

## Course guide

# 280685 - 280685 - Maintenance and Repair of Equipment and Electric Systems on Board

**Last modified:** 09/05/2023

**Unit in charge:** Barcelona School of Nautical Studies  
**Teaching unit:** 709 - DEE - Department of Electrical Engineering.  
**Degree:** BACHELOR'S DEGREE IN MARINE TECHNOLOGIES (Syllabus 2010). (Optional subject).  
**Academic year:** 2023    **ECTS Credits:** 6.0    **Languages:** Catalan, Spanish

### LECTURER

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**Coordinating lecturer:** VICTOR FUSES NAVARRA  
**Others:** Segon quadrimestre:  
VICTOR FUSES NAVARRA - GTDT

### REQUIREMENTS

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To register this subject, it must be approved:  
280641 Electricity and electrical engineering  
280660 Electric propulsion and power electronics, or, 280665 Vessel Power Plant.

### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**Specific:**

GTM.CE24. Knowledge of the organization and project management of repair, installation, modification, redesign and maintenance of machines and systems of ships, within the scope of its special ad, ie, operation and exploitation.

**Generical:**

CG8. IDENTIFY I resoldre Capacitat PER L'Ambit problemes IN MARINA DE L'ENGINYERIA.

Capacitat per the plantejament i resolució of problemes de l'àmbit enginyeria assumint marina iniciatives, prenent decisions i aplicant solucions creatives in the marc d'a systematic methodology.

**Transversal:**

AAT N2. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.

**STCW:**

- ETO.1. A-III/6-1.1 Monitor the operation of electrical, electronic and control systems
- ETO.2. A-III/6-KUP 1.1.1.6 Basic understanding of the operation of mechanical engineering systems, including: .6 hotel systems
- ETO.3. A-III/6-KUP 1.1.2 Basic knowledge of heat transmission, mechanics and hydromechanics
- ETO.4. A-III/6-KUP 1.1.3 Knowledge of Electrotechnology and electrical machines theory
- ETO.5. A-III/6-KUP 1.1.4 Knowledge of Fundamentals of electronics and power electronics
- ETO.6. A-III/6-KUP 1.1.5 Knowledge of: Electrical power distribution boards and electrical equipment
- ETO.7. A-III/6-KUP 1.1.6 Knowledge of: Fundamentals of automation, automatic control systems and technology
- ETO.8. A-III/6-KUP 1.1.7 Knowledge of: Instrumentation, alarm and monitoring systems
- ETO.9. A-III/6-KUP 1.1.8 Knowledge of: Electrical drives
- ETO.10. A-III/6-KUP 1.1.9 Knowledge of: Technology of electrical materials
- ETO.11. A-III/6-KUP 1.1.10 Knowledge of: Electrohydraulic and electro-pneumatic control systems
- ETO.12. A-III/6-KUP 1.1.11 Knowledge of: Appreciation of the hazards and precautions required for the operation of power systems above 1,000 volts
- ETO.13. A-III/6- 1.3 Operate generators and distribution systems
- ETO.14. A-III/6-KUP 1.3.1 Coupling, load sharing and changing over generators
- ETO.15. A-III/6-KUP 1.3.2 Coupling and breaking connection between switchboards and distribution
- ETO.16. A-III/6-2.1 Maintenance and repair of electrical and electronic equipment
- ETO.17. A-III/6-KUP 2.1.1 Safety requirements for working on shipboard electrical systems, including the safe isolation of electrical equipment required before personnel are permitted to work on such equipment
- ETO.18. A-III/6-CCS 2.1.2 Maintenance and repair of electrical system equipment, switchboards, electric motors, generators and DC electrical systems and equipment
- ETO.19. A-III/6-CCS 2.1.3 Detection of electric malfunction, location of faults and measures to prevent damage
- ETO.20. A-III/6-CCS 2.1.4 Construction and operation of electrical testing and measuring equipment
- ETO.21. A-III/6-CCS 2.1.5.1 Function and performance tests of the following equipment and their configuration: .1 monitoring systems
- ETO.22. A-III/6-CCS 2.1.5.2 Function and performance tests of the following equipment and their configuration: .2 automatic control devices
- ETO.23. A-III/6-CCS 2.1.5.3 Function and performance tests of the following equipment and their configuration: .3 protective devices
- ETO.24. A-III/6-CCS 2.1.5.4 Function and performance tests of the following equipment and their configuration: .4 The interpretation of electrical and electronic diagrams
- ETO.25. A-III/6-2.2 Maintenance and repair of automation and control systems of main propulsion and auxiliary machinery
- ETO.26. A-III/6-CCS 2.2.1 Appropriate electrical and mechanical knowledge and skills
- ETO.27. A-III/6-CCS 2.2.2 Safety and emergency procedures: Safe isolation of equipment and associated systems required before personnel are permitted to work on such plant or equipment
- ETO.28. A-III/6-CCS 2.2.3 Safety and emergency procedures: Practical knowledge for the testing, maintenance, fault finding and repair
- ETO.29. A-III/6-CCS 2.2.4 Safety and emergency procedures: Test, detect faults and maintain and restore electrical and electronic control equipment to operating condition
- ETO.30. A-III/6-CCS 2.3.2 Theoretical knowledge: Electrical and electronic systems operating in flammable areas
- ETO.31. A-III/6-2.4 Maintenance and repair of electrical, electronic and control
- ETO.32. systems of deck machinery and cargohandling equipment
- ETO.33. A-III/6-CCS 2.4.1 Appropriate electrical and mechanical knowledge and skills
- ETO.34. A-III/6-CCS 2.4.2 Safety and emergency procedures: Safe isolation of equipment and associated systems required before personnel are permitted to work on such plant or equipment
- ETO.35. A-III/6-CCS 2.4.3 Safety and emergency procedures: Practical knowledge for the testing, maintenance, fault finding and repair
- ETO.36. A-III/6-CCS 2.4.4 Safety and emergency procedures: Test, detect faults and maintain and restore electrical and electronic control equipment to operating condition
- ETO.37. A-III/6-2.5 Maintenance and repair of control and safety systems of hotel equipment
- ETO.38. A-III/6-CCS 2.5.1 Theoretical knowledge: Electrical and electronic systems operating in flammable areas
- ETO.39. A-III/6-CCS 2.5.2 Practical knowledge: Carrying out safe maintenance and repair procedures

## TEACHING METHODOLOGY

- Receive, understand and synthesize knowledge.
- Analysis of real applications.
- Define and solve problems.
- Application of theoretical knowledge to the maintenance of electrical systems.
- Perform work individually.

## LEARNING OBJECTIVES OF THE SUBJECT

- Understand and apply the norms or technical regulations.
- Use the electrical diagrams as an inspection and maintenance tool.
- Know the different types of maintenance applicable.
- Apply procedures for early detection of breakdowns.
- Know the security procedures.
- Understand the properties of the materials and the electrical installations in case of fire.

## STUDY LOAD

Type	Hours	Percentage
Hours large group	60,0	40.00
Self study	90,0	60.00

**Total learning time:** 150 h

## CONTENTS

### 1. Electric Technical Regulations. Electrical testing and measuring equipment

#### Description:

UNE, IEC, etc. Standardization committees, classification societies. Safety requirements. Electrical working authorisations. Safe isolation equipment. Examples of test regulations: power switches, insulators, conductors, generators, etc. Electrical testing and measuring equipment.

#### Specific objectives:

Use of basic measuring instruments: voltmeter, clamp ammeter, shunt resistor, megohmmeter, ohmmeter, continuity, millimeter, Kelvin connection., oscilloscope.

#### Related activities:

Use the laboratory of measuring equipment.  
Research work on commercial measuring equipment.

#### Related competencies :

A36-1.1.7. A-III/6-KUP 1.1.7 Knowledge of: Instrumentation, alarm and monitoring systems  
A36-2.1.4. A-III/6-CCS 2.1.4 Construction and operation of electrical testing and measuring equipment  
A36-1.1.5. A-III/6-KUP 1.1.5 Knowledge of: Electrical power distribution boards and electrical equipment

#### Full-or-part-time: 4h

Theory classes: 2h  
Laboratory classes: 1h  
Guided activities: 1h

## 2. Electrical diagrams as a maintenance and repair tool. Neutral regime. Protections.

### Description:

Functional, topographic, wiring, cabinets and connectors. Numbering criteria for conductors: equipotentials, round-trip directions. Identification of components, coordinates in the plane, index of elements. Management of modifications in the schemes and correction of originals.

Neutral regimes: TT, TN, IT. Equipotentials. Fuses. Magnetothermal switches. Surge protection. Varistors. Differential switches. Insulation meters.

### Specific objectives:

Identification of neutral regime and its implications for electrical safety and adequate protections.

### Related activities:

Elaboration of the electrical scheme of a simple installation.

Directed work on electrical protections and neutral regimes.

Electrical protection laboratory test.

### Related competencies :

A36-2.1.5d. A-III/6-CCS 2.1.5.4 Function and performance tests of the following equipment and their configuration: .4 The interpretation of electrical and electronic diagrams

A36-1.1.7. A-III/6-KUP 1.1.7 Knowledge of: Instrumentation, alarm and monitoring systems

A36-2.4.4. A-III/6-CCS 2.4.3 Safety and emergency procedures: Practical knowledge for the testing, maintenance, fault finding and repair

A36-2.1.5c. A-III/6-CCS 2.1.5.3 Function and performance tests of the following equipment and their configuration: .3 protective devices

A36-2.2.4. A-III/6-CCS 2.2.4 Safety and emergency procedures: Test, detect faults and maintain and restore electrical and electronic control equipment to operating condition

A36-2.1.5a. A-III/6-CCS 2.1.5.1 Function and performance tests of the following equipment and their configuration: .1 monitoring systems

A36-2.1.5b. A-III/6-CCS 2.1.5.2 Function and performance tests of the following equipment and their configuration: .2 automatic control devices

### Full-or-part-time: 6h

Theory classes: 3h

Laboratory classes: 1h

Guided activities: 2h

### 3- Maintenance

**Description:**

Types of maintenance: corrective, preventive, predictive, proactive. Maintenance philosophies: based on time or based on the condition. Statistical tools: Weibull, FMEA, frequency index, index of severity. Justification of the non-failure saving. Cleaning, cooling and lubrication. Spare parts management. Cases of study: DC systems, switchboards, motors, generators. Safety evaluation in maintenance plans and procedures, including flammable areas.

STCW competences and KUPs from Section A-III/6: E.8.2, E.11.3, E.11.6, E.12.2.

**Related activities:**

Analysis work on some electrical equipment or installations.

First outline of maintenance plan.

**Related competencies :**

A36-2.2.1. A-III/6-CCS 2.2.1 Appropriate electrical and mechanical knowledge and skills

A36-2.1.2. A-III/6-CCS 2.1.2 Maintenance and repair of electrical system equipment, switchboards, electric motors, generators and DC electrical systems and equipment

A36-2.4.1. systems of deck machinery and cargohandling equipment

A36-2.5.1. A-III/6-2.5 Maintenance and repair of control and safety systems of hotel equipment

A36-1.1.0. A-III/6-1.1 Monitor the operation of electrical, electronic and control systems

**Full-or-part-time:** 6h

Theory classes: 4h

Guided activities: 2h

#### 4. Premature fault detection

##### Description:

Periodic reviews: land, verification of protections, ringing of alarms. Inspection rounds and thermographies. Dysfunction sensors. Analysis of clues and weighted decision making. Influence of time. Adaptation of the electrical installations to the new technologies of generation, control, automation and sensors.

##### Related activities:

Tests for fault detection.

Writing an inspection report, or breakdown, or accident.

##### Related competencies :

A36-2.5.2. A-III/6-CCS 2.5.1 Theoretical knowledge: Electrical and electronic systems operating in flammable areas

A36-2.4.3. A-III/6-CCS 2.4.2 Safety and emergency procedures: Safe isolation of equipment and associated systems required before personnel are permitted to work on such plant or equipment

A36-2.1.5d. A-III/6-CCS 2.1.5.4 Function and performance tests of the following equipment and their configuration: .4 The interpretation of electrical and electronic diagrams

A36-2.4.4. A-III/6-CCS 2.4.3 Safety and emergency procedures: Practical knowledge for the testing, maintenance, fault finding and repair

A36-2.1.4. A-III/6-CCS 2.1.4 Construction and operation of electrical testing and measuring equipment

A36-2.1.5c. A-III/6-CCS 2.1.5.3 Function and performance tests of the following equipment and their configuration: .3 protective devices

A36-2.2.4. A-III/6-CCS 2.2.4 Safety and emergency procedures: Test, detect faults and maintain and restore electrical and electronic control equipment to operating condition

A36-1.1.0. A-III/6-1.1 Monitor the operation of electrical, electronic and control systems

A36-2.1.3. A-III/6-CCS 2.1.3 Detection of electric malfunction, location of faults and measures to prevent damage

A36-2.1.5a. A-III/6-CCS 2.1.5.1 Function and performance tests of the following equipment and their configuration: .1 monitoring systems

A36-2-5.3. A-III/6-CCS 2.5.2 Practical knowledge: Carrying out safe maintenance and repair procedures

A36-2.1.5b. A-III/6-CCS 2.1.5.2 Function and performance tests of the following equipment and their configuration: .2 automatic control devices

A36-2.2.3. A-III/6-CCS 2.2.3 Safety and emergency procedures: Practical knowledge for the testing, maintenance, fault finding and repair

##### Full-or-part-time: 8h

Theory classes: 4h

Laboratory classes: 4h

#### 5. Knowledge and behaviour of materials.

##### Description:

Incompatibilities. Electro corrosion: detection, measurement and prevention. Condensations. Flammable areas.

##### Related activities:

Research work on devices and market elements on corrosion, ATEX equipment, roofing materials, inn equipment materials.

##### Related competencies :

A36-2.3.2. A-III/6-CCS 2.3.2 Theoretical knowledge: Electrical and electronic systems operating in flammable areas

A36-2.1.2. A-III/6-CCS 2.1.2 Maintenance and repair of electrical system equipment, switchboards, electric motors, generators and DC electrical systems and equipment

A36-2.1.4. A-III/6-CCS 2.1.4 Construction and operation of electrical testing and measuring equipment

A36-1.1.0. A-III/6-1.1 Monitor the operation of electrical, electronic and control systems

A36-2-5.3. A-III/6-CCS 2.5.2 Practical knowledge: Carrying out safe maintenance and repair procedures

##### Full-or-part-time: 4h

Theory classes: 4h

## 6. Operation in degraded modes

### Description:

Study of cases:

Recovery of a "electric lock out".

Management of large electrical collapses.

Load sharing, coupling and breaking.

### Related activities:

50 kW plant start-up laboratory test, mains synchronization, frequency and voltage stability, protection tripping, load transfer.

### Related competencies :

A36-1.3.1. A-III/6-KUP 1.3.1 Coupling, load sharing and changing over generators

A36-1.3.2. A-III/6-KUP 1.3.2 Coupling and breaking connection between switchboards and distribution

A36-1.1.0. A-III/6-1.1 Monitor the operation of electrical, electronic and control systems

A36-1.3.0. A-III/6- 1.3 Operate generators and distribution systems

### Full-or-part-time: 10h

Laboratory classes: 8h

Guided activities: 2h

## 7. Repairs

### Description:

Actions aimed at recovering the operation of the installation. Detection, localization, neutralization, stabilization. Sectorization to speed up the location. Collection of materials, repair, verification, commissioning. Modifications and improvements in electrical installations. The repair as an opportunity to improve the installation, in repetitive breakdowns. Analysis of collateral damage.

Insurance, performances of insurers.

### Related activities:

Laboratory test on electrical panel with motor and drives. Capacitor refurbishment. Batteries.

### Related competencies :

A36-2.5.2. A-III/6-CCS 2.5.1 Theoretical knowledge: Electrical and electronic systems operating in flammable areas

A36-2.2.1. A-III/6-CCS 2.2.1 Appropriate electrical and mechanical knowledge and skills

A36-2.4.3. A-III/6-CCS 2.4.2 Safety and emergency procedures: Safe isolation of equipment and associated systems required before personnel are permitted to work on such plant or equipment

A36-2.1.2. A-III/6-CCS 2.1.2 Maintenance and repair of electrical system equipment, switchboards, electric motors, generators and DC electrical systems and equipment

A36-2.1.5d. A-III/6-CCS 2.1.5.4 Function and performance tests of the following equipment and their configuration: .4 The interpretation of electrical and electronic diagrams

A36-2.4.4. A-III/6-CCS 2.4.3 Safety and emergency procedures: Practical knowledge for the testing, maintenance, fault finding and repair

A36-2.1.4. A-III/6-CCS 2.1.4 Construction and operation of electrical testing and measuring equipment

A36-2.4.1. systems of deck machinery and cargohandling equipment

A36-2.2.4. A-III/6-CCS 2.2.4 Safety and emergency procedures: Test, detect faults and maintain and restore electrical and electronic control equipment to operating condition

A36-1.1.0. A-III/6-1.1 Monitor the operation of electrical, electronic and control systems

A36-2.5.3. A-III/6-CCS 2.5.2 Practical knowledge: Carrying out safe maintenance and repair procedures

A36-2.2.3. A-III/6-CCS 2.2.3 Safety and emergency procedures: Practical knowledge for the testing, maintenance, fault finding and repair

### Full-or-part-time: 10h

Theory classes: 8h

Laboratory classes: 2h

## 8. Safety procedures

### Description:

Safety in the electrical maintenance of: people, installation, third parties. Effects of electricity on the human body. Direct contact and indirect contact. The 5 golden rules. Prevention of returns. Energy storage elements. Voltage absence certification procedure. Tension work procedures. Qualified work and authorized work. Responsible for electrical work. Personal protective equipment (PPE) and collective protection equipment (CPE). Emergency procedures.

### Specific objectives:

Writing electrically safe work procedures.

### Related activities:

Risk identification activity.

Case study on the development of safe work procedures.

Manipulation, verification and use of the most important PPE

### Related competencies :

A36-2.5.2. A-III/6-CCS 2.5.1 Theoretical knowledge: Electrical and electronic systems operating in flammable areas

A36-2.2.1. A-III/6-CCS 2.2.1 Appropriate electrical and mechanical knowledge and skills

A36-2.1.1. A-III/6-KUP 2.1.1 Safety requirements for working on shipboard electrical systems, including the safe isolation of electrical equipment required before personnel are permitted to work on such equipment

A36-2.4.2. A-III/6-CCS 2.4.1 Appropriate electrical and mechanical knowledge and skills

A36-2.2.2. A-III/6-CCS 2.2.2 Safety and emergency procedures: Safe isolation of equipment and associated systems required before personnel are permitted to work on such plant or equipment

A36-2.4.1. systems of deck machinery and cargohandling equipment

### Full-or-part-time: 6h

Theory classes: 2h

Laboratory classes: 2h

Guided activities: 2h

## 9. Fires of electrical origin

### Description:

Causes, spread, accelerators, extinction, repair, expertise. Electrical insulation and fire on board. Flammability of electrical origin. Investigation and appraisal of fires of electrical origin. Types of cables: halogen free, flame transmission, fire transmission, fire resistant cables. Areas at risk of fire and explosion. Classification of ATEX zones, by particles, by gas, by probability. Examples of electrical and electronic equipment in ATEX areas. Risk and prevention of electrostatic discharges. Lightning strike: prevent or attract lightning, return prevention, atmospheric electric field meters. Protection and prevention measures: review of electrical safety procedures.

### Related activities:

Exercise to identify ignition mechanisms and propose corrective measures.

Fire case assessment.

Laboratory: Inspection of materials involved in fires

### Related competencies :

A36-2.1.1. A-III/6-KUP 2.1.1 Safety requirements for working on shipboard electrical systems, including the safe isolation of electrical equipment required before personnel are permitted to work on such equipment

A36-1.1.7. A-III/6-KUP 1.1.7 Knowledge of: Instrumentation, alarm and monitoring systems

A36-2.4.2. A-III/6-CCS 2.4.1 Appropriate electrical and mechanical knowledge and skills

A36-2.2.2. A-III/6-CCS 2.2.2 Safety and emergency procedures: Safe isolation of equipment and associated systems required before personnel are permitted to work on such plant or equipment

A36-2.5.1. A-III/6-2.5 Maintenance and repair of control and safety systems of hotel equipment

A36-1.1.9. A-III/6-KUP 1.1.9 Knowledge of: Technology of electrical materials

### Full-or-part-time: 6h

Theory classes: 4h

Laboratory classes: 2h





## GRADING SYSTEM

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The final grade is the sum of the following partial grades:

$$N_{\text{final}} = 0.2 * N_{\text{pf}} + 0.8 * N_{\text{ac}}$$

$N_{\text{final}}$ : final grade.

$N_{\text{pf}}$ : final evaluation grade.

$N_{\text{ac}}$ : grade for continuous evaluation and directed activities.

The continuous evaluation consists of different cumulative activities, both individual and group, of a formative nature, carried out during the course (in the classroom and outside of it), exams, work, practical and laboratory activities, etc.

Demonstration criteria for STCW competence: approved training in the electricity laboratory

## EXAMINATION RULES.

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- Assistance and completion of laboratory practices is mandatory.
- If any of the laboratory activities or continuous evaluation is not carried out, it will be considered as not punctuated.
- Will be considered Not Submitted: Who has not attended or has a global grade lower than 0.5 points.
- In no case you can have forms in the learning controls or exams.
- In exams only calculator and pens are allowed.
- The use of mobile phones is not allowed.

## BIBLIOGRAPHY

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### Basic:

- Organització Internacional Marítima. Electro-technical officer. Imo Model Course 7.08. London: IMO, 2014. ISBN 9789280115802.

### Complementary:

- Casals Torrens, Pau; Bosch i Tous, Ricard. Máquinas eléctricas : aplicaciones de ingeniería eléctrica a instalaciones navales y marinas. Prácticas [on line]. Barcelona: Edicions UPC, 2005 [Consultation: 07/02/2022]. Available on: <http://hdl.handle.net/2099.3/36708>. ISBN 8483018136.
- Boix Aragonès, Oriol; Sainz Sopera, Luis; Córcoles López, Felipe; Suelves Joanxich, Francisco J. Tecnología eléctrica. Barcelona: Ceysa, 2002. ISBN 9788486108236.
- Chapman, Stephen J; Rodríguez Pérez, Carlos; Santana Díaz Alfredo. Máquinas eléctricas [on line]. Quinta edición. México DF: McGraw-Hill Education, [2012] [Consultation: 01/09/2022]. Available on: [https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB\\_BooksVis?cod\\_primaria=1000187&codigo\\_libro=4297](https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=4297). ISBN 9781456218454.
- Wildi, Théodore. Electrical machines, drives, and power systems. Sixth edition international. Essex: Pearson Education, [2014]. ISBN 9781292024585.

## RESOURCES

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### Other resources:

Notes and technical articles contributed by the professor.

Regulations of the Classification Societies.

Dossiers of manufacturers: Electra Molins, ABB, Siemens, Schneider Electric.