a new format with some updating, where necessary, to reflect modern conditions and language
- explains that the Convention "consolidates" the existing international law on all these matters
- states that the MLC 2006 applies to all ships engaged in commercial activities (except fishing vessels, ships of traditional build and warships or naval auxiliaries)
- states that ships of 500 GT or over are required to be certified: they must carry a maritime labour certificate as well as a declaration of maritime labour compliance
- states that ships below 500 GT are subject to inspection at intervals not exceeding three years
- explains that the existing ILO maritime labour Conventions will be gradually phased out as ILO Member States that have ratified those Conventions ratify the new Convention, but there will be a transitional period when some parallel Conventions will be in force
- explains that countries that ratify the Maritime Labour Convention, 2006, will no longer be bound by the existing Conventions when the new Convention comes into force for them

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- explains that countries that do not ratify the new Convention will remain bound by the existing Conventions they have ratified, but those Conventions will be closed to further ratification
- describes that the Convention is organized into three main parts: the Articles coming first set out the broad principles and obligations which is followed by the more detailed Regulations and Code (with two parts: Parts A and B) provisions
- states that the Regulations and the Standards (Part A) and Guidelines (Part B) in the Code are integrated and organized into general areas of concern under five Titles:
  - **Title 1: Minimum requirements for seafarers to work on a ship:** minimum age, medical certificates, training and qualification, recruitment and placement
  - **Title 2: Conditions of employment:** Seafarers Employment Agreements, Wages, Hours of Work and Hours of Rest, Entitlement to Leave, Repatriation, Seafarer compensation for the ship's Loss or Foundering, Manning Levels, Career and Skill Development and Opportunities for Seafarers' Employment
  - **Title 3: Accommodation, recreational facilities, food and catering**
  - **Title 4: Health** protection**, medical care, welfare and social security protection:** Medical Care on board ship and Ashore, Shipowners' Liability, Health & Safety Protection and Accident Prevention, Access to Shore-based Welfare Facilities, Social Security
  - **Title 5: Compliance and enforcement:**
    Flag State Responsibilities: General Principles, Authorization of Organizations, Maritime Labour Certificate and Declaration of Maritime Labour Compliance, Inspection and Enforcement, On board Complaint Procedures, Marine Casualties
  - **Port State Responsibilities:** Inspections in Port, Detailed Inspection, Detentions, On-shore Seafarer Complaint Handling Procedures
  - **Labour-supplying Responsibilities:** Recruitment and Placement services, Social security provisions

    These five Titles essentially cover the same subject matter as the existing 68 maritime labour instruments, updating them where necessary
- explains that it occasionally contains new subjects in comparison to the existing ILO maritime labour Conventions, particularly in the area of occupational safety and health to meet current health concerns, such as the effects of noise and vibration on workers or other workplace risks
- explains that the standards in the new Convention are not lower than existing maritime labour standards as the aim is to maintain the standards in the current maritime labour Conventions at their present level, while leaving each country greater discretion in the formulation of their national laws establishing that level of protection
- explains that the advantages for ships of ratifying countries that provide decent conditions of work for their seafarers will have protection against unfair competition from substandard ships and will benefit from a system of certification, avoiding or reducing the likelihood of lengthy delays related to inspections in foreign ports

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- explains that the Maritime Labour Convention, 2006, aims to establish a continuous "compliance awareness" at every stage, from the national systems of protection up to the international system and it will improve compliance and enforcement:
  - Starting with the individual seafarers, who – under the Convention – have to be properly informed of their rights and of the remedies available in case of alleged non-compliance with the requirements of the Convention and whose right to make complaints, both on board ship and ashore, is recognized in the Convention
  - It continues with the shipowners. Those who own or operate ships of 500 gross tonnage and above, engaged in international voyages or voyages between foreign ports, are required to develop and carry out plans for ensuring that the applicable national laws, regulations or other measures to implement the Convention are actually being complied with
  - The masters of these ships are then responsible for carrying out the shipowners' stated plans, and for keeping proper records to evidence implementation of the requirements of the Convention
  - As part of its updated responsibilities for the labour inspections for ships above 500 gross tonnage that are engaged in international voyages or voyages between foreign ports, the flag State (or recognized organization on its behalf) will review the shipowners' plans and verify and certify that they are actually in place and being implemented
  - Ships will then be required to carry a maritime labour certificate and a declaration of maritime labour compliance on board
  - Flag States will also be expected to ensure that national laws and regulations implementing the Convention's standards are respected on smaller ships that are not covered by the certification system
  - Flag States will carry out periodic quality assessments of the effectiveness of their national systems of compliance, and their reports to the ILO under article 22 of the Constitution will need to provide information on their inspection and certification systems, including on their methods of quality assessment
  - This general inspection system in the flag State (which is founded on ILO Convention No. 178) is complemented by procedures to be followed in countries that are also or even primarily the source of the world's supply of seafarers, which will similarly be reporting under article 22 of the ILO Constitution
  - The system is further reinforced by voluntary measures for inspections in foreign ports (port State control)
- states that the appendices to the Convention contain key model documents: a maritime labour certificate and a declaration of maritime labour compliance
- explains that the Maritime Labour Certificate would be issued by the flag State to a ship that flies its flag, once the State (or a recognized organization that has been authorized to carry out the inspections) has verified that the labour conditions on the ship comply with national laws and regulations implementing the Convention
- states that the certificate would be valid for five years subject to periodic inspections by the flag State

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– explains that the declaration of maritime labour compliance is attached to the certificate and summarizes the national laws or regulations implementing an agreed-upon list of 14 areas of the maritime standards and setting out the shipowner's or operator's plan for ensuring that the national requirements implementing the Convention will be maintained on the ship between inspections
– states that the lists of the 14 areas that must be certified by the flag State and that may be inspected, if an inspection occurs, in a foreign port are also set out in the Appendices to the Convention

1.6.3 Assistance and salvage (1 hour)

International Convention on Salvage, 1989 (The London Salvage Convention)

– defines 'salvage operation', 'vessel' and 'property'
– describes the 'no cure – no pay' principle
– describes the application of the Convention
– describes the duties of the salvor, of the owner and of the master
– describes the rights of salvors
– states the criteria for assessing a reward as:
  – salved value of property (ship, cargo and bunkers)
  – skill and efforts of salvor
  – measure of success
  – nature and degree of danger
  – expenses of salvor
  – equipment used
  – vessel's equipment used
  – time taken to complete the salvage operation
  – preventing or minimizing the damage to environment
– states the criteria for assessing Special Compensation
– explains that the apportionment of the remuneration amongst the owners, master and other persons in the service of each salving vessel is to be determined by the law of the vessel's flag
– explains that every agreement as to assistance or salvage entered into at the moment and under the influence of danger may, at the request of either party, be annulled, or modified by the court, if it considers that the conditions agreed upon are not equitable
– states that no remuneration is due from persons whose lives are saved except as provided in national law
– states that every master is bound, so far as he can do so without serious danger to his vessel, her crew and her passengers, to render assistance to everybody, even though an enemy, found at sea in danger of being lost
– explains the provision of security by the owner and the application of the salvor's maritime lien

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Lloyd's Standard Form of Salvage Agreement (LOF 2000)

– states that LOF 2000 should be used where the ship or marine environment are at risk and the master has insufficient time to request the owner to arrange salvage services on the basis of a pre-agreed rate or sum

Special Compensation P and I Club (SCOPIC) Clause

– explains that SCOPIC clause is supplementary to any Lloyd's Form Salvage Agreement "No Cure – No Pay" ("Main Agreement") which incorporates the provisions of Article 14 of the International Convention on Salvage 1989 ("Article 14")

– explains that SCOPIC clause determines the method of assessing special compensation where payable under Article 14(1) to 14(4) of the Convention

1.6.4 Convention on Limitation of Liability for Maritime Claims, 1976 (LLMC 1976)

– lists the persons entitled to limit liability

– lists the claims subject to limitation of liability

– lists the claims exempted from limitation

– explains the circumstances in which limitation would be barred

– explains that, except for claims in respect of death or injury of passengers, the calculation of limits of liability is based on the ship's gross tonnage

– explains that the limit for claims in respect of death or injury of passengers is based on the number of passengers the ship is authorized to carry, subject to a maximum sum

– describes the constitution of a limitation fund

– states the scope of application of the Convention

1.6.5 Classification societies (2 hours)

– explains the reasons for having a ship classed with a classification society

– states that the majority of ships are built under survey

– explains that the classification society approves plans, examines the manufacture of parts and tests materials during the building of hull, machinery, equipment and, where appropriate, refrigerating machinery

– explains that equipment refers to anchors, chain cables, mooring ropes and wires, mooring arrangements, windlasses and mooring winches

– states that, if requested, the classification societies will also survey and certificate cargo handling equipment

– states that on satisfactory completion of surveys and sea trials the society issues certificates of class, which are kept aboard ship, and enters the particulars of the ship in its register

– states that a classification society will also survey an existing ship and providing it meets the society's rules regarding scantlings, materials, workmanship and condition, assign a class to it

– states that to retain its class a ship must undergo periodical surveys as laid down in the society's rules

– explains the nature and frequency of all surveys undertaken for classification purposes including machinery surveys

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- states that periodical surveys are:
  - annual survey
  - docking survey at approximately 2 yearly intervals
  - intermediate survey
  - special survey every 4 years, which may be extended to 5 years
- explains the special survey requirements may be met by a system of continuous survey such that the interval between successive surveys on any given item does not exceed 5 years
- explains the use of conditions of class and removal of classification
- states that an occasional survey, additional to the regular surveys, must be conducted after any damage to the hull, machinery or equipment which may affect the ship's seaworthiness
- states that repairs or alterations must be carried out under survey and to the satisfaction of the society's surveyors
- states that classification societies carry out surveys for the issue of statutory certification on behalf of many governments
- states that a classification society may be asked to conduct the loading port survey on its classed refrigerating machinery
- explains that, when convenient, the loading port survey may be combined with a periodical survey for classification

1.6.6 General average and marine insurance (1 hour)

- defines a general average act
- states that general average sacrifices and expenses are to be borne by the different contributing interests on the basis of these Rules
- explains that only such losses, damages or expenses which are the direct consequence of the general average act are allowed as general average and that no indirect loss whatsoever will be admitted
- explains in general terms the purpose of marine insurance
- explains what is meant by an insurable interest
- describes briefly how insurance is arranged through brokers
- explains the principle of 'utmost good faith'
- explains the effect of misrepresentation or non-disclosure of material circumstances known to the assured
- explains 'warranty' and the effect on a marine insurance policy of breach of warranty
- describes briefly voyage policies, time policies and floating policies
- describes briefly the perils usually covered in a marine insurance policy
- explains the use of 'Institute Clauses'
- explains the 'duty of assured' clause ('Sue and Labour' clause)
- explains the function of Protection and Indemnity Associations (P and I clubs)
- lists risks, liabilities and expenses covered by P and I clubs

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1.6.7 Charter parties

- briefly explains the use of charter parties in so far as these relate to the role of the management level engineering officer
  - Voyage charter
  - Time charter
  - Bareboat charter
  - Laydays and cancelling date (Laycan)
  - Notice of readiness (NOR)
  - Demurrage
  - Dispatch
  - Delivery – On hire
  - On hire survey
  - Redelivery – Off hire
  - Off hire survey

1.7 Responsibilities under international instruments affecting the safety of the ship, passengers, crew and cargo

Ballast Water Convention 2004 (1 hour)

- defines the following:
  - ballast water
  - ballast water management
  - sediments
- describes the application of this convention
- describes the conditions where the application of this convention may be exempted
- describes the management and control requirement based on section B, regulation B1 to B6
- describes the annex – section A, B, C, D and E briefly
- describes the standards that need to be observed in ballast water exchange
- states under regulation B-4 Ballast Water Exchange, all ships using ballast water exchange should:
  - whenever possible, conduct ballast water exchange at least 200 nautical miles from the nearest land and in water at least 200 metres in depth, taking into account Guidelines developed by IMO;
  - in cases where the ship is unable to conduct ballast water exchange as above, this should be as far from the nearest land as possible, and in all cases at least 50 nautical miles from the nearest land and in water at least 200 metres in depth

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- states as per annex – section B Management and Control Requirements for Ships:
  - ships are required to have on board and implement a Ballast Water Management Plan approved by the Administration (regulation B-1). The Ballast Water Management Plan is specific to each ship and includes a detailed description of the actions to be taken to implement the Ballast Water Management requirements and supplemental Ballast Water Management practices
- explains that in accordance with SOLAS chapter V, regulation 28 – Records of navigational activities and daily reporting, the commencement and termination of the operation should be recorded
- explains that the navigational records generated during ballast water exchange may be reviewed during ISM Audits and port State control inspections

Port State control (2 hours)

- explains that "port State control" is the inspection of foreign ships present in a nation's ports for the purpose of verifying that the condition of the ships and their equipment comply with the provisions of international conventions and codes, and that the ships are manned and operated in compliance with those provisions
- explains that the primary responsibility for maintaining ships' standards rests with their flag States, as well as their owners and masters. However, many flag States do not, for various reasons, fulfil their obligations under international maritime conventions, and port State control provides a useful "safety net" to catch substandard ships
- states that a "port State control regime", where set up under a "memorandum of understanding" ("MOU") or similar accord between neighbouring port States, is a system of harmonized inspection procedures designed to target substandard ships with the main objective being their eventual elimination from the region covered by the MOU's participating States
- states that there are eight international PSC agreements currently in force worldwide
- identifies how to ascertain which port State agreement a particular port State might be party to and any areas of particular focus that may currently be in place
- outlines that in addition to the general control of above listed certificate and documents, examinations/inspections of the following are generally given priority by Port State Control Officer (PSCO):
  - Nautical publication (SOLAS 74 R V/20)
  - Navigational equipment (SOLAS 74 R V/12 and 19)
  - Emergency starting and running tests (SOLAS 74 R II-2 – 4.3)
  - Lifesaving equipment. Rafts FF (SOLAS 74 R III/20, 23, 26 and 29)

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COMPETENCE 4.2	Monitor and Control Compliance with Legislative Requirements and Measures to Ensure Safety of Life at Sea and the Protection of the Marine Environment	IMO Reference

- Emergency Generator (start/stop only) (SOLAS 74 R II-1/42 & 43)
- Hull corrosion and damages (Load Lines) (SOLAS 74 R I/11)
- Main engine and aux. engines (SOLAS 74 R II/26, 27 & 28)
- Oily water separator 15 ppm alarm (MARPOL Annex I/16(1))
- Oil discharge monitor (ODM) (MARPOL Annex I/16)
- Charts corrected and proper scale (SOLAS 74 R V/20)
- Fire safety Control plan (SOLAS 74 R II-2/20)
- Ventilation inlets/outlets (SOLAS 74 R II-2/16.9 & 48)
- Emergency training and drills (Log book rec. SOLAS 74 R III/18)
- Emergency lighting/batteries (SOLAS 74 R II/42 & 43)
- Deck and hatches corrosion and damages (LL 1966)
- Steering gear – incl. auxiliary and emergency (Bridge inspection only – SOLAS 74 R V/19)
- Cleanliness in engine room (SOLAS 74 R II-1/26 and ILO 134)
- Cleanliness in accommodation (ILO 92 & 133)

– explains that the port State control inspections may be conducted on the following basis:
  - initiative of the port State Administration;
  - the request of, or on the basis of, information regarding a ship provided by another Administration;
  - information regarding a ship provided by a member of the crew, a professional body, an association, a trade union or any other individual with an interest in the safety of the ship, its crew and passengers, or the protection of the marine environment

– explains that the PSC inspections may be on random, targeted or periodical basis. The following types of PSC inspections are used in PSC:
  1. Initial inspection (random)
  2. More detailed inspection (escalated)
  3. Expanded inspection (targeted/periodical)

– states that the definition of inspection is: “A visit on board a ship to check both the validity of the relevant certificates and other documents, and the overall condition of the ship, its equipment, and its crew”

– explains that the certificates and documents listed above should therefore be readily available and presented to the PSCO at his request during the PSC inspection

– states that the definition of more detailed inspection is: “An inspection conducted when there are clear grounds for believing that the condition of the ship, its equipment, or its crew does not correspond substantially with the particulars of the certificates”

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COMPETENCE 4.2	Monitor and Control Compliance with Legislative Requirements and Measures to Ensure Safety of Life at Sea and the Protection of the Marine Environment	IMO Reference

- states that the definition of Clear grounds is: "Evidence that the ship, its equipment, or its crew does not correspond substantially with the requirements of the relevant conventions or that the master or crew members are not familiar with essential shipboard procedures relating to the safety of ships or the prevention of pollution"
- outlines that "Clear grounds" to conduct a more detailed inspection include:
  1) the absence of principal equipment or arrangements required by the conventions;
  2) evidence from a review of the ship's certificates that a certificate or certificates are clearly invalid;
  3) evidence that documentation required by the conventions are not on board, incomplete, are not maintained or are falsely maintained;
  4) evidence from the PSCO's general impressions and observations that serious hull or structural deterioration or deficiencies exist that may place at risk the structural, watertight or weathertight integrity of the ship;
  5) evidence from the PSCO's general impressions or observations that serious deficiencies exist in the safety, pollution prevention or navigational equipment;
  6) information or evidence that the master or crew is not familiar with essential shipboard operations relating to the safety of ships or the prevention of pollution, or that such operations have not been carried out;
  7) indications that key crew members may not be able to communicate with each other or with other persons on board;
  8) the emission of false distress alerts not followed by proper cancellation procedures;
  9) receipt of a report or complaint containing information that a ship appears to be substandard
- explains that the PSCO during a more detailed inspection generally takes the following into account:
  - structure;
  - machinery spaces;
  - conditions of assignment of load lines;
  - life-saving appliances;
  - fire safety;
  - regulations for preventing collisions at sea;
  - Cargo Ship Safety Construction Certificate;
  - Cargo Ship Safety Radio Certificates;
  - equipment in excess of convention or flag State requirements

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COMPETENCE 4.2	Monitor and Control Compliance with Legislative Requirements and Measures to Ensure Safety of Life at Sea and the Protection of the Marine Environment	IMO Reference

- guidelines for discharge requirements under Annexes I and III of MARPOL 73/78 which includes:
  - inspection of crude oil washing (COW) operations;
  - inspection of unloading, stripping and prewash operations
- guidelines for control of operational requirements which include:
  - muster list;
  - communication;
  - fire drills;
  - abandon ship drills;
  - damage control plan and Shipboard Oil Pollution Emergency Plan;
  - fire control plan;
  - bridge operation;
  - cargo operation;
  - operation of the machinery;
  - manuals, instructions, etc.;
  - oil and oily mixtures from machinery spaces;
  - loading, unloading and cleaning procedures for cargo spaces of tankers;
  - dangerous goods and harmful substances in packaged form;
  - garbage
- minimum manning standards and certification;
  - STCW 78;
  - ISM; and
  - ISPS Code
- states that expanded inspection is an inspection conducted according to non-mandatory guidelines only once during 12 month period for certain types of ships and certain categories of age and size
- explains that oil tankers, bulk carriers, gas and chemical carriers and passenger ships are subject to expanded inspections once during a period of 12 months
- outlines the IMO resolutions pertaining to port State controls are as follows:
  - A.9/Res.321 Procedures for the control of ships 12/11/1975
  - A.12/Res.466 Procedures of port state control 19/11/1981
  - A.15/Res.597 Amendments to the procedures for the control of ships 19/11/1987
  - A.19/Res.787 Procedures for port state control 23/11/1995
  - A.21/Res.882 Amendments to the procedures for port state control (resolution A.787(19)) 25/11/1999

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COMPETENCE 4.2	Monitor and Control Compliance with Legislative Requirements and Measures to Ensure Safety of Life at Sea and the Protection of the Marine Environment	IMO Reference

– states that the publication by IMO which gives the General Procedural Guidelines for Port State Control Officers are also of particular relevance to shipmaster
– explains that a record of port State control inspections including safety-related details of many ships is available on the internet from the Equasis database and may be viewed by any member of the public
– explains that Equasis forms part of the Quality Shipping campaign launched by the EU in 1997 which is formally supported by signatories from marine Administrations, classification societies, P and I clubs and the ITF
– explains that more than 40 organizations provide information to Equasis and is used heavily by charterers and insurers as well as marine Administrations with port State control functions

1.8 Methods and aids to prevent pollution of the marine environment by ships (2 hours)

Convention of the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention) (LDC)

– explains the aims of the Convention
– defines, for the purpose of the Convention:
  – dumping
  – wastes or other matter
  – special permit
  – general permit
– states that the dumping of wastes or other matter in whatever form or condition, as listed in annex I, is prohibited
– states that the dumping of wastes or other matter listed in annex II requires a prior special permit
– states that the dumping of all other wastes or matter requires a prior general permit
– explains that the provisions of Article IV do not apply when it is necessary to secure the safety of human life or of vessels in cases of ‘force majeure’ caused by stress of weather, or in any case which constitutes a danger to human life or a real threat to vessels
– states that such dumping should be done so as to minimize the likelihood of damage to human or marine life and must be reported immediately
– states that the Addendum to annex I contains regulations on the incineration of wastes at sea
– explains that the appropriate authority of a Contracting Party should issue prior special or general permits in respect of matter intended for dumping:
  – loaded in its territory
  – loaded by a vessel flying its flag when the loading occurs in the territory of a State not party to the Convention

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COMPETENCE 4.2	Monitor and Control Compliance with Legislative Requirements and Measures to Ensure Safety of Life at Sea and the Protection of the Marine Environment	IMO Reference

International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969

- describes the rights of Parties to the Convention to intervene on the high seas following a maritime casualty
- defines, for the purposes of the Convention:
  - maritime casualty
  - ship
  - oil
  - related interests
- describes the provisions which a coastal State should apply when exercising the right to take measures in accordance with Article I

Protocol relating to Intervention on the High Seas in Cases of Pollution by Substances other than Oil, 1973

- describes the rights of Parties to the Protocol to intervene on the high seas following a maritime casualty
- defines 'substances other than oil'
- explains that the Protocol extends the rights and obligations of coastal States to cases involving imminent threat of pollution by substances other than oil

International Convention on Civil Liability for Oil Pollution Damage,1969 (CLC 1969)

- states that no claim for compensation may be made against the servants or agents of the owner
- explains that, with certain exceptions, the owner may limit his liability by constituting a fund for the sum representing the limit of his liability with the Court of a Contracting State where the action is brought
- states that claims in respect of expenses reasonably incurred by the owner voluntarily to prevent or minimize pollution damage rank equally with other claims against the fund
- explains that where a fund has been constituted and the owner is entitled to limit his liability, no person having a claim for pollution damage resulting from that incident is entitled to exercise any rights over other assets of the owner and that the ship or any other property belonging to the owner should be released
- states that the owner of a ship registered in a Contracting State and carrying more than 2,000 tons of oil in bulk as cargo is required to maintain insurance in the sum of his limit of liability
- states that the appropriate authority of a Contracting State, after determining that the requirements have been complied with, should issue a certificate attesting that insurance or other financial security is in force
- states that the certificate should be carried on board ship and a copy deposited with the relevant authorities
- states that a Contracting State must not permit a ship under its flag to which this Article applies to trade without a certificate

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COMPETENCE 4.2	Monitor and Control Compliance with Legislative Requirements and Measures to Ensure Safety of Life at Sea and the Protection of the Marine Environment	IMO Reference
	– states that Contracting States must ensure under their national legislation, that insurance or other security is in force in respect of any ship, whenever registered, entering or leaving their ports of offshore terminals if the ship actually carries more than 2,000 tons of oil in bulk as cargo **1.9 National legislation for implementing international agreements and conventions (1 hour)** – explains the process by which international agreements and conventions are ratified and implemented into national legislation	

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COMPETENCE 4.3	**Maintain Safety and Security of Crew and Passengers and the Operational Condition of Safety Systems**	**IMO Reference**
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 4.3.1 KNOWLEDGE OF LIFE-SAVING APPLIANCE REGULATIONS (SOLAS) 4.3.2 ORGANIZATION OF FIRE AND ABANDON SHIP DRILLS 4.3.3 MAINTENANCE OF OPERATIONAL CONDITION OF LIFE-SAVING, FIREFIGHTING AND OTHER SAFETY SYSTEMS 4.3.4 ACTIONS TO BE TAKEN TO PROTECT AND SAFEGUARD ALL PERSONS ON BOARD IN EMERGENCIES 4.3.5 ACTIONS TO LIMIT DAMAGE AND SALVE THE SHIP FOLLOWING A FIRE, EXPLOSION, COLLISION OR GROUNDING		STCW Code table A-III/2

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COMPETENCE 4.3	Maintain Safety and Security of Crew and Passengers and the Operational Condition of Safety Systems	IMO Reference
4.3.1 KNOWLEDGE OF LIFE-SAVING APPLIANCE REGULATIONS (SOLAS) **Textbooks/Bibliography:** **Teaching aids:** A1 Required performance: **1.1 Life-saving appliance regulations (SOLAS) (2 hours)** – demonstrates a thorough knowledge of the regulations concerning life-saving appliances and arrangements (SOLAS), including the LSA Code		R1
4.3.2 ORGANIZATION OF FIRE AND ABANDON SHIP DRILLS **Textbooks/Bibliography:** **Teaching aids:** A1 Required performance: *Note that students must be familiar with the content and application of the requirements for the scheduling and organization of fire and abandon ship drills of IMO model courses 7.03, 1.23 and 2.03. This knowledge is considered so fundamental for much of the management level content within this course that there is merit in reviewing the operational level content quickly before covering the additional elements required at management level. The learning time has been reduced for many elements on the basis that trainees will be reviewing rather than learning much of this content at this level. It may be necessary for some students to refresh their knowledge of such techniques before undertaking this management level content* **2.1 Organization of fire and abandon ship drills** – prepares schedules for the conduct of fire and abandon ship drills so that all required drills and equipment are covered within required timeframes – discusses ways in which crew can be motivated to participate fully in drills – prepares plans for effective drills – organizes effective drills including the briefing, conduct and debriefing of the drill – discusses the process for ensuring that required changes are made to the safety management system and on board procedures as a result of the lessons learnt from drills		
4.3.3 MAINTENANCE OF OPERATIONAL CONDITION OF LIFE-SAVING, FIREFIGHTING AND OTHER SAFETY SYSTEMS **Textbooks/Bibliography:** **Teaching aids:** A1 Required performance: **3.1 Maintenance of life-saving, firefighting and other safety systems** – discusses the use and upkeep of the SOLAS training manual in terms of the safety equipment provided and the required maintenance of this equipment		

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COMPETENCE 4.3	Maintain Safety and Security of Crew and Passengers and the Operational Condition of Safety Systems	IMO Reference
	– prepares procedures and checklists for the inspection of life-saving, firefighting and other safety systems on board – ensures that regular inspections of life-saving, firefighting and other safety systems on board are undertaken and that any deficiencies are identified and rectified – prepares procedures and schedules for the maintenance of life-saving, firefighting and other safety systems on board – prepares schedules for the required survey of life-saving, firefighting and other safety systems on board – prepares for and supports the survey of life-saving, firefighting and other safety systems on board – prepares procedures and checklists for the inspection of watertight doors, side scuttles, cross flooding arrangements, valves and other closing mechanisms – prepares maintenance plans and procedures for watertight doors, side scuttles, cross flooding arrangements, valves and other closing mechanisms	
4.3.4 ACTIONS TO BE TAKEN TO PROTECT AND SAFEGUARD ALL PERSONS ON BOARD IN EMERGENCIES **Textbooks:** **Teaching aids:** A1 Required performance: **4.1 Actions to protect and safeguard all persons on board in emergencies (4 hours)** – states that some crew members will be assigned specific duties for mustering and control of passengers – lists those duties as: – warning the passengers – ensuring that all passenger spaces are evacuated – guiding passengers to muster stations – maintaining discipline in passageways, stairs and doorways – checking that passengers are suitably clothed and that life jackets are correctly donned – taking a roll-call of passengers – instructing passengers on procedure for boarding survival craft or jumping into the sea – directing passengers to embarkation stations – instructing passengers during drills – ensuring that a supply of blankets is taken to the survival craft		R1

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COMPETENCE 4.3	Maintain Safety and Security of Crew and Passengers and the Operational Condition of Safety Systems	IMO Reference
4.3.5 ACTIONS TO LIMIT DAMAGE AND SALVE THE SHIP FOLLOWING A FIRE, EXPLOSION, COLLISION OR GROUNDING **Textbooks:** **Teaching aids:** A1 Required performance: **5.1 Actions to limit damage and salve the ship following a fire, explosion, collision or grounding (4 hours)** Means of limiting damage and salving the ship following a fire or explosion – describes the use and limitations of standard procedures and prepared contingency plans in emergency situations – describes methods of fighting fires (see IMO model course 2.03, Advanced training in firefighting) – states that cooling of compartment boundaries where fire has occurred should be continued until ambient temperature is approached – explains the dangers of accumulated water from firefighting and describes how to deal with it – states that watch for re-ignition should be maintained until the area is cold – describes the precautions to take before entry to a compartment where a fire has been extinguished – describes the inspection for damage – describes measures which may be taken to plug holes, shore-up damaged or stressed structure, blank broken piping, make safe damaged electrical cables and limit ingress of water through a damaged deck or superstructure – outlines the measures to be taken when the inert-gas main and gas lines to a mast riser are fractured – states that continuous watch should be kept on the damaged area and temporary repairs – states that course and speed should be adjusted to minimize stresses and the shipping of water **5.2 Procedure for abandoning ship** – states that a ship should only be abandoned when imminent danger of sinking, breaking up, fire or explosion exists or other circumstances make remaining on board impossible – describes the launching of boats and liferafts when the ship is listing heavily – describes the launching of boats and liferafts in heavy weather conditions – describes the use of oil to calm the sea surface and explains why fuel oil is not suitable		R1

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COMPETENCE 4.4	Develop Emergency and Damage Control Plans and Handle Emergency Situations	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 4.4.1 PREPARATION OF CONTINGENCY PLANS FOR RESPONSE TO EMERGENCIES 4.4.2 SHIP CONSTRUCTION, INCLUDING DAMAGE CONTROL 4.4.3 METHODS AND AIDS FOR FIRE PREVENTION, DETECTION AND EXTINCTION 4.4.4 FUNCTIONS AND USE OF LIFE-SAVING APPLIANCES		STCW Code table A-III/2

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COMPETENCE 4.4	Develop Emergency and Damage Control Plans and Handle Emergency Situations	IMO Reference

4.4.1 PREPARATION OF CONTINGENCY PLANS FOR RESPONSE TO EMERGENCIES

Textbooks/Bibliography:

Teaching aids: A1, V29

Required performance:

This content is not directly required for management level engineering officers under STCW Code, part A, chapter III, table A-III/1 but it is recommended to be included in training courses

1.1 Contingency plans for response to emergencies (9 hours) — R1

- draws up a muster list and emergency instructions for a given crew and type of ship
- assigns duties for the operation of remote controls such as:
  - main engine stop
  - ventilation stops
  - lubricating and fuel oil transfer pump stops
  - dump valves
  - CO_2 discharge
  - watertight doors
  - and for the operation of essential services such as:
    - emergency generator and switchboard
    - emergency fire and bilge pumps
- describes options for the division of the crew, e.g., into a command team, an emergency team, a back-up emergency team and an engine-room emergency team
- explains the composition of the emergency teams in the above objective
- states that crew members not assigned to emergency teams would prepare survival craft, render first aid, assemble passengers and generally assist the emergency parties as directed
- designates muster positions for the command team, both at sea and in port
- designates muster positions for the emergency teams
- states that the engine-room emergency team would take control of engine-room emergencies and keep the command team informed
- states that good communications between the command team and the emergency teams are essential
- prepares contingency plans to deal with:
  - fire and/or explosion in specific areas, such as galley, accommodation, container stows on or under deck, engine-room or cargo space, including coordination with shore facilities in port, taking account of the ship's fire-control plan
  - rescue of victims from an enclosed space
  - water ingress into the ship
  - serious shift of cargo

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COMPETENCE 4.4	Develop Emergency and Damage Control Plans and Handle Emergency Situations	IMO Reference
	– piracy attack – being towed by another ship or tug – heavy-weather damage, with particular reference to hatches, ventilators and the security of deck cargo – rescue of survivors from another ship or from the sea – leakages and spills of dangerous cargo stranding – abandoning ship – explains how drills and practices should be organized – describes the role of a shipboard safety committee in contingency planning	
	Actions to be taken when emergencies arise in port – describes actions to take in the event of fire on own ship, with particular reference to cooperation and communication with shore facilities – describes action which should be taken when fire occurs on a nearby ship or an adjacent port facility – describes the circumstances in which a ship should put to sea for reasons of safety	R1
4.4.2	SHIP CONSTRUCTION, INCLUDING DAMAGE CONTROL	
Textbooks:		
Teaching aids: A1		
Required performance:		
2.1	**Flooding of compartments (4 hours)** – defines: – margin line – permeability of a space – explains what is meant by ‘floodable length’ – explains what is meant by ‘permissible length of compartments’ in passenger ships – describes briefly the significance of the factor of subdivision – states the assumed extent of damage used in assessing the stability of passenger ships in damaged condition – summarizes, with reference to the factor of subdivision, the extent of damage which a passenger ship should withstand – describes the provisions for dealing with asymmetrical flooding – states the final conditions of the ship after assumed damage and, where applicable, equalization of flooding – states that the master is supplied with data necessary to maintain sufficient intact stability to withstand the critical damage	R1

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COMPETENCE 4.4	Develop Emergency and Damage Control Plans and Handle Emergency Situations	IMO Reference

- explains the possible effects of sustaining damage when in a less favourable condition
- distinguishes between ships of Type A and Type B for the purposes of computation of freeboard
- describes the extent of damage which a Type A ship of over 150 metres length should withstand
- explains that a Type A ship of over 150 metres length is described as a 'one-compartment ship'
- describes the requirements for survivability of Type B ships with reduced freeboard assigned
- summarizes the equilibrium conditions regarded as satisfactory after flooding
- states that damage to compartments may cause a ship to sink as a result of:
  - insufficient reserve buoyancy, leading to progressive flooding
  - progressive flooding due to excessive list or trim
  - capsizing due to loss of stability structural failure

4.4.3 METHODS AND AIDS FOR FIRE PREVENTION, DETECTION AND EXTINCTION

Textbooks:

Teaching aids:

Required performance:

3.1 Methods and aids for fire prevention, detection and extinction

- See IMO model course 2.03

4.4.4 FUNCTIONS AND USE OF LIFE-SAVING APPLIANCES

Textbooks:

Teaching aids:

Required performance:

4.1 Functions and use of life-saving appliances

- See IMO model course 1.23

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COMPETENCE 4.5	Use of Leadership and Managerial Skills	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 4.5.1 SHIPBOARD PERSONNEL MANAGEMENT AND TRAINING 4.5.2 RELATED INTERNATIONAL MARITIME CONVENTIONS AND RECOMMENDATIONS, AND NATIONAL LEGISLATION 4.5.3 APPLICATION OF TASK AND WORKLOAD MANAGEMENT 4.5.4 EFFECTIVE RESOURCE MANAGEMENT 4.5.5 DECISION-MAKING TECHNIQUES 4.5.6 DEVELOPMENT, IMPLEMENTATION AND OVERSIGHT OF STANDARD OPERATING PROCEDURES		STCW Code table A-III/2

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COMPETENCE 4.5	Use of Leadership and Managerial Skills	IMO Reference
4.5.1 SHIPBOARD PERSONNEL MANAGEMENT AND TRAINING **Textbooks/Bibliography:** T37 **Teaching aids:** A1 Required performance: *Note that trainees should be familiar with the content and application of the operational level IMO model course 1.39 on Leadership and teamwork. This knowledge is considered so fundamental for much of the management level content within this course that there is merit in reviewing the operational level content quickly before covering the additional elements required at management level. The learning time has been reduced for many elements on the basis that trainees will be reviewing rather than learning much of this content at this level. It may be necessary for some trainees to refresh their knowledge of this content before undertaking this management level content*		
1.1	**Shipboard personnel management (10 hours)**	
	Principles of controlling subordinates and maintaining good relationships – identifies sources of authority and power – discusses theories on how effective authority and power may be enhanced or diminished by management level officers on ships – reviews theories in cultural awareness and cross cultural communication – discusses strategies that management level officers could adopt to enhance their effectiveness in managing crews of different cultures – reviews theories in human error, situational awareness, automation awareness, complacency and boredom – discusses strategies that management level officers can adopt to optimize situational awareness and to minimize human error and complacency of individuals and teams – reviews theories in leadership and teamwork – discusses strategies that management level officers can adopt to enhance leadership and teamwork – discusses theories of personnel motivation and relates these to shipboard situations encountered by management level officers – explains that an individual's motivation and well being may be affected by both real and perceived influences on board ship and at home – discusses strategies that management level officers could adopt to optimize the motivation of individuals and teams – discusses theories on coaching individuals and teams to improve performance – discusses approaches to managing and improving the performance of oneself, individuals and teams – prepares for and conducts a simulated formal performance review – identifies the impact of repeated harassment including bullying on individuals – recognizes indications that crew members may be physically or mentally unwell or badly demotivated	R1

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COMPETENCE 4.5	Use of Leadership and Managerial Skills	IMO Reference

– describes strategies that can be adopted when a crew member is believed to be physically or mentally unwell or badly demotivated
– describes strategies that management level officers can take to ensure that crew remain physically well and are encouraged to remain physically active

Crew employment

– explains the need for management level officers to be fully familiar with the requirements of national law relating to crew employment and of all crew agreements in place on the ship
– discusses the process for signing on and discharging crew under national law
– discusses the need to ensure that new crew are appropriately certificated, competent and familiarized with the safety management system, security plan, working procedures and equipment of the ship
– explains that procedures for conducting investigations and applying consequences in disciplinary situations are governed by national law, codes of conduct, employment agreements and company procedures
– explains the process for investigating and applying consequences in disciplinary situations under relevant national law and procedures
– explains the formal process for addressing continuing levels of unacceptable performance by a crew member under national law
– explains the process for investigating and responding to incidents of harassment or bullying of crew members under national law
– explains requirements for handling crew wages, advances and allotments when this is done by management level officers on board ship

1.2 Training (6 hours)

Training methods

– reviews training methods that could be adopted on board ship
– discusses the effectiveness of training methods that can be adopted for training:
  – in attitude
  – in skills
  – in knowledge
– describes the preparation needed before the start of a training session
– discusses methods for ensuring that crew are motivated to participate fully in training
– demonstrates how to conduct a training session for a given topic
– lists the areas in which training is required by regulation including the requirements of SOLAS
– identifies other topics where training might be desirable
– delivers a training session to other members of the class
– discusses the resources that may be available on board ship that can be used for training

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COMPETENCE 4.5	Use of Leadership and Managerial Skills	IMO Reference

4.5.2 RELATED INTERNATIONAL MARITIME CONVENTIONS AND RECOMMENDATIONS, AND NATIONAL LEGISLATION

Textbooks/Bibliography:

Teaching aids: A1

Required performance:

2.1 Related international maritime conventions and national legislation (4 hours)

ISM Code

- explains the principles underlying the ISM Code
- describes the content and application of the ISM Code

STCW Convention

- explains the principles underlying the STCW Convention
- describes the content and application of the STCW Convention
- explains how to implement the regulations for ensuring fitness for duty
- states that seafarers new to a particular type of vessel require ship specific shipboard familiarization
- describes what shipboard familiarization may involve for watchkeeping officers
- describes what tasks or duties elementary basic safety familiarization involves for a watchkeeping officer
- describes how to organize shipboard training and how to maintain records
- states that penalties are prescribed for breaches of STCW 95 requirements and that these are determined by the flag State
- states that national legislation is required to implement the provisions of an international convention
- states that for STCW 1978, as amended, national legislation is subject to scrutiny and checking by IMO appointed persons
- states national legislation may differ from one flag to another

Maritime Labour Convention (MLC)

- demonstrates a working knowledge of the Maritime Labour Convention provisions relating to the management of personnel on board ship, with particular reference to:
  - engagement of crew
  - employment conditions
  - crew entitlements and repatriation
  - medical requirements

4.5.3 APPLICATION OF TASK AND WORKLOAD MANAGEMENT

Textbooks/Bibliography:

Teaching aids: A1

Required performance:

3.1 Task and workload management (8 hours)

- reviews theories on applying task and workload management from IMO model course 1.39, Leadership and teamwork

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COMPETENCE 4.5	Use of Leadership and Managerial Skills	IMO Reference

- explains that the scope of activity and conflict between activities managed by management level officers is broader than for operational level officers and requires greater task and workload management ability
- plans the task and workload allocation for significant shipboard activities so that the following are considered:
  - human limitations
  - personal abilities
  - time and resource constraints
  - prioritization
  - workload, rest and fatigue
- discusses strategies to monitor the effectiveness of task and workload management during an activity and to adjust the plan as necessary
- discusses strategies to ensure that all personnel understand the activity to be undertaken and their tasks in this
- discusses whether the encouragement of a challenge and response environment is appropriate to the task and workload management of particular shipboard tasks
- discusses the importance of debriefs and reflection after activities have been conducted to identify opportunities for improving task and workload management

4.5.4 EFFECTIVE RESOURCE MANAGEMENT

Textbooks/Bibliography:

Teaching aids: A1

Required performance:

Note that trainees should be familiar with the content and application of the operational level IMO model course 1.39 on Leadership and teamwork in terms of resource management. This knowledge is considered so fundamental for much of the management level content within this course that there is merit in reviewing the operational level content quickly before covering the additional elements required at management level. The learning time has been reduced for many elements on the basis that trainees will be reviewing rather than learning much of this content at this level. It may be necessary for some trainees to refresh their knowledge of this content before undertaking this management level content

4.1 Application of effective resource management at a management level (10 hours)

- reviews theories on effective communication
- demonstrates effective communication in simulated or real situations involving communications on board ship and between ship and shore
- discusses how management level officers can encourage other personnel to use effective communications
- reviews theories on effective resource allocation, assignment and prioritization
- demonstrates the effective allocation, assignment and prioritization of resources when managing simulated or real shipboard activities
- reviews theories on decision making that considers team experience

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COMPETENCE 4.5	Use of Leadership and Managerial Skills	IMO Reference

– demonstrates the ability to involve team member effectively in decision making when managing simulated or real shipboard activities
– reviews theories on assertiveness and leadership
– discusses appropriate leadership styles and levels of assertiveness for management level officers in a range of shipboard activities
– demonstrates the ability to apply appropriate leadership styles and levels of assertiveness when managing simulated or real shipboard activities
– reviews theories on obtaining and maintaining situational awareness
– demonstrates the ability to obtain and maintain situational awareness when managing complex simulated or real shipboard activities
– reviews theories on the use of short and long term strategies
– demonstrates the ability to apply short and long term strategies when managing simulated or real shipboard activities

4.5.5 DECISION-MAKING TECHNIQUES

Textbooks/Bibliography:

Teaching Aids: A1

Required performance:

Note that trainees should be familiar with the content and application of the operational level IMO model course 1.39 on Leadership and teamwork. This knowledge is considered so fundamental for much of the management level content within this course that there is merit in reviewing the operational level content quickly before covering the additional elements required at management level. The learning time has been reduced for many elements on the basis that trainees will be reviewing rather than learning much of this content at this level. It may be necessary for some trainees to refresh their knowledge of this content before undertaking this management level content

5.1 Situation and risk assessment (2 hours)

– reviews theories of situation and risk assessment
– discusses formal and informal approaches to risk assessment
– identifies typical risks that management level officers may have to assess
– demonstrates the ability to effectively assess risk in the planning and conduct of simulated or real shipboard activities

5.2 Identify and generate options (2 hours)

– reviews theories on identifying and generating options
– demonstrates the ability to identify and generate options when making decisions as a management level officer in simulated or real shipboard activity

5.3 Selecting course of action (2 hours)

– reviews theories on selecting the course of action in making decisions
– demonstrates the ability to select appropriate courses of action when making decisions as a management level officer in simulated or real shipboard activity

5.4 Evaluation of outcome effectiveness (1 hour)

– explains how to carry out the evaluation of outcome effectiveness and the importance of doing it

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COMPETENCE 4.5	Use of Leadership and Managerial Skills	IMO Reference
4.5.6 DEVELOPMENT, IMPLEMENTATION AND OVERSIGHT OF STANDARD OPERATING PROCEDURES **Textbooks/Bibliography:** **Teaching Aids:** A1 Required performance: **6.1 Development, implementation and oversight of standard operating procedures (1 hour)** – discusses approaches to developing standard operating procedures (SOPs) – explains the methods to implement the SOPs – explains why it may be desirable for there to be oversight and approval of many SOPs		

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Part D4: Instructor Manual

The following notes are intended to highlight 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.

On completion of training for this function officers will have knowledge of the principal structural members of a ship and methods of construction. They will understand the theory of stability and trim and be able to use tables, diagrams and stress calculators to plan loading and ballasting so as to maintain satisfactory stability and trim (taking account of applicable IMO recommendations concerning intact stability) and to ensure that hull stresses remain within acceptable limits.

The effects of damage to, and the consequent flooding of, a compartment on the trim and stability of a ship and the counter-measures to be taken will be understood.

Officers will also be thoroughly conversant with the certificates required to be on board, their periods of validity and the procedures for their renewal.

The officers will also be aware of their legal obligations and responsibilities concerning international provisions for the safety of the ship, crew, passengers and cargo and for the prevention of pollution from the ship.

They will also be able to follow the correct procedures for all matters concerning the crew; their engagement and discharge, treatment of wages and deductions, discipline and dealing with disciplinary offences, the discharge of a sick seaman abroad, repatriation, deceased seamen and engagement of substitutes.

Officers will have sufficient knowledge of shipping documents related to cargo and the shipowner's liabilities and obligations in respect of charter parties and the carriage of cargo to enable them to protect the ship's interests.

Officers will be capable of organizing and managing the crew for the safe and efficient operation of the ship and be able to draw up an organization for dealing with emergencies. Officers will also know the requirements for training in the operation and maintenance of safety equipment and be able to implement that training on board.

On completion of training for this function officers will be able to use plans and tables or diagrams of stability and trim data to calculate the ship's initial stability, draughts and trim for any given disposition of cargo and other weights. They will also be able to determine whether stresses on the ship are within permitted limits by the use of stress data, calculating equipment or software. The fundamental actions to take in the event of partial loss of intact buoyancy will be understood.

Training concerned with fire prevention and firefighting is covered in IMO model course 2.03.

Training concerned with proficiency in medical care on board ship is covered in IMO model course 1.15.

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4.1 CONTROL TRIM, STABILITY AND STRESS

4.1.1 FUNDAMENTAL PRINCIPLES OF SHIP CONSTRUCTION, TRIM AND STABILITY (90 hours)

1.1 Stresses in Ship Structure (4 hours)

Instructors should highlight to trainees the terms commonly associated with stresses and their causes that a ship encounters in various conditions. Instructors to use the following text to assist in their delivery: T4, T19, T25, T34. Terms include: longitudinal bending, still water bending, and load diagram, shear force diagram, bending moment diagram, hogging, sagging, wave bending, transverse bending, docking, grounding, pounding, and panting.

1.2 Construction Arrangements (27 hours)

The instructor should refer to R1 (SOLAS chap II) and also the following texts and teaching aids when preparing to deliver this section: T4, T19, T25, T33, T35, B97, B102, V27. Coverage should include:

(i) Terms used to describe structural members: keel, bilge keel, duct keel, bottom plating, double bottom, tank top, girder, centre girder, side girder, floor, side frame, shell plating, deck plating, flanges, margin plate, longitudinal, intercostal, stiffener, web frame, bulkhead, collision bulkhead, panting stringer, stringer, pillars, garboard strake, sheer strake;

(ii) Double bottom construction, structural members used and purposes;

(iii) duct keels – purpose and safety features;

(iv) Forward and after peak structures, reasons for the varying dimensions and members;

(v) Anchor cable termination details;

(vi) Longitudinal, transverse and combined framed vessels;

(vii) Decks, Hatch covers, Bulwarks;

(viii) Deep frames and design consideration for discontinuities in the vessel structure;

(ix) Bilge keel consideration;

(x) Strakes for the hull;

(xi) Fittings through the hull requirements;

(xii) Engine, deck machinery and stabilizer strengthening members;

(xiii) Bulkhead construction and their position;

(xiv) Requirements for maintaining of strength and watertight integrity when bulkheads are pierced for normal operation;

(xv) the rudder and its supporting arrangements;

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(xvi) Stern frame;

(xvii) Design criteria for specialized ships;

(xviii) Structural fire protection, its classes and requirements;

(xix) Ship's General arrangement drawing;

(xx) Shell expansion;

(xxi) Deck plan and ship's midship section construction.

1.3 Ship Dynamics (2 hours)

Instructors should refer to the following text for reference, T4, T25, T19, T35, T34 and should address these areas:

(i) Ship motions: Rolling, Pitching, Heaving;

(ii) Bilge keels;

(iii) Fin Stabilizers;

(iv) Passive and active anti-roll tanks;

(v) Vibration.

1.4 Watertight and Weathertight Doors (3 hours)

The provisions of SOLAS for drills and inspections of watertight doors and related damage-control devices have been included with the details of construction and operation.

1.5 Corrosion and Its Prevention (4 hours)

Trainees should not be required to remember the galvanic series for seawater. It should be used for reference when dealing with corrosion cells and the suitability of metals as anodes for sacrificial anodes.

Many paints contain poisonous substances and release toxic fumes as solvents evaporate. The vapours of most paint solvents will produce flammable or explosive mixtures with air in poorly ventilated spaces.

The risks are greatest when using spray equipment in enclosed spaces. Personnel must wear breathing apparatus, sources of ignition must be excluded and ventilation must be provided while work is in progress. Precautions for entering enclosed spaces should be taken after painting has been completed until the paint has thoroughly dried and no risk of release of vapour remains. Manufacturers' instructions regarding protective clothing and safety precautions should be followed.

1.6 Surveys and Dry-Docking (2 hours)

This section deals with the surveys and inspections required by classification societies. The requirements for survey under international conventions are dealt with in subject module 3.2, Maritime Law. The annual inspection required by the International Convention on Load Lines, 1966, is usually carried out by a classification society surveyor, acting on behalf of the flag

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State Administration. The inspection is similar to that required for the classification society's annual survey.

The hardeners that are used in two-pack (or bi-pack) polyurethane and epoxy paints are toxic and may also cause allergic reactions following contact with skin. Protective clothing and disposable gloves should always be worn when working with these paints.

1.7 Stability (42 hours)

Calculations on box-shaped vessels have been introduced at a number of places in this syllabus. They are included to illustrate basic principles and to aid trainees' understanding of actual ships' data. The appendix to this instructor manual contains stability data and capacity tables for use in the preparation of exercises. Instructors should make a collection of data for other ships as the opportunity arises.

It is not intended that management level engineers will be required to apply the stability principles of this course to problems involving the planning and assessment of the stability or trim of the vessel involving cargo and other deadweight items. Calculations should be aligned to supporting the principles outlined in the detailed teaching syllabus.

Approximate Calculation of Areas and Volumes, First and Second Moments

This section covers the use of the trapezoidal rule and Simpson's rules for the calculation of areas. The derivation of Simpson's rules and their use for finding moments or second moments of area has not been included. The calculation of volume where the given ordinates are areas is covered.

The use of Simpson's rules is required for finding areas under a GZ curve, for checking compliance with recommendations on intact stability. Trainees should also be able to apply them for calculating areas of decks and volumes of compartments aboard ship.

Instructors should refer to text T3, T19, T34, to explain and also solve problems using:

(i) Simpson's 1st and 2nd Rules for areas and volumes;

(ii) Application of Simpson's Rules to calculate areas and volumes;

(iii) Common areas such as waterplanes, sections and bulkheads;

(iv) Immersed volume of hull by sections and waterplanes;

(v) Simpson's 1st and 2nd Rules for 1st moments and centroid;

(vi) Application of Simpson's Rules to find centroids;

(vii) Centroids of common areas such as, waterplanes, sections and bulkheads;

(viii) Vertical Centre of Buoyancy, VCB; Longitudinal Centre of Buoyancy, LCB;

(ix) Simpson's 1st and 2nd Rules for 2nd moments of area;

(x) Application of Simpson's Rules to find 2nd moments of area;

(xi) Transverse moment of inertia, I_T; Longitudinal moment of inertia, I_L.

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Effects of Density

In tidal estuaries the density of the water may vary considerably according to the state of the tide. When checking draughts or freeboard near completion of loading it is essential to check the density at the same time: using a density obtained earlier in the day could lead to appreciable error.

The term 'inertia' and the abbreviation 'I' are used in keeping with common practice. They may also appear in a ship's hydrostatic data. Strictly, it is the transverse second moment of area of the tank which is involved. Trainees should understand the concept of second moments of area but the method of determining them in general is not required. The formula for a rectangular surface should be known.

Stability at Moderate and Large Angles of Heel

The equation BM = I / V has been quoted partly to show that the BM is a function of the ship's dimensions and state of loading and partly to explain the typical behaviour of KM as the draught is increased from light ship conditions. Use is also made of the equation in the treatment of damage stability. The proof of the equation is not required.

GZ curves will normally be constructed from KN curves, but trainees should be able to correct a GZ curve when the value of KG differs from that used in drawing the curve, either by drawing a new curve or by superimposing the curve of GG_1 sin (angle of heel) on the GM should be used as an aid to constructing the curve at small angles should not be expected to deduce the GM from a given curve.

Figure 1 shows a ship with its centre of gravity, G_1, at a distance GG_1 horizontally from the centreline. When inclined to an angle θ, the righting lever is G_1Z_1.

$G_1Z_1 = GZ - GY$
$= GZ - GG_1 \cos \theta$

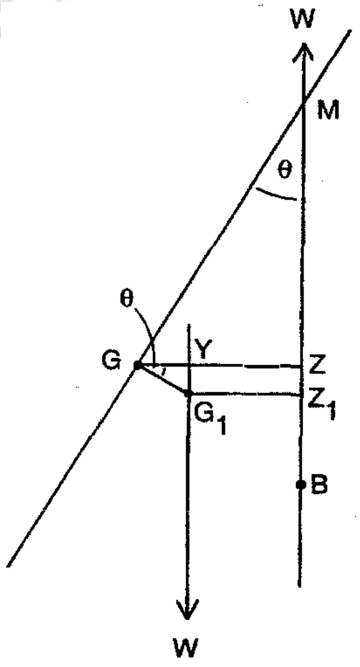


Figure 1

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The values of GZ derived from KN curves can be reduced to GG1 cos θ before plotting or the curve GG1 cos θ can be superimposed on the GZ curve, as shown in Figure 2.

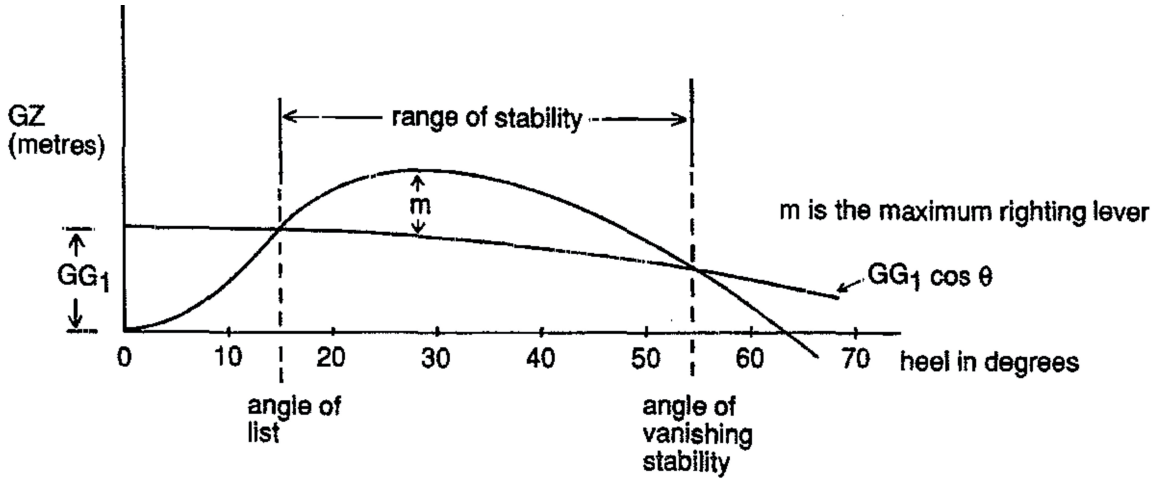


Figure 2

A list reduces the righting levers and the range of stability when heeled towards the listed side. When heeled in the opposite direction, righting levers are increased.

Simplified Stability Data

Simplified stability data were originally intended for use in small ships, but data in that form may also be found in some larger ships. Each of the several different presentations shows the ship's stability as adequate or inadequate to meet the recommended criteria for intact stability for passenger and cargo ships under 100 metres in length or, in the case of larger ships, the criteria laid down by the Administration.

Data necessary to maintain sufficient intact stability under service conditions to enable the ship to withstand the critical damage assumptions of SOLAS would be provided in passenger ships.

Trim and List

Trim calculations using moments about the centre of flotation or trimming tables were covered in IMO model course, Officer in charge of a navigational watch. These methods are suitable only in cases where the change in displacement is sufficiently small so that there are no large changes in the position of the centre of flotation or the value of MCT. When large changes in displacement are involved, as, for example, in planning the loading of a ship, the following method should be used.

Figure 3 shows a ship on an even keel with longitudinal centres of buoyancy and gravity indicated. The weight and buoyancy forces form a couple, called the trimming moment, equal to the product of the displacement and the horizontal separation between B and G, in this case acting to trim the ship by the stem. The ship will trim until the centre of buoyancy of the new underwater volume is in the same vertical line as G, which is fixed.

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The trim is given by trimming moment/MCT 1cm where the MCT is taken for the displacement of the ship.

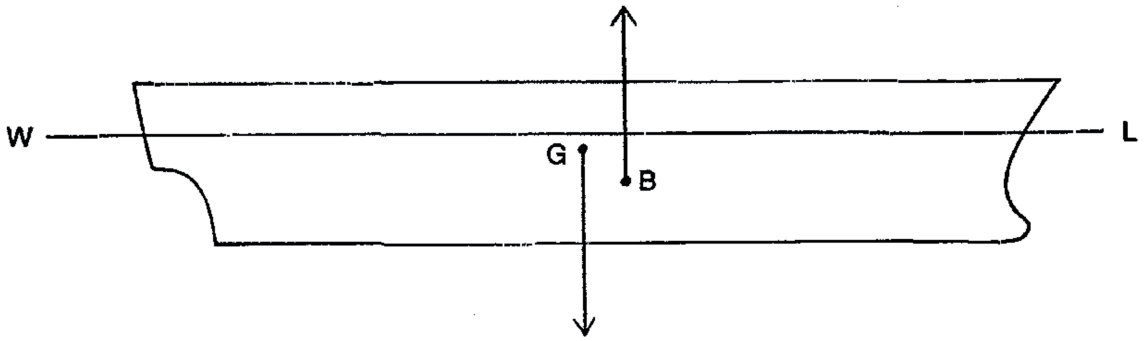


Figure 3

The position of the longitudinal centre of buoyancy (LCB), for an even-keel condition, depends upon the ship's draught and is given in the hydrostatic data as a distance, either from the after perpendicular or from amidships.

The position of the longitudinal centre of gravity is found by taking moments of mass, about the after perpendicular or about amidships, of the light ship and all of its contents. The LCG for the light ship is included in the hydrostatic data, LCGs of tanks and holds are given in the capacity plans or can be measured from the profile plan.

To find the draughts at each end, the trim is divided in the usual way, according to the proportionate distances of the perpendiculars from the centre of flotation, and applied to the ship's true mean draught.

When a ship is hogged or sagged there is a difference between the mean draught calculated from the draughts at the ends and the draught amidships. The difference is the amount of hog or sag. Taking the case of a ship with a sag, the draught amidships is greater than the mean draught. The ship's displacement lies between the values obtained for the two draughts and corresponds to some intermediate draught.

A weighted average of the mean draught and draught amidships is used. The commonly used values are:

corrected draught = ¾ x draught amidships + ¼ x mean draught;
or corrected draught = ⅔ x draught amidships + ⅓ x mean draught.

These amount to applying ¼, in the first case, or ⅓, in the other, of the hog or sag to the amidships draught.

A method known as the mean of mean of means is sometimes used. The mean of the forward and after draughts is found, the mean of that and the draught amidships is found and the mean of that with the draught amidships again gives the required draught, The result is the same as for the first equation above.

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Nemoto's Formula

When utmost accuracy is required, as in draught surveys for quantity loaded or discharged, a second correction for trim, using Nemoto's formula, may be applied to the displacement. It is usually only applied when the trim exceeds 1% of the ship's length.

$$\text{correction (tonnes)} = \frac{t^2 \times 50}{L} = \frac{dM}{dZ}$$

where: t is the trim in metres
L is the length between perpendiculars in metres
d is the mean draught

$$\frac{dM}{dZ} = \text{MCT 1cm at (d + 0.5)m} - \text{MCT 1cm at (d - 0.5)m}$$

The correction is always added to the displacement.

Dynamical Stability

In calculating the area under a GZ curve to a given angle, using Simpson's rules, the interval between ordinates may be expressed in degrees.

The calculated area would be expressed in metre-degrees, which can be converted to metre-radians, if required, by dividing by 57,3. The dynamical stability is the area under the curve in metre-radians multiplied by the ship's displacement in tonnes. The result is expressed in metre-tonnes, the radians being omitted since they are dimensionless. Usually, it is areas under the GZ curve which are required for checking stability criteria which, depending upon the ship's data, may be expressed in metre-degrees or metre-radians.

The area under the GZ curve to a given angle represents not only the work done in heeling the ship to that angle but also the potential energy available to return the ship to the upright. By the principle of conservation of energy, the potential energy is converted into rotational energy as the ship moves towards the upright. When upright, all of the energy is in the form of rotational energy, so the ship continues to roll until an angle is reached where the area under the curve is equal to that rotational energy. The energy used in overcoming friction between hull and water and in creating turbulence reduces the angle to which the ship will roll.

The wind exerts a horizontal force on the above-water area of the ship and deck cargo which can be considered to act at the centre of the projected area. That force is resisted by the water acting on the underwater area on the other side, usually considered to act at about half the draught. The two forces form a couple inclining the ship until the righting moment is equal to the inclining couple. In the Recommendation on a Severe Wind and Rolling Criterion for the Intact Stability of Passenger and Cargo Ships of 24 metres in Length and Over, no allowance is made for a reduction in the projected lateral area or the vertical separation between the centres of areas, above and below the waterline, as the ship heels. The wind pressure used in the recommendation corresponds approximately to storm force 10 on the Beaufort scale.

List should always be removed before sailing and cargo should be adequately secured to prevent a shift producing a listed condition while on passage.

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Approximate GM by Means of Rolling Tests

The method is described in the Intact Stability Code.

Inclining Test

The purpose of the inclining test is to determine the displacement and position of the ship's centre of gravity in an accurately known condition. It is usually carried out when the ship is as nearly complete as possible, small corrections being made for any components still to be fitted or shipyard stores aboard at the time to obtain values for the light ship condition.

The draughts and water density are carefully measured for use with the ship's lines plan to calculate the displacement, the height of the transverse metacentre above the base (KM) and the position of the longitudinal centre of buoyancy.

The test consists of moving weights across the deck under controlled conditions and measuring the resultant angle of list. The angles are deliberately kept small and are measured by long pendulums suspended down holds or engine-room skylights.

The mean value of GM calculated from the deflections is subtracted from the KM to give the vertical height of the centre of gravity. Since the centre of gravity and centre of buoyancy are in the same vertical line for a ship in equilibrium, the position of the LCG can be calculated from the previously determined LCB.

Recommendations on Intact Stability for Passenger and Cargo Ships Under 100 Metres in Length

The recommendations are contained in R43. Instructors should refer to the stability requirements of the Administration for ships of 100 metres in length and over.

Rolling of Ships

A mathematical treatment of rolling is not required. Trainees should know that the natural rolling period is inversely proportional to the square root of the GM. Rolling in a seaway is a forced oscillation, the period depending upon the period of encounter of the waves or swell as well as the natural rolling period; when the period of wave encounter equals the natural rolling period, synchronization occurs. Very heavy rolling can be induced by a moderate sea. An alteration of course or speed, or both, changes the encounter period of the sea and breaks the synchronization.

The equation in this objective produces a result in force units (kilonewtons in this case), hence the balancing heeling couple must be expressed in the same units in the equation in the objective relating to the righting moment equaling the heeling couple, by multiplying the usual mass moment by g, the acceleration due to gravity.

In the unusual event of the centre of gravity falling below half draught the heel would be towards the turn.

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Dry-Docking and Grounding

When dealing with stability during dry-docking, it is simplest to consider the righting moment when heeled by taking moments about the centre of buoyancy, which produces the equation:

$$\text{righting moment} = \Delta \times GM \sin\theta - P \times KM \sin\theta$$

directly.

The righting level GZ, is given by the equation:

$$GZ = \left(GM - \frac{P \times KM}{\Delta}\right) \sin\theta,$$

which is the righting lever for the ship with its GM reduced by $\frac{P \times KM}{\Delta}$

By making use of KM = KG ÷ GM, the alternative expression for righting lever can be obtained.

This approach has the advantage of showing that, although different values of GM are obtained, the value of the righting moment is the same in each case. The value of P for which

GM — 0 is also the same for both expressions.

The stability of a ship grounded at a point on the centreline is treated in exactly the same way as the dry-docking problem. A ship grounded forward, say, on a falling tide, would experience a reducing righting lever and the point could be reached at which it became zero. Providing the ship did not touch bottom elsewhere, it would flop over to an angle of loll or possibly capsize.

When grounded at a point off the centreline, a heeling moment is also produced. Considering the case where only heeling moment is involved, at the point of capsize the upthrust from the bottom becomes zero, therefore the ship would not capsize until heeled to its angle of vanishing stability when afloat. In most circumstances, cargo would have shifted, water entered through non-watertight openings or the ship would have slid off before reaching that angle. When the grounding force causes trim as well as heel the angle of vanishing stability may be much smaller.

It should be recalled that buoyancy is provided by the vertical component of water pressure on the ship's hull. When a ship is grounded on firm sand or a bottom of similar nature, water is unable to exert any pressure on the grounded portion and there is a loss of buoyancy compensated by an increased upthrust from the ground. If a ship is grounded over the whole of its bottom there is a large loss of buoyancy for any drop in water level, however small. Stability is not a problem in that circumstance but the fact that nearly all the weight of the ship is supported by the ground must be considered when deciding how to refloat her.

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1.8 Resistance and Fuel Consumption (5 hours)

Instructors should refer to the following texts B115, T3, T34, T28, for explanation of the following:

(i) Frictional resistance;

(ii) Reynolds' number;

(iii) Residuary resistance;

(iv) Froude number;

(v) Speed length ratio;

(vi) Effective power;

(vii) Admiralty coefficient;

(viii) Fuel coefficient and fuel consumption. Trainees should know how to solve problems involving the above variables.

1.9 Rudders (2 hours)

Instructors should refer to the following texts B115, T3, T34, T28, for explanation of the following:

(i) Force on a rudder and Torque on a rudder stock;

(ii) Angle of heel due to force on rudder;

(iii) Angle of heel when turning.

4.1.2 EFFECT ON TRIM AND STABILITY IN THE EVENT OF DAMAGE AND FLOODING

The methods of calculating transverse stability, list and trim in a damaged condition are based upon the principles used in the textbook T4 but the problem has been approached in a way more applicable to the use of a ship's hydrostatic data, although still confined to compartments with roughly rectangular waterplanes.

Flooding of Compartments

The requirements for the watertight subdivision of passenger ships are set out in SOLAS. Depending upon the type of service and its size, the ship will be required to withstand the flooding of one, two or three adjacent main compartments.

The International Convention on Load Lines lays down requirements for the survivability of ships of Type A, if over 150 metres in length, and for ships of Type B which are over 100 metres in length and are assigned freeboards less than the tabular freeboards for Type B ships.

Classification society rules stipulate the minimum number of bulkheads to be fitted in dry cargo ships, depending upon length, but do not specify that they should be fitted in such a way that the ship could withstand flooding of a main compartment.

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Amendments to the SOLAS Convention provide regulations governing the subdivision and damage stability of cargo ships. They apply to ships over 100 metres in length intended primarily for the carriage of dry cargoes, but exclude those ships already covered by other damage stability regulations in IMO instruments.

The regulations are based on consideration of the probability of the location and extent of damage and the probability of survival after damage. The probabilities of survival conditional upon each possible damage configuration for compartments, singly or in adjacent groups, are summed for the summer draught and for a draught intermediate between light and loaded. The average of the two sums gives a value known as the "attained subdivision index, A" which must not be less than the "required subdivision index, R", which is a function of the length.

Effect of Flooding on Transverse Stability

When a space is flooded without free communication with the sea, the stability can be calculated by taking account of the mass of water and the free surface effect. Examples would be the accumulation of water in tween-decks as a result of firefighting, or flooding through a crack in the hull or through a fractured pipe. The ship's hydrostatic data for the increased displacement are applicable for the calculations.

If a compartment is holed so that water can flow freely in and out of it, that compartment can be considered as part of the sea and no longer part of the ship. The buoyancy of the space up to the water level before damage is lost and the waterplane area of the ship is reduced by the waterplane area of the damaged compartment. These changes give rise to changes in the hydrostatic data needed to calculate the transverse stability and trim. The mass of the ship and its centre of gravity remain unaltered. Such a treatment is known as the 'lost buoyancy method' and is the one used in this course and in the textbook T4.

The lost buoyancy, expressed in tonnes, is the mass of water which could enter the space up to the original waterplane, i.e. the volume x permeability x density of water in which the ship is floating.

The lost waterplane area is the area of the bilged compartment at the original waterplane. If the compartment is completely contained below the waterline, e.g. a double-bottom tank, there is no loss of waterplane area provided the tank top remains intact. The original waterplane area may be given in the ship's data or it can be calculated from

$$\text{waterplane area} = \frac{100 \times \text{TPC}}{1.025}$$

Of the two corrections in this objective, the first is the second moment of lost waterplane area about its own centroid, the second a correction to give the loss about the new centroid of the intact waterplane. In the case of symmetrical flooding, the second correction is zero. For wing compartments, the second correction is very much greater than the first, even for compartments extending half the breadth of the ship.

Generally, the displacement of the ship and the position of the centre of gravity will remain unchanged after bilging. However, if a tank containing a liquid is bilged, the weight of the tank contents is lost, causing a reduction in displacement and a shift in the position of the ship's

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centre of gravity. The lost buoyancy would be comparable with the lost weight, causing a similar shift in the centre of buoyancy with the result that there would be little change of draught, trim or list. The loss of waterplane area would result in a reduction of GM.

Permeability

The permeability of a space is the percentage or fraction of the space which could be occupied by water. The lost buoyancy equals the permeability x the volume. If a cargo was stowed solidly, with no space for water in infiltrate, it would occupy

$$\frac{1}{density}\ m^3/t$$

The space occupied in the hold by one tonne is its stowage factor, so the space available to water = stowage factor – $\frac{1}{density}\ m^3/t$

The proportion of the stow which could be occupied by water, i.e. the permeability, equals

$$\frac{\text{stowage factor} - \frac{1}{density}}{\text{stowage factor}}$$

For example, a cargo has a stowage factor of 1.2 m^3/t and a density of 2.5 t/m^3

$$\frac{1}{density} = \frac{1}{2.5} = 0.4 m^3/t$$

$$permeability = \frac{1.2\text{-}0.4}{1.2} = \frac{0.8}{1.2} = 0.67$$

Notice, if a cargo has a permeability of 0.4 but only occupies half of the compartment, the permeability of the whole compartment is 0.4 x 0.5 + 0.5 = 0.7.

The loss of waterplane area is taken to be permeability x waterplane area of the compartment, but if the water level is above the top of the cargo the whole area is lost.

Angle of Heel

Buoyancy is lost at the damaged compartment and an equal amount of buoyancy is gained at the position of the new centre of flotation. The transverse shift in the ship's centre of buoyancy is, therefore, lost buoyancy x transverse distance from centre of flotation divided by the displacement. On the assumption that the centre of gravity is still on the centreline, the shift in buoyancy is the heeling arm.

The angle of heel would be given by the intersection of the GZ curve for the damaged ship with the heeling-arm curve $BB_1 \cos \theta$. Since KN curves for the damaged condition are not available, the GZ curve has to be constructed, using values for the intact ship at a displacement corresponding to the damaged draught and a KG chosen to give the modified

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value of GM. The angle of heel read from the curve will be approximate. If the angle is small it can be calculated from:

$$\tan \theta = BB_1 / GM$$

Effect of Flooding on Trim **(9 hours)**

Similar calculations are necessary to find the longitudinal position of the centre of flotation after damage, and the reduction of BM_L. The change in GM_L is used to calculate the change in MCT 1cm.

Buoyancy has been lost at the damaged compartment and replaced at the centre of flotation, hence the trimming moment is the product of lost buoyancy and the distance from the centre of the damaged compartment to the new centre of flotation. The change of trim and the draught at each end are then calculated in the usual way.

Flooding of a compartment near an end of the ship causes a large shift in the centre of flotation away from the damaged end and a large reduction in MCT 1cm. Combined with the sinkage due to lost buoyancy, this may produce a large increase in draught at the damaged end. The original trim of the ship will influence the chances of the ship surviving the damage.

A ship already trimmed towards the damaged end is more vulnerable than one on an even keel or trimmed the other way.

Measures to Improve Stability or Trim when Damaged

The immediate action should be to restrict the flooding and, if possible, to stop it. In the event of collision or stranding damage, it will not be possible to stop the flooding or reduce it significantly by the use of pumps. Even a comparatively small hole below the waterline admits water at a much higher rate than the capacity of bilge or ballast pumps. All watertight doors, valves, dampers in ventilation shafts and access hatches should be closed to prevent flooding progressing to other compartments. Where cross-flooding arrangements are required, they should be put into operation at once to restrict the resulting list.

In passenger ships, the guidance in the damage control booklet should be followed. The same applies to cargo ships where damage control information is provided.

In nearly all cases, damage will result in sinkage, list and trim, loss of stability and loss of longitudinal strength. Corrective action for one condition will affect the others.

Excessive list or trim should be corrected by moving weights, fuel, water or liquid cargoes, when possible. If ballast is added, it increases the sinkage. In some cases it may be possible to pump out ballast to improve list or trim and lighten the ship at the same time. If the ballast is taken from double-bottom tanks, however, the stability will be further reduced.

Stability may be improved by transferring fuel from wing or cross bunker tanks to double bottoms if suitable tanks are empty. Efforts should be made to reduce free surface to a minimum. Water accumulating in upper decks as a result of firefighting should be drained to the lowest level possible if means of pumping it out of the ship cannot be arranged.

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After collision or stranding damage, particularly near the middle length of the ship, the longitudinal strength will be impaired and account should be taken of that when deciding on the transfer or addition of weights.

Cases have occurred where a slow leakage of water has been absorbed by a cargo, such as grain, with no water reaching the drain wells. The added weight, high on one side of the hold, has led to a steadily increasing list and eventual capsizing. As the source of the leakage was inaccessible, nothing could be done. Cargo spaces should be thoroughly inspected whenever they are empty for signs of leakage, indicating cracks or damage to overside discharge valve covers.

4.1.3 KNOWLEDGE OF IMO RECOMMENDATIONS CONCERNING SHIP STABILITY (2 hours)

Instructors should refer to the IMO publications referenced in the detailed teaching syllabus.

4.2 MONITOR AND CONTROL COMPLIANCE WITH LEGISLATIVE REQUIREMENTS AND MEASURES TO ENSURE SAFETY OF LIFE AT SEA AND THE PROTECTION OF THE MARINE ENVIRONMENT

4.2.1 INTERNATIONAL MARITIME LAW EMBODIED IN INTERNATIONAL AGREEMENTS AND CONVENTIONS (1 hour)

Instructors should note that the following areas are covered in the training at the operational level. Some areas are covered again with emphasis on the responsibilities of management level engineering officers and include:

An introduction to Maritime Law

Safety

- International Convention on Load Lines, 1966, as amended
- International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS) — General Provisions
- SOLAS — Subdivision and stability, machinery and electrical installations
- SOLAS — Fire protection, fire detection and fire extinction
- SOLAS — Life-saving appliances and arrangements
- SOLAS — Safety of navigation
- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978

1.1 Certificates and Other Documents Required to be Carried on Board Ships by International Conventions and Agreements (1 hour)

The management level engineer should be familiar with all the certificates and other documents required by the vessel and by the crew. These will be subject to inspection by both the flag State and by port State control officers. Documents found not to be in order can cause delays on detentions to the voyage.

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Relatively new requirements include the Safety Management Certificate denoting that the company and its shipboard management operate in accordance with the approved safety management system. A copy of the Document of compliance shall also be kept on board the ship in order that the master can produce it for verification.

A complete list of certificates and documents, with reference to which convention it is required, is provided in the detailed teaching syllabus.

The requirements for their issue and renewal are dealt with under the appropriate conventions, except for those mentioned below.

A certificate of nationality, often called the ship's register, is required by the Geneva Convention on the High Seas, 1958, and by the UNCLOS, 1982. The form of certificate and the conditions for its issue are determined by each national government. In some cases it remains valid until the ship is scrapped or changes ownership or nationality, in others it is subject to regular renewal.

The Panama and Suez Canal Tonnage Certificates are included for completeness; they are not required by international conventions. Any ship wishing to traverse either canal must be measured and obtain the appropriate certificate before doing so. In general, they remain valid until alterations to the ship's structure or in the use of spaces are made.

Tonnage

The International Tonnage Certificate remains valid until alterations in construction or the use of spaces are made, the subdivision load line is changed or the ship is transferred to the flag of another State.

The licence for the ship radio station is required by the radio regulations of the ITU. The form of the licence is determined by the national government which issues it.

There are no international agreements requiring a ship to be classed by a classification society, but practically all ships are. Loss of class would be an indication to a port State control officer that a thorough inspection of the ship should be made. Maintenance of class is a condition for the continuance of insurance in many cases.

The form of the official logbook, the entries made in it and its eventual disposal are decided by each Administration.

The documents listed as minimum additional documents required at arrival or departure are those mentioned in the Convention on Facilitation of International Maritime Traffic, the International Health Regulations and the dangerous goods manifest required by SOLAS.

1.2 Responsibilities Under the Relevant Requirements of the International Convention on Load Lines (1 hour)

Instructors should note that the Load Lines Protocol of 1988 entered into force in February 2000. The 1988 Protocol has been modified by the 2003 Amendments which were adopted by MSC.143(77) in June 2003 and entered into force in January 2005.

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1.3 Responsibilities Under the Relevant Requirements of the International Convention for the Safety of Life at Sea (2 hours)

Of all the international conventions dealing with maritime safety the most important is the International Convention for the Safety of Life at Sea, better known as SOLAS, which covers a wide range of measures designed to improve the safety of shipping.

The convention is also one of the oldest of its kind: the first version was adopted in 1914 following the sinking of the SS Titanic with the loss of more than 1,500 lives. Since then there have been four more versions of SOLAS. The present version was adopted in 1974 and entered into force in 1980. Some recent additions are covered in and the 1996 Amendments in R2.

Reference should be made to the International Safety Management (ISM) Code in chapter IX, which sets out the master's responsibility with regard to safety and environmental protection.

1.4 Responsibilities Under the International Convention for the Prevention of Pollution From Ships, 1973, and the Protocol of 1978 Relating Thereto (MARPOL 73/78) (3 hours)

Relatively new additions to maritime law should be noted including MARPOL 73/78 Annex 1, regulation 26 that requires every oil tanker of l50gt and above and every ship other than a tanker of 400gt and above to have a shipboard oil pollution emergency plan (a SOPEP), and amendments to MARPOL Annex V that require garbage management plans to be in place.

Under Annex IV ships are not permitted to discharge sewage within a specified distance of the nearest land, unless they have in operation an approved treatment plant. Between 4 and 12 miles from land, sewage must be comminuted and disinfected before discharge.

Annex VI entered into force on 19 May 2005. It sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone-depleting substances. The instructors should use the topics included in the detailed teaching syllabus, in order to prepare the lesson. The local regulations which may be more stringent than as laid down by Annex VI, pertaining to SECA and ECA, should be pointed out to the trainees.

Pollution

Tanker officers who have had responsibility for loading, discharging and handling cargo will have completed an approved specialized training programme. This includes instruction in pollution prevention relevant to tankers, V2, V79.

Examples of checklists can be found in the references. More extensive checklists are used at many oil installations and include, amongst other things, a list of equipment on board and ashore, whether it is fully operational or not, the communications to be used and emergency procedures. The completed checklists are signed by the responsible persons from the ship and the installation when it is agreed to start the operation.

It is recommended that, whenever possible, disposal of garbage should be made to port facilities. Disposal at sea is strictly regulated by the provisions of the appropriate legislation.

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Records of waste and garbage disposed of at sea must be kept. These records are subject to inspection and checking by port State control officers.

The annexes to the Convention contain the applicable technical regulations. These are:

Annex I — Oil

Annex II — Noxious liquid substances in bulk

Annex III — Harmful substances carried by sea in packaged forms

Annex IV — Pollution by sewage from ships

Annex V — Pollution by garbage from ships

Annex VI — Air pollution from ships and NO_x technical code

1.5 Maritime Declarations of Health and the Requirements of the International Health Regulations (1 hour)

Arrival Documents and Procedures: these are all very practical requirements that have to be followed.

Officers should be aware that many States will require forms and declarations in addition to those mentioned in the FAL and in the International Health Regulations. The ship's agents should be consulted for the current requirements at any port.

1.6 Responsibilities under other international maritime law embodied in international agreements and conventions that impact on the role of management level engineering officers (11 hours)

There are a large number of international agreements and practices that impact on the legal and commercial elements of the role of a management level engineer. It is important that trainees are familiar with the practical implications of the critical parts of these agreements and that they have the ability to be able to find, extract and understand detail from these agreements. Requirement for students to learn detail that in practice would normally be obtained from reference documents should be avoided.

Maritime Labour Convention, 2006

This has been added to this section. The MLC was adopted on 23 February 2006 at International Labour Organization, Geneva, Switzerland but at the time of writing this book, is still awaiting full ratification. Ratification has now been achieved and the convention is about to come into force. MLC is the result of a joint resolution in 2001 by the international seafarers' and shipowners' organizations, later supported by governments.

The Maritime Labour Convention, 2006, aims to establish a continuous "compliance awareness" at every stage, from the national systems of protection up to the international system starting with individual seafarers.

It sets out their rights to decent conditions of work and helps to create conditions of fair competition for shipowners. It is intended to be globally applicable, easily understandable,

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readily updatable and uniformly enforced. The MLC will be another pillar of the international regulatory regime for quality shipping, complementing the key Conventions of the IMO.

The rather large number of the existing maritime Conventions, many of which are not even ratified by several Governments, some totally out of date and not in line with present day situations make it difficult for governments to ratify or enforce them.

MLC is a comprehensive set of global standards, based on 68 existing maritime labour instruments (Conventions and Recommendations), adopted by the ILO since 1920. MLC brings almost all these requirements together incorporating present day conditions and language.

Conventions addressing the seafarers' identity documents which were recently revised in 2003 (Nos. 108 and 185) are not incorporated in the MLC. The Seafarers' Pension Convention, 1946 (No. 71) and one Convention (The Minimum Age [Trimmers and Stokers] Convention, 1921 {No. 15}), which is no longer relevant to the sector, are also not included in the MLC.

MLC should help eliminate substandard ships and it would work within the well-established international system for enforcement of the international standards for ship safety, security and environmental protection that have been adopted by the IMO, in other words fall under PSC inspection systems.

Existing ILO maritime labour Conventions will be gradually phased out as ILO Member States that had ratified those Conventions ratify the MLC, but there will be a transitional period when some parallel Conventions will remain in force. Countries that ratify the MLC will no longer be bound by the existing Conventions when MLC enters into force since it incorporates the requirements of all these old conventions. Countries that do not ratify MLC will remain bound by the existing Conventions they have ratified, but these will be closed to any further revisions.

Ships flying the flags of countries that do not exercise effective jurisdiction and control will have no choice but to observe the minimum criteria enshrined in the MLC and prevent seafarers from having to work under unacceptable conditions, to the detriment of their well-being, health and safety and the safety of the ships on which they work.

MLC is designed on the principle of being "firm on rights and flexible on implementation". This is in line with the Constitution of the ILO and most ILO instruments that seek to take account of national circumstances and provide for some flexibility in their application. The ILO view is to gradually improve protection of workers by taking into account the specific situation in some sectors and the diversity of national circumstances. ILO addresses flexibility on the principles of tripartism, transparency and accountability. When a government exercises flexibility it usually involves consultation with the workers' and employers' organizations concerned, with any determinations that are made reported to the ILO.

Ships of 500 gross tonnage and above, engaged in international voyages or voyages between foreign ports, will be required to carry a 'Maritime Labour Certificate' (MLC) and a 'Declaration of Maritime Labour Compliance' (DMLC) on board. However, most other vessels will also be subject to inspections under MLC; this will get clear on studying the requirements of MLC in detail.

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MLC also incorporates the "no more favourable treatment" concept similar to that adopted in the IMO conventions. That is, ships of all countries (irrespective of ratification) will be subject to inspection in any country that has ratified the Convention, and to possible detention if they do not meet the minimum standards of the new Convention.

In covering the Maritime Labour Convention, 2006, and recommendations, the relevant national laws and regulations or collective bargaining agreements, where applicable, should be dealt with. The administrative procedures involved, e.g. the correct procedures for signing off a sick seaman abroad, the disposal of a deserter's wages and effects or the engagement of replacements abroad and similar procedural matters, should be included in detail. Reference should also be made to arrangements to safeguard the shipmaster in the proper discharge of his responsibilities in regard to maritime safety and protection of the marine environment.

The International Medical Guide for Ships, 3rd edition upholds a key principle of the Maritime Labour Convention, 2006: to ensure that seafarers are given health protection and medical care no less favourable than that which is generally available to workers ashore, including prompt access to the necessary medicines, medical equipment and facilities for diagnosis and treatment and to medical information and expertise. By ensuring that this guide is carried on board ships entitled to fly their flags, and following its instructions, countries can fulfil their obligations under the terms of the Maritime Labour Convention, 2006, and ensure the best possible health outcomes for their seafaring population. The Guide was prepared jointly by ILO and WHO.

Assistance and Salvage

At the request of IMO, the CMI drew up a new draft convention on salvage at Montreal in 1981 to update and revise the 1910 convention. The main new features relate to damage to the environment.

The draft Convention also made provision for special compensation to a salvor in cases where the salvor has carried out salvage operations in respect of a ship or cargo which threatened the environment but has failed to earn a reward for physical salvage. The International Convention on Salvage, 1989, was adopted by a diplomatic conference in March 1989 and entered into force on 14 July 1996.

Lloyd's Standard Form of Salvage Agreement (LOF) is widely used throughout the world.

Special Compensation P and I Club (SCOPIC) Clause, has been added in the detailed teaching syllabus, which is supplementary to any Lloyd's Form Salvage Agreement "No Cure – No Pay" ("Main Agreement") which incorporates the provisions of Article 14 of the International Convention on Salvage 1989 ("Article 14").

Need to Render Assistance

Also that every State must require the master of a ship sailing under its flag, in so far as he can do so without serious danger to the ship, the crew or the passengers, to render assistance to any person found at sea in danger of being lost, to proceed with all possible speed to the rescue of persons in distress if informed of their need of assistance, in so far as such action may be reasonably expected of him, and, after a collision, to render assistance to the other

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ship, her crew and her passengers and, where possible, to inform the other ship of the name of his own ship, her port of registry and the nearest port at which she will call.

Convention on Limitation of Liability for Maritime Claims, 1976 (LLMC 1976)

The LLMC Convention sets global limits to liability. For example, the limit in respect of death or injury of passengers in Article 7 is the global limit for all claims. Each individual claim is subject to the limitation in the Athens Convention.

Classification Societies

Classification societies are independent, normally non-commercial organizations. They were originally established to designate minimum standards on which underwriters could rely before insuring a vessel but have, over the years of their existence, developed into standard-setting institutions for every section of the shipping community. Through their rules for construction and a regime of periodical surveys they are in a position to enhance ship construction and operation. They supervise all stages of the construction or major repairs of a ship, even to the extent of ensuring that the right materials are used. A ship so constructed is assigned a class in accordance with some code.

In order to retain its class, the vessel must be presented for survey at periodical intervals as specified in the rules. Failure to meet these terms or to comply with recommendations issued may result in the suspension or cancellation of its class.

Although it is not a legal requirement to be classed, practically all ships are. It is usually a condition for marine insurance or a maritime mortgage that the ship is classed and is maintained so as to retain her class.

The large classification societies have surveyors stationed at the major ports round the world who, in addition to classification work, carry out statutory surveys required by international conventions under authority delegated to them by national maritime Administrations.

General Average and Marine Insurance

The role of the York-Antwerp Rules in the adjustment of general average is covered in the Marine Claims Handbook, see below. The rules are also included.

1.7 Responsibilities Under International Instruments Affecting the Safety of the Ship, Passengers, Crew and Cargo (3 hours)

Ballast Water Convention, 2004, has been added in the detailed teaching syllabus, all 5 sections should be explained to the trainees. Ballast water exchange must be conducted in accordance with the ship's ballast water management plan, taking into account the recommendations adopted by the IMO.

A new paragraph, 4, has been added with effect from 1 July, 2010 to SOLAS chapter V, regulation 22 – Navigation bridge visibility, some changes are operational and others introduce new requirements applicable to navigation records.

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The instructors should emphasize that as a consequence of this amendment, any increase in blind sectors or reduction in horizontal fields of vision resulting from ballast water exchange operations is to be taken into account by the master before determining that it is safe to proceed with the exchange.

The instructor should also point out to the trainees that as an additional measure, to compensate for possible increased blind sectors or reduced horizontal fields of vision, the master must ensure that a proper lookout is maintained at all times during the exchange.

Trainees should be familiar with the organization and both the effect and coverage of port State control.

1.8 Methods and Aids to Prevent Pollution of the Marine Environment by Ships (2 hours)

This covers the following IMO conventions:

- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention)
- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969
- International Convention on Civil Liability for Oil Pollution Damage, 1969
- International Convention for the Prevention of Pollution from Ships, 1973, and the Protocol of 1978 relating thereto (MARPOL 73/78) has been covered earlier.

1.9 National Legislation for Implementing International Agreements and Conventions (1 hour)

Instructors should develop their own objectives here to ensure that national legislation, that is the flag State laws, are covered to an extent that meets or exceeds the standards laid down in the international conventions, codes and agreements. Emphasis should be on monitoring compliance, identifying areas where there may be potential for non-compliance or differences compared to international standards.

4.3 MAINTAIN SAFETY AND SECURITY OF CREW AND PASSENGERS AND THE OPERATIONAL CONDITION OF SAFETY SYSTEMS

4.3.1 KNOWLEDGE OF LIFE-SAVING APPLIANCE REGULATIONS (2 hours)

The requirement of the STCW Convention is covered by IMO model course 1.23, Proficiency in survival craft and rescue boats other than fast rescue boats. 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 concerning life-saving.

The obligations and responsibilities of the master under the requirements of the life-saving appliance regulations of the International Convention for the Safety of Life at Sea, 1974, as amended, are dealt with in the subject, Maritime Law, of this course.

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4.3.4 ACTIONS TO BE TAKEN TO PROTECT AND SAFEGUARD ALL PERSONS ON BOARD IN EMERGENCIES (4 hours)

SOLAS Regulations list the duties related to passengers which must be assigned to members of the crew. These duties would usually be so arranged that each member of the catering staff would be responsible for a group of rooms. A small party would be charged with taking additional supplies to the lifeboats.

4.3.5 ACTIONS TO LIMIT DAMAGE AND SALVE THE SHIP FOLLOWING A FIRE, EXPLOSION, COLLISION OR GROUNDING (4 hours)

1. Means of Limiting Damage and Salving the Ship Following a Fire or Explosion

No definite procedures can be laid down as each occurrence will be unique. Trainees should consider the measures which could be taken in a variety of situations, using materials to be found aboard ship.

It is important to keep observation on damaged areas and temporary repairs, to ensure that there is immediate warning of a worsening situation.

2. Procedure for Abandoning Ship

A ship should not be abandoned prematurely. It is generally safer to remain aboard a wreck, to await the arrival of assistance, for as long as possible. This is particularly true in severe weather conditions, when abandoning ship is very hazardous and the condition of the crew will deteriorate rapidly in survival craft. Also, in those conditions, craft are likely to become widely dispersed, making rescue more difficult.

When the condition of the ship is such that sinking or breaking up is inevitable, the ship should be abandoned in time to get clear of her before she sinks or before wreckage makes the launching of survival craft dangerous. In the event of fire or explosion or of the release of toxic fumes it may be essential to get clear of the ship as quickly as possible.

Consideration should be given to the method of passing the ‘abandon ship’ signal. It should be distinctive, so that it is not confused with other signals or instructions which may be given in an emergency. The instruction to abandon ship may have to be given by word of mouth if other communication systems have broken down.

The duties of the emergency party should include provision for the shutting down of any machinery, as required.

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4.4 DEVELOP EMERGENCY AND DAMAGE CONTROL PLANS AND HANDLE EMERGENCY SITUATIONS

4.4.1 PREPARATION OF CONTINGENCY PLANS FOR RESPONSE TO EMERGENCIES (9 hours)

Contingency plans for response to emergencies

Given a brief description of a ship and a crew list, trainees should be able to divide the crew into appropriate emergency teams and draw up the muster list and emergency instructions. Instructions should cover general emergency and fire stations separately

Plans for dealing with fires in specific areas should be considered. Actual plans would depend upon the construction and arrangement of a particular ship, but principles such as containment of a fire, escape routes, access for fire fighters and the medium to be used can be dealt with. Trainees should be reminded that drills at sea should put these plans into action and that a different location for the fire should be chosen at each practice. It may be found that the plans need revising in the light of practice drills (V29).

Similarly, boat drills should sometimes be organized on the assumption that certain survival craft have been destroyed or are not usable for some reason.

The ship safety committee should be involved in the organization of emergency drills and the evaluation of the plans in the light of those drills. Representatives can bring any difficulties or deficiencies to the attention of the committee and suggest solutions to the problem. The committee can increase awareness of the actions required from crew members through their representatives.

The control centre for the command team in port should normally be at main deck level, at a location suitable for liaison with shore authorities. It should have a shore telephone connection and have emergency equipment and information stored there ready for use.

4.5 USE OF LEADERSHIP AND MANAGERIAL SKILLS

The detailed syllabus for this section builds on the content of IMO model course 1.39, Leadership and teamwork. Many of the concepts introduced in this course are developed further to consider a more senior management perspective to these concepts.

4.5.1 SHIPBOARD PERSONNEL MANAGEMENT AND TRAINING

Officers will have different experiences of personnel management. As officers in charge of a watch they will also have had to exercise their authority. They will therefore recognize and understand many of the learning objectives. It should be possible to build on this and use their prior experience to the maximum to improve their knowledge and ability to cope with seagoing and other personnel such as pilots, ship agents, ship repairers and other shore staff.

There should also be a good opportunity to establish useful facts on the varying conditions of employment experienced by the group of trainees and perhaps to learn something of the

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advantages and disadvantages of the various systems which the trainees might find to be helpful in the course of their duties.

If time permits, the trainees should be given group assignments to recreate and learn how to deal with some of the typical arguments and problems which occur on board ship.

Personnel Management **(10 hours)**

Management level deck officers have significant responsibility for the management of personnel on board ship. It is important that these officers are aware of national law and the detail of employment agreements that relate to personnel on board. It is equally important, however, that senior officers are able to motivate and manage the performance of personnel as well as dealing with disciplinary situations

Training **(6 hours)**

Organization and management skills are best learnt through teamwork activities and case studies. As much time as possible should be devoted to this aspect. Role playing exercises may be designed in communications, meetings, organizing drills and training sessions, to name but a few areas (T37). This is an important part of the course as it involves teaching various subjects to the trainees so that they, in due course, have the capability to train staff on board in the same subjects in order to improve safety and operational standards. There is scope in this section to use role playing and group assignments for some aspects of this training.

Nearly all of the training undertaken aboard ship will be on-the-job training, i.e. the trainee uses the normal ship's tools, equipment and materials during the ordinary running of the ship. Off-the-job training will probably be restricted to the use of video cassettes.

For trainee watchkeepers the STCW Convention requires that an approved programme of on-board training is supervised and monitored and is adequately documented in a training record book (STCW Code, section A-II/1, paragraph 6). An example of one such book is that produced by the International Shipping Federation. Extensive guidance regarding training is given in the STCW Code, section B-II/1.

Purpose of Training

All training is intended to modify attitudes, to increase skills or to provide knowledge which can be applied by the trainee in carrying out his work. The desired outcomes include a reduction in accidents, less need for supervision, greater productivity and improved quality of work. A thorough mastery of a task and a knowledge of its relevance to other tasks in the running of the ship also increase the job satisfaction of the crew member concerned.

Preparation

Before starting training, the instructor should prepare what he wishes to teach, decide the order of the instruction and make a note of the important points to be emphasized. Any tools or materials which are needed should be ready to hand and equipment, such as video players, should be tested to ensure that it is working.

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Methods of Training

For training to be effective, the trainee must be able to see that it is relevant to him and his work or duties on the ship. The instructor should question the trainees before starting to establish what they already know and can do and to explain why the task is necessary.

Nearly all on-board training is of an informal nature, often one-to-one, so trainees should be encouraged to ask questions or have demonstrations repeated, if necessary, during the training. The instructor should also question or test the trainees at suitable intervals to make sure that they have understood, or are able to perform the skill being taught, up to that point. Where appropriate, provide the trainee with a written note to support the tuition.

Changing Attitudes

An attitude is an individual's habitual mode of responding to an object or situation. Attitudes are developed by experience within social groups, including those of the work place, and may become firmly implanted. To produce a change of attitude by training is therefore difficult and cannot be done quickly.

A crew member may know the correct safe working practice to adopt for a particular task and yet ignore it when not being directly supervised. The necessary insistence on following safe working practices will not necessarily change a careless attitude to safety. A discussion of the consequences to himself and his family of an accident resulting in permanent disablement might be more effective. Officers should remember that their own attitudes and behaviour help to form those of trainees and new entrants, who will not develop desirable attitudes to required standards if their seniors do not adopt them or if they ignore breaches of them by others.

Training in Skills

On-the-job training usually consists of pulling the trainee to watch and work with an experienced person (e.g. a cadet, watchkeeping with a qualified officer). This arrangement fails if the experienced person uses incorrect methods in his work.

In teaching a particular skill, such as a manual task, the instructor should divide the task into self-contained stages, each of which can be taught as a unit. He should identify any critical points at each stage. The job is demonstrated and explained to the trainees in stages, with emphasis on the critical points. The trainee then carries out the job under the supervision of the instructor. Stages are repeated as necessary until the trainees' performances are satisfactory.

Training in Knowledge

In the majority of cases aboard ship this will involve an officer or petty officer describing equipment or a particular task to others, for example, instruction in how to launch an inflatable liferaft and board it, and how to survive when in it. Trainees should be encouraged to participate in the instruction by asking questions or making suggestions. Sufficient questions should be directed to trainees to test that the necessary knowledge is being transferred.

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Knowledge which is not often used (how to survive in a liferaft, for example) is forgotten with the passage of time, hence the necessity for repeating such instruction at intervals.

Each trainee should deliver a short training session (about 10 minutes would be sufficient) to the other members of the class. Subjects drawn from those which would be undertaken aboard ship, should be assigned to the trainees well in advance to allow them ample time for preparation.

4.5.2 RELATED INTERNATIONAL MARITIME CONVENTIONS AND NATIONAL LEGISLATION (4 hours)

It is suggested that where national legislation implementing an international agreement or convention exists, both the national legislation and the international requirements are taught together. For example, a topic could be treated by dealing with the national legislation, including the administrative details necessary for the master to carry out his duties effectively, and making reference to the relevant sections of the international agreement or convention on which the national regulations are based.

In addition to the national laws implementing the international conventions and agreements, the following areas of concern to a ship's master, not touched upon in the syllabus, are mentioned:

- a review of the national system of courts, hearings and appeals
- the procedures for preliminary enquiry and formal investigation of accidents
- contracts of towage
- the carriage of the official logbook, entries and surrender of the logbook at the completion of a voyage
- crew disciplinary procedures, powers and obligations of the master
- the master's disciplinary powers concerning passengers
- calculation of crew wages, rules concerning allotment of wages, deductions of tax and social security contributions, advances, fines, forfeitures, other deductions and payment of the balance
- collective bargaining agreements between seafarers' and shipowners' organizations affecting the employment of crew

4.5.3 APPLICATION OF TASK AND WORKLOAD MANAGEMENT (8 hours)

The importance of identifying fatigue should be emphasized by the instructors. Overload situations can have catastrophic results; the instructors should include case studies involving fatigue, as the major reason for the accident/incident.

Personnel Assignment, time and resource constraints and prioritization should be explained to the trainees. Providing opportunities for trainees to apply principles by planning complex typical shipboard activities either individually or in groups will enhance learning and the outcomes for trainees.

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4.5.4 EFFECTIVE RESOURCE MANAGEMENT (10 hours)

This content is intended to build on the learning of trainees through operational level training and experience. The structure follows the concepts from IMO model course, Leadership and teamwork but develops these to a management level.

Trainees are likely to enhance their learning where they are able to participate in group discussion and practical group activities where the principles of effective resource management can be applied and developed.

4.5.5 DECISION-MAKING TECHNIQUES (7 hours)

Situation and risk assessment, Identifying and Generating Options, Selecting Course of Action and evaluating the outcome effectiveness are covered under this topic.

4.5.6 DEVELOPMENT, IMPLEMENTATION AND OVERSIGHT OF STANDARD OPERATING PROCEDURES (1 hour)

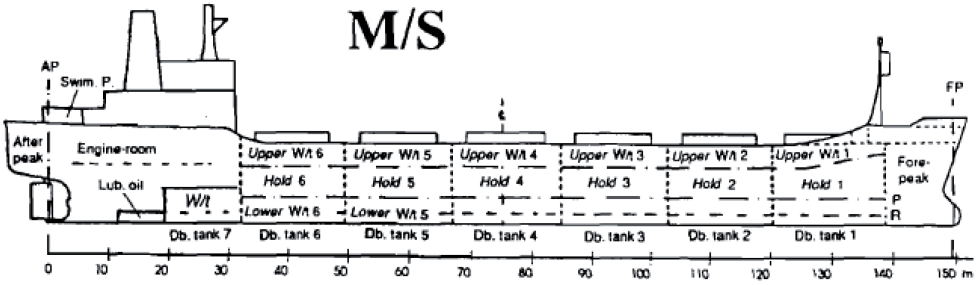
Instructors should explain the methods of developing and implementing standard operating procedures (SOPs) and the reason and dangers of oversighting these procedures. Case studies should be used by the instructors, highlighting these topics.

INTERNATIONAL MARITIME ORGANIZATION
IMO PUBLISHING

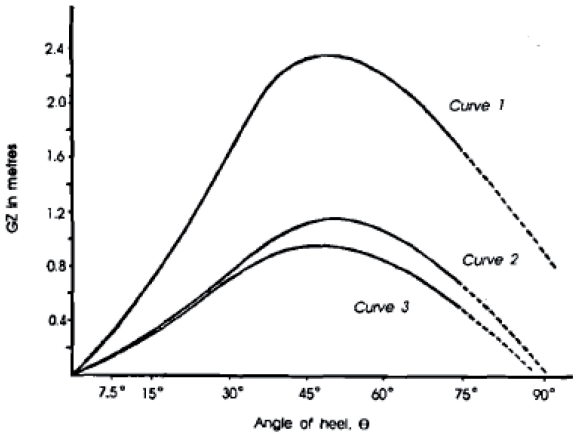
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Appendix 1

Stability Data



Curves of statical stability



Curve	Condition	Cargo	*H.O.*	*D.O.*	Stores
1	Ballast	–	695.6	155.3	150
2	Load 1	14 894.3	250.0	53.5	150
3	Load 2	16 040.0	200.0	51.2	150

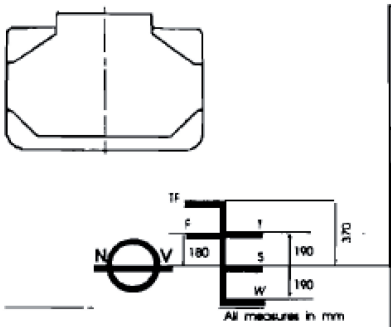
Curve	*F/W*	Ballast	*L/S*	Δ
1	263.3	5070.5	4895	11 229.7
2	104.8	672.4	4895	21 020
3	104.8	–	4895	21 441

Curve	KG	GG_1	Corrected KG	GM
1	6.54	–	6.54	2.56
2	7.113	0.043	7.156	1.484
3	7.320	0.043	7.363	1.307

Capacities in tanks	Volume in m^3	Weights in tonnes					Centre of Gravity		Free surface $I = \frac{l \times b^3}{12}$ m^4
		Lub. oil (ρ = 0.9)	Diesel oil (ρ = 0.9)	Fuel oil (ρ = 0.95)	Fresh w. (ρ = 1.0)	Ballastw. (ρ = 1.02)	VCG (metres)	From AP (metres)	
Forepeak	268.4					275.1	7.28	142.77	67
Db. tank No. 1	2 × 214.0					438.7	1.49	128.44	495
Db. tank No. 2	2 × 296.0					606.8	1.19	110.64	2757
Db. tank No. 3	2 × 328.0					672.4	1.13	93.39	2936
Db. tank No. 4	2 × 328.0					672.4	1.13	75.80	2936
Db. tank No. 5	2 × 191.3			363.5		392.2	0.76	58.22	1094
Db. tank No. 6	2 × 174.8			332.1		358.3	0.76	40.78	785
Db. tank No. 7	2 × 86.3		155.3				1.34	24.69	81
Lower W/t. No. 5	2 × 136.1					279.0	1.76	58.46	81
Lower W/t. No. 6	2 × 100.8			191.5		206.6	1.89	40.63	55
W/t. Eng. Room	2 × 145			275.5			4.88	26.79	120
Upper W/t. No. 1	2 × 149.5					306.1	11.57	127.41	152
Upper W/t. No. 2	2 × 204.8					419.8	11.25	110.98	393
Upper W/t. No. 3	2 × 204.8					419.8	11.25	93.39	393
Upper W/t. No. 4	2 × 204.8					419.8	11.25	75.80	393
Upper W/t. No. 5	2 × 204.8					419.8	11.25	58.22	393
Upper W/t. No. 6	2 × 204.8					419.8	11.25	40.60	393
After-peak	158.5				158.5		7.98	3.44	206
Swim. pool	32				30	30.8	21.86	2.20	24
Freshw. tank	2 × 52.4				104.8		11.40	5.27	83
Daily diesel tank	52.2		47.0				10.76	15.00	39
Daily fuel oil tank	71.1			67.5			10.82	11.22	102
Diesel oil tank	6.0		5.4				13.99	28.53	1
Lub. oil tank	40.0	36.0					10.76	29.81	4
Lub. oil tank	2 × 20.8	37.4					0.67	20.60	20
Total:			207.7	1230.1	293.3	6307.1			

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Loading Scale



TF	17039	tonnes	deadweight at	9.35 m
F	16538	"	"	" 9.16 m
T	17057	"	"	" 9.17 m
S	16546	"	"	" 8.98 m
W	16037	"	"	" 8.79 m

Ships data

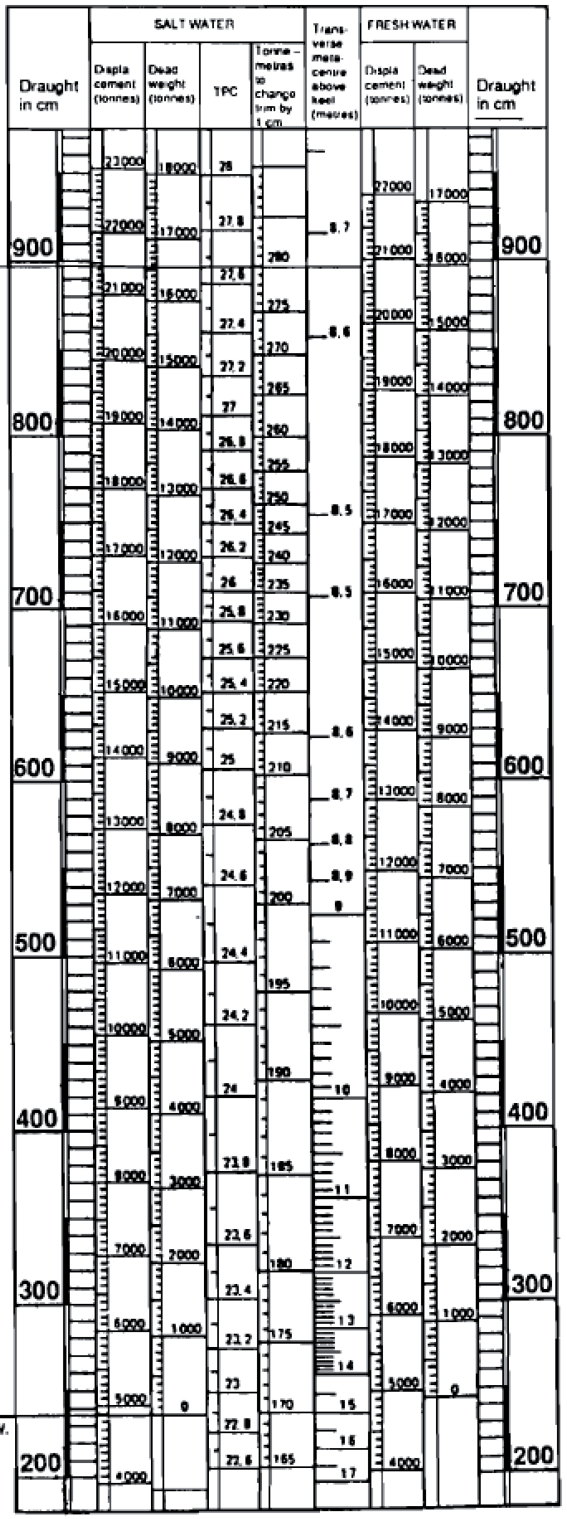
LOA = 159.4 m
LBP = 149.35 m
B = 20.4 m
D = 12.5 m
Gross = 11 182 tonnes
Net = 5 971 tonnes
Δ (s) = 21 441 tonnes
C_b (s) = 0.765

Light ship:

Displacement 4 895 tonnes
Draught F 0.25 m, A 4.62 m, M 2.43 m
VCG 7.8 m
LCG from AP 61.587 m

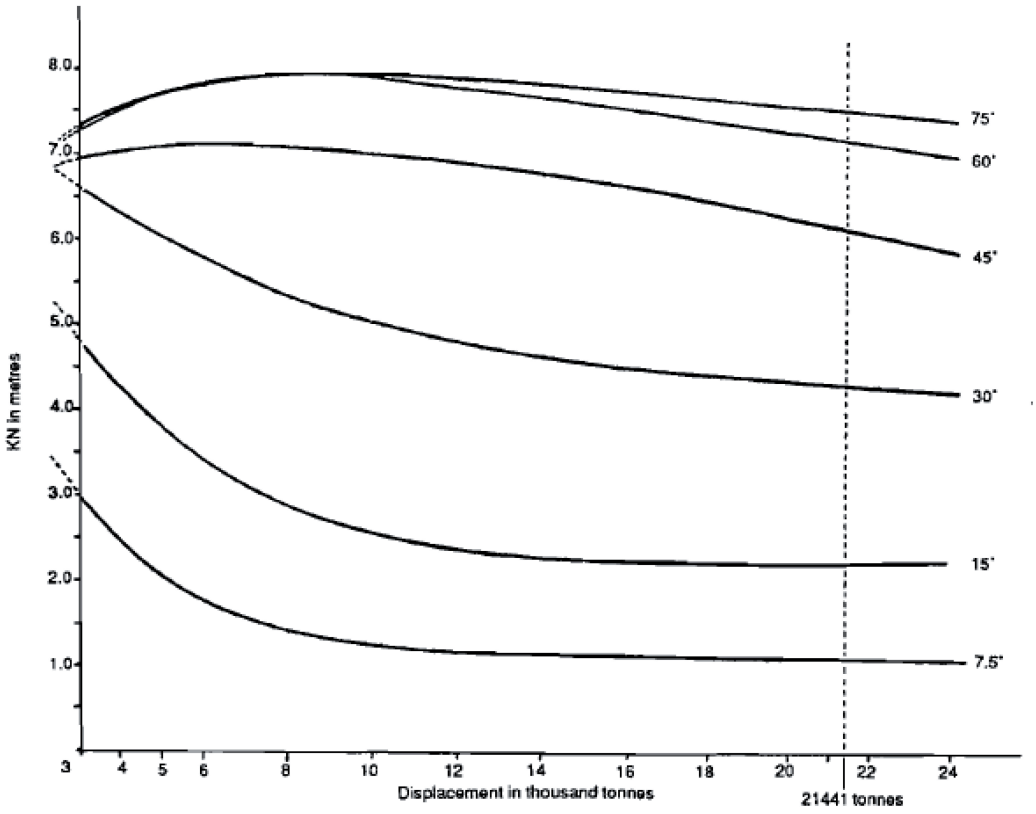
Cargo holds:

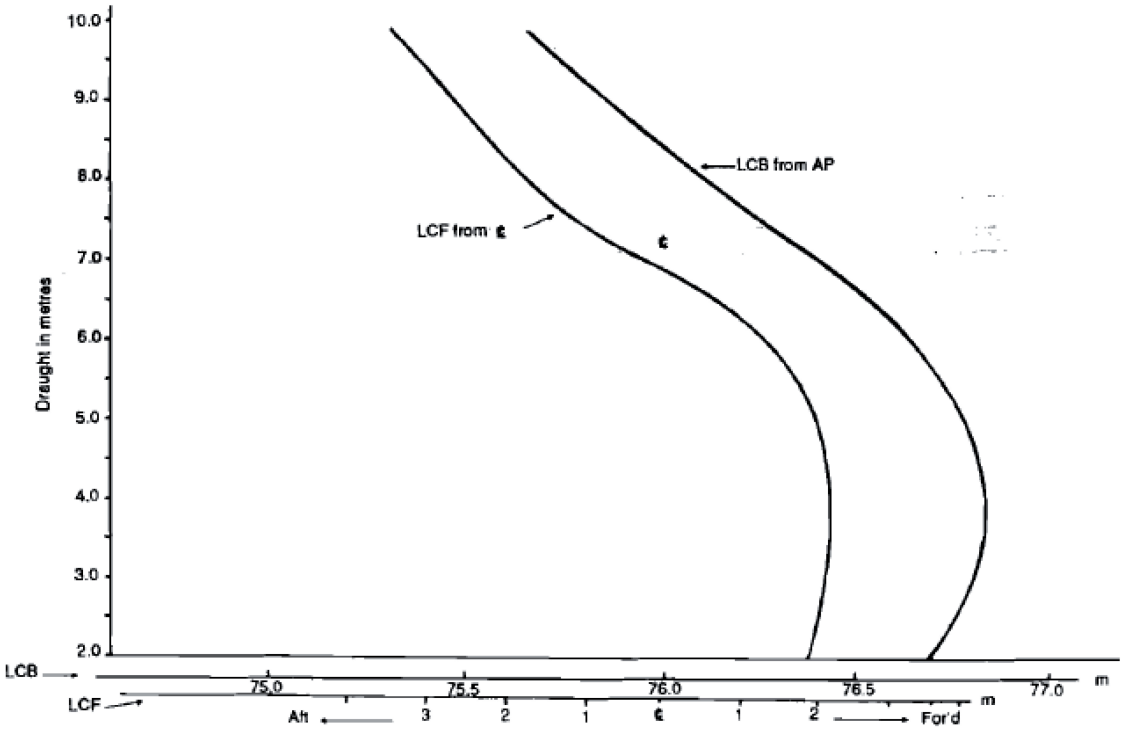
Hold No.	Volume (m^3)		Centre of Gravity	
	Grain	Bales	VCG (m)	from AP (m)
1	2 919	2 761	7.83	128.32
2	3 577	3 435	7.14	111.43
3	3 607	3 465	7.13	93.88
4	3 607	3 465	7.13	76.29
5	3 603	3 460	7.13	58.73
6	3 539	3 430	7.19	41.09
Total:	20 852	20 017		



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KN Curves



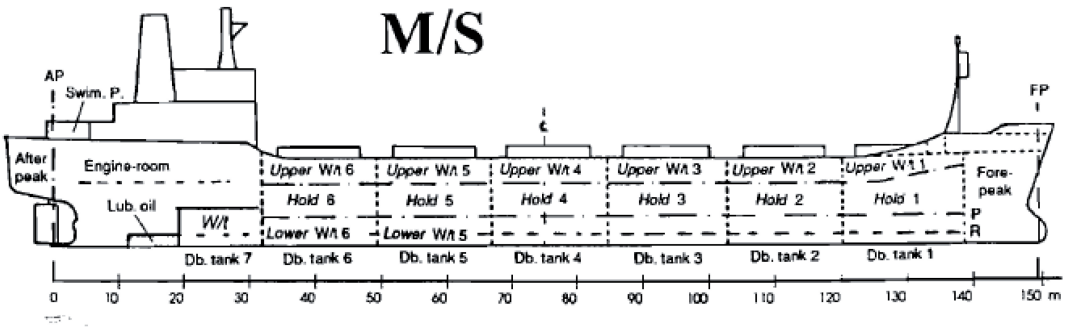


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Appendix 2

Trim Table

Tables of changes in centimetres of draught forward and aft for each 100 tonnes loaded.



3.0m Draught

F	−16	−13	−10	−6	−1	+4	+9	+14	−18	+23	F
A	+26	+22	+19	+15	+10	+5	0	−6	−11	−15	A

6.0m Draught

F	−15	−10	−8	−4	0	+4	+8	+12	+16	+20	F
A	+23	+19	+17	+13	+8	+4	0	−4	−9	−12	A

9.0m Draught

F	−9	−7	−5	−2	+1	+4	+7	+11	+14	+17	F
A	+15	+13	+12	+9	+6	+3	0	−3	−6	−9	A

Example – Find the draughts after loading 250 tonnes in No. 2 hold.

Initial draught forward 5.76 m	aft 6.38 m		
Correction	+0.30	−0.10	$\left(\frac{250}{100} \times \text{tabulated values}\right)$
New draught	6.06 m	6.28 m	

Notes 1. Interpolation can be used for intermediate draughts.

2. Reverse the signs of the corrections for discharged weights.

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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 towards a course or qualification.

Evaluation/assessment can also be used:

- To assist trainee learning.
- To identify trainees' strengths and weaknesses.
- To assess the effectiveness of a particular instructional strategy.
- To assess and improve the effectiveness of curriculum programmes.
- To assess and improve teaching effectiveness.

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

■ Initial/Diagnostic assessment

This should take place before the trainee commences a course/qualification to ensure they are 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 during an individual or group setting by the use of relevant tests.

■ Formative assessment

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

Purpose of formative assessment

- To provide feedback to trainees.
- To motivate trainees.
- To diagnose trainees' strengths and weaknesses.
- To help trainees to develop self-awareness.

■ Summative assessment

It is designed to measure 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.

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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 should all 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.
- Simulations (also refer to section A-I/12 of the STCW Code 2010).
- CBT.

■ Validity

The evaluation methods must be based on clearly defined objectives, and they must truly represent what is meant to be assessed, for example 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 you receive similar results). We may have to deliver the same subject to different groups of learners at different times. If other assessors are also assessing the same course/ qualification as us, we need to ensure we are all 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.

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If the instructors are going to assess 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 assignments, tests or examinations.

The instructors need to consider the best way to assess the skills, knowledge and attitudes of our learners, whether this will be formative and/or summative and how the assessment will be valid and reliable.

All work assessed should be valid, authentic, current, sufficient and reliable; this is often know 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 job at sea.

■ STCW Code

The training and assessment of seafarers, as 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/2 (Specification of minimum standard of competence for chief engineer officers and second engineer officers on ships powered by main propulsion machinery of 3,000 kW propulsion power or more) of 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 the instructors, some extracts from the model course is used to explain in depth.

When evaluation consists of calculations, the following should be taken into consideration:

■ Calculations

To carry out their duties, chief engineer officers and second engineer officers must be able to solve technical problems by performing calculations in various subject areas such as cargo work, ship stability and navigation calculations.

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The ability to perform such calculations and to resolve such problems can be tested by having the candidates carry out the calculations in their entirety. Since a large variety of technical calculations is involved and the time necessary for their complete solution is considerable, it is not possible to completely test the abilities of candidates within a reasonable examination time.

Resort must therefore be made to some form of sampling technique, as is the case with the assessment of knowledge, comprehension and application of principles and concepts in other subject fields.

In examinations conducted on a traditional essay-type basis, the sampling technique that is applied in respect of calculation requirements is to attempt to cover as much of the subject area as possible within the examination time available. This is frequently done by using questions involving shorter calculations and testing in depth on one or two topics by requiring the completion of more complex calculations. The employment of this 'gross sampling' technique reduces the reliability of the examination as compared with what can be achieved with a more detailed sampling technique.

A greater breadth of sampling can be achieved by breaking down calculations into the various computational steps involved in their solution. This technique can only be applied to calculations in which the methodology is standardized. Fortunately, most calculations follow a standard format; where alternative methods of solution exist, the examination can be developed so as to allow candidates an appropriate freedom of choice. Such freedom of choice must be a feature of examinations of all types, in any event.

In order to develop a series of 'step test items', covering an entire calculation, it is necessary to identify each intermediate step in each calculation involved by all methods which are accepted as being correct in principle. These questions, after they have been reviewed for clarity and conciseness, form the standard 'step test items' in that calculation topic.

This approach allows questions to be posed which sample the candidate's knowledge and ability to perform parts of various calculations, which process takes up less time than having him perform entire calculations. The assumption is made that if the candidate can or cannot correctly complete a calculation step leading to the solution, then he can or cannot successfully carry out the entire calculation. Such detailed sampling allows a larger number of questions to be answered by the candidate within the time allotted for the examination, thus allowing a broader sampling of the candidate's knowledge and abilities, thereby increasing the reliability of the examination.

It must be pointed out that because of the greater number of test items used more time will be spent by candidates in reading the questions and in appreciating the precise step which each question involves.

However, the ability to answer correctly questions that are based on each intermediate step leading to the solution does not necessarily indicate competence in the application of the calculation methodology nor in the interpretation of the intermediate or final results. Further questions must therefore be developed which are of a 'procedural' and principle nature.

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Such ‘step test’ and ‘procedural’ items may be drawn up as ‘essay-type’ items, supply-type items or multiple-choice items. Marking or scoring is easier if multiple-choice test items are used, but in some cases difficulties may arise in creating plausible distracters.

Detailed sampling can allow immediate identification of errors of principle and those of a clerical nature. It must be emphasized that this holds true, in general, only if the test item is based on a single step in the overall calculation. Multiple-choice items involving more than one step may, in some cases, have to be resorted to in order to allow the creation of a sufficient number of plausible distracters, but care must be exercised to ensure that distracters are not plausible for more than one reason if the nature of the error made (and hence the distracter chosen) is to affect the scoring of the test item.

■ 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 sociological 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 candidate’s comprehension of principles, concepts and methodology; his ability to apply principles, concepts and methodology; his ability to organize facts, ideas and arguments and his abilities and skills in carrying out those tasks he will be called upon to perform in the duties he 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.

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SCORING TESTS

Scoring subjective tests

The assessment of seafarers is concerned with judging whether they are competent, in terms of meeting sufficient specified learning objectives, to perform the tasks required by the qualification they are seeking. That is, they should be tested against predetermined criteria rather than against the performance of other examinees or the norm for the group as a whole, as is the case in many examinations.

To achieve that end in subjective tests, an analytical scoring scheme should be drawn up in which a complete model answer, which would attract full marks, is produced for each question. The model answer is then analysed for the definitions, facts, explanations, formulae, calculations, etc., contained in it and marks are allocated to each item, the aim being to make the scoring as objective as possible. A subjective element will still exist in the original allocation of marks to the various sections and, to some extent, in the scoring of incomplete or partially correct sections.

Either credit scoring or deductive scoring may be used. In credit scoring, marks are awarded, in accordance with the scoring scheme, for each correctly completed part of the answer, no marks being credited for incorrect parts or omissions. With deductive scoring, marks are deducted for errors and omissions from the total mark for the question or part question (where a question has been divided into two or more sections). When applied to essay questions, the two methods should produce virtually the same score. Deductive scoring is usually confined to the marking of calculations.

Deductive scoring can be weighted to take account of the relative seriousness of different types of error. Errors are commonly classed and weighted as follows:

.1 errors of principle; for example, using the formula for righting moment in a calculation of list; deduct 50% of the mark for the question or part question;

.2 major errors; for example, extracting data for the wrong day or time from a publication; deduct 30% of the mark for the question or part question; and

.3 clerical errors; for example, transposition of numbers from tables or question paper, careless arithmetic; deduct 10% of the mark for the question or part question for each error.

In the case of clerical errors, only one deduction for a single error should be made. No deductions are made for incorrect answers which follow through from the original error. If deductions exceed the total mark for a question or part question it is given a zero score; negative scores are not carried over to other parts.

The different types of error can be taken into account in credit scoring schemes by suitably weighting the marks allocated to method, to the extraction of data and to clerical accuracy at each step of the calculation. The steps need to be smaller and more detailed than the division into parts used in deductive marking. As a result, the marks lost for errors of principle tend to be smaller in credit scoring than in deductive scoring.

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A small percentage of the total mark, to be credited only for the correct final answer, is sometimes included in a credit scoring scheme. The answer must lie within stated accuracy limits to qualify for that credit. In deductive schemes, an answer that has otherwise been correctly calculated but which falls outside the accuracy limits is treated as a clerical error.

Where tests are to be marked locally at more than one test centre, a well-defined scoring scheme, which will give the same score when applied to the same paper by different markers, is essential for the uniform and fair treatment of candidates. To aid in any subsequent review of marks, possibly resulting from an appeal, the marker should make brief marginal notes on the paper to indicate the reasons for deductions.

Guidance on the treatment of answers produced by pocket calculators is needed. Examination rules usually warn candidates that all working must be shown to gain full marks for a question. The marks to deduct when insufficient working is shown but a correct answer is produced, or when all working is correctly shown but the answer is wrong, need to be known by the marker.

In papers in which all questions are to be answered, the marks may be weighted to reflect the importance or difficulty of individual questions or the length of time which will be needed to answer them. When this is done, it is usual to indicate the mark for each question on the question paper. Optional questions should all be of similar standard and carry equal marks, so that the standard of the complete test is the same regardless of the questions chosen.

Use can be made of a compulsory and an optional section in the same paper. Questions on which it is felt that all candidates should be tested can be placed in the compulsory section and suitably weighted, while the remainder of the paper offers a choice of questions each of similar standard.

A problem that arises with optional papers is how to deal with cases where more than the required number of questions is answered. Various solutions are adopted by different examining boards. Many mark all questions and discard the lowest marked question or questions, although that fact is not generally advertised as it may encourage candidates to attempt extra questions. Others take the requisite number of answers in the order in which they are on the question paper and ignore the remainder. A similar problem arises in papers in which candidates are required to answer a given number of questions and including at least some stated number from each of several sections.

The pass mark should be set at the lowest score for which sufficient skills and knowledge are demonstrated for competency in each subject. In practice, that score is difficult to determine exactly for an individual paper and could vary slightly from one examination to another. Such an arrangement would be difficult to administer and would be considered unfair by candidates, so the pass mark is fixed and published in the examination regulations. It is, therefore, essential when preparing papers to maintain as constant a standard as possible, such that the pass mark is an appropriate measure of competency.

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The following instructions are typical of those produced for guidance of examiners on the marking of examinations:

In order to achieve uniformity in marking between the examiners in various centres and to facilitate the review of papers, the following guidelines are to be used at all centres:

.1 When several candidates write the same examination, papers, other than multiple choice, should be marked question by question, that is to say, question 1 of paper 1 should be marked for all applicants before proceeding to question 2, etc. This gives more uniform marking.

.2 All questions should be marked even if it becomes apparent that the candidate cannot achieve the pass mark.

.3 Neatness and Orderly Layout of Work:

Where work is not properly laid out or is not neat, marks should be deducted without regard to correctness of the answer. The number of marks deducted should vary according to the quality of the work up to a maximum of 10% where the correct answer is obtained.

.4 Important Engineering and Technical Terms:

Where, in general calculations or general questions, an incorrect term is used and such a term is incidental to the work, the examiner should exercise his judgement as to whether or not marks should be deducted, but in any case, a deduction should not exceed 10% of the allotted marks. This does not apply to direct answers involving definitions or in answers involving the naming of parts.

.5 Types of Errors:

Errors can be divided into 3 types:

(a) P – error in principle; 50% of marks allotted for the whole or part of the question should be deducted.

(b) C – clerical error; 10% of the marks allotted should be deducted for each such error.

(c) M – major error; 30% of the marks allotted for the question or part of the question should be deducted.

Note: Large mark questions should be considered in their main sections and percentages of the sections deducted. Candidates should be given the benefit of any doubt which may exist.

.6 Drawings:

Too much importance should not be attached to elaborate drawings. Often a simple sketch with captions is very explanatory and indicative of a good understanding.

.7 Incomplete answers:

Where a problem or distinct section of a large problem is only partly worked and a step of principle remains to be made, marks allotted should not exceed 50% of the total marks or the split marks allotted as the case may be.

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MARKING PAPERS:

.8 When marking papers, examiners should enter appropriate marginal notes in brief showing why marks have been deducted, using abbreviations in Paragraph 5. The actual error should be ringed and marked with a brief statement of the reason for the error, e.g., 'wrong answer'. A paper should be so marked that any reviewing examiner can see at a glance just what happened, including a marginal note to indicate award of a 'benefit of doubt'.

.9 In the case of marginal failure, the paper concerned should be carefully reviewed. This review is not to be regarded as having the purpose of passing the candidate; it is to ensure that the foregoing marking standards have been correctly applied and are consistent with those of other responses to the same examination. It may result in either an increase or a decrease in marks assigned. This review having been completed, the examiner should issue a fail result if it is still below the pass mark.

.10 Use of calculators:

When a pocket, non-programmable calculator is used by a candidate in an examination, all necessary formulae and transpositions must be shown for full marks to be allotted. In the case of a correctly set out answer, or partial answer, which has an incorrect final result, 30% of the whole or part should be deducted on the major error rule.

When the evaluation consists of oral and practical tests, which many topics as per the table A-III/2, 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.

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Part 1: Preparation

1. Introduction

1.1 The success of any enterprise depends heavily on sound and effective preparations.

1.2 Although the IMO model course "package" has been made as comprehensive as possible, it is nonetheless vital that sufficient time and resources are devoted to preparation. Preparation not only involves matters concerning administration or organization, but also includes the preparation of any course notes, drawings, sketches, overhead transparencies, etc., which may be necessary.

2. General considerations

2.1 The course "package" should be studied carefully; in particular, the course syllabus and associated material must be attentively and thoroughly studied. This is vital if a clear understanding is to be obtained of what is required, in terms of resources necessary to successfully implement the course.

2.2 A "checklist", such as that set out in annex A1, should be used throughout all stages of preparation to ensure that all necessary actions and activities are being carried out in good time and in an effective manner. The checklist allows the status of the preparation procedures to be monitored, and helps in identifying the remedial actions necessary to meet deadlines. It will be necessary to hold meetings of all those concerned in presenting the course from time to time in order to assess the status of the preparation and "troubleshoot" any difficulties.

2.3 The course syllabus should be discussed with the teaching staff who are to present the course, and their views received on the particular parts they are to present. A study of the syllabus will determine whether the incoming trainees need preparatory work to meet the entry standard. The detailed teaching syllabus is constructed in "training outcome" format. Each specific outcome states precisely what the trainee must do to show that the outcome has been achieved. An example of a model course syllabus is given in annex A2. Part 3 deals with curriculum development and explains how a syllabus is constructed and used.

2.4 The teaching staff who are to present the course should construct notes or lesson plans to achieve these outcomes. A sample lesson plan for one of the areas of the sample syllabus is provided in annex A3.

2.5 It is important that the staff who present the course convey, to the person in charge of the course, their assessment of the course as it progresses.

3. Specific considerations

3.1 Scope of course

In reviewing the scope of the course, the instructor should determine whether it needs any adjustment in order to meet additional local or national requirements (see Part 3).

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3.2 Course objective

.1 The course objective, as stated in the course material, should be very carefully considered so that its meaning is fully understood. Does the course objective require expansion to encompass any additional task that national or local requirements will impose upon those who successfully complete the course? Conversely, are there elements included which are not validated by national industry requirements?

.2 It is important that any subsequent assessment made of the course should include a review of the course objectives.

3.3 Entry standards

.1 If the entry standard will not be met by your intended trainee intake, those entering the course should first be required to complete an upgrading course to raise them to the stated entry level. Alternatively, those parts of the course affected could be augmented by inserting course material which will cover the knowledge required.

.2 If the entry standard will be exceeded by your planned trainee intake, you may wish to abridge or omit those parts of the course the teaching of which would be unnecessary, or which could be dealt with as revision.

.3 Study the course material with the above questions in mind and with a view to assessing whether or not it will be necessary for the trainees to carry out preparatory work prior to joining the course. Preparatory material for the trainees can range from refresher notes, selected topics from textbooks and reading of selected technical papers, through to formal courses of instruction. It may be necessary to use a combination of preparatory work and the model course material in modified form. It must be emphasized that where the model course material involves an international requirement, such as a regulation of the International Convention on Standards of Training, Certification and Watchkeeping (STCW) 1978, as amended, the standard must not be relaxed; in many instances, the intention of the Convention is to require review, revision or increased depth of knowledge by candidates undergoing training for higher certificates.

3.4 Course certificate, diploma or document

Where a certificate, diploma or document is to be issued to trainees who successfully complete the course, ensure that this is available and properly worded and that the industry and all authorities concerned are fully aware of its purpose and intent.

3.5 Course intake limitations

.1 The course designers have recommended limitations regarding the numbers of trainees who may participate in the course. As far as possible, these limitations should not be exceeded; otherwise, the quality of the course will be diluted.

.2 It may be necessary to make arrangements for accommodating the trainees and providing facilities for food and transportation. These aspects must be considered at an early stage of the preparations.

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3.6 Staff requirements

.1 It is important that an experienced person, preferably someone with experience in course and curriculum development, is given the responsibility of implementing the course.

.2 Such a person is often termed a "course coordinator" or "course director". Other staff, such as lecturers, instructors, laboratory technicians, workshop instructors, etc., will be needed to implement the course effectively. Staff involved in presenting the course will need to be properly briefed about the course work they will be dealing with, and a system must be set up for checking the material they may be required to prepare. To do this, it will be essential to make a thorough study of the syllabus and apportion the parts of the course work according to the abilities of the staff called upon to present the work.

.3 The person responsible for implementing the course should consider monitoring the quality of teaching in such areas as variety and form of approach, relationship with trainees, and communicative and interactive skills; where necessary, this person should also provide appropriate counselling and support.

3.7 Teaching facilities and equipment

.1 Rooms and other services

It is important to make reservations as soon as is practicable for the use of lecture rooms, laboratories, workshops and other spaces.

.2 Equipment

Arrangements must be made at an early stage for the use of equipment needed in the spaces mentioned in 3.7.1 to support and carry through the work of the course. For example:

- blackboards and writing materials
- apparatus in laboratories for any associated demonstrations and experiments
- machinery and related equipment in workshops
- equipment and materials in other spaces (e.g. for demonstrating firefighting, personal survival, etc.)

3.8 Teaching aids

Any training aids specified as being essential to the course should be constructed, or checked for availability and working order.

3.9 Audiovisual aids

Audiovisual aids (AVA) may be recommended in order to reinforce the learning process in some parts of the course. Such recommendations will be identified in Part A of the model course. The following points should be borne in mind:

.1 Overhead projectors

Check through any illustrations provided in the course for producing overhead projector (OHP) transparencies, and arrange them in order of presentation. To produce transparencies, a supply of transparency sheets is required; the illustrations can be

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transferred to these via photocopying. Alternatively, transparencies can be produced by writing or drawing on the sheet. Coloured pens are useful for emphasizing salient points. Ensure that spare projector lamps (bulbs) are available.

.2 Slide projectors

If you order slides indicated in the course framework, check through them and arrange them in order of presentation. Slides are usually produced from photographic negatives. If further slides are considered necessary and cannot be produced locally, OHP transparencies should be resorted to.

.3 Cine projector

If films are to be used, check their compatibility with the projector (i.e. 16 mm, 35 mm, sound, etc.). The films must be test-run to ensure there are no breakages.

.4 Video equipment

It is essential to check the type of video tape to be used. The two types commonly used are VHS and Betamax. Although special machines exist which can play either format, the majority of machines play only one or the other type. Note that VHS and Betamax are not compatible; the correct machine type is required to match the tape. Check also that the TV raster format used in the tapes (i.e. number of lines, frames/second, scanning order, etc.) is appropriate to the TV equipment available. (Specialist advice may have to be sought on this aspect.) All video tapes should be test-run prior to their use on the course.

.5 Computer equipment

If computer-based aids are used, check their compatibility with the projector and the available software.

.6 General note

The electricity supply must be checked for correct voltage, and every precaution must be taken to ensure that the equipment operates properly and safely. It is important to use a proper screen which is correctly positioned; it may be necessary to exclude daylight in some cases. A check must be made to ensure that appropriate screens or blinds are available. All material to be presented should be test-run to eliminate any possible troubles, arranged in the correct sequence in which it is to be shown, and properly identified and cross-referenced in the course timetable and lesson plans.

3.10 IMO references

The content of the course, and therefore its standard, reflects the requirements of all the relevant IMO international conventions and the provisions of other instruments as indicated in the model course. The relevant publications can be obtained from the Publication Service of IMO, and should be available, at least to those involved in presenting the course, if the indicated extracts are not included in a compendium supplied with the course.

3.11 Textbooks

The detailed syllabus may refer to a particular textbook or textbooks. It is essential that these books are available to each student taking the course. If supplies of

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textbooks are limited, a copy should be loaned to each student, who will return it at the end of the course. Again, some courses are provided with a compendium which includes all or part of the training material required to support the course.

3.12 Bibliography

Any useful supplementary source material is identified by the course designers and listed in the model course. This list should be supplied to the participants so that they are aware where additional information can be obtained, and at least two copies of each book or publication should be available for reference in the training institute library.

3.13 Timetable

If a timetable is provided in a model course, it is for guidance only. It may only take one or two presentations of the course to achieve an optimal timetable. However, even then it must be borne in mind that any timetable is subject to variation, depending on the general needs of the trainees in any one class and the availability of instructors and equipment.

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Part 2: Notes on teaching technique

1. Preparation

1.1 Identify the section of the syllabus which is to be dealt with.

1.2 Read and study thoroughly all the syllabus elements.

1.3 Obtain the necessary textbooks or reference papers which cover the training area to be presented.

1.4 Identify the equipment which will be needed, together with support staff necessary for its operation.

1.5 It is essential to use a "lesson plan", which can provide a simplified format for coordinating lecture notes and supporting activities. The lesson plan breaks the material down into identifiable steps, making use of brief statements, possibly with keywords added, and indicating suitable allocations of time for each step. The use of audiovisual material should be indexed at the correct point in the lecture with an appropriate allowance of time. The audiovisual material should be test-run prior to its being used in the lecture. An example of a lesson plan is shown in annex A3.

1.6 The syllabus is structured in training outcome format and it is thereby relatively straight forward to assess each trainee's grasp of the subject matter presented during the lecture. Such assessment may take the form of further discussion, oral questions, written tests or selection-type tests, such as multiple-choice questions, based on the objectives used in the syllabus. Selection-type tests and short-answer tests can provide an objective assessment independent of any bias on the part of the assessor. For certification purposes, assessors should be appropriately qualified for the particular type of training or assessment.

REMEMBER – POOR PREPARATION IS A SURE WAY TO LOSE THE INTEREST OF A GROUP

1.7 Check the rooms to be used before the lecture is delivered. Make sure that all the equipment and apparatus are ready for use and that any support staff are also prepared and ready. In particular, check that all blackboards are clean and that a supply of writing and cleaning materials is readily available.

2. Delivery

2.1 Always face the people you are talking to; never talk with your back to the group.

2.2 Talk clearly and sufficiently loudly to reach everyone.

2.3 Maintain eye contact with the whole group as a way of securing their interest and maintaining it (i.e. do not look continuously at one particular person, nor at a point in space).

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2.4 People are all different, and they behave and react in different ways. An important function of an instructor is to maintain interest and interaction between members of a group.

2.5 Some points or statements are more important than others and should therefore be emphasized. To ensure that such points or statements are remembered, they must be restated a number of times, preferably in different words.

2.6 If a blackboard is to be used, any writing on it must be clear and large enough for everyone to see. Use colour to emphasize important points, particularly in sketches.

2.7 It is only possible to maintain a high level of interest for a relatively short period of time; therefore, break the lecture up into different periods of activity to keep interest at its highest level. Speaking, writing, sketching, use of audiovisual material, questions, and discussions can all be used to accomplish this. When a group is writing or sketching, walk amongst the group, looking at their work, and provide comment or advice to individual members of the group when necessary.

2.8 When holding a discussion, do not allow individual members of the group to monopolize the activity, but ensure that all members have a chance to express opinions or ideas.

2.9 If addressing questions to a group, do not ask them collectively; otherwise, the same person may reply each time. Instead, address the questions to individuals in turn, so that everyone is invited to participate.

2.10 It is important to be guided by the syllabus content and not to be tempted to introduce material which may be too advanced, or may contribute little to the course objective. There is often competition between instructors to achieve a level which is too advanced. Also, instructors often strongly resist attempts to reduce the level to that required by a syllabus.

2.11 Finally, effective preparation makes a major contribution to the success of a lecture. Things often go wrong; preparedness and good planning will contribute to putting things right. Poor teaching cannot be improved by good accommodation or advanced equipment, but good teaching can overcome any disadvantages that poor accommodation and lack of equipment can present.

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Part 3: Curriculum development

1. Curriculum

The dictionary defines *curriculum* as a "regular course of study", while *syllabus* is defined as "a concise statement of the subjects forming a course of study". Thus, in general terms, a curriculum is simply a course, while a syllabus can be thought of as a list (traditionally, a "list of things to be taught").

2. Course content

The subjects which are needed to form a training course, and the precise skills and depth of knowledge required in the various subjects, can only be determined through an in-depth assessment of the job functions which the course participants are to be trained to perform (job analysis). This analysis determines the training needs, hence the purpose of the course (course objective). After ascertaining this, it is possible to define the scope of the course.

(**Note**: Determination of whether or not the course objective has been achieved may quite possibly entail assessment, over a period of time, of the "on-the-job performance" of those completing the course. However, the detailed learning objectives are quite specific and immediately assessable.)

3. Job analysis

A job analysis can only be properly carried out by a group whose members are representative of the organizations and bodies involved in the area of work to be covered by the course. The validation of results, via review with persons currently employed in the job concerned, is essential if undertraining and overtraining are to be avoided.

4. Course plan

Following definition of the course objective and scope, a course plan or outline can be drawn up. The potential students for the course (the trainee target group) must then be identified, the entry standard to the course decided and the prerequisites defined.

5. Syllabus

The final step in the process is the preparation of the detailed syllabus with associated timescales; the identification of those parts of textbooks and technical papers which cover the training areas to a sufficient degree to meet, but not exceed, each learning objective; and the drawing up of a bibliography of additional material for supplementary reading.

6. Syllabus content

The material contained in a syllabus is not static; technology is continuously undergoing change and there must therefore be a means for reviewing course material in order to eliminate what is redundant and introduce new material reflecting current practice. As defined above, a syllabus can be thought of as a list and, traditionally, there have always been an "examination syllabus" and a "teaching

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syllabus"; these indicate, respectively, the subject matter contained in an examination paper, and the subject matter a teacher is to use in preparing lessons or lectures.

7. Training outcomes

7.1 The prime communication difficulty presented by any syllabus is how to convey the "depth" of knowledge required. A syllabus is usually constructed as a series of "training outcomes" to help resolve this difficulty.

7.2 Thus, curriculum development makes use of training outcomes to ensure that a common minimum level and breadth of attainment is achieved by all the trainees following the same course, irrespective of the training institution (i.e. teaching/ lecturing staff).

7.3 Training outcomes are trainee-oriented, in that they describe an end result which is to be achieved by the trainee as a result of a learning process.

7.4 In many cases, the learning process is linked to a skill or work activity and, to demonstrate properly the attainment of the objective, the trainee response may have to be based on practical application or use, or on work experience.

7.5 The training outcome, although aimed principally at the trainee to ensure achievement of a specific learning step, also provides a framework for the teacher or instructor upon which lessons or lectures can be constructed.

7.6 A training outcome is specific and describes precisely what a trainee must do to demonstrate his knowledge, understanding or skill as an end product of a learning process.

7.7 The learning process is the "knowledge acquisition" or "skill development" that takes place during a course. The outcome of the process is an acquired "knowledge", "understanding", "skill"; but these terms alone are not sufficiently precise for describing a training outcome.

7.8 Verbs, such as "calculates", "defines", "explains", "lists", "solves" and "states", must be used when constructing a specific training outcome, so as to define precisely what the trainee will be enabled to do.

7.9 In the IMO model course project, the aim is to provide a series of model courses to assist instructors in developing countries to enhance or update the maritime training they provide, and to allow a common minimum standard to be achieved throughout the world. The use of training outcomes is a tangible way of achieving this desired aim.

7.10 As an example, a syllabus in training-outcome format for the subject of ship construction appears in annex A2. This is a standard way of structuring this kind of syllabus. Although, in this case, an outcome for each area has been identified – and could be used in an assessment procedure – this stage is often dropped to obtain a more compact syllabus structure.

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8. Assessment

Training outcomes describe an outcome which is to be achieved by the trainee. Of equal importance is the fact that such an achievement can be measured OBJECTIVELY through an evaluation which will not be influenced by the personal opinions and judgements of the examiner. Objective testing or evaluation provides a sound base on which to make reliable judgements concerning the levels of understanding and knowledge achieved, thus allowing an effective evaluation to be made of the progress of trainees in a course.

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Annex A1 – Preparation checklist

Ref	Component	Identified	Reserved	Electricity supply	Purchases	Tested	Accepted	Started	Finished	Status OK
1	Course plan									
2	Timetable									
3	Syllabus									
4	Scope									
5	Objective									
6	Entry standard									
7	Preparatory course									
8	Course certificate									
9	Participant numbers									
10	Staffing									

Coordinator _____

Lecturers _____

Instructors _____

Technicians _____

Other _____

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Annex A1 – Preparation checklist *(continued)*

Ref	Component	Identified	Reserved	Electricity supply	Purchases	Tested	Accepted	Started	Finished	Status OK
11	Facilities									
	a) Rooms									
	Lab									
	Workshop									
	Other									
	Class									
	b) Equipment									
	Lab									
	Workshop									
	Other									
12	AVA Equipment and Materials									
	OHP									
	Slide									
	Cine									
	Video									
13	IMO Reference									
14	Textbooks									
15	Bibliography									

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Annex A2 – Example of a model course syllabus in a subject area

Subject area : Ship construction

Prerequisite : Have a broad understanding of shipyard practice

General aims : Have knowledge of materials used in shipbuilding, specification of shipbuilding steel and process of approval

Textbooks : No specific textbook has been used to construct the syllabus, but the instructor would be assisted in preparation of lecture notes by referring to suitable books on ship construction, such as *Ship Construction* by Eyres (T12) and *Merchant Ship Construction* by Taylor (T58)

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Course outline

Knowledge, understanding and proficiency		Total hours for each topic	Total hours for each subject area of Required performance
Competence :			
3.1 CONTROL TRIM, STABILITY and STRESS			
3.1.1 FUNDAMENTAL PRINCIPLES OF SHIP CONSTRUCTION, TRIM AND STABILITY			
.1	Shipbuilding materials	3	
.2	Welding	3	
.3	Bulkheads	4	
.4	Watertight and weathertight doors	3	
.5	Corrosion and its prevention	4	
.6	Surveys and dry-docking	2	
.7	Stability	83	102

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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 training 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 organized 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.

The header of the first column denotes the **COMPETENCE** concerned. Each function comprises a number of COMPETENCES. Each competence is uniquely and consistently numbered on this model course.

In this function the competence is **Control Trim, Stability and Stress**. 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, 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 three training outcomes. The first is concerned with FUNDAMENTAL PRINCIPLES OF SHIP CONSTRUCTION, TRIM AND STABILITY. Each training outcome is uniquely and consistently numbered in this model course. That concerned with fundamental principles of ship construction, trim and stability is uniquely numbered 3.1.1. For clarity, training outcomes are printed in black type on grey, for example TRAINING OUTCOME.

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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 concerned with the fundamental principles of ship construction, trim and stability there are three areas of performance. These are:

3.1.1.1 Shipbuilding materials
3.1.1.2 Welding
3.1.1.3 Bulkheads

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:

- state that steels are alloys of iron, with properties dependent upon the type and amount of alloying materials used
- state that the specification of shipbuilding steels are laid down by classification societies
- state that shipbuilding steel is tested and graded by classification society surveyors who stamp it with approved marks

and so on.

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 the TRAINING OUTCOME title.

It is not intended that lessons are organized to follow the sequence of Required performances listed in the Tables. The Syllabus Tables are organized to match with the competence in the STCW Code, table A-II/2. Lessons and teaching should follow college practices. It is not necessary, for example, for shipbuilding materials to be studied before stability. What is necessary is that *all* of the material is covered and that teaching is effective to allow trainees to meet the standard of the Required performance.

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FUNCTION 3: CONTROLLING THE OPERATION OF THE SHIP AND CARE FOR PERSONS ON BOARD AT THE MANAGEMENT LEVEL

COMPETENCE 3.1	**Control trim, stability and stress**	**IMO reference**

3.1.1 FUNDAMENTAL PRINCIPLES OF SHIP CONSTRUCTION, TRIM AND STABILITY

Textbooks: T11, T12, T35, T58, T69

Teaching aids: A1, A4, V5, V6, V7

Required performance:

1.1 Shipbuilding materials (3 hours) R1

- states that steels are alloys of iron, with properties dependent upon the type and amounts of alloying materials used
- states that the specifications of shipbuilding steels are laid down by classification societies
- states that shipbuilding steel is tested and graded by classification surveyors, who stamp it with approved marks
- explains that mild steel, graded A – E, is used for most parts of the ship
- states why higher tensile steel may be used in areas of high stress, such as the sheer strake
- explains that the use of higher tensile steel in place of mild steel results in saving of weight for the same strength
- explains what is meant by:
  - tensile strength
  - ductility
  - hardness
  - toughness
- defines strain as extension divided by original length
- sketches a stress-strain curve for mild steel
- explains
  - yield point
  - ultimate tensile stress
  - modulus of elasticity
- explains that toughness is related to the tendency to brittle fracture
- explains that stress fracture may be initiated by a small crack or notch in a plate
- states that cold conditions increase the chances of brittle fracture
- states why mild steel is unsuitable for the very low temperatures involved in the containment of liquefied gases
- lists examples where castings or forgings are used in ship construction
- explains the advantages of the use of aluminium alloys in the construction of superstructures
- states that aluminium alloys are tested and graded by classification society surveyors
- explains how strength is preserved in aluminium superstructures in the event of fire
- describes the special precautions against corrosion that are needed where aluminium alloy is connected to steelwork

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Annex A3 – Example of a lesson plan for annex A2

Subject area : 3.1 Control trim, stability and stress **Lesson Number: 1** **Duration : 3 hours**

Training Area : 3.1.1 Fundamental principles of ship construction, trim and stability

Main element Specific training outcome in teaching sequence, with memory keys	Teaching method	Textbook	IMO reference	A/V aid	Instructor guidelines	Lecture notes	Time (minutes)
1.1 Shipbuilding materials (3 hours)							
States that steels are alloys of iron, with properties dependent upon the type and amounts of alloying materials used	Lecture	T12, T58	STCW II/2, A-II/2	V5 to V7	A1	Compiled by the lecturer	10
States that the specifications of shipbuilding steels are laid down by classification societies	Lecture	T12, T58	STCW II/2, A-II/2	V5 to V7	A1	Compiled by the lecturer	20
Explains that mild steel, graded A to E, is used for most parts of the ship	Lecture	T12, T58	STCW II/2, A-II/2	V5 to V7	A1	Compiled by the lecturer	15
States why higher tensile steel may be used in areas of high stress, such as the sheer strake	Lecture	T12, T58	STCW II/2, A-II/2	V5 to V7	A1	Compiled by the lecturer	10
Explains that use of higher tensile steel in place of mild steel results in a saving of weight for the same strength	Lecture	T12, T58	STCW II/2, A-II/2	V5 to V7	A1	Compiled by the lecturer	15

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