COURSE MANUAL

MARINE ENGINEERING AND ELECTRICAL, ELECTRONIC AND CONTROL ENGINEERING MANAGEMENT LEVEL

MANAGEMENT LEVEL

PROJECT: COMPETING
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PREFACE

To assist education and training entities to meet the requirements of the Standards of competence for inland navigation personnel, required by Directive (EU) 2017/2397 on the recognition of professional qualifications in inland navigation, and Delegated Directive (EU) 2020/12 supplementing Directive (EU) 2017/2397 as regards the standards of competences and corresponding knowledge and skills, for the practical examinations, for the approval of simulators and for medical fitness, the transnational Course Manual on MARINE ENGINEERING for Management Level Personnel was developed.

This Course Manual will be a useful transnational training tool for conducting the 'Train the Trainer' session and is intended to assist education and training providers and their teaching staff in organising and introducing new education & training programmes, or in enhancing, updating and supplementing existing didactical materials with the ultimate end results of raising quality and effectiveness of the education & training programmes.

Since education & training systems as well as the cultural background of inland navigation topics differ considerably from one country to another, the Course Manual on MARINE ENGINEERING has been designed so as to support the preparation, organisation and planning of effective teaching and training and to be used as a part of the quality assurance of the education and training institutes.

Technical content and levels of knowledge and abilities are in line with the applicable Delegated Directive (EU) 2020/12 supplementing Directive (EU) 2017/2397 as regards the standards of competences and corresponding knowledge and skills, for the practical examinations, for the approval of simulators and for medical fitness, being an essential tool for Boatmasters, to be able to perform human resource management, be socially responsible, and take care of organisation of workflow and training on board the craft.

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1. GENERAL INFORMATION

1	**Aim**	Provide training to meet the requirements of Directive (EU) 2017/2397 on the recognition of professional qualifications in inland navigation and ES-QIN-Standards of competence – Marine Engineering (Management Level) for crew members at the ML.
2	**Objective**	Provide training and practical guidance for trainees in order to be able to perform human resource management, be socially responsible, and take care of organisation of workflow and training on board the craft.
3	**Entry standards**	See Directive (EU) 2017/2397 - Annex 1.
4	**Course certificate**	On successful completion of the course, a document may be issued, stating that the holder graduated this learning module
5	**Course intake limitation**	Admittance may be limited by the capacity of the educational infrastructure used for this learning module.
6	**Staff requirements**	The trainer should at least: • have professional specialisation in this field and/or hold the certificate of competence as a deck crew member on board of inland craft • hold the appropriate "Train the Evaluator" certificate • hold the appropriate "Train the Instructor" certificate • meet the requirements of the Directive (EU) 2017/2397, Art. 18
7	**Training facilities, equipment and teaching aids**	For the theoretical part of the course a classroom is required with video presentation equipment, teaching aids, etc. The practical part of the course requires a communication laboratory equipped with communication devices.
8	**Learning outcomes**	The Boatmaster shall be able to perform human resource management, be socially responsible, and take care of organisation of workflow and training on board the craft. At the end of the course the trainee shall be able to: • State some physiological and psychological limitations of human factors • State some of the factors that lead to human failure • Define attitude and behaviour, motivation, situational and cultural awareness • State ways of maintaining a good level of awareness and signs of loss of it • State the functionality of the main engines and auxiliary equipment • Perform the monitoring and supervising of crew members when operating and maintaining the main engines and equipment • Identify malfunctions, common faults and take actions to prevent damage • Identify the physical and chemical characteristics of oil and other lubricants • State engine performance • Provide tests of control systems and instruments to recognise faults • Characterise limitations of materials and procedures used to maintain and repair technical devices • Define technical and internal documentation • Define the challenge and response mechanism and establish importance of team involvement for ensuring safe operations at all times • Apply decision making procedures taking into account the factors that may influence the process • Apply relevant international policies to control the operation of the vessel and care for persons on board
9	**Assessment & evaluation**	Minimum requirements for assessment & evaluation of the trainees for graduating the learning module (i.e. minimum score for theoretical evaluation, for practical evaluation, etc.). I.e. Online training record book as a pathway for the course.

2. INSTRUCTOR MANUAL

2.1 Introduction

This instructor manual provides guidance on the material that is to be presented during the training course for MARINE ENGINEERING - ML, and has been arranged under the thirteen Learning Outcomes (competences) identified in the course outline.
The reference material indicated may be supplemented by additional texts or material at the discretion of the teacher/trainer.

The course outline and provisional timetable also provide guidance on the time allocation for the course, because the time actually taken for each subject area may vary, especially in respect of time allocated to practical activities. The detailed teaching syllabus must be carefully studied and appropriate lesson plans or lecture notes compiled. A template of a lesson plan is presented under […] to 2.1.

Each lesson should commence with a statement of the learning outcomes it is intended to achieve. At the end of each lesson, the participants should be told which associated portions of the reference material they should read and any activity they should undertake. Questions arising from such readings and activities must be given priority at an appropriate time.

The presentation of the various subject areas should be done in such a way that those taking part in the course are involved in an interactive participation during the lessons and learning process. Questions from the course participants should be encouraged, as should answers to such questions from other course participants.

The lessons should aim at conveying as much practical instruction and practice as possible to the participants, in order to develop their knowledge of and their skills in the tasks they will be expected to carry out.
Course materials for additional study must be prepared and distributed if required.

2.2 Lesson plan

This lesson plan is just a template to give the teachers/trainers a general idea on how to create their lessons for the various competences. This template can be used for every competence and adjusted as suitable for the institute to use.

Competence 4.1.1 Organise and stimulate teambuilding and coach the crew members regarding shipboard duties and, if necessary, take disciplinary measures;
Learning objective
Learning outcomes
Required equipment

Lesson structure			
Learning activity	Didactical method (ABC method)	Materials	Time

2.3 Background materials

Bibliographical materials, reference documents, and other didactical materials are presented in Annexes of this Course Manual.

2.4 Practical training

This practical training links the theoretical content of the lessons to their practical use.

Case studies
Theoretical subjects are elaborated by the candidates autonomously in case studies. The candidate should deepen his or her knowledge in defined theoretical subjects by elaborating on a variety of facts and figures about this topic and present them in front of his or her classmates afterwards.

Discussions and reflection, interactive learning
Possible solutions to theoretical and practical subjects can be discussed within (parts of) the learning group. Different views and opinions on a defined subject are exchanged and discussed by the participants in order to broaden the view of the individual on this problem and show different possible solutions and their respective advantages and disadvantages. A discussion should be monitored and steered (stimulated or consolidated) if necessary, in order to secure that every participant actively participates.

Team work
Assignments can be individual as well as group assignments, depending on the objective. An individual assignment should stimulate and show the competences of the individual. In team work assignments the participants will have exposure to a wide range of experiences from quick problem-solving involving synergy, to experiences which may relate to such items as interpersonal difficulties in a group setting. Depending on the purpose of the assignment the team should be defined in advance and the assignment and the rules of the working process, if there are any, should be communicated to the group in a very clear and formal manner.

Annex 2 of this Course Manual presents a few practical scenarios that are useful for practical training and examination of inland navigation personnel.

2.5 Class room facilities and educational tools

The theoretical part of the course requires a classroom with video presentation equipment, teaching aids, etc. A communication laboratory equipped with communication devices is necessary for the practical part of the course.

2.6 Examination & assessment

According to Article 17 of Directive (EU) 2017/2397 on the recognition of professional qualifications in inland navigation and assessment of competences, Member States shall ensure that persons who apply for the Boatmaster certificate demonstrate that they meet the standards of competence by passing an examination that was organised:
(a) under the responsibility of an administrative authority in accordance with Article 18 or;
(b) as part of a training programme approved in accordance with Article 19.

The essential competence requirements set out in Annex II of Directive (EU) 2017/2397 for Marine Engineering - Management Level are:

The Boatmaster shall be able to:
- plan the workflow of marine engineering and electrical, electronic and control engineering;
- monitor the main engines and auxiliary machinery and equipment;
- plan and give instructions in relation to the pump and the pump control system of the craft;
- organise the safe use and application, maintenance and repair of the electro-technical devices of the craft;
- control the safe maintenance and repair of technical devices.

To assess the progress and level of understanding of the students it is necessary to test the students in a formative way. The main goal of these tests is to give feedback to the student.

A standard for practical examination for Boatman has been developed in CESNI QP.3.

The Illias platform provides examples of assessments for the separated competences for 'Marine Engineering' at Operational Level.

3. REGULATION AND CERTIFICATION

According to Chapter 2, Union Certificates of Qualification, Article 4, Obligation to carry a Union certificate of qualification as a deck crew member of Directive (EU) 2017/2397 on the recognition of professional qualifications in inland navigation:

- member States shall ensure that deck crew members who navigate on Union inland waterways carry either a Union certificate of qualification as a deck crew member issued in accordance with Article 11 or a certificate recognised in accordance with Article 10(2) or (3);
- annex I of Directive (EU) 2017/2397 sets out the minimum requirements for certification as a Boatmaster, such as:

Every applicant for a Union certificate of qualification shall:

(a)
- be at least 18 years of age;
- have completed an approved training programme as referred to in Article 19, which was a duration of at least three years and which covered the standards of competence for the management level set out in Annex II;
- have accumulated navigation time of at least 360 days as part of this approved training programme or after completion thereof;
- hold a radio operator's certificate.

or

(b)
- be at least 18 years of age;
- hold a Union certificate of qualification as a helmsman or a certificate recognised in accordance with Article 10 (02) or 10 (03);
- have accumulated navigation time of at least 180 days;
- have passed an assessment of competence by an administrative authority as referred to in Article 18 to verify that the standards of competence for the management level set out in Annex II are met;
- hold a radio operator's certificate.

or

(c)
- be at least 18 years of age;
- have accumulated navigation time of at least 540 days, or have accumulated navigation time of at least 180 days, if the applicant can also provide proof of work experience of at least 500 days that the applicant acquired on a sea-going ship as a member of the deck crew;
- have passed an assessment of competence by an administrative authority as referred to in Article 18 to verify that the standards of competence for the management level set out in Annex II are met;
- hold a radio operator's certificate.

or

(d)
- have a minimum of five years' work experience prior to the enrolment in an approved training programme, or have at least 500 days' work experience on a sea-going ship as a member of the deck crew prior to the enrolment in an approved training programme, or have completed any vocational training programme of at least three years' duration prior to the enrolment in an approved training programme;
- have completed an approved training programme referred to in Article 19, which was a duration of at least one and a half years, and which covered the standards of competence for the management level set out in Annex II;
- hold a radio operator's certificate.

4. LESSON MATERIALS

The lesson materials referred to in this course manual are for inspiration and are free to use for the teachers of the educational institutes. The lesson materials will be available on the Edinna website (https://www.edinna.eu/) until the end of the project.

As already mentioned, background materials and practical activities can be found in ANNEXES 1 and 2 of this course manual. The background materials referenced can be used as additional documentation for the teachers to create their lessons and/or add more details. Annex 2 consists of suggestions and examples of exercises, case studies and/or practical scenarios.

Thematic content of the Course Manual for MARINE ENGINEERING AND ELECTRICAL, ELECTRONIC AND CONTROL ENGINEERING – ML is presented in Annex 4 of this document, which is linked to the European Standard for Qualifications in Inland Navigation (ES-QIN), Part I, Chapter 1, Point 4 Marine engineering and electrical, electronic and control engineering[1].

The numbering of the chapters is in accordance with the Standards for competences for Management Level - 4. MARINE ENGINEERING AND ELECTRICAL, ELECTRONIC AND CONTROL ENGINEERING.

ML 4 - Marine engineering and electrical, electronic and control engineering

4.1 The Boatmaster shall be able to plan the workflow of marine engineering and electrical, electronic and control engineering.

Competence	Knowledge and skills
1. Use the functionality of the main engines and auxiliary equipment and their control systems;	1. Knowledge of operation of main engine and auxiliary equipment. 2. Knowledge of characteristics of fuels and lubricants. 3. Knowledge of control systems. 4. Ability to use various systems of different propulsion systems and auxiliary machinery and equipment.
2. Monitor and suprvise crew members when operating and maintaining the main engines, auxiliary machinery and equipment;	1. Ability to manage the crew with respect to operating and maintaining technical equipment. 2. Ability to manage start up and shut down main propulsion auxiliary machinery and equipment.

1 https://www.cesni.eu/en/standards-and-explanatory-notices/#02

4.2 The Boatmaster shall be able to monitor the main engines and auxiliary machinery and equipment

COLUMN 1 COMPETENCE	COLUMN 2 KNOWLEDGE AND SKILLS
1. give instructions to prepare main engines and auxiliary machinery and equipment;	1. Ability to instruct the crew in the preparation and operation of main and auxiliary machinery and equipment. 2. Ability to set up and monitor checklists and to give instructions to properly use such checklists. 3. Ability to instruct crew on principles to be observed during engine surveillance.
2. detect malfunctions, common faults and take actions to prevent damage;	1. Knowledge of methods to detect engine and machinery malfunction. 2. Ability to detect malfunctions, frequent sources of error or inappropriate treatment, and to respond adequately. 3. Ability to instruct actions to be taken in order to prevent damage or to take measures for damage control.
3. understand the physical and chemical characteristics of oil and other lubricants;	1. Knowledge of the characteristics of the materials used. 2. Ability to use oil and other lubricants according to their specifications. 3. Ability to understand machinery handbooks. 4. Knowledge of operational characteristics of equipment and systems.
4. evaluate engine performance.	Ability to use and interpret manuals to evaluate engine performance and operate engines appropriately.

4.3 The Boatmaster shall be able to plan and give instructions in relation to the pump and the pump control system of the craft

COLUMN 1 COMPETENCE	COLUMN 2 KNOWLEDGE AND SKILLS
1. monitor routine pump works, ballast and loading pump systems.	1. Knowledge of pump systems and pumping operations. 2. Ability to ensure monitoring of safe operation of bilge, ballast and cargo pump systems including adequate instructions to the crew, taking into account free surface effects on stability.

4.4 The Boatmaster shall be able to organise the safe use and application, maintenance and repair of the electro-technical devices of the craft.

COLUMN 1 COMPETENCE	COLUMN 2 KNOWLEDGE AND SKILLS
1. prevent potential damage to electric and electronic devices on board;	1. Knowledge of electro-technology, electronics and electrical equipment and safety devices e.g. automation, instrumentation and control systems to prevent damage. 2. Ability to apply safe working practices.
2. test control systems and instruments to recognise faults and at the same time take actions to repair and maintain electric or electronic control equipment;	1. Knowledge of the craft´s electro-technical testing devices. 2. Ability to operate, test and maintain control systems and take appropriate measures.
3. give instructions before and follow-up activities to connect or disconnect technical shore-based facilities.	1. Knowledge of safety requirements for working with electrical systems. 2. Knowledge of the construction and operational characteristics of shipboard electrical systems and equipment in relation to shore-based facilities. 3. Ability to give instructions to guarantee safe shore connection at any time and to recognise dangerous situations with regard to shore-based facilities.

4.5 The Boatmaster shall be able to control the safe maintenance and repair of technical devices.

COLUMN 1 COMPETENCE	COLUMN 2 KNOWLEDGE AND SKILLS
1. ensure appropriate use of tools to maintain and repair technical devices;	1. Knowledge of the maintenance and repair procedures for technical devices. 2. Ability to organise and instruct on safe maintenance and repair using appropriate procedures (control), equipment and software.
2. assess characteristics and limitations of materials as well as necessary procedures used to maintain and repair technical devices;	1. Knowledge of characteristics of maintenance and repair material for technical devices. 2. Ability to apply maintenance and repair procedures on devices according to manuals.
3. evaluate technical and internal documentation.	1. Knowledge of construction specifications and technical documentation. 2. Ability to set up checklists for maintenance and repair of technical devices.

5. EFFECT ON THE HUMAN ELEMENT ON SUSTAINABLE SHIPPING

The human activities of deck crew members on board of vessels have a direct relation with sustainability in Inland Shipping. Due to the uniformization of training and conformity with Directive (EU) 2017/2397 on the recognition of professional qualifications in inland navigation, there will be an increase of navigational safety.

Different factors affect the development of sustainability in shipping, from regulatory to socio-economic factors, market related aspects and human factors, which all together contribute in different ways to the development of these three pillars. Since many different stakeholders are involved in the process, it follows that one of the main factors in supporting Sustainable Shipping is the understanding of all parties' concerns, needs and expectations.

The shipping industry is run by people, for people. People design ships, build them, own them, crew them, maintain them, repair them and salvage them. People regulate them, survey them, underwrite them and investigate them when things go wrong. While these people vary in all sorts of ways, they are all, nevertheless, people – with the same basic set of capabilities and vulnerabilities.

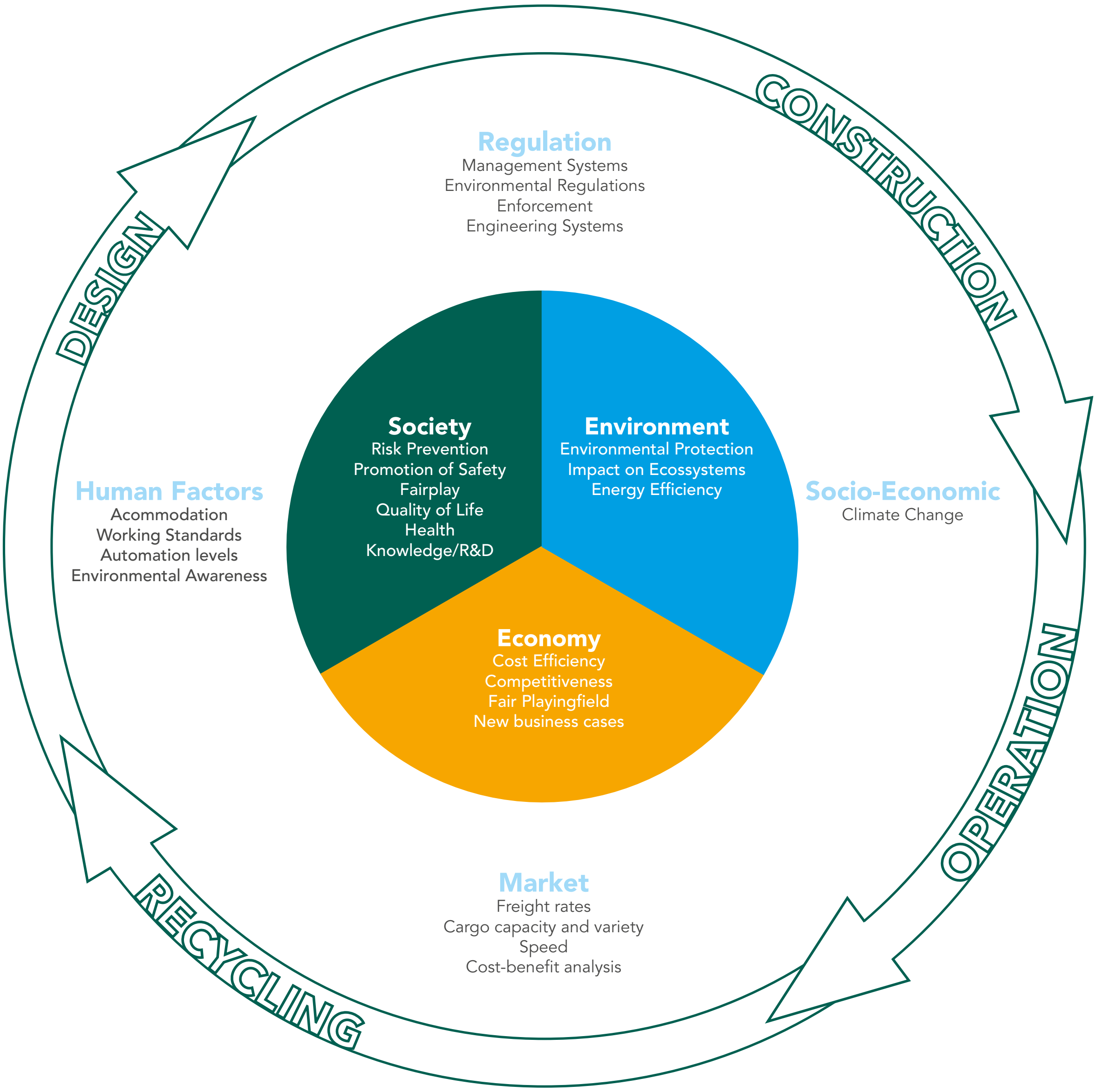

Figure 1 https://www.emsa.europa.eu/implementation-tasks/environment/sustainable-toolbox.html?start=10

Humans are not simply an element like the weather. They are at the very centre of the shipping enterprise. They are the secret of its successes and the victims of its failures. It is human nature that drives what happens every day at work – from the routine tasks of a ship's rating, right through to policy decisions.

The eight aspects of human nature are:

1. **People actively make sense of things** What's obvious to you may be far from apparent to somebody else. We explain how it is that most of what you see and understand is down to you and your expectations, rather than a response to 'what's out there'. The key problem is ensuring that the sense you make of things is enough for you to deal effectively with the reality of a continuously unfolding situation – a situation that you must also share with your colleagues.

2. **People take risks**
   Everybody takes risks all the time. In a world that is essentially uncertain, this is not only normal but inescapable. We explain how the human perception of risk is quite different from the probability with which events actually occur. The key problem is in ensuring that your own perception of risk maps well onto the world with which you are interacting.

3. **People make decisions**
   We explain the difference between how people think they make decisions and how they actually do it – and how the decision making of experts is quite different from the way they did it when they were learning. We also explain why experience does not always lead to expertise, but that expertise always requires experience – and lots of it. The key problem is to understand what the components of a good decision are, and how to recognise when you are about to make a bad one.

4. **People make mistakes**
   A fundamental human strength depends directly on the ability to make, and then recover from, mistakes. Without error there can be no learning or development. And without these, organisations cannot achieve their goals. The important aspect is in ensuring that potentially harmful or expensive mistakes are prevented, caught or minimised before they have a chance to get far enough to matter. We explain how this depends as much on organisational culture as on individual competence.

5. **People get tired and stressed**
   We explain the causes and consequences of fatigue and stress, and explain what you can do to avoid them or lessen their impact. We also explain why workload turns out to be as much to do with your own experience, as the actual demands placed on you by the job.

6. **People learn and develop**
   People learn all the time. They can't help themselves. The main problem is in ensuring that they learn the right things at the right time. People also have aspirations which can be managed by an organisation to further its own safety and profitability. However, in the absence of good management, people's aspirations will either be ignored or permitted to dominate – with potentially disastrous consequences either way. We explain the enormous power that effective, well-timed training can give to an organisation.

7. **People work with each other**
   Working with each other sometimes requires us to work as individuals in pursuit of our own goals, and at other times as members of a team with a common purpose. The key problem is in ensuring that we have effective 'people' skills, as well as technical task skills. We explain what these other skills are, why they are important and what can go wrong when they are absent.

8. **People communicate with each other**
   Successful communication involves the clear transmission of a message. We explain what has to happen for communication to be successful. We explain the responsibilities of both listener and messenger.

These are eight things we do that help to make us human. They are inescapable and will not go away. Understanding a little more about their nature, and how you can deal with them more effectively, will change your behaviour – and, maybe, that of those around you.

6. REFERENCE TO NQF, EQF, ECTS

Nowadays, the European Union (EU) consists of 27 member states, and each state has a different education system. The European Commission (EC) therefore prepared the **European Qualifications Framework (EQF)** because it wanted to:

- make national qualifications more readable across Europe;
- harmonise national qualification systems of different countries in a common European reference framework;
- promote workers' and learners' mobility between the countries of the EU and to facilitate their lifelong learning.

The EQF system has got eight reference levels (figure 1), each level describes what a learner has to know, understand and be able to do.[1]

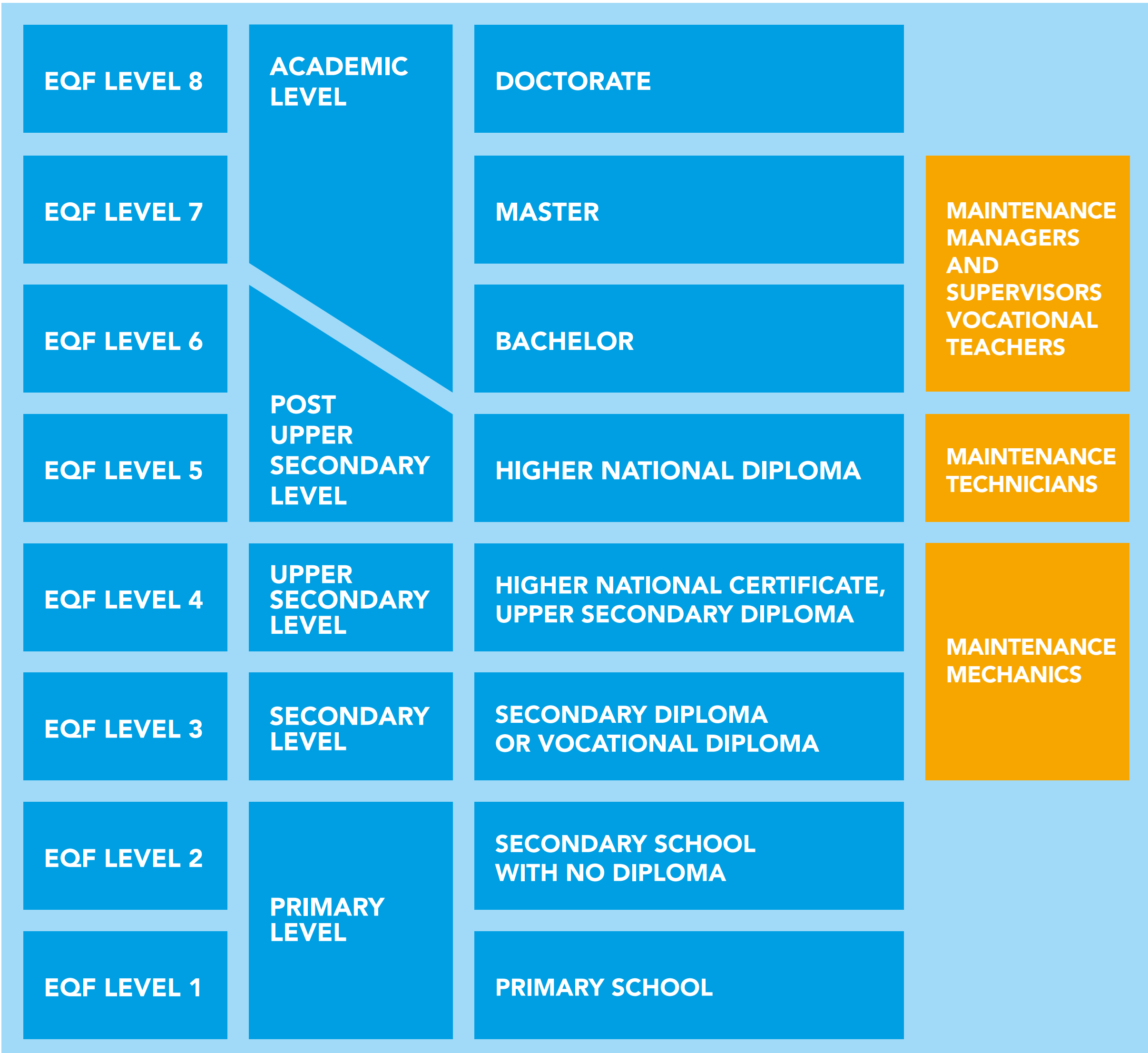

Figure 1 EQF levels compared with achieved education and maintenance personnel positions

1 http://www.maintworld.com/R-D/Application-of-European-Qualification-Framework-EQF-in-Maintenance, 1 December 2016

Germany	DQR Deutscher Qualifikationsrahmen für lebenslanges Lernen	www.dqr.de
The Netherlands	NLQF Nationaal Coördinatiepunt	www.nlqf.nl
Romania	anc Autoritatea Naţională pentru Calificări	www.anc.edu.ro
Slovakia	TREXIMA PEOPLE . PROFESSION . PROSPERITY	www.trexima.sk/new

Table 1 Overview of national organisations in the EQF context

Inland waterway transport (IWT) plays an important role in the EU in cargo exchange, especially at the international level on the network of the European waterways. On the one hand the transport is still more economical than any other mode of transport for many types of cargo, particularly such as bulk, general, liquid cargo and containers. On the other hand, it is the friendliest mode to the environment.

The field of IWT includes various job positions that are related to its segments such as vessels, ports and waterways. Project IWTCOMP focused on EQF and the job qualifications in IWT in 4 countries (Germany, the Netherlands, Romania and Slovakia) because each country uses a different education system.

In all the EU countries involved in the project there are organisations dedicated to the use of EQF in the national context.

The IWTCOMP project outlined the fact that regarding international sectoral qualifications there is (still) not an agreement on the approach and international process of comparing the EQF levels via the National QFs (NQFs). Some member states do not want to adjust their procedures and this means all member states all still have their own NQF procedure.

Slovakia used to have two vocational schools which prepared students for jobs in IWT but they were closed because of low interest of young people to work in this field. Nowadays, the Transport Authority examines the candidates for lower job positions in IWT such as skipper, captains, boatmen (EQF 2 and 4). Before the exams it organises the courses for applicants. The exam has oral and written forms and consists of various areas in IWT. The Department of Water Transport at the University of Zilina educates students for higher job positions (EQF 6, 7, 8) in IWT. The curricula are approved by the Ministry of Education, Science, Research and Sport of the Slovak Republic and its control body (Accreditation Commission). They are prepared according to the requirements of practice and standards of higher education in Slovakia.

In Germany there is a combined system of education at school and in a shipping company ending in centralised exams held by the chamber of commerce. Both schools and companies have to follow the curricula, but they are not responsible for the exams. The exams consist of two parts, one focussing on knowledge and one focussing on skills. Therefore both school and shipping company contribute to the education of the students, enabling them to pass the centralised exams.

In Romania there are dedicated programmes for IWT boatman (EQF 2). There are vocational schools for boatmen in Galati and Orsova, offering courses for boatmen qualification.

In the Netherlands there are qualifications set for the different levels of education within the IWT sector. For each educational level there is a set of qualifications given by the national contact point in cooperation with the work field and educational institutes. The Netherlands government decided to place the Captain/Manager IWT qualification in NQF level 5 (EQF5), but at a later stage it was withdrawn and placed in NQF level 4 (EQF4).

In conclusion, although the EQF system in the field of inland water transport has been accepted in all EU countries, this EQF system is not used by all countries. This is due to the fact that some institutes have to focus on the professional competences based on national and international legislation. The curricula at schools, universities and training centres are prepared according to the international or national standards and these curricula are approved, or not, by national designated authorities in each country. The educational programmes developed in the COMPETING project can be considered to fit Level 2 for Operational Level and Level 3 for Management Level.

ANNEX 1

Reference documents

- TRAINING COURSE BOOK - Marine Engine Captain's Class CATERPILLAR;
- Human Resource Management and Social Responsibility on Board - Management Level - Course Compendium – 2018 - Danube SKILLS project;
- Directive (EU) 2017/2397 on the recognition of professional qualifications in inland navigation;
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- S. Bay, N.Y. Brooklyn, "Engine Room Tools", United States Maritime Service Institute;
- Marine Insight, "Operating Procedures for Engine Room Machinery", 2019;
- The United States Army, "Naval Ships Technical Manual Chapter 600 Structural Closures", 2013;
- Allison Courses on Maritime Construction, Engines and Machinery. Online;
- Solas Maintenance Manual, 2018.

ANNEX 2

Practical scenarios

Case Studies & Teaching Methods

Case Study

The "Failure diagnosis" course requires good background knowledge of many other disciplines (i.e. diesel engines, turbines, steam generators, auxiliary machineries, electrical, hydraulic or pneumatic systems or different on board piping systems, etc.), so it might be 3 called "the 'crown' of marine engineer knowledge", especially taking into consideration the real on board situation where students (or 'future marine engineers') will be expected not only to detect the problems but to solve them. In many cases it cannot be done without good theoretical knowledge and 'the database of facts' they have to build during study. From the perspective of today's students, the theory and the facts can be obtained easily on the Internet, from books or instruction manuals, so they always ask for more practical issues to be included in lectures. It is often justified, but in the real situation on board, this is not always the case.

One of the most important aspects usually highlighted by experienced marine engineers and experts is: "there is nothing more practical than a good theoretical knowledge". So, on board problem detection and problem solving have 'to begin' and 'to end' with knowing the theory and the facts.

The Concept Of Teaching Method

To optimise learning objectives, at the very beginning of the course the teacher might be challenged to compromise the level of difficulty of the problem that could be assigned in accordance with the students' background knowledge, so an assessment diagnostic test is a prerequisite for the success of the course. During the lecture, the students are allowed to use any source of information they find necessary to solve the problem (books, the Internet, instruction manuals, etc.). The students are divided into teams (5-7). Each team elects the 'Team leader' and the 'Team leader' selects his or her assistant.

When teams are set up, the basic conditions are presented:

- ship with fixed propeller under manoeuvring on departure
- propulsion – M/E: two-stroke, 6 cylinder, reversible diesel engine with T/C

The lecture is divided into three different levels: basic knowledge, thorough understanding of the systems (working principles) and thorough understanding of the safety, time and cost aspects.

1. Level Failure: M/E Start failure. Team task: to specify possible reasons for the failure and their indication.

The teams are given ten minutes to discuss and specify possible reasons and their indication, which after collecting team member opinions, are to be presented and explained by each team leader. All teams are invited to discuss different opinions and to question each team leader after presentation. As it is the first level that represents 'activation of background knowledge', the teacher's role is to moderate the discussion as necessary and give the feedback as a conclusion.

2. Level Failure: the failure of only one starting air valve on the cylinder head.

Team tasks: to explain in the given situation (manoeuvring): 'Is it possible to detect quickly that failure relates to one of the starting air valves?' and 'How they can be sure which one is faulty?' and 'What possible mitigation options are there?'
The teams are given fifteen minutes to discuss and express different opinions that are collected and presented by each team leader. All teams are invited to discuss different opinions and to question each team leader after presentation. As it is the second level that requires thorough understanding, the teacher's role is to moderate the discussion, to challenge the teams by asking provocative or supportive questions, and to give feedback as a conclusion.

3. Level Failure circumstances: safety, time and costs aspects

Team tasks: to specify: 'Who must be informed first upon detection of the problem and why?', 'What information should be provided and why?', 'What restrictions must they be aware of?', 'What are the possible mitigating solutions and who decides what to do?', 'What is the safety procedure that has to be followed when replacing the faulty starting air valve?' and 'What is the procedure for starting air valve replacement?'

The teams are given twenty minutes to discuss and specify opinions that are then collected and presented by each team leader. All teams are invited to discuss different opinions and to question each team leader after the presentation. As it is the third level that requires thorough understanding of safety issues and time and costs restrictions, the teacher's role is to moderate the discussion, to challenge the teams by asking provocative or supportive questions, and to give feedback as a conclusion again.

Learning Outcomes

The first level tasks should be easily solved by the teams and they represent 'the activation of background knowledge' the students gained from other courses (marine diesel engines, marine engine simulator training, etc.). In this example, the students explain the causes for the failure.

The second level tasks require thorough understanding of working principles of the M/E. The students have to demonstrate understanding of working principles, because they have to know that (in the given basic conditions with a reversible engine) it is possible to reverse the engine just by trying to start it in the opposite direction. In doing so, the camshaft will be positioned on the other cylinder to start, and the other starting valve is to be engaged. But before reversing the engine, the students must check the mark on the flywheel (or on the HP pump) to detect which cylinder was at the start position when starting failure happened. If the engine was started in the opposite direction, the one detected was the failed one.

The third level tasks require thorough understanding of the safety issues and time and cost restrictions that are to be considered in such circumstances.
When manoeuvring the ship, before trying to reverse the engine the Master should be informed about the failure immediately because he or she had to be aware of the problem regarding the M/E. The Chief Engineer (C/E) has to explain where the problem is (i.e. starting air valve on cylinder No. 3) and what the possible options to solve the problem are. There are several things to be discussed:

- if there is a possibility to stop the M/E (mooring, anchoring) to replace the failed valve, the Master should inform the C/E about this;
- if there are tugs engaged to assist the manoeuvring, there are restrictions that should be considered, such as: delay of ship departure, costs connected with tugs and mooring payment, possible port traffic congestions, etc.;
- if the ship is in a position where there is no possibility to stop and replace the failed valve, the Master should be informed that manoeuvring is possible in order to continue but with a possibility of delay in responding to the command from the engine room (i.e. if the cylinder with the failed starting valve comes to the starting position again, which will require reversing to turn the engine to the other position to start), as well as of the fact that if stopping during manoeuvring can be avoided, the ship can proceed with manoeuvring and the failed valve can be replaced afterward;
- both of them (the Master and the C/E) ,as well as other crew members must be aware of the possible risks if manoeuvring is continued, but the Master is the one who has to decide what should be done.

The last part of the third level tasks is connected with the safety procedures that need to be followed when replacing the failed starting air valve with the spare one. The students are required to demonstrate a thorough understanding of safety precautions and measures to be applied in preventing the engine from starting during replacement (i.e. informing each crew member about work in progress, closing the starting air master valve and releasing the pressure in the starting system, engaging the turning gear, putting the visible warning signs that engine should not be started, etc.). They must also demonstrate an understanding of the replacement procedure (i.e. 1. dismantling of connection piping and failed starting valve, 2. cleaning the valve seat in the cylinder head, 3. testing the spare one before mounting and applying anti-seizure compounds on sealing surfaces, and 4. mounting the spare valve and connection piping). Testing of M/E is to be done after replacement.

Method Benefits And Observations

The teaching method used in this case study is based on a real practical problem that might occur on board, so the students can realise that it is based on their needs and is relevant to their future jobs, so usually they are highly motivated. The similarity in grouping with the on board engine crew organisation (Chief Engineer, 2nd Engineer, etc.) is obvious. By working in groups, 'peer to peer' interactive learning is achieved which is the most comfortable for the students as they are not afraid to be mistaken and corrected by their peers. Stimulating the 8 discussion after presentation of each team leader, learning becomes interactive between the groups and it promotes reflection and feedback from the peers themselves. The teacher is in a position that allows him or her to moderate the discussion in an appropriate way, to challenge the teams and collect findings (i.e. on the blackboard) for each level of the lecture which finally presents the verifiable learning outcomes and promotes teacher feedback to the students for that specific lecture.

The teacher's observations should also cover the behaviour of students within the team and attitudes of team leaders. It is to be noted that the students, when asked to elect the team leader, usually elect the best student among themselves and they are quite confident about his/her knowledge. The best students are also to be future on board leaders. Nevertheless, some of the elected team leaders do not want to be elected, so it might be helpful to encourage the leaders by allowing them to elect assistants of their own choosing. The task of the leader upon presentation is also to evaluate the participation of each team member of his/her team when discussing and solving problems. This is a common practice and an obligation for on board leaders (i.e. 'appraisal form' at the end of the contract) which for students is especially hard to accept. They perceive such an obligation as a peer evaluation. The teacher must explain the reasons for such a decision, because they are expected to be on board leaders and a fair and honest evaluation is necessary.

The message they are sending is that each member of the team is equal in terms of the relationship within the team, but they might not participate in solving problems equally. The member of the team who participates more than others when solving problems, expects that his/her efforts should be recognised within the group as well as by the leader. If the leader fails to do that (i.e. giving equal parts of credit to every member of the team), he/she must be aware that there will be a member who will not be happy with the evaluation. Also, if there is a member who didn't participate at all, by giving him/her a credit for nothing, the leader sends the 'wrong message' 9 to the team. To encourage honest evaluation, the teacher should explain the fact that if the team leader wants to improve the results, the starting point must be improving the performance of the weakest member of the team. Thus, the role of the leader is to lead the team, to run team discussions, to assign tasks, to motivate, to help and to raise awareness among the members that participation of each member is important if they want to obtain better results. The students might ask the teacher to advise them in advance of the failure that will be assigned as a task during the next lecture, with the explanation that they want to be better prepared. Unfortunately, on board, failures are not announced in advance.

So the teacher might suggest the system that will fail, but not specify the failure itself. In some cases it might an idea to demand a 'trade-off' for such a student request by giving the students a more complex failure if they are told which system will be involved (i.e. "you are going to be better prepared, so the problem can be more complex"). Regarding complexity, the teacher should be aware that if the assigned problem is too easy to solve, the students will not be so motivated. If the problem is too difficult, they will be demoralised. So, it should be just a little bit above their knowledge as a group, but solvable if they function as a good team; this is quite a challenging task for the teacher. In this manner the students will obtain experience of working together and collaborating, skills very much required on board.

It is not to be expected that all issues regarding on board failures will be covered in the course by the Faculty, but the main aspects and approaches can be taught. Students should be aware that on board problem detection and problem solving 'begins' and 'ends' with knowing the theory and the facts. The teacher might support that by assigning real practical tasks (faults, failures, problems) that are complex enough and in such a manner that the students have to search for the information by themselves using all available resources (books, 10 the Internet, etc.) or by holding team discussions, when they become aware why they have to know some theory or facts.

ANNEX 3

Standards For Practical Examination For Obtaining A Certificate Of Qualification As A Boatmaster - Module 4 – Marine Engineering

The draft standard for the practical examination ML sets the framework for practical examinations at ML. To provide guidance to authorities on how to conduct an exam in this regard, the CESNI/QP working group has decided to develop a model examination in accordance with ES-QIN. In this draft standard practical examination for ML, knowledge and skills elements that will be tested during the practical examination are specified. Listed are all elements described in the tables of competence standards on ML as "ability". Skills are usually tested during a practical examination. However, some abilities have knowledge elements. In this model examination, the term "examination element" is used to indicate both skills and knowledge. The model examination is carried out on the assumption that the applicant has passed the knowledge elements (theoretical examination) of the standards for competence at ML as well as the assessment of the skills that for practical reasons were not assessed on board the craft during this practical part prior to the model examination.

For practical reasons, the exam is divided into four parts:

Part 1: Navigation

- part 1a Steering the craft (including applicable regulations);
- part 1b Assisting with anchor operations;
- part 1c Mooring, unmooring and docking operations for pushed convoys / coupled convoys from deck, including operation and maintenance;
- part 1d Loading and unloading.

Part 2: Sailing the craft

Skills shall be demonstrated on an approved simulator or a craft. Experts recommend the use of a craft of more than 38 meters length.

Part 3: Security and communication

- part 3a Safety and environment;
- part 3b Communication.

Part 4: Technology and maintenance

- part 4a Propulsion engine / machines;
- part 4b Marine engineering, electricity, electronics, measurement and control technology;
- part 4c Maintenance and repair.

For this Course Manual, Part 4 must be taken into account.

The examination elements are listed in the table below:

★ All examination elements with a star may be tested prior to or during a practical examination or in a written assignment.

No.	Competence	Examination elements	Cat.
40	4.2.3 (2)	use required tools to ensure general technical safety;	II
41	4.2.4 (2)	follow procedures of maintenance and repair;	II

Other examination elements that will be tested during a practical exam which do not belong to any of the aforementioned groups:

No.	Competence	Examination elements	Cat.
30	4.1.1 (5)	assist in monitoring the engines and propulsion system;	I
31	4.1.2 (3+4+5+6)	prepare main engines and auxiliary equipment for operation;	I
32	4.1.3 (2)	react adequately to malfunctions of engines;	II
33	4.1.4 (2+3+4)	operate machinery including pumps, piping systems, bilge and ballast systems;	I
34	4.1.5 (3)	assist in monitoring electronic and electrical devices;	I
35	4.1.6 (2+3)	prepare, start, connect and change generators, and control their systems and shore supply;	I
36	4.1.7 (2)	define malfunctions and common faults, and describe the actions to prevent damage;	II
37	4.1.8 (2)	use required tools to ensure general technical safety;	II
38	4.2.1 (2)	perform the daily maintenance work on the main engines, auxiliary machinery and control systems;	I
39	4.2.2 (2)	perform the daily maintenance work on machinery including pumps, piping systems, bilge- and ballast systems;	I
42	4.2.5 (2)	use technical information and document technical procedures;	II

ANNEX 4

Thematic content

This annex contains the thematic content of the competences of Marine Engineering at Management Level as indicated in Chapter 4, if necessary.

Competences of Marine engineering and electrical, electronic and control engineering – ML

The numbering of the chapters is in accordance with the Standards of competence for Operation Level 4. MARINE ENGINEERING AND ELECTRICAL, ELECTRONIC AND CONTROL ENGINEERING

ML 4 - MARINE ENGINEERING AND ELECTRICAL, ELECTRONIC AND CONTROL ENGINEERING

4.1 The Boatmaster Shall Be Able To Plan The Workflow Of Marine Engineering And Electrical, Electronic And Control Engineering

Competences

The Boatmaster shall be able to:

1. Use the functionality of the main engines and auxiliary equipment and their control systems
2. Monitor and supervise crew members when operating and maintaining the main engines, auxiliary machinery and equipment

4.1.1 Use the functionality of the main engines and auxiliary equipment and their control systems.

Knowledge and skills

4.1.1.1 Knowledge of operation of main engine and auxiliary equipment installations.

Principles of operation of main engine and equipment

Based on their operational cycle, diesel engines are classified as two-stroke and four-stroke engines. For the deep-sea trade, large two-stroke engines are used for main propulsion or Main Engine as it is commonly called. Medium-sized four-stroke engines are generally used for coastal and smaller vessels and are also common as main engines on RO-RO Ferries and in some instances on passenger ships.

For the brown water applications, especially in US waters, both high- and medium-speed diesel has been the trend, due to the relatively small size of the vessels. The deep-sea applications largely use 2-stroke diesel main engines since they are the most efficient engines for large cargo vessels.

Diesel engines can be of many types, but their existence has been made possible due to the early heat engines developed in the 1900s. Some historical perspective has been included as an area of interest for students, before getting into the discussion on the operating principles of diesel engines.
The diesel engine is a compression ignition engine, meaning that air is compressed by the piston and at the correct time, just before the piston reaches the top dead centre, the high-pressure fuel is injected, and ignition takes place.

This heat energy is converted into mechanical energy at the crankshaft. Diesel engines are furthermore sub-divided into three categories: slow, medium, and high speed. Slow speeds are considered to be up to 300 rpm, such as most big two-stroke engines commonly found on ships.

Basic knowledge of ship engines includes the principles of several types of engines, such as:

- steam engine;
- internal combustion engine;
- electric engine;
- diesel electric engine;
- turbo-electric engine;
- and also new types of engines – powered by batteries.

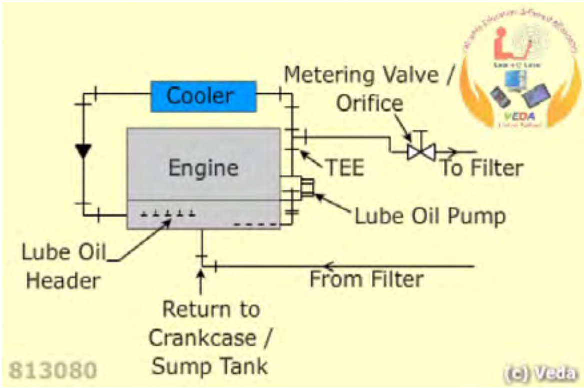
The basic knowledge also includes division of internal combustion engines, identification of the main parts of engines (fixed, movable and accessories) and phases of operation of diesel four-stroke engines. A very important part of this competency is to recognise the types of regulator and its purpose, the process of supercharging and overfilling.

The knowledge will be verified according to the description of the scheme of different types of engines. The student will be able to describe not only the composition of individual moving and stationary parts of the engine, but also the way the engine works.

4.1.1.2 Knowledge of characteristics of fuels and lubricants.

Characteristics of fuels and lubricants

In an engine system, a lubricant will reduce friction and wear between the moving parts and it will keep metal surfaces clean by carrying away possible deposits, plus provide a seal to keep out dirt. Lubricating oil will also carry away the heat generated in bearings and gears, thereby preventing overheating, seizure, and possible breakdown.



Lubricants thus preserve machine health and are used in machines and equipment ranging from small to very large. Solid lubricants like greases are also extremely important to allow long-term use of roller and ball bearings. In discussing this topic, however, we will only focus on liquid lube oils and their applications in modern diesel engines. The lubrication system of an engine provides a supply of lubricating oil to the various moving parts in the engine. Its main function is to enable the formation of a film of oil between the moving parts, which reduces friction and wear. The lubricating oil is also used as a cleaner and in some engines as a coolant.

Learning outcomes:

- lubrication principles;
- lubrication by oil;
- lube oil properties;
- categories and classification of lube oil;
- types of lubrication.

In addition, lubrication systems will be explained as followed:

- introduction;
- main lubrication systems;
- lubrication equipment;
- external lubrication systems;
- internal lubrication systems;
- summary.

The Boatmaster will be able to:

- describe the lube oil properties that are important for lubrication ;
- explain the categorisation of lube oils used on board;
- discuss the principles of various types of lubrication;
- explain the reasons for the use of additives in lube oil;
- describe the types of lube oils that need be selected for use in marine diesel engines;
- describe the cylinder lubrication system used for propulsion engines.

4.1.1.3 Knowledge of control systems

The successful handling of vessels is dependent upon the handler having a knowledge of the factors that affect the handling of the vessel. Some of these factors are under his/her control, while others are not. To handle a vessel properly, the handler must assess the factors not under his/her control and make allowance for them in a timely manner. This is because some of them can be used to advantage while for others precautions may need to be taken.

The ship is manoeuvred with the assistance of the rudder, main engine(s) and other auxiliary equipment, using knowledge of the rolling, pitching and yawing characteristics of the vessel in waves. In handling the vessel it is necessary to consider the effects of environmental conditions while controlling the position of the vessel, its attitude, and its speed, to move the vessel in the designed direction in a safe and efficient manner, and to stop at the intended position.

To handle a vessel well one needs to know the handling properties of a vessel. The handling properties of a vessel depend upon the following factors, among others:

The effect of external forces:

- the steering effects of a vessel;
- the methods used to stop a vessel.

External factors that affect handling of a vessel are:

- the wind;
- the current.

The handling properties of a vessel are determined by steering and stopping trial manoeuvres; the effects of wind and current on ship handling and the stopping and steering will also be factors of influence.

The Boatmaster will be able to:

- discuss how to berth and unberth a ship under various conditions of wind and current;
- explain the effects of wind and current on ship handling;
- explain the basic principles in the use of various types of tugboats;
- describe steering trial manoeuvres;
- describe stopping trial manoeuvres.

4.1.1.4 Ability to use various systems of different propulsion systems and auxiliary machinery and equipment.

The 'propulsion system' refers to the assembly of engines, propellers or propulsion units, and any associated gearboxes, clutches, driveshafts, and steering gear. Elements vital to the movement of any vessel are its motive force (the propelling machinery), and the equipment that controls its direction of movement (the steering gear).

While deep-sea vessels are primarily fitted with direct drive slow speed diesel with fixed pitch propellers, the smaller inland waterway system uses many tug-barge combinations that use combined propulsion and steering systems, using thrusters, etc. In the case of tugs, both merit special attention and should be discussed together. All tug steering and propulsion systems can be divided into 3 areas:

- power source;
- power transfer and control system;
- thrust creation and directional control mechanism.

Hydrodynamic Drives (For Thrust) - Propellers

In practice the propeller never travels the full theoretical distance, since it has a certain degree of slip. Slip refers to the potential amount of power loss between propeller and vessel speed.

Propeller design for any ship is a compromise, but in tugs there are a number of conflicting demands that make the designer's choice more difficult. The basic factors to be considered are propeller diameter, pitch and rotational speed, and power. The diameter will be governed by the hull design, operating draft, and the power to be absorbed from the powerplant. Pitch can be defined as the theoretical distance the propeller will travel in one complete rotation.

Hydrodynamic Drives (For Thrust) - Nozzles And Controllable-Pitch Propellers (Cpp)

Nozzles and Controllable-Pitch Propellers (CPP): Two propulsion refinements have been incorporated to address these deficits. Nozzles (ducted propellers) consist of a circular-shaped sleeve that shrouds the propeller. The first nozzles were designed by Ludwig Kort in 1927 and have been in use since 1936.

Although initially developed as a device to protect canal banks from propeller wash, they also improve propeller thrust. The nozzles are shaped like a foil and offer distinct advantages over an open wheel. For a given horsepower, ducted propellers can produce 15 to 60 percent more thrust than unducted propellers. They are particularly efficient on slow-moving vessels with propellers under high load, making them well suited for tugboats.

Propulsion Nozzle

The propulsion nozzle was produced in Germany in 1932 by Ludwig Kort and was intended originally as a device to reduce the effects of propeller wash from tugs that were causing erosion damage to the banks of German canals. It was soon apparent that the fixed tubular shroud fitted around the propeller not only had the desired effect but also considerably improved the tug's performance.

Known as the 'Kort nozzle', the original device was soon adopted by towage concerns elsewhere in Europe and Britain. The nozzle has been developed considerably since its inception and is now capable of producing significant improvements in performance.

To quantify the benefits of a nozzle exactly is not simple since each tug design has differing characteristics, but generally an improvement in bollard pull of between 30 and 40 per cent would be expected, when compared with an open propeller. The nozzle is basically a tube within which the propeller rotates. In cross-section the tube is tapered with an aerofoil shape on the interior. The effect of the nozzle is to cause a differential pressure between the outside and front inside surfaces, inducing additional forward thrust from the nozzle. This additional thrust is transmitted through the nozzle mountings to the vessel's hull.

The diagram shows the flow of water through a typical Kort nozzle of the steerable type. Additional thrust generated by the action of the nozzle is shown by the arrows adjacent to the top and bottom pivot points. In a fixed nozzle, thrust is transmitted to the hull through the supporting structure.

The steerable nozzle (sometimes referred to as a Kort rudder) provides an alternate solution. Although the position of the propeller is fixed, the nozzle is movable and turned by the tug's steering gear.

Due to the increased side thrust, nozzle angles need only be 25 to 30 degrees. The movable nozzle is superior to conventional rudders in two respects: it improves the engine thrust ahead and permits the tug to steer when manoeuvring astern.

Conventional Tugs And Nozzle Designs

Conventional tugs combine the rudder and propeller systems in a variety of configurations. In tugs designed for ship work, the three purposes are to:

- provide bollard pull ahead and astern;
- enhance the tug's ability to steer when manoeuvring astern;
- maintain position when backing.

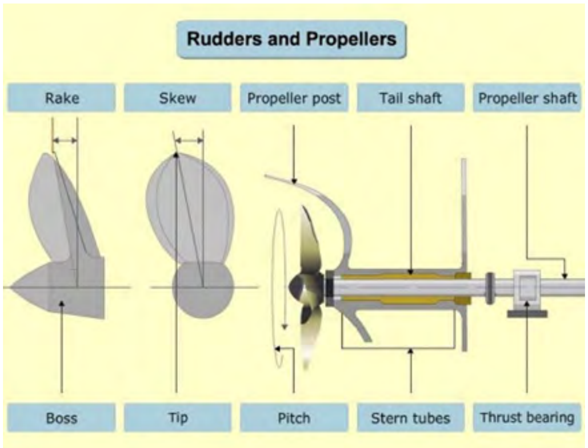
Rudder And Propeller Features - Constructional Features

Rudders are designed depending upon the size and requirement of a ship. Rudders are streamlined so as to offer the least resistance when the ship moves through the water. They are strengthened internally by frames. Rudder and propeller help to propel and steer a ship. They are designed to suit the ship's design and construction and are immersed in water for their entire operational period. Hence, they are carefully examined during dry docking.

Screw Propellers convert the power delivered by the engine and drive the ship through water. The force required to move the ship forward has to be secured from a reaction against the water by making a stream of water move in the direction opposite to the direction of movement of the ship.

The screw propeller converts the rotary movement and torque in the shaft on which it is mounted to a thrust to overcome the resistance of the ship and move the ship. The screw propeller works on the same principle as a bolt and nut. It has a helicoidal surface and screws its way through the water.

Rudder is used to turn the ship to the port or starboard side when the ship is moving. Rudder when turned, deflects the water flow, in such a way a thrust is created which is effectively used to turn the ship. There are basically three types of rudders known as Balanced, Semi-Balanced and Unbalanced.



Knowledge and abilities:

- correctly explain the power transmission systems used on ships, both large and small;
- explain the concept of hydrodynamic thrust as applied on vessels;
- describe the constructional features of various types of rudders;
- evaluate the constructional features of various types of propellers including CPP;
- describe the operation of a tug using a Voith-Schneider and Azimuthing propulsion.

4.1.2 Monitor and supervise crew members when operating and maintaining main engines, auxiliary machinery and equipment.

Knowledge and skills

4.1.2.1 Ability to manage the crew with respect to operating and maintaining technical equipment.

Knowledge in relation to managing the crew in terms of operating the technical equipment onboard lies mainly in the first and most important step – to discover diesel engine maintenance strategies:
reliability centred maintenance (RCM)

- predictive maintenance;
- breakdown/reactive maintenance;
- preventive maintenance.

There is most definitely a need to differentiate between the 4-Stroke & 2-Stroke Cycles and to have a thorough understanding of both. Other abilities include:

- explain thermodynamic cycles (Otto, Brayton, & Diesel);
- describe the importance of engine protection and learn how to protect a diesel engine using temperature, pressure, flow & level measurements;
- explain the alarms and shutdowns associated with a diesel engine;
- describe the starting circuit associated with the diesel engine (how an engine is started);
- list the components through which engine control is accomplished;
- define Centrifugal and electrical-hydraulic governors;
- define indicator and compression diagrams.

4.1.2.2 Ability to manage start up and shut down of main propulsion, auxiliary machinery and equipment.

Large Marine Diesel Engines are started using high pressure compressed air. The air is admitted into the cylinder when the piston is just past TDC and continued until just before the exhaust valve opens. There is always more than one air start valve open: - a situation known as overlap. This ensures that the engine will start in any position. The opening of the main air start valves is controlled by a set of pilot valves located in the air start distributor, which in turn are timed to operate by a drive linked to the main camshaft. In the example shown, a small camshaft is used to control the opening and closing of the air start pilot valves.

Solas Requirments

1. In every ship means shall be provided to prevent over pressure in any part of compressed air systems and wherever water jackets or casings of air compressors and coolers might be subjected to dangerous over pressure due to leakage into them from air pressure parts. Suitable pressure relief arrangements shall be provided for all systems.
2. The main starting air arrangements for main propulsion internal combustion engines shall be adequately protected against the effects of backfiring and internal explosion in the starting air pipes.
3. All discharge pipes from starting air compressors shall lead directly to the starting air receivers, and all starting pipes from the air receivers to main or auxiliary engines shall be entirely separate from the compressor discharge pipe system.
4. Provision shall be made to reduce to a minimum the entry of oil into the air pressure systems and to drain these systems.
5. Air intakes for the compressors shall be so located as to minimise the intake of oil or water contaminated air.
6. Pipes from air compressors with automatic start shall be fitted with a separator or similar device to prevent condensate from draining into the compressors.
7. Starting systems for internal combustion engines shall have capacity for a number of starts specified without reloading of air receivers.
   The capacity shall be divided between at least two air receivers of approximately same size.
8. If a starting system serves two or more of the above specified purposes, the capacity of the system shall be the sum of the capacity requirements.
9. For multi-engine propulsion plants the capacity of the starting air receivers shall be sufficient for 3 starts per engine. However, the total capacity shall not be less than 12 starts and need not exceed 18 starts.
10. Two or more compressors shall be installed with a total capacity sufficient for charging the air receivers from atmospheric to full pressure in the course of one (1) hour.
11. The capacity shall be approximately equally shared between the compressors. At least one of the compressors shall be independently driven.
12. If the emergency generator is arranged for pneumatic starting, the air supply shall be from a separate air receiver.
13. The emergency starting air receiver shall not be connected to other pneumatic systems, except for the starting system in the engine room. If such a connection is arranged, then the pipeline shall be provided with a screw-down non-return valve in the emergency generator room.

Starting Up/ Shutting Down The Propulsion

The first step in gaining knowledge about the starting up and shutting down of the main propulsion and equipment is to realise that these procedures mainly depend on the manufacturer's specifications and instructions and marine practice.

The process of starting up and shutting down consists of:

- starting up;
- warming;
- checking pressures, temperatures, …
- shutting down;
- supervising the cooling down of the engine.

When starting up, the following criteria must be met:

- main propulsion and auxiliary machinery is started up and warmed up in response to bridge orders in accordance with established procedures;
- checks of pressures, temperatures, and revolutions and other relevant parameters during the start up and warm up period of the operation of main propulsion and auxiliary machinery are made in accordance with manufacturer's technical specifications and agreed work plans;
- out of specification measures of pressures, temperatures, and revolutions during the start up and warm up period are investigated and appropriate action initiated to rectify any malfunctions or faults.

When shutting down, the following criteria must be met:

- method of preparing the shut down of main propulsion and auxiliary machinery is in accordance with manufacturer's specifications and instructions and established engineering practice;
- required precautions are taken prior to shut down of main propulsion and auxiliary machinery to minimise and control hazards and operational risks;
- potential problems with the shut down of main propulsion and auxiliary machinery are identified and investigated and appropriate action is initiated to report and rectify the problems.

For the cooling process, the following criteria must be met:

- the cooling down of the engine is supervised in accordance with manufacturer's specifications and instructions and established engineering practice.

4.2 The Boatmaster Shall Be Able To Monitor The Main Engines And Auxiliary Machinery And Equipment

Competences

The Boatmaster shall be able to:

I. Give instructions to prepare main engines and auxiliary machinery and equipment
II. Detect malfunctions, common faults and take actions to prevent damage
III. Understand the physical and chemical characteristics of oil and other lubricants
IV. Evaluate engine performance

4.2.1 Give instructions to prepare main engines and auxiliary machinery and equipment

Knowledge and skills

4.2.1.1. Ability to instruct the crew in the preparation and operation of main and auxiliary machinery and equipment

Three principal types of machinery installation are to be found at sea today. Their individual merits change with technological advances and improvements and economic factors such as the change in oil prices. It is intended therefore only to describe the layouts from an engineering point of view. The three layouts involve the use of direct-coupled slow-speed diesel engines, medium-speed diesels with a gearbox, and the steam turbine with a gearbox drive to the propeller. A propeller, in order to operate efficiently, must rotate at a relatively low speed. Thus, regardless of the rotational speed of the prime mover, the propeller shaft must rotate at about 80 to 100 rev/min. The slow-speed diesel engine rotates at this low speed and the crankshaft is thus directly coupled to the propeller shafting. The medium-speed diesel engine operates in the range 250-750 rev/min and cannot therefore be directly coupled to the propeller shaft. A gearbox is used to provide a low-speed drive for the propeller shaft. The steam turbine rotates at a very high speed, in the order of 6000 rev/min. Again, a gearbox must be used to provide a low-speed drive for the propeller shaft.

Ability to prepare and operate the machinery and equipment lies in the first place in the safety. Provision shall be made to facilitate cleaning, inspection and maintenance of main propulsion and auxiliary machinery, including boilers and pressure vessels. Easy access to the various parts of the propulsion machinery is to be provided by means of metallic ladders and gratings fitted with strong and safe handrails. Spaces containing main and auxiliary machinery are to be provided with adequate lighting and ventilation.

Engines shall be installed and fitted in such a way as to be adequately accessible for operation and maintenance, and shall not endanger the persons assigned to those tasks. It shall be possible to make them secure against unintentional starting.
So, during the process of instructing the crew how to prepare and operate the main and auxiliary machinery and equipment, mainly the skills and experience is crucial.

Instruction Before Starting Up The Main Engine

The starting procedure of marine engines on ships requires several points to be taken into consideration. While it is necessary that none of these points should be missed, there are a few extremely important things that should be done without fail while starting these ship engines.

Ten of these important points (in no particular sequence) are as follows:

1. **Lubrication of Main Engine:** Start pre-lubrication of the engine well before starting the marine engine. For the main engine it should be started 1 hour in advance and for auxiliary 4-stroke engines at least 15 minutes in advance.
2. **Check All Important Parameters**: After starting the lubrication pump, check lube oil levels and all other running pump parameters such as cooling water pressure, fuel oil temp and pressure, control and starting air pressure, etc. to ensure that all are in the accepted range.
3. **Open Indicator Cocks and Blow Through** All the indicator cocks of the marine engine must be opened up for blow-through of the combustion chamber prior to starting in order to avoid hydraulic damage because of water leakage
4. **Rotate the Crankshaft**: Rotate the crankshaft of the marine engine by means of turning gear so that all the parts are thoroughly lubricated before starting.
5. **Manually Check Turning Gear**: Ensure that the turning gear is properly disengaged by checking it locally even when the remote signal is showing the "disengaged" sign. Some auxiliary engines are provided with a tommy bar for rotation, ensure that it is removed from the flywheel before the engine is started.
6. **Check Jacket Cooling Water Temperature**: The jacket cooling water temperature of the engine should be maintained at least 60 deg C for the main engine and 40 deg C for the auxiliary engine (it may vary depending upon the KW rating of the engine).
7. **Warm up the Engine**: The incoming ship generator should be run at no load for at least 5 mins to allow warming up of the system.
8. **Put Load Sharing Switch to Manual**: When the 2nd generator is started, it will try to come on load as soon as possible due to the autoload automation provided for sharing the equal load (if same rated capacity).

1. While starting the 2nd generator, keep in mind to put the load sharing switch to manual. This will avoid the "just started" generator coming on load, giving it some time for warm-up.
9. **Avoid Excessive Opening of Exhaust Valve**: When starting the main engine with hydraulic oil operated exhaust valves, open the spring air first and then start the hydraulic oil to the exhaust valve. This will avoid the excessive opening of valves.
10. **Examine the Engine**: The ship's engineer in charge must be present near the engine when it is started from a remote position. Auxiliary engine to be started from a local position (avoid using remote start if possible).

4.2.1.2 Ability to set up and monitor checklists and to give instructions to properly use such checklists

There are many things that are to be kept in mind when a ship leaves port and prepares for a long voyage at sea. In this article we will learn about the various jobs that are to be taken care of without fail for a smooth sea voyage. The article is presented in the form of a checklist so that those interested can take a printout for their personal use.

Presented here is the engine department departure checklist for a ship leaving port, assuming cold start with boiler and generator in running condition.

Things To Do At 24 Hours Notice Period Prior To Departure For The First Time

- check the oil level or sound the bunker tanks to measure level and make sure that the temperature is maintained to about 40 degrees or as per analysis report by opening steam. this is done for the transfer of oil from bunker tank to settling tank. if the oil is kept cold the pump might get damaged due to very high viscosity;
- check the jacket water header tank for level and fill accordingly. do not fill too much as when the engine starts running, the water expands and it will start overflowing;
- after checking the level, start the jacket water circulating pumps if there is a separate system for the main engine;
- check the jacket water temperature of the main engine and maintain it at about 60 degrees, as below this temperature it might start leaking into the scavenge space.

THINGS TO DO AT 6 HOURS NOTICE PERIOD

- check the oil level in the main engine sump, turbocharger tank;
- the duty engineer will start the lubricating oil pump and the cross head pump (generally in sulzer engines) and turbocharger pump;
- check the oil flow through the sight glass of turbocharger outlet.
- check the pressure of the lube oil pump and turbocharger pump and cross head pumps;
- start the shaft bearing pumps and check the level of the header tank;
- generally in UMS there is a program for starting all these pumps in sequence. This program is started after taking the engine room rounds and the levels are checked.

Things To Do At 1 Hour Notice Period

- a quick round of the engine room and report to chief engineer regarding the departure;
- check oil level, header tank level, cylinder oil daily tank level;
- check the pressure of fuel oil pump, booster pump, lube oil pump, etc.;
- check sump oil level in air compressor;
- drain air bottles for any water inside;
- check that the turning gear is out;
- check parameters of the running machinery;
- start an additional generator so as to supply for additional demand of power from winches and thrusters;
- start exhausts gas boiler water circulating pump;
- check the telegraph for functioning in conjunction with deck officer on watch;
- telegraph is checked for local and remote panels;
- emergency telephones to be checked for functioning;
- if the chief engineer is in the control room, go to the steering gear and check for any leaks and port to starboard movement;
- check the functioning of limit switches in steering gear;
- check gyro reading in steering gear and cross check with reading on the bridge.

Things To Do At 15 Minutes Notice

- open the main air starting valve for main engine;
- ensure all air compressors are in auto and air bottles are full;
- air is blown through main engine with open indicator cocks to check for any water ingress in main engine;
- if no leaks or ingress are found, report to chief engineer and close indicator cocks;
- close the turbocharger drain valves;
- chief engineer reports to captain on bridge that the engine is ready for use and control is transferred from engine control room to the bridge;
- flow meter counters of main engine, generator and boiler are taken for calculation purposes of oil in port.

Checks Made When The Engine Is Running

- another round is taken of engine room;
- check for any abnormality;
- check all the parameters of the main engine like temperature of exhaust valve, jacket water, etc.;

- close steam heating for jacket later if not auto controlled;
- once the ship is out of port and pilot has left, open the other sea suction valve.

Checks Made When Ship Is Full Away

- stop the additional generator;
- stop the boiler if exhaust gas boiler is fitted;
- start fresh water generator;
- open sewage overboard valve;
- start turbine and shaft generator if fitted;
- take flow meter counter again for calculation of fuel consumed from port to full away;
- the watch is handed over to next duty engineer if watch has to be changed;
- in case of ums ship, after taking rounds of the engine room the bridge is informed of your taking a break.

4.2.1.3 Ability to instruct crew on principles to be observed during engine surveillance

The Boatmaster must be willing to instruct crew on principles during engine surveillance. Surveys that have identified poorly maintained engine rooms list findings such as excessive oil in bilges and throughout the engine room.
Other findings in this category include inoperable remote controls on boiler safety valves; defective fuel-oil valves on main and auxiliary engines; improperly adjusted steering gear; accumulation of water leaking on auxiliary engines; frozen or inoperable sea water inlet valves; defective generators; defective and leaky fuel-oil pumps and poorly maintained air compressors (resulting in the shortage of starting air for the main engine); leaky or wasted hydraulic lines servicing deck machinery and cargo hatches; and leaky engine exhaust piping.

Safety precautions

Merchant Shipping regulations require every dangerous part of a ship's machinery to be securely guarded unless it is so positioned or constructed that it is as safe as if it were securely guarded or is otherwise safeguarded. All steam pipes, exhaust pipes and fittings which by their location and temperature present a hazard, should be adequately lagged or otherwise shielded. The insulation of hot surfaces should be properly maintained, particularly in the vicinity of oil systems. Personnel required to work in machinery spaces which have high noise levels should wear suitable hearing protectors. Where a high noise level in a machinery space, or the wearing of ear protectors may mask an audible alarm, a visual alarm of suitable intensity should be provided, where practicable, to attract attention and indicate that an audible alarm is sounding. This should preferably take the form of a light or lights with rotating reflectors. Guidance may be found in the IMO Code on Alarms and Indicators.

4.2.2 Detect malfunctions, common faults and take actions to prevent damage

Knowledge and skills

4.2.2.1 Knowledge of methods to detect engine and machinery malfunction

The stable operation of maritime diesel engine is critical to the normal production of the industry, and the prevention, monitoring and identification of faults are of great significance. At present, the fault research on diesel engine still has some defects, such as only a few types of fault diagnoses are identified, the accuracy of fault diagnosis is still low, and fault identification is located at a constant speed.

A modern propeller marine engine with 10000kW of nominal power consumes about 48 tons of fuel and emits more than 3 tons of nitric oxide per day into the atmosphere. Abnormalities in the operation of marine piston engines cause an increase of fuel consumption and an increase of the emission of toxic combustion products into the atmosphere. The result is a deterioration in the economic conditions of maritime transport and an increase in environmental pollution. For this reason, technical diagnostics of marine engines is an important problem in the operation of ships. The increase in environmental pollution induced International Maritime Organization (IMO) to enact provisions on the prevention of pollution at sea

A malfunction diagnosis system is provided to aid a technician or engineer in diagnosing an internal combustion engine. The diagnostic system comprises an electronic control unit that is operatively coupled to a data storage device and to one or more engine sensors. The electronic control unit is configured to collect data from one or more engine sensors, compare the collected data with predetermined engine parameter values, and store the collected and compared data in the data storage device in various formats. A computer is selectively coupled to the data storage device. The computer program is configured to display specific sets of data and to clearly display any faulty engine parameter values resulting from the collected data comparison.

The ability to recognise malfunctions of engine or machinery is represented by the gained knowledge about the proper diagnostic procedures and methods.

Methods Of Diagnosis Of Surface And Subsurface Damage:

- visual;
- luminescence method;
- kerosene method;
- magnetic - powder method;
- ultrasonic method;
- radiological method;

The Boatmaster's abilities include:

- recognising failure;
- choosing the proper method of diagnostics according to faults and malfunction characteristics;
- proper fault classification according to the time course of parameter changes;
- proper wear and tear classification and identification;
- proper breakdown classification and identification;
- identification of the basic disorders of the steering system, engine and machinery (shape deformations, corrosion, cracks, abrasive wear, etc.)

4.2.2.2 Ability to detect malfunctions, frequent sources of error or inappropriate treatment, and to respond adequately

For a rather extended period of time, the main objective of the developers of marine propulsion engines was to increase their efficiency and reliability. The need for larger propellers, along with the associated capacity limitations and low rotation rates to increase hydrodynamic efficiency, have all together led to the prevalence of two-stroke low-speed engines for the propulsion of merchant ships. Two-stroke engines have a very high degree of efficiency, as well as the ability to burn low-grade heavy fuel. It is therefore not a coincidence that in recent years almost all new ships buildings over 2000dtw were equipped with diesel propulsion engines, the vast majority of which were two-stroke low-speed ones. Engine control and reliability are both equally important for normal ship operations; specially trained engineers and researchers/naval architects are always involved in the respective engine development efforts, as well as their repair and maintenance.

The combination of the above-mentioned facts has provided a strong incentive for those involved with engine design and development to take advantage of innovative technologies that improve the performance outcome. Modern information technology (IT) applications can facilitate detection and fault diagnosis techniques; the terms artificial intelligence, machine learning, fuzzy logic are just a few of those terms that were envisioned in the recent past to offer optimal utilisation of the engine for ship propulsion in all operating conditions. It is indicative that the authors of the analysis at hand have very recently put forward a proposed IT application in order to facilitate Monitoring-Reporting-Verification (MRV) anomaly detection with the aim of early identification and correction of the respective risks arising during the ship's operations.

In any case, a diagnostic system is responsible for controlling engine operating parameters in order to identify engine variations that are associated with specific failures; the use of an IT based system can achieve both the reduction of human involvement (therefore reducing the probability of human error), as well as contributing to an increased safety level. It is indicative that timely fault detection can help to avoid damage to the engine that can lead to economic loss or poor environmental performance. As a result, new IT techniques and electronic equipment are increasingly being sought to create diagnostics systems suitable for engine fault detection and diagnosis, with reliability and effectiveness being the focus of attention. In the current analysis, an optimal method of using a machine learning algorithm is proposed, which provides a very high percentage of accuracy in the detection and diagnosis of the faults.

This is achieved through: testing of various machine learning algorithms and comparison of the results obtained (percentage of correct predictions, performance metrics and model construction time), and implementation of ensemble methods to enhance and improve the results.

4.2.2.3 Ability to instruct actions to be taken in order to prevent damage or to take measures for damage control

Ship equipment contains many items that could be defined as 'critical'. Normally, criteria for choosing a critical item of equipment or operation are based on its potential to lead to a hazardous situation. When trying to decide which equipment items are 'critical', consideration is given to human safety and pollution prevention.

Thus, a critical item of equipment or operation is one where the failure of such equipment or operation will lead to a potentially hazardous situation, resulting in injury, loss of life, damage to the marine environment or loss of property. The three basic objectives of the damage control are:

1. Prevention
2. Minimisation
3. Restoration.

Prevention means to take all practical preliminary measures, such as maintaining watertight integrity, providing reserve buoyancy and stability before damage occurs. Minimisation is to minimise and localise damage by taking measures to control flooding and preserve stability and buoyancy. Restoration is to accomplish as quickly as possible emergency repair or restoration after occurrence of damage. Restoration requires regaining a safe margin of stability and buoyancy. The primary duty of the damage control organisation is to control damage. Damage control objectives are attained by taking the necessary action to do the following:

- preserve stability;
- preserve watertight integrity (buoyancy);
- control list and trim;

- maintain effective segregation of the vital systems
- prevent, isolate, combat, extinguish and remove the effects of fire;
- detect, confine, and remove the effects of nuclear, biological, and/or;
- chemical attack.
- assist in the care of injured personnel;
- make rapid repairs to structures and equipment

Actions To Be Taken In Case Of Damage

The following actions are to be taken immediately after damage occurs in order to ensure the watertight integrity of the vessel and to assess the damage:

1. **Closing of watertight doors and hatches**
   All watertight hatches are to be closed immediately. In general the status of the closed hatches can be checked on the status panel on the bridge. Additionally a visual check by a designated person shall be performed. In the event it is deemed absolutely necessary to open a watertight door or hatch in the damaged condition in order to proceed with further actions, it should be carefully judged whether this hatch/door is crucial to prevent progressive flooding. After use, the hatch is to be closed immediately.

2. **Closing of weather tight openings**
   All weather tight openings are to be closed immediately, further more the closing appliances for ventilation openings are to be secured.

3. **Closing of valves**
   All valves in the piping system are to be closed immediately as far as the connected pipes are not used for the pumping operations.

4. **Check the extent of damage**
   If possible a visual check of the extent of damage and the affected compartments shall be carried out.

5. **Sounding of flooded compartments**
   After having found out which compartments are damaged, the amount of water ingress shall be determined by sounding measurements. In case a compartment is connected to the remote sounding system, the amount of water ingress can be determined directly.

6. **Draught readings**
   Draught readings at the forward, mid and aft draft marks shall be performed, the heel angle and trim shall be calculated based on the draught readings.

7. **Calculation of water ingress**
   By periodical checking of the soundings of the damaged compartments and comparison with the draft readings, a calculation of the water ingress and flooding rate shall be made.

8. **Use of pumps**
   Bilge and ballast pumps are available for pumping out water from the damaged compartments. Two scenarios – a) the amount of water ingress (flooding rate) exceeds the available pump capacity, the compartment must be isolated by closing all water tight accesses including valves in the piping system and b) the pump capacity exceeds the flooding rate, the pumping shall be continued. It is important that the pumps are kept in a permanent stand-by mode and ready for use, at any time.

9. **Use of loading computer**
   For determining the possible scenarios of liquid transfer operations, the loading computer shall be used. The loading computer shall be used for estimating stability and strength after damage. For loading computers which are intended to calculate intact conditions only, the amount of water ingress can be considered as additional load in the respective compartments for the actual loading condition. It is to be noted that such an idealisation gives approximate results only. In case the loading computer is capable of damage stability calculation, the actual extent of damage shall be considered.

10. **Liquid transfer operations**
    Before any filling or discharging of water ballast is carried out, a thorough check and precalculation of the resulting floating position is to be carried out and the limit values for stability and strength are to be checked. The crew must be aware that filling or discharging of water ballast tanks can have negative influences on the stability due to the effect of free surfaces for partially filled tanks. In order to minimise the heel and trim of the vessel, it may be advisable that water should be pumped in the tanks opposite to the damage location. If possible, the filling of slack tanks should be preferred to improve stability of the vessel.

11. **Determination of ground condition, in case of grounding**
    Have a diver check the ground condition and extent of damage. This check shall be performed only with the necessary safety measures when the ship is in a stable position and no movement of the ground is anticipated.

12. **Information to the owner, coast guard**
    The local coast guard and the ship owner shall be informed of the present situation. A possible outflow of oil must be reported immediately.

4.2.3 Understand the physical and chemical characteristics of oil and other lubricants

Knowledge and skills

4.2.3.1 Knowledge of the characteristics of the materials used

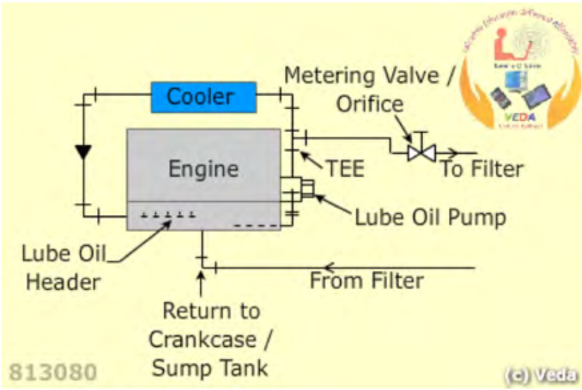
The steels most widely used for hull structures are of the medium, high-tensile, and special-treatment types. By far the greatest proportion of parts are of medium steel, where the working strains are small or moderate compared with the yield strain. Both high-tensile and special-treatment steels have higher yield points; the latter has ballistic and shock-resisting properties as well. They are used for parts subjected to high strains in order to save hull weight. Cargo ships have been built entirely of high-tensile steel, with a considerable saving in steel weight.

It is important to understand why a particular type of material is used for different parts of the vessel. Aluminium alloys are used for the hulls of patrol boats, small cargo ships, and for large shipboard elevator platforms and similar structures. They are also used for the superstructures and upper works of many cargo and passenger vessels; they form the upper parts of steel hull girders which bend elastically in service. For the last-named purpose, the increased deformation or stretch of these alloys is an advantage. For a given weight, panel plates of aluminium alloy are thicker and stiffer than those of steel. They thus provide a better appearance and for many installations they do not require painting.
Use of aluminium for large ship structures, such as the hull proper, in which appreciable savings in weight are to be achieved, requires reliable welding and riveting in large thicknesses. What is more, it necessitates the acceptance of increased bending deformations along the length and lowered natural frequencies of vibration as compared with similar structures of steel.

Hulls of heavily reinforced concrete have been used for ships and barges in times of emergency, when steel reinforcing rods and labour trained in building construction were available and shipbuilding steel and labour having shipbuilding skills were not.
Plastics reinforced with glass fibre eliminate many of the joints in a boat and greatly decrease the deterioration encountered in wooden or metal hulls. They may be coloured with pigment and they lend themselves admirably to “sticking in” stiffening members and other parts and to repairs in a similar manner when damaged. Many non-structural parts of boats and ships of all sizes and types are easily fabricated by moulding in reinforced plastic.

4.2.3.2 Ability to use oil and other lubricants according to their specifications

In an engine system, a lubricant will reduce friction and wear between the moving parts and it will keep metal surfaces clean by carrying away possible deposits, plus provide a seal to keep out dirt.
Lubricating oil will also carry away the heat generated in bearings and gears, thereby preventing overheating, seizure and possible breakdown.
Lubricants are thus a preserver of machine health and are used in equipment and machinery ranging from small to very large. Solid lubricants like greases are also extremely important to allow long-term use of roller and ball bearings. In the discussion of this topic, however, we shall only focus on liquid lube oils and their applications in modern diesel engines.



The lubrication system of an engine provides a supply of lubricating oil to the various moving parts in the engine. Its main function is to enable the formation of a film of oil between the moving parts, which reduces friction and wear. The lubricating oil is also used as a cleaner and in some engines as a coolant.

Lubricating oils are designed to perform multiple tasks. A modern engine lubricating oil, apart from keeping the engine parts moving freely, is expected to withstand high temperatures without carbonising, to neutralise acidic combustion products, to keep the engine clean and to prevent corrosion. This is achieved by blending oils and adding additives.

The Boatmaster will be able to:
- describe the lube oil properties according to their specifications;
- discuss the categorisation of lube oils used on board;
- explain the principles of various types of lubrication;
- describe the reasons for the use of additives in lube oil;
- explain the importance of viscosity in engines;
- explain the relationship between viscosity and temperature for oil ;
- analyse the concept of viscosity index;
- list the advantages of synthetics over mineral oils;

4.2.3.3 Ability to understand machinery handbooks

Systems, machinery and equipment onboard maritime vessel is a very complex subject, which requires equally specialised books to learn and understand its concepts. Marine engineers, both students and sea-going professionals, have to continuously keep themselves abreast of the changing technologies and policies in the maritime field.

As the systems are very complicated and complex, it is necessary to understand and operate them properly. For this reason, the main ability of a person operating ship equipment is to ensure safety onboard, according to correct recommendations and knowledge gained from such handbooks.

4.2.3.4 Knowledge of operational characteristics of equipment and systems

Ships are large, complex vehicles which must be self-sustaining in their environment for long periods with a high degree of reliability. A ship is the product of two main areas of skill, those of the naval architect and the marine engineer. The naval architect is concerned with the hull, its construction, form, habitability and ability to endure its environment. The marine engineer is responsible for the various systems which propel and operate the ship. More specifically, this means the machinery required for propulsion, steering, anchoring and ship securing, cargo handling, air conditioning, power generation and its distribution. Some overlap in responsibilities occurs between naval architects and marine engineers in areas such as propeller design, the reduction of noise and vibration in the ship's structure, and engineering services provided to considerable areas of the ship.

Auxiliary Marine Machinery

Marine machinery is designed to ensure the proper functioning of a ship's main engines, piping systems, and equipment. Auxiliary marine machinery includes pumps, compressors, and blowers for circulating fuel and the fresh water and seawater used in cooling systems, for supplying air to the starting system of the main engine, for cooling refrigerated holds, and for air-conditioning various parts of the ship and for refrigeration machinery.
Auxiliary marine machinery also includes separators for removing water and other contaminants from fuel and oil, steering machinery, capstans, windlasses, winches for anchoring, mooring, and cargo loading, and cranes.
Other items include heat exchangers used to condense vapours and to heat and cool working fluids, such as water, oil and air, filters for the seawater and fuel supplies, and separators for bilge water.

Cooling Water System

The cooling water system serving the ME is divided into two different systems:

- low temperature (LT) cooling water system;
- jacket cooling water (JCW) system, also known as the high temperature (HT) cooling water system;
- low temperature cooling water system;
- the LT cooling water system supplies cooling water for the lubricating oil, jacket water and scavenge air coolers. The LT cooling water system can be arranged in several configurations;
- central cooling water system, the most common system choice and the basic execution for MAN B&W engines;
- seawater (SW) cooling system, the most simple system;
- combined cooling water system with SW-cooled scavenge air cooler, but freshwater-cooled (FW-cooled) jacket water and lubricating oil cooler. The following efficiency improvement proposals and calculations have been made for a central cooling water system.

Fuel Oil System

The recommended conventional fuel oil (FO) system is divided into a supply system and a circulation system. From the service tank, the supply pumps supply an amount of fuel to the circulation system equal to the ME fuel consumption. The remaining supply pump flow capacity is bypassed to the suction side again through the 4 barg self-acting pressure setting valve. The capacity of the supply pumps is based on 110% ME FO consumption including circulation rate and safety factor. The circulation circuit circulates fuel oil through the heater, filter, engine, venting tank and back again to the suction side of the circulation pumps. At the engine, a self-acting pressure setting valve is installed for maintaining a constant inlet pressure independent of the ME FO consumption.

Engine load 85% at SW temp. = 6°C and engine load 95% at all SW temperatures; therefore, zero is entered in these matrix cells.

VFD-controlled supply pump

If the FO supply pumps deliver only the necessary fuel oil amount to the circulation circuit, a VFD can be installed for the supply pump electric motor. This VFD must be controlled so that a constant inlet pressure of 4 barg is maintained for the circulation system, see valve arrangement in Fig. 16. As the number of minimum revolutions of the electric motor for the supply pump is, for example, 30% (supplier specific), the self-acting pressure setting valve is still necessary. The valve set pressure must be increased to 4.2 barg to obtain hysteresis between the control pressure signal and the set pressure for this valve. The capacity of the circulation pumps is based on 110% ME FO consumption, including the circulation rate and safety factor.

Figure [ ] shows the recommend ME FO system. It should be mentioned that the arrangement of the FO system may differ: the automatic filter may, for example, be installed on the supply side, including a duplex safety filter in the circulation circuit, etc.

Lubricating Cooling Oil

LO is pumped from a bottom tank by the main LO pump to the LO cooler, thermostatic valve and through a full flow filter to the ME inlet flange as shown in Fig. 20. The LO system lubricates main bearings, thrust bearing, axial vibration damper, piston cooling, crosshead bearings and crankpin bearings. It also supplies oil to the hydraulic power supply unit, the moment compensator and the torsional vibration damper, if installed. From the engine, the oil collects in the oil pan where it is drained off to the bottom tank again. The LO pumps must supply a well-defined, load-independent inlet pressure to the ME with the LO capacity specified by MAN Energy Solutions. For the specific engine type, 8G95ME-C9.5 TII, the LO inlet pressure is normally 2.8 barg measured 1,800 mm above the crankshaft.

4.2.4 Evaluate engine performance

Knowledge and skills

4.2.4.1 Ability to use and interpret manuals to evaluate engine performance and operate engines appropriately

Marine engines on ships are used for 2 main purposes – for propelling the ship and for generating electricity, which assists in powering the ship's propulsion plant. The efficiency of any machinery on board ship is directly related to its performance. In order to get the best out of marine engines, it is very important to monitor their performance and take measures to achieve an efficient combustion.

Ensuring this will not only reduce generation of pollution from engines but also the overall operating cost of the ship.

The Boatmaster should be familiar with these following methods of monitoring and measuring the performance of the engine:

1. Measure the Peak Pressure by Mechanical Peak Pressure Gauge: This method is normally applied in 4 stroke generator engines where a peak pressure gauge is used for individual cylinders and pressure generated during combustion is noted. With the same gauge, the compression pressure of the cylinder is also measured when the unit is not firing. The variation in the peak pressures generated is then taken into account for drawing out faulty units, adjusting fuel racks and overhauling combustion chamber parts in order to achieve efficient combustion.
2. Indicator Card Measurement: This is another mechanical method to measure the performance of engine cylinders by applying the indicator drum and plotting graph on cards. Two types of cards are used for this purpose: the power card and the draw card. With the help of these two diagrams, we can determine the compression pressure, peak pressure and engine power.
3. Digital Pressure Monitoring by DPI: Digital pressure indicator is an electronic mode to monitor the power and performance of the engine. With the help of DPI, the variation in the cylinder performance can be plotted and interpreted in graphical form and corrective action can be taken.
4. Intelligent Combustion Monitoring (ICM): The new generation engines are continuously monitored by ICM, which measures the real time in-cylinder pressure in all engine cylinders. This package offers a broad range of data processing tools for evaluating performance and for helping to determine engine malfunctions (extensive blow by, exhaust valve operation, fuel injection, etc.).
5. Monitoring of Engine Control Parameters: The engine control parameters like fuel injection timing, exhaust valve timing, variable turbocharger vane opening angles, lambda control, etc. are monitored and any variation is set to achieve the best possible efficient combustion.
6. Engine Parameters: The engine parameters are the best source for finding out any fault or variation in the engine performance. Variation in temperature, pressure and power produced by each cylinder must be frequently monitored and adjustments must be carried out accordingly to achieve efficient combustion.
7. Log Book Monitoring: This is the most basic but commonly ignored method for monitoring engine performance. The log book record for engine room machinery is kept onboard the ship for years.
   The log book for the current month and for previous months must be compared for recorded parameters, which will give the exact variation of engine parameters. If the variation figure is high, engine controls, parameters and parts may have to be adjusted/overhauled.
8. Engine Emission: The marine engine releases exhaust smoke as waste product after the combustion. The colour and nature of the exhaust should be monitored continuously and engineers must know which exhaust trunk discharge is dedicated to which engine. The change in exhaust smoke is a prominent indication of a problem in the combustion chamber.

4.3 The Boatmaster Shall Be Able To Plan And Give Instructions In Relation To The Pump And The Pump Control System Of The Craft

Competences

The Boatmaster shall be able to:

I. Monitor routine pump works, ballast and loading pump systems.

4.3.1 Monitor routine pump works, ballast and loading pump systems.

Knowledge and skills

4.3.1.1 Knowledge of pump systems and pumping operations

A pump is a mechanical device used to transfer fluid from one point to other by imparting energy supplied by a prime mover to the liquid. Pumps can be of many types, but, based on the principles of operation, they are made either reciprocating or rotary. Reciprocating pumps are self-priming; whereas rotary pumps may not have the capability of lifting a fluid from a low position due to their non-self-priming nature.

Rotary pumps take up less space and are more powerful; either a centrifugal pump or a rotary pump is commonly used for the majority of applications on board. As for the blowers and the fans, they are primarily used for air circulation and ventilation for the confined spaces of ships, including the machinery space which needs a much higher supply of air due to a hot engine-room environment as well as for combustion air supply purposes in the main engines and boilers.

The most common pump used to move large volumes of water is the centrifugal pump because it is simple in construction and operation:

- start a centrifugal pump with its discharge valve closed. however, do not run it for long periods of time without a flow of liquid since the fluid flowing through cools the pump. running the pump dry can overheat it, vaporise any liquid in its casing and bind the pump. with a closed discharge valve, the pump has an “efficiency” of 0%. (i.e. 0% of pump’s full flow)
- centrifugal pumps often require “priming,” particularly when operating with a negative suction head (i.e. when the fluid on the suction side must be lifted to reach the pump’s level)
- if a centrifugal pump becomes “air bound,” open the vent on the top of the casing to remove the air
- to operate a centrifugal pump at reduced capacity, throttle the discharge valve
- if a centrifugal pump cannot produce the designed pressure, it may have worn wearing rings;
- when two centrifugal pumps are discharging to a common (i.e. the same) line, the pump with the slower speed may churn (i.e. fail to pump) and overheat;
- noise and vibration are the usual symptoms of “cavitation” when a centrifugal pump sucks air.

The Boatmaster will be able to:

- define the basic principle of suction and delivery heads in a pumping system;
- describe the types of pumps used on a ship;
- describe the working principles of reciprocating and rotary pumps;
- identify the components of various pumps and state their functions;
- identify the faults in the pumps and their maintenance schemes.

4.3.1.2 Ability to ensure monitoring of safe operation of bilge, ballast and cargo pump systems including adequate instructions to the crew, taking into account free surface effects on stability

Ballast and de-ballast operations on the ship must be carried out by an experienced and responsible officer as these operations are directly related to the stability factor of the ship. A ballast system may differ from ship to ship but the basics of all ballast systems remain the same: filling, removing and transferring water from one tank to another to get the required stability for a ship. All valves in the ballast system are normally hydraulically operated from the remote operator station in the ship’s control centre or in the ECR in manual mode or in automatic sequence.
The ballast pump suction and discharge valves, along with other valves, have their fail-safe in the OPEN position so that if any valve malfunctions or gets stuck, it still remains open to carry out the ballast operation. The overboard discharge valves have their fail-safe as fail-stay position.

A typical bilge and ballast system consists of a general service pump, bilge and ballast pump, and a dedicated bilge pump. The two systems take suction from their dedicated valve manifold and are separated from each other using a non-return dedicated suction valve as displayed in the above diagram.
The output from the bilge pump is then discharged overboard through an oil content monitor for cargo holds bilges or via an oily water separator for bilges from engine room bilge wells. Their role is to ensure the discharged water does not contain more oil than 15 ppm; under Marpol regulation 1 oil content may have to be as low as 5 ppm.

As shown in the above diagram the ballast pump can also take suction from the bilge well but this is only to be used under emergency conditions. This ensures that the ballast pump lines remain free from any oil or harmful chemicals. Typically bilge water contains traces of oil, emulsifier, various solvents and other liquids; these must be minimised before discharging overboard the ship.

All bilge suction on board, whether in cargo holds or engine space, is fitted with mud holds or a pair of strainers, followed by the screw down non-return valve. In larger ships, an additional submersible pump is installed above the bulkhead deck with a separate power supply, which is connected to the bilge suction.

The Boatmaster should be able to recognise different forms of ballasting and de-ballasting:

- transferring water between tanks using gravity;
- ballasting or de-ballasting tanks from the sea using gravity;
- ballasting the tanks using the ballast pump/pumps;
- de-ballasting the tanks using the ballast pump/ pumps;
- de-ballasting the tanks using the stripping ejectors.

The Boatmaster should also be familiar with other significant steps:

- care should be taken to ensure that the tank is not overfilled, as this will damage the tanks because the pressure vacuum valves have a lower capacity than that of the pump. The filling valves will close automatically when the tanks reach their set point level, which has been pre-set;
- also, care has to be taken not to run the pump dry or run the pump with discharge valves closed. This can be taken care of by an automated system, which ensures that the pump will not start until all the necessary valves are opened;
- valves can be put in auto mode, which ensures that the valve closes automatically once the ballast tank is filled with the required amount of water or once the setpoint is reached;
- port and starboard sides are considered two separate systems, each having its own automatic sequence for ballast /de-ballasting;
- when filling ballast tanks with ballast pumps it should be observed that the motors are not overloaded (check current in ammeter). If this occurs, the number of opened valves to ballast tanks shall immediately be reduced (closed) until the current is within the allowable limit. A ballast pump motor overload alarm is given for the safety of the ballast pump;
- sometimes during a sea voyage, an alarm on the ballast pumps might go off if suction pressure is high. At that time just open the suction valve to the sea chest and close it when the pressure is reduced;
- the water in the heeling tanks should always be half of their total capacity. But if required the heeling tanks can be used as ballast tanks. The ballast pump is used to empty or fill the heeling tank;
- also in some ports, the port authorities may ask for a sample of the ballast that the ship is carrying. In this case, the sample has to be taken from the sounding pipe connection. The locations of all the sounding pipes are provided on the ballast system plan of the ship.

4.4 The Boatmaster Shall Be Able To Organise The Safe Use And Application, Maintenance And Repair Of The Electro-Technical Devices Of The Craft

Competences

The Boatmaster shall be able to:

I. Prevent potential damage to electric and electronic devices on board.

II. Test control systems and instruments to recognise faults and at the same time take actions to repair and maintain electric or electronic control equipment.

III. Give instructions beforehand and for follow-up activities to connect or disconnect technical shore-based facilities.

4.4.1 Prevent potential damage to electric and electronic devices on board

Knowledge and skills

4.4.1.1 Knowledge of electro-technology, electronics and electrical equipment and safety devices, e.g. automation instrumentation and control systems to prevent damage

Electric power is a wide field covering the generation, distribution and use of electrical energy. The programme of study will focus on green power generation and provide a broad overview of trends in the energy sector. In modern vessels, most of the equipment is powered by electric energy, from propulsion systems to cranes and winches.

Marine electricity generation on board ships comes from diesel, shaft or steam-driven generators.
For ports, shipyards and structures located inland, marine electricity comes from the electricity supply of the land-based power generation plants. Unlike land, the ship's generator has insulated neutral points, i.e. its neutral is not grounded or connected to the ship's hull. This is done to ensure all the essential machinery are up and running even if there is an earth fault.

The ships sailing in international waters generally have a 3 phase D.C. supply with 440v insulated neutral system. Ships like RORO, passenger, etc. that have large electrical load requirements are installed with high voltage operating gensets in the range of 3KV to 11KV.

On land, the frequency of the power supplied can be 50 or 60 Hz depending on different parts of the world. On ships, 60hz frequency is adopted as standard practice which helps hundreds of motors on a ship run at higher speed even if they are of a smaller size.

The supply which is at 440v is stepped down using a transformer to 220V or 110V for lights and low power signal equipment. All the electrical equipment on board ships is similar to land-based equipment, however, they are upgraded to withstand the rigorous atmosphere of the sea and the moving ship, to withstand humid surroundings, high temperatures, salty and corrosive atmosphere, vibrations, etc.

Parts Of The Marine Electricity System

The electricity system on board ships can be divided into five specific systems:

- Generator system;
- Main Switchboard System;
- Emergency Switchboard System;
- Distribution system.

Generator System

The generator system consists of an alternator and driver for the alternator which can be a diesel-driven or steam-driven engine. Many ships are equipped with a shaft generator where the rotation of the main engine of the ship is used to operate the alternator and generate additional electricity. The power generated by these marine generators is transported to the main switchboard using busbars. There are no electrical wire connections inside the main and emergency switchboards on ships for connecting the power supply from the generators to these switchboards. All high voltage and high current systems are connected by busbars.

Main Switchboard System

The main switchboard is considered the distribution hub of the ship's electrical system, taking power from the power generator and distributing it to the power consumers spread out all over the ship. It provides a power supply to all important ships machinery with 440V. A part of the main switchboard is provided with a 220V supply via a stepdown transformer. It includes bridge equipment, navigation lights, radio communication equipment, etc. The power from the auxiliary switchboard is used to charge the battery which is used for emergency lights.

Emergency Switchboard System

An emergency generator is required to be operational at all times once the main generator fails. This emergency generator will start automatically and provide power to the emergency switchboard. All the emergency equipment supply is connected to the emergency switchboard. The emergency switchboard is also divided into two sections – 440V and 220V, providing supply to appropriate machinery and equipment.

Distribution System

The distribution system comes after the switchboard and consists of the following

Distribution boxes: These boxes are enclosed and made up of metal to supply power to localised parts of the ship's machinery.

Motor starter boxes: There are hundreds of motors operating a range of mechanical machines on board ship. Each group of motors is provided with a motor starter box containing their "ON & OFF" switch along with safety devices. Local gauges for amperage and temperature are fitted on the starter panel.

Shore connection boxes: When the ship is in a port with emission control requirements or during the dry-docking process where the ship generator cannot run, use is made of shore-based power to run ship machinery. A shore panel is provided which is usually located near the accommodation entry or near the bunker station to easily accept the shore supply cable.

Marine Generator Working Principle

The generator works on the principle that when a magnetic field around a conductor varies, a current is induced in the conductor. The generator consists of a stationary set of conductors wound in coils on an iron core. This is known as the stator. A rotating magnet called the rotor turns inside this stator producing a magnetic field. This field cuts across the conductor, generating an induced EMF or electro-magnetic force as the mechanical input causes the rotor to turn. The magnetic field is generated by induction (in a brushless alternator) and by a rotor winding energized by DC current through slip rings and brushes.

Safety Of Marine Electricity System

The safety of marine electrical systems includes safekeeping of personnel from electrical shock and damage to the machinery due to electrical malfunction. For machinery safety, depending on the size and power rating of the equipment, a relay, circuit breaker or fuse can be used which prevents the electrical equipment from overcurrent or overheating.

Temperature gauges, RPM of the motor, direction indicator, Amperage meter, etc. are different types of equipment used locally to monitor the performance of the electrical machinery or equipment and to understand the general health of the machinery.

Marine Electronics

Marine electronics refers to electronics devices designed and classed for use in the marine environment on board ships and yachts where even a small amount of salt water can destroy some electronics devices. Therefore, the majority of these types of devices are either water resistant or waterproof. Marine electronics devices include chartplotter, marine VHF radio, autopilot and self-steering gear, fishfinder and sonar, marine radar, GPS, fibre optic gyrocompass, satellite television, and marine fuel management.

The electronics devices communicate by using a protocol defined by the National Marine Electronics Association (NMEA), with two standards available, NMEA 0183 (serial communication network) and NMEA 2000 (controller-area network based technology). There is also Lightweight Ethernet (LWE).
In recent years, the International Electrotechnical Commission (IEC) has created a new standards suite for "Digital interfaces for navigational equipment within a ship". This is known as IEC 61162 and includes NMEA 0183, NMEA 2000 and LWE.
Additionally, different suppliers of marine electronics have their own communications protocol.

Navigation

Another important part of marine electronics is the navigation equipment. Compasses, which includes both gyro compasses and magnetic compasses, make up for equipment that is used by the entire shipping industry.

The Boatmaster will be able to:

- state and understand the basic laws of electricity;
- discuss energy and power;
- recall Ohm's law and how it relates to the basic laws of electricity;
- define direct current (DC);
- List the objectives of using DC sources on a ship;
- describe the effects of series and parallel connections of DC voltage sources.

4.4.1.2 Ability to apply safe working practices

Working with electricity and electrical equipment/devices

Crew members and Boatmaster should receive adequate training before being permitted to work on electrical installations. The installation should be maintained and protected to minimise the possibility of fire, external explosion, electrical shocks and danger to crew members. All live parts should be effectively insulated and enclosed in conduits or otherwise protected and should be maintained in that condition.
All electrical equipment should be regularly inspected to ensure that it is suitable for its intended use. Any electrical faults or other defects should be immediately reported to the appropriate person and repaired by a competent person.

Attention should be paid to the maintenance of the emergency source of electrical power. All electrical appliances should be clearly marked to indicate their safe operating voltage. Flickering lights should be investigated and repaired by a competent person.
Circuits and appliances carrying different voltages in the same installation should be clearly distinguishable by notices, markings on distribution boxes and other conspicuous means. Repairs to electrical installations should be carried out only by a competent person or when a "permit-to-work" has been issued.
Every circuit should be protected against overload currents, so as to reduce damage to the system and keep the danger of fire to a minimum. Personal protective equipment, such as rubber gloves and rubber boots, should be used whenever there is a risk of electric shock, but should not be regarded as providing full protection against such a risk.

Protection against contact with live equipment should be afforded by:

- placing live parts out of reach;
- effective enclosure of live parts; and
- adequate insulation.

The following notices should be exhibited at suitable places:

- a warning notice prohibiting unauthorised persons from entering electrical equipment rooms, interfering with switchboards, and handling or interfering with electrical apparatus;
- a warning notice specifying the person to be notified in the event of an electrical accident or some other dangerous occurrence, and indicating how to communicate with that person;
- a notice specifying the voltage present in equipment or conductors; and a notice prohibiting the use of naked flames in the vicinity of the battery room.

Only authorised persons should have access to and enter equipment rooms containing live electrical equipment or have access to the rear of live switchboards. No work should be done in dangerous proximity to a conductor or installation until it has been made dead and signs have been suitably posted. If a conductor or an installation is in the immediate vicinity of a work location and cannot be made dead, special precautions should be taken. Any such operation should be supervised by a competent person.
All conductors and equipment should be considered to be live unless there is definite proof to the contrary. Before the current is restored, a competent person should ensure that no crew members remain in a dangerous position.

After work has been done on electrical equipment, the current should be switched on again only by, or on the orders of, a competent person. If temporary connections have to be made while repairs are being carried out, the connections should be made with cables having an adequate margin of current and voltage rating and by a competent person. They should be disconnected and removed as soon as they are no longer required. Crew members not authorised to carry out electrical work should never install new equipment or alter existing equipment.

Rectifiers And Electronic Equipment

No maintenance or repair work should be attempted until the equipment has been effectively isolated and any stored energy dissipated. Special attention should be paid to the hazard of working near charged capacitors associated with rectification circuits. Only competent persons should be authorised to repair electronic equipment.

Radio Communication Equipment

Aerials and open wire feeders should be placed and guarded in a way to make them inaccessible to unauthorised persons. Conductors that pass through areas of high electromagnetic flux should be insulated or otherwise protected in areas to which crew members have access.
Any work in the vicinity of transmitting aerials should be carried out only within the "permit-to-work" system. Warning notices should be posted at appropriate places until the work has been completed.
No crew members should be allowed to work in the vicinity of transmitting aerials whilst there is a possibility that such aerials may be energised. Suitable means should be provided and maintained to exclude any persons from the vicinity of equipment where there is a danger from shock, radio frequency burns and injury from X-rays or other radiation.

Work With Visual Display Units (Vdus) Including Microcomputers

Crew members should be given adequate individual training in the use and capabilities of VDUs and microcomputers. Work with VDUs can be mentally tiring and measures should be taken to minimise the risk of eyestrain. Lighting should be adequate for the task, with glare and reflection cut to a minimum, and the display screen should be clear and easy to read. Rest periods should be provided.
Symptoms such as neck and arm pains may arise as a result of bad posture. VDU operators should avoid sitting in a slumped or cramped position and should be provided with an adjustable chair. Screens and keyboards should be adjustable to the correct height and the correct distance from the operator.

4.4.2 Test control systems and instruments to recognise faults and at the same time take actions to repair and maintain electric or electronic control equipment

Knowledge and skills

4.4.2.1 Knowledge of the craft's electro-technical testing devices

Electrical tester tools are used for measuring various electrical parameters. These parameters include current, voltage, resistance, continuity, etc. It is commonly used by professional electricians and electrical contractors to test live wires, circuit breakers, electrical panels or power transformers. They are both multi-function and single-function devices that can conduct typical electrical testing duties. The various types of an electrical tester include clamp meters, insulation testers, multimeters, ohmmeters, voltage detectors, etc.

Types Of Electrical Testing Equipment

It is essential to have electrical power testers to protect yourselves from potential bursts, fire, shocks and other hazards. They play a very important role in various industrial sectors for multiple reasons. So, let us look into the different types of electrical power testers.

Clamp Meters - This is an electrical testing tool, being a combination of a digital multimeter with a current sensor. It is preferred for measuring the high level of current in the circuit without disconnecting it. The advanced versions can measure voltage, continuity and resistance as well as the current. They are preferred for both safety and convenience. The clamp meters are basically used for service, installation and maintenance. It is used on industrial equipment, industrial controls, residential and commercial systems, and HVAC. Its 3 types include:

- **Current transformer** - It can measure alternating current
- **Hall effect** - It can measure both alternating and direct current.
- **Flexible type** - It has a Rogowski coil that can measure only AC. It is suitable for use in confined spaces or congested areas.

Cord Flexing Testers - This is used for testing and measuring the quality of power cords. It determines whether the material in the flexible cable can withstand constant flexing under an electrical load.

DC Power Supply - This is the tool that supplies a constant DC voltage to its load. It can be powered from both DC source or AC source such as the power mains. It is mainly used in voltage applications like charging batteries, automotive applications, aircraft and low current & voltage applications.

Insulation Testers – This is used to prevent the users from hazards like an electric shock, short circuits that occur when the insulation in electrical parts are used in industrial plants, buildings, etc. The portable type of tester is used for testing insulation resistance, continuous current, alternating current, etc. Also, it is used for testing supply lines to protect the user and ensure the proper functioning of the system.

Multimeters - This is also known as the volt-ohm meter. It is an electronic measuring instrument that combines several measurement functions in one unit. It can measure various parameters like voltage, current, resistance, etc. Technicians in electrical industries most commonly use it. It is a portable tool used for detecting basic faults at field service work. It is also used for measuring a high degree of accuracy. An analogue multimeter is used for measuring the current. The digital multimeter has a resolution in digits. It performs all functions from AC to DC other than analogue. It is used for applications like production testing, diode testing, capacitance, voltage reference, etc.

Ohmmeters - This is an electrical instrument that can measure electrical resistance. A micro ohmmeter makes low resistance measurements, whereas a mega ohmmeter measures large values of resistance. It comprises a needle and 2 test leads. The needle deflection is controlled with the battery current. The 2 test leads of the meter are shorted together to measure the resistance of an electric circuit. Series, shunt and multi-range are types of ohmmeter. It is mostly used at electronic labs in engineering to test the electronic components.

Power & Energy Meters - This is used for measuring energy utilised by an electric load. Energy is the power consumed by the electrical appliances for a certain amount of time. Users can use it in both a domestic and industrial circuit for measuring power consumption. It works on the principle of converting electrical energy into mechanical work.

Transformer Turns Ratio Meter - This is mostly used to test the turns ratio of high voltage windings to low voltage windings of the transformer. It has high accuracy, is compact in size and light weight. Some of its applications include overload protection, distribution system, switchgear, control device, etc.

Voltage Detector - This is used for detecting the electric fields or electricity in the piece of equipment under test. It can identify precise voltage levels in an electrical system. The internal circuit of the detector leads to a sensor that is fixed to the tip of the tool. The electromagnetic waves touch the sensor and a signal is sent through the circuit. It thus makes the light glow or turns on the buzzer. It is used to detect AC voltages in sockets, outlets, switches, circuit breakers, fuses and cables. It also detects breaks in wires.

The standard electrical test kits consist of a multimeter, voltage tester and a receptacle tester. The voltage tester is used to identify voltage in circuit breakers, wires or outlets. At the same time, the receptacle tester is used to identify a common wiring problem. The kits include batteries as well.

The Boatmaster will be able to:

- list the various tools used for electro-technical testing process;
- summarise standard electronic and electrical components;
- discuss the importance of device maintenance;
- recall the four main steps of servicing;
- compare direct current to alternative current ;
- explain practical aspects of current measurement ;
- recall basic symbols ;
- recognise resistors.

4.4.2.2 Ability to operate, test and maintain control systems and take appropriate measures

In the process of operating, testing and maintaining of vessel's control systems, safety is the first thing that the Boatmaster has to take into consideration. There are a several safety steps that must be taken when operating/ maintaining or handling remote control system:

1. Never touch any machinery part or open any door/ cover when operating remote control components as this is dangerous and can lead to malfunction if mistreated during operation
2. Once the maintenance is performed on the devices, close the door/put cover on them to avoid entry of dust or foreign material
3. Always check all the remote control operations using the manoeuvring handle in the engine control room before entering or leaving port
4. If the main engine is stopped due to automatic shutdown/slowdown, the first action is to move the manoeuvring handle to the stop position and then troubleshoot the problem before restarting the engine
5. Before doing maintenance of the electrical circuit of remote control system, ensure to switch off the supply. There can be multiple power supplies for such systems, check and turn off all power supply before opening
6. Before applying a megger or withstand voltage test to such a circuit, ensure total of all wires to the unit that prohibit megger test in order to safeguard the electronic device
7. Ensure to check drawings of the electrical circuit before working on it and do the contact cleaning routine as loose contacts and deposits are the most common causes of malfunction in the electrical system of remote control manoeuvring
8. If shore power is being connected to the ship in layup or dry dock, ensure to turn off the power supply switches of the remote control system as voltage drop during transfer of the power supply can damage the remote control system and lead to failure in operation of the same
9. Before doing any maintenance in the pneumatic part of the remote control system, ensure to shut the air supply and drain the air inside the piping system

10. When opening air pipes, ensure to replace damaged rubber seals and thread tapes when re-assembling. When assembling pipe fitting to a pneumatic device, never apply seal tape or sealant to the pipefitting or to screws to avoid falling of detached parts into the device or piping

The remote control system has to be the most important system in the main engine and any malfunction of this system during manoeuvring or in traffic channels may lead to a critical condition like accident, grounding, collision, etc. Periodic maintenance of the remote control system is of extreme importance and the engineers have to keep a check on the correct operation and spare parts (often ignored) of pneumatic and electrical devices incorporated in the remote control manoeuvring system.

4.4.3 Give instructions beforehand and follow-up activities to connect or disconnect technical shore-based facilities

Knowledge and skills

4.4.3.1 Knowledge of safety requirements for working with electrical systems

Working with electricity and electrical equipment/ devices represents a serious danger. The installation should be maintained and protected to minimise the possibility of fire, external explosion, electrical shocks and danger to crew members. All live parts should be effectively insulated and enclosed in conduits or otherwise protected and should be maintained in that condition. All electrical equipment should be regularly inspected to ensure that it is suitable for its intended use. Any electrical faults or other defects should be immediately reported to the appropriate person and repaired by a competent person. Attention should be paid to the maintenance of the emergency source of electrical power. All electrical appliances should be clearly marked to indicate their safe operating voltage.

Flickering lights should be investigated and repaired by a competent person. Circuits and appliances carrying different voltages in the same installation should be clearly distinguishable by notices, markings on distribution boxes and other conspicuous means. Repairs to electrical installations should be carried out only by a competent person or when a "permit-to-work" has been issued. Every circuit should be protected against overload currents, so as to reduce damage to the system and keep the danger of fire to a minimum.

Personal protective equipment

Equipment such as rubber gloves and rubber boots should be used whenever there is a risk of electric shock, but should not be regarded as providing full protection against such a risk.

Protection against contact with live equipment should be afforded by:

- placing live parts out of reach;
- effective enclosure of live parts; and
- adequate insulation.
- The following notices should be exhibited at suitable places:
- a warning notice prohibiting unauthorised persons from entering electrical equipment rooms, interfering with switchboards, and handling or interfering with electrical apparatus;
- a warning notice specifying the person to be notified in the event of an electrical accident or some other dangerous occurrence, and indicating how to communicate with that person;
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All conductors and equipment should be considered to be live unless there is definite proof to the contrary. Before the current is restored, a competent person should ensure that no crew members remain in a dangerous position. After the work has been done on electrical equipment, the current should be switched on again only by, or on the orders of, a competent person. If temporary connections have to be made while repairs are being carried out, the connections should be made with cables having an adequate margin of current and voltage rating and by a competent person. They should be disconnected and removed as soon as they are no longer required. Crew members not authorised to carry out electrical work should never install new equipment or alter existing equipment.

4.4.3.2 Knowledge of the construction and operational characteristics of shipboard electrical systems and equipment in relation to shore-based facilities

The majority of current sea-going ships have a separated field in their main switchboard enabling the connection of the vessel electric supply system to a land electric grid. The panel for "shor connection" is equipped only with the connecting installation and alternatively phase sequence control. The ship might be alternatively shore connected only if a shore voltage source is available with ship electric system voltage ratings. At present, electric incompatibility is the main obstacle, therefore supplying the vessel electric system by means of a land electric grid is relatively rare. The method of switching from the own-ship autonomous electric system to a shore connection and the other way round is an important aspect as short black-out appears.

In a modern automated engine room automation and vessel control systems it is unacceptable. In current economic and organizational conditions as well as technical infrastructure of sea transportation with an emphasis on safety, the way of changing the electric power source, when there is black-out cannot be considered. As mentioned above, the main problem while designing the connection of the vessel electric supply system to a land electric grid is "adapting" the land electric grid to various, autonomous vessel systems. The concept of a universal Shore to Ship electric system, recommended in the EU directives, might be one of the solutions.

The main system elements are the following:

- transformer in the main switch board, matching the land distributive grid voltage to the system installation (shore to ship),
- frequency converter matching land grid frequency to the vessel system,
- cable reel system enabling the supply of low voltage to the ship,
- transformer (on the ship) matching low voltage to ship voltage.

The cost of the whole system is determined by a frequency converter which is the only technologically complicated device in the Shore to Ship system. Owing to systematic development of electric technologies of high power in the range of up to 20 MVA, a possibility arose to build an AC current frequency converter. Currently, high power frequency converters have been dominated by two types of fully-controlled valves: Insulated Gate Bipolar Transistor and Insulated Gate-Commutated Thyristor which are a connection between the Gate Turn Off and the Gate Control System. Alternative configurations of the vessel electric supply system may differ depending on local conditions and each of them has distinctive characteristics. The following configurations are distinguished:

- one central frequency converter located in the main switch board, whereas at the quay there are only matching transformers,
- in the main station there is only a land grid voltage descended transformer, whereas the converters with matching transformer are located at given quays,
- in the main station there is a transformer and rectifier; the energy supply in the port goes through a direct current transfer system, and at quays there are inverters and matching transformers.

4.4.3.3 Ability to give instructions to guarantee safe shore connection at any time and to recognise dangerous situations with regard to shore-based facilities

The system configuration must reduce the number of system elements located directly at quays because of intensified port operations: cars, tractors, cranes and others. The configuration of Ship to Shore system (see figure) ensures the reduction of system elements at quays to a minimum. Matching transformers and frequency converters are located in the main station. The section independence of frequency converters (for every quay) increases the independence of the whole system. In the case of failure of one section, it is still possible for other converters to operate. Only low voltage flexible cable cranes (6.6 kV) are located directly at the quay. The crane may be operated remotely onboard.

Safe quick-connectors will be used for the onboard cable connection. A matched transformer converting low land voltage (6.6 kV) into low voltage (LV) of the ship electric system (440VAC) will be installed on ferries. Switching from an autonomous power supply to a land electric grid must happen without breaks. This fact imposes the requirement of synchronization of autonomous diesel generators with a land electric grid. A synchronizing panel with breakers will be installed on the ferry. The LV for the transformer secondary winding will be connected to the main switchboard. The land electric grid must satisfy the port power demand to such an extent that the operation of autonomous auxiliary diesel generators is not required.

4.5 The boatmaster shall be able to control the safe maintenance and repair of technical devices

Competences

The Boatmaster shall be able to:

I. Ensure appropriate use of tools to maintain and repair technical devices.
II. Assess characteristics and limitations of materials as well as necessary procedures used to maintain and repair technical devices
III. Evaluate technical and internal documentation.

4.5.1 Ensure appropriate use of tools to maintain and repair technical devices.

Knowledge and skills

4.5.1.1 Knowledge of the maintenance and repair procedures for technical devices

Repair methods

1. **The right parts** - static method in which it is not needed to comply with the original unconditional

geometrical shape and dimensions. It is used for paired components and their mutual dimensions are required.

2. **Part renovatio**n - this is a special type of restoration of the wear of the part, in which the original geometric shape and dimensions must be unconditionally restored. Restoration of the original technical properties is not a condition. It is permitted to reduce them, but only to such an extent that sufficient safety and operability and reliability are not limited.

3. **Life extension repair** - is a recovery method that has all the features of renovation. One of the conditions of renovation is not observed, either the observance of the original geometric shape or dimensions.

4. **Component regeneration** - a restoration method in which some physical or chemical properties of a part are restored. During regeneration, it is mainly a matter of restoring the original properties of the components, such as the regeneration of springs, no significant features of the original geometric shape can be detected.

5. **Repair to the repair dimension** - this started to be used for components whose replacement would be economically demanding, but which can continue to be used with a partial repair. They are used in pairs of plain bearings and pins. Used for repairs of pins, bearings, drive motors.

When worn, there are 3 changes in geometric shape:

- Ellipticity A ≠ B ≠ C
- Conicity A> B> C
- Barrel A A

7. Repair for repair dimensions - eliminates shape deformations either completely or partially, so that the dimensions of shape deformation were still in the norm. This is in order not to affect the reliability and safety of the component (operation). It is a mechanical treatment of the grinding surface to a smaller diameter. The wear process is specified by the manufacturer.

The average is based on the relation: $d_1 = d - 2\,(OZ + m)$
$d_2 = d_1 - O$
This repair is also used to repair holes and holes that have lost their original shape.
$D_1 = D + 2\,(OZ + m)$

Turbine diagnostics

1. **diagnostics of shape deformations of turbines,** bearing surfaces between the upper and lower part of the turbine body are checked, the size of the slits is determined by a leaf feeler. Subsequently, both parts of the turbine body are pulled off with the help of bolts and the gap between them is measured with a leaf feeler. The unevenness of the bearing surfaces is measured using metal guides and sheet feelers. Magnetic-powder method, visual inspection or capillary (penetration) method is used for diagnostics of cracks and fissures. Corrosion disturbance is detected mainly in the inner part of the turbine body by the method of castings, i.e. the so-called potting compound, which separates from the body after hardening, on the surface of the hardened mass we see a negative image of corrosive destruction of the surface of the inner part of the turbine.

2. **Diagnosis of distribution wheels** - the first inspection consists in the inspection of shape deformations , the so-called corrugation of the camshaft, is performed on a grinding pad, the camshaft is placed on its side on such a pad and the distance of the gap between the cam wheel washer is measured by means of leaf feelers.

3. **Diagnosis sealing device** - Input and output shafts of the turbine housing is sealed by a labyrinth seal (at the exit shaft of the turbine housing to the shaft positioned combs at several levels), thereby preventing leakage of working medium of the turbine housing. The thickness of the combs is the order of tenths of a mm, they are very thin flakes, and quite often we encounter their deformation in shape, and then the gaps between the ridges are measured with a leaf feeler.

4. **Disassembly and diagnostics of turbine rotors** - moving parts - the main part is the rotor which consists of a shaft and impellers. The impellers are pressed on the shaft, i.e. in the diagnostic process it is necessary to remove these impellers from the shaft.

Repair of steam and gas turbine details

The whole activity is entrusted to experts. The costs are high, they are compensated by the fact that these repairs are performed every 4-5 years. Renovation of individual parts - shape deformations of bearing pins, in case of exceeding the conicity or ellipticity - the pin in question is reground to the repair dimension. The maximum sanding limit corresponds to a diameter loss of up to 3%, if a larger sanding would be required, strength calculations must be performed. In the event of microcracks, punches, scratches on the surface of the bearing journals, they can be removed by grinding with grinding stones.

Rotor repair - in case of shaft bending, repair can be performed in three ways

1. By means of mechanical repair - by means of mechanical blows to the surface of the shaft at the point of greatest bending; this is used for shafts with smaller diameters and relatively low radial rust.

2. **Heat treatment** - used to compensate or shape deformation of shafts made of materials, it is not recommended to repair shafts with steel, high carbon and alloyed. The repair can be performed directly in the turbine body by placing the shaft directly into the bearing nests, so that instead of max. the deformation is built towards the mountains and local heating of this place is performed. It is heated to a temperature of 500-550 ° C, for carbon steel shafts and for alloy steels it is 600-650 ° C. The heating time depends on the amount of deformation and the diameter of the shaft and ranges from 3-12 minutes. After this heating, the shaft should level with its own weight. If it is insufficient, the process is repeated. After the heating process, the annealing process is performed to remove the internal stress. Then we allow it to drop a little lower by its own weight and then it will return to the desired level during the annealing process.

3. **Thermo-mechanical treatment** - This consists of heating in place of max. bending to a temperature of 600-650 ° C. during this heating it is necessary for the shaft to rotate slowly. After reaching the heating temperature (in the whole diameter) we set the shaft to the position with max. deflection upwards and ensure that the temperature lasts for 1 hour. This thermal endurance and the action of its own weight cause the value of the elastic deformation to change to plastic. We call this process stress relaxation. During relaxation, internal stresses in the shaft are removed, ensuring dimensional stability.

Vessel maintenance systems

Recent years have brought changes in the operation and maintenance of internal combustion engines, associated with the use of new technologies in their construction. At the same time, the requirements for the level of diagnostics are changing. Despite the use of complex diagnostic systems in the operation of the vessel, the resolution of the occurring faults or accidents is still at the final operational decision of the operator. The pressure to increase operational safety and increased requirements for environmental protection are forcing designers to look for solutions that are in line with this trend and at the same time do not enormously increase operating costs. An example of such a solution is the concept of an electronically controlled "intelligent motor" requiring the management of the latest generation diagnostic system. Modern diagnostic systems for marine engines consist of a diagnosed system, which is the engine mentioned, and a diagnostic system that allows the identification of conditions important to the operator. However, it is essential that the diagnosed devices already have suitably designated measuring points and the possibility of installing sensors already in the design phase. The diagnosis developed by a modern diagnostic system is intended to reduce the number of erroneous operator decisions made due to limited perception in monitoring, collecting and processing information on the technical and operational status of the equipment. This means that the role of the diagnostic system is not only to manage the operation of the engine room, but is also an auxiliary tool in the decision-making process of the operator.

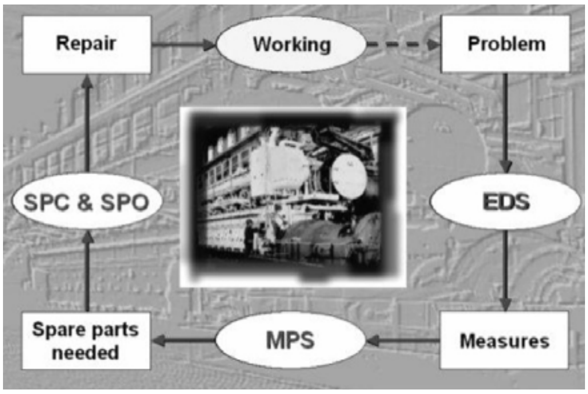
The Boatmaster should be able to:
- define and practically use the methods of diagnostic procedures for technical devices;
- define and practically use the methods of maintenance procedures for technical devices;
- define and practically use the methods of repair procedures for technical devices;
- recognise different types of malfunctions, weaknesses, etc.;
- choose the correct method for each malfunction.

4.5.1.2 Ability to organise and instruct on safe maintenance and repair using appropriate procedures (control), equipment and software

Modern diagnostic systems for marine engines consist of a diagnosed system, which is the engine mentioned, and a diagnostic system that allows the identification of conditions important to the operator. However, it is essential that the diagnosed devices already have suitably designated measuring points and the possibility of installing sensors in the design phase. The diagnosis developed by a modern diagnostic system is intended to reduce the number of erroneous operator decisions made due to limited perception in monitoring, collecting and processing information on the technical and operational status of the equipment. This means that the role of the diagnostic system is not only to manage the operation of the engine room, but is also an auxiliary tool in the decision-making process of the operator.

Cocos system

The abbreviation Cocos (Computer Controlled Surveillance System) reflects the software applications used in the diagnostics of MAN B&W Diesel A / S engines. The motivation for MAN B&W designers to create the most advanced marine engine diagnostic system was the following factors:
- increased demand for ships with high tonnage, and thus an increase in the power of the main propulsion engines;
- the growing complexity of the main engines;
- a tendency to reduce the number of crew members and reduce their qualification requirements;
- random selection of international crew members and rotation of the company's permanent technical staff, which leads to the termination of the crew's identification with the vessel's engine room.



The main goal in the design was to create an "intelligent marine engine management system" that satisfies:

- increase of technical readiness and reliability of the engine;
- effective reduction of operating costs and losses;
- effective planning of engine maintenance and repairs;
- simple and unambiguous identification of spare parts;
- integration of stock management of spare parts with the ordering process.

The system consists of four modules:

1. CoCoS EDS (Engine Diagnosis System) - engine diagnostics system - consists of stationary and portable engine measuring devices, computer and engine software,
2. CoCoS MPS (Maintenance Planning System) - engine maintenance planning system - consists of an application program with an archive of cards with information on maintenance of individual engine segments,
3. CoCoS SPC (Spare Parts Catalog) - spare parts catalog - consisting of an application program with an archive of spare parts,
4. CoCoS SPO (Stock Handling and Spare Parts Ordering) - a system for managing stock and ordering spare parts - consisting of an application program and an archive of spare parts and suppliers.

4.5.2 Assess characteristics and limitations of materials as well as necessary procedures used to maintain and repair technical devices

Knowledge and skills

4.5.2.1 Knowledge of characteristics of maintenance and repair material for technical devices

The structural framework of most ships is constructed of various grades of mild and high-strength steel. Steel provides the formability, machinability and weldability required, combined with the strength needed for ocean-going vessels. Various grades of steel predominate in the construction of most ships, although aluminium and other nonferrous materials are used for some superstructures (e.g. deck-houses) and other specific areas within the ship. Other materials found on ships, like stainless steel, galvanized steel and copper-nickel alloy, are used for a variety of corrosion-resistance purposes and to improve structural integrity. However, nonferrous materials are used in far less quantity than steel. Shipboard systems (e.g. ventilation, combat, navigational and piping) are usually where the more "exotic" materials are used. These materials are required to perform a wide variety of functions, including the ship propulsion systems, back-up power, kitchens, pump stations for fuel transfer and combat systems. Steel used for construction can be subdivided into three types: mild, high-strength and high-alloy steel. Mild steels have valuable properties and are easy to produce, purchase, form and weld. On the other hand, high-strength steels are mildly alloyed to provide mechanical properties that are superior to the mild steels. Steel is an excellent material for shipbuilding purposes, and the choice of welding electrode is critical in all welding applications during construction.

The standard goal is to obtain a weld with equivalent strength characteristics to that of the base metal. Since minor flaws are likely to occur in production welding, welds are often designed and welding electrodes chosen to produce welds with properties in excess of those of the base metal. Aluminium has found increased application as a shipbuilding metal due to its high strength-to-weight ratio compared to steel.

Although the use of aluminium for hulls has been limited, aluminium superstructures are becoming more common for both military and merchant ship construction. Vessels made solely from aluminium are primarily smaller-sized boats, such as fishing boats, pleasure boats, small passenger boats, gunboats and hydrofoils. The aluminium used for shipbuilding and repair is generally alloyed with manganese, magnesium, silicon and/or zinc. These alloys offer good strength, corrosion resistance and weldability.

Welding

Shipyard welding processes, or more specifically fusion welding, is performed at nearly every location in the shipyard environment. The process involves joining metals by bringing adjoining surfaces to extremely high temperatures to be fused together with a molten filler material. A heat source is used to heat the edges of the joint, permitting them to fuse with molten weld fill metal (electrode, wire or rod). The required heat is usually generated by an electric arc or a gas flame. Shipyards choose the type of welding process based on customer specifications, production rates and a variety of operating constraints including government regulations.

The Boatmaster should be able to recognise the most common welding methods:

- MIG Welding - Gas Metal Arc Welding (GMAW);
- TIG Welding - Gas Tungsten Arc Welding (GTAW);
- Stick Welding - Shielded Metal Arc Welding (SMAW);
- Flux Welding - Cored Arc Welding (FCAW);
- Energy Beam Welding (EBW);
- Atomic Hydrogen Welding (AHW);
- Gas Tungsten-Arc Welding;
- Plasma Arc Welding.

Painting and finish coating

Painting is performed at almost every location in the shipyard. The nature of shipbuilding and repair requires several types of paints to be used for various applications. Paint types range from water-based coatings to high-performance epoxy coatings. The type of paint needed for a certain application depends on the environment to which the coating will be exposed. Paint application equipment ranges from simple brushes and rollers to airless sprayers and automatic machines. In general, shipboard paint requirements exist in the following areas:

- underwater (hull bottom);
- waterline;
- topside superstructures;
- internal spaces and tanks;
- weather decks;
- loose equipment.

Surface preparation and painting areas in the shipyard

To illustrate painting and surface preparation practices in the shipbuilding and repair industry, practices can be generically described in five main areas. The following five areas help to illustrate how painting occurs in the shipyard:

- **Hull painting** - occurs on both repair ships and new construction ships. Hull surface preparation and painting on repair ships is normally performed when the ship is fully drydocked (i.e. on the graving dock of a floating drydock). For new construction, the hull is prepared and painted at a building position using one of the techniques discussed above. Air and/or water blasting with mineral grit are the most common types of surface preparation for hulls. Surface preparation involves blasting the surface from platforms or lifts. Similarly, paint is applied using sprayers and high-reach equipment such as man-lifts, scissor lifts or portable scaffolding. Hull painting systems vary in the number of coats required.
- **Superstructure painting** - consists of the exposed decks, deck houses and other structures above the main deck. In many cases, scaffolding will be used on board the ship to reach antennas, houses and other superstructures. If it is likely that paint or blast material will fall into adjacent waters, shrouding is put into place. On ships being repaired, the ship's superstructure is painted mostly while berthed. The surface is prepared using either hand tools or air-nozzle blasting. Once the surface is prepared and the associated surface materials and grit are cleaned up and disposed of, then painting can commence. Paint systems usually are applied with airless paint sprayers.
- **Interior tank and compartment painting**. Tanks and compartments on board ships must be coated and re-coated to maintain the longevity of the ship. Re-coating of repair ship tanks requires a large amount of surface preparation prior to painting. The majority of the tanks are at the bottom of the ship (e.g. ballast tanks, bilges, fuel tanks). The tanks are prepared for paint by using solvents and detergents to remove grease and oil build-up. The wastewater developed during tank cleaning must be properly treated and disposed of. After the tanks are dried, they are abrasive blasted. The vacuum systems and ventilation systems are generally located on the dock's surface, and access to the tanks is through holes in the hull. Once the surface is blasted and the grit is removed, painting can begin.
- **Paint surface preparation as stages of construction**. Once the blocks, or multiple units, leave the assembly area, they are frequently transported to a blast area where the entire block is prepared for paint. At this point, the block is usually blasted back down to bare metal (i.e. the construction primer is removed). The most frequent method for block surface preparation is air-nozzle blasting. The next stage is the paint application stage. Painters generally use airless spray equipment on access platforms. Once the block's coating system has been applied, the block is transported to the on-block stage, where outfitting materials are installed.
- **Small parts painting areas**. Many parts comprising a ship need to have a coating system applied to them prior to installation. For example, piping spools, vent ducting, foundations and doors are painted before they are installed on block. Small parts are generally prepared for paint in a designated area of the shipyard. Small parts painting can occur in another designated location in the shipyard that best matches production needs. Some small parts are painted in the various shops, while others are painted in a standard location operated by the paint department.

The Boatmaster should be able to:

- identify materials used for the ship's hull;
- identify materials of which ship's equipment consists;
- identify the most frequently used materials fort the repair processes, such as welding, painting, coating, etc.

4.5.2.2 Ability to apply maintenance and repair procedures on devices according to manuals

The safety guides on maintenance and repair provide guidance on the maintenance of structures, systems and components of a maritime vessel. However, a more detailed approach to maintenance activities is needed for implementation of the recommendations in the guides.
Manuals give illustrative examples of good practices and recommendations from operating and other organisations. Manuals and guides directed primarily towards ship management should serve as a guideline for the preparation and improvement of the maintenance programme, its implementation and related maintenance activities.

The Boatmaster should be able to:
- understand the most important maintenance procedures on devices according to manuals;
- understand the most important repair procedures on devices according to manuals;
- state all manuals needed on board for maintenance and repair processes;
- recognise types of malfunctions and failures;
- state which type of repair procedure is used on each malfunction.

4.5.3 Evaluate technical and internal documentation

Knowledge and skills

4.5.3.1 Knowledge of construction specification and technical documentation

The operational documentation defines main particulars and technical features of a ship, its equipment and systems, terms and conditions of safe operation within the specified service life. It also comprises stability booklets, software user manuals, test programs, lists of materials, etc. that are to be available on board in compliance with the RS Rules as well as with the applicable requirements of the international codes and conventions.

4.5.3.2 Ability to set up checklists for maintenance and repair of technical devices.

Equipment should only be inspected, tested and maintained by qualified trained personnel.
Continued safe operation of equipment depends on regular maintenance and testing of its operating and protective controls. Should any test indicate that the device being tested or observed is not in good operating condition, it should be repaired immediately. Record and maintain records of repairs or changes so that a complete record will be available for review at any time.

Preventive maintenance is a set of regularly performed procedures to prevent unexpected plant or equipment downtimes. The process includes planned inspections of the organisation's assets and scheduling for their replacement or service. Checklist analysis is the main tool of preventive maintenance.

Check List Analysis - CLA is a method of risk analysis to verify control records used for the completeness and accuracy of the procedure. Control records include a "yes" or "no" rating, or often an "inappropriate" rating, which can help to complete the information. Checklists are often used to determine compliance of the real situation with standards and regulations. Checklists allow problems to be identified and compared to a pre-prepared list. It is important when identifying problems that have already occurred in the past.

Preparation of checklist

The first set of questions: Equipment details
Within the first part of the Equipment Maintenance Questionnaire, the inspector identifies the equipment.

The second set of questions: Equipment Maintenance
After equipment identification, maintenance details can be attached to the report. The inspector can include a text description, periodicity, and also a photo of the equipment. Visual information helps to quickly identify equipment type and condition. With date settings, the user is able to schedule the time for the next required maintenance.

The third set of questions: Recommended Action
Equipment Maintenance Checklist allows adding the inspector's recommendation based on equipment condition. If a repair, replacement, order, or other action is necessary, the text description field provides space for more detailed information, so anyone reading the report has all the essential information at one place.

The fourth set of questions: Conclusion
After all the necessary steps of the inspection have been conducted, results can be summarised in the final part of the questionnaire. Was the inspection satisfactory? When was it held? And what is the recommended date for the follow-up actions? Also, the inspector's signature is necessary for the validation of results.

The Boatmaster should be able to:
- check each device and its parts visually;
- check each device and its parts with proper method;
- carry out periodical checks with a checklist;
- if there is a malfunction or failure of device, report this ASAP.

COMPETING

Co-funded by the Erasmus+ Programme of the European Union