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ENGLISH FOR THE GRADUATE STUDY PROGRAMME IN ELECTRICAL ENGINEERING AND COMMUNICATION TECHNOLOGIES FOR MARITIME INDUSTRY

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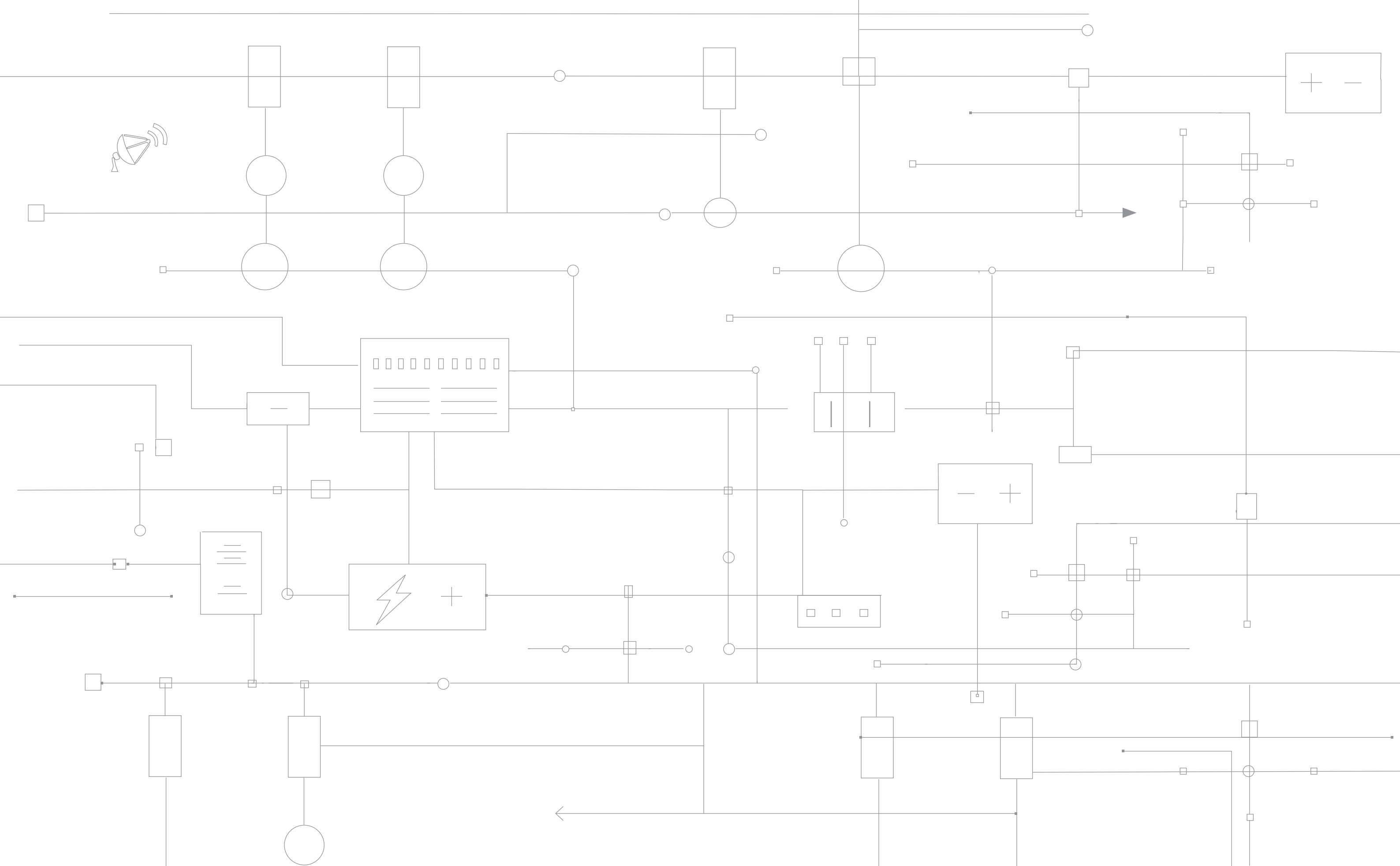
Martina Hrnić, univ. spec. philol., Senior Lecturer

2026.

TABLE OF CONTENTS

Lesson 1



CAREER OF AN ELECTRO-TECHNICAL OFFICER ON A SHIP[1]

Objective

To understand the role of an Electro-Technical Officer (ETO) on a ship, the skills required, and the qualifications needed to pursue a career in this field.

Introduction

If you're interested in a marine career, particularly in the field of electrical engineering, becoming an Electro-Technical Officer (ETO) could be a suitable and rewarding option. The ETO is a crucial member of the ship's crew, specializing in the operation and maintenance of the vessel's electrical systems. This role combines technical expertise with a deep understanding of maritime operations.

What is the Role of an Electro-Technical Officer?

An Electro-Technical Officer (ETO) is responsible for the electrical systems on board a vessel. This includes maintaining and troubleshooting a wide range of electrical equipment and systems, ensuring they function properly throughout the voyage.

Key Responsibilities:

1. Maintenance of Electrical Equipment:

- Ensuring the proper functioning of electrical equipment such as engine room systems, communication tools, and navigational equipment.
- Supervising and maintaining equipment like radar, echo sounders, gyrocompasses, and satellite communication systems.

2. Supervision of Systems:

- Overseeing essential shipboard systems such as refrigeration, air conditioning, bridge systems, and control rooms.
- Ensuring the proper functioning of emergency systems like fire alarms, emergency lighting, and backup batteries.

3. Emergency Management:

- Acting swiftly in emergencies, including electrical failures, ensuring safety equipment is functional and operational.
- Collaborating with the Chief Engineer and other crew members during critical situations.

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[1] https://www.marineinsight.com/careers-2/career-of-electro-technical-officer-on-ship/ (Accessed 14 April 2025)

4. Coordination with Shore Technicians:
- Communicating with shore-based technicians for advanced troubleshooting or repairs when necessary.

5. Vessel's Electrical Components:
- Handling critical ship components such as navigation lights, electrically powered machinery, and battery backups.
- Ensuring all systems comply with safety and operational standards.

6. Assisting the Chief Engineer:
- Providing support to the Chief Engineer in routine maintenance and repair work related to electrical and electronic systems.

Skills and Knowledge Required

To become an effective Electro-Technical Officer, certain qualifications and skills are essential.

Technical Skills:

- Knowledge of Shipboard Electrical Systems: Understanding the intricacies of power generation, distribution, and communication systems.
- Troubleshooting and Maintenance: The ability to identify faults and repair electrical systems under various conditions.
- Emergency Preparedness: Training to manage electrical systems during emergencies, including handling backup systems and alarms.

Certifications:

- STCW 95 Basic Safety Training (including firefighting, fire prevention, and first aid).
- STCW 2010 Manila Amendments: A certificate of competency from the maritime authorities, which is a requirement for becoming a qualified ETO.

Why is the Role of the ETO Important?

- The role of the ETO is particularly crucial on large vessels, such as passenger ships and cruise liners, where electrical systems are complex and vital for the vessel's operation. With an increasing reliance on unmanned systems and automated technologies, the ETO ensures that everything from air conditioning to refrigeration runs smoothly.
- In addition to handling daily operations, the ETO is key during emergencies, ensuring that all electrical systems necessary for safety, such as emergency power and communication devices, remain functional.

Career Outlook

- The demand for skilled Electro-Technical Officers is high, especially as maritime technology evolves and ships become more reliant on electrical and automated systems. The position offers good career prospects, with opportunities for advancement into higher roles such as Chief Electro-Technical Officer or other senior technical positions.

Exercises

Discussion Questions:

1. What challenges might an ETO face when troubleshooting electrical failures at sea?
2. How does the ETO's role differ from that of the Chief Engineer?
3. Why is it important for an ETO to have strong communication skills when coordinating with shore-based technicians?
4. In what ways does the ETO contribute to the safety of the vessel and crew?
5. How do you think advancements in automation and unmanned systems will change the role of the ETO in the future?
6. Why do you think STCW certifications are necessary for ETOs?
7. Which shipboard electrical systems do you think are most critical for smooth daily operations?
8. What qualities might make an ETO successful in emergency management situations?
9. How could poor maintenance of electrical systems impact the overall voyage of a vessel?
10. Do you think the role of an ETO offers good long-term career prospects? Why or why not?

Vocabulary exercise 1: Match the terms with the definitions

1. Electro-Technical Officer (ETO)
2. STCW
3. Chief Engineer
4. Navigational Equipment
5. Refrigeration System
6. Emergency Systems
7. Certificate of Competency
8. Troubleshooting

a) The equipment used for ensuring a ship's safe movement and navigation, such as radar, gyrocompass, and echo sounders.
b) A specialized officer responsible for the electrical systems and maintenance of equipment aboard a vessel.
c) A certification issued by maritime authorities indicating that an officer has met the standards and is qualified to perform specific duties.

d) The process of identifying and fixing problems with electrical systems.
e) A high-ranking officer responsible for the overall technical and mechanical operation of the ship, including machinery and systems.
f) Systems on board the ship designed to ensure safety in emergencies, such as fire alarms and emergency lighting.
g) A standard for maritime safety and training, specifically the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers.
h) A system that keeps things cold, used on ships for storage and air conditioning.

Vocabulary exercise 2: Fill in the Blanks

Use the vocabulary terms above to complete the sentences:

1. The_______________ is responsible for managing all electrical systems on the ship, including communication, navigation, and safety systems.
2. To become an ETO, you need to complete the_______________training, which includes basic safety courses like firefighting and first aid.
3. In case of a failure, the ETO must quickly engage in_______________ to identify and repair any electrical issues.
4. The_______________is essential in maintaining the correct temperature for food storage and the comfort of passengers on cruise ships.
5. All seafarers must obtain a_______________to prove their competence before working on a vessel.
6. A ship's_______________ include equipment like RADAR, GPS, and echo sounders, which are critical for safe navigation.
7. The_______________ is a key member of the crew who supervises the ship's technical operations and supports the Electro-Technical Officer.
8. During an emergency, it is crucial to ensure that the_______________are fully functional, including emergency lights and alarm systems.

Vocabulary exercise 3: True / False

1. The Electro-Technical Officer (ETO) is mainly responsible for operating the ship's engines.
2. An ETO supervises systems such as refrigeration, air conditioning, and control rooms.
3. One of the ETO's duties is ensuring that emergency systems like fire alarms and backup batteries function properly.

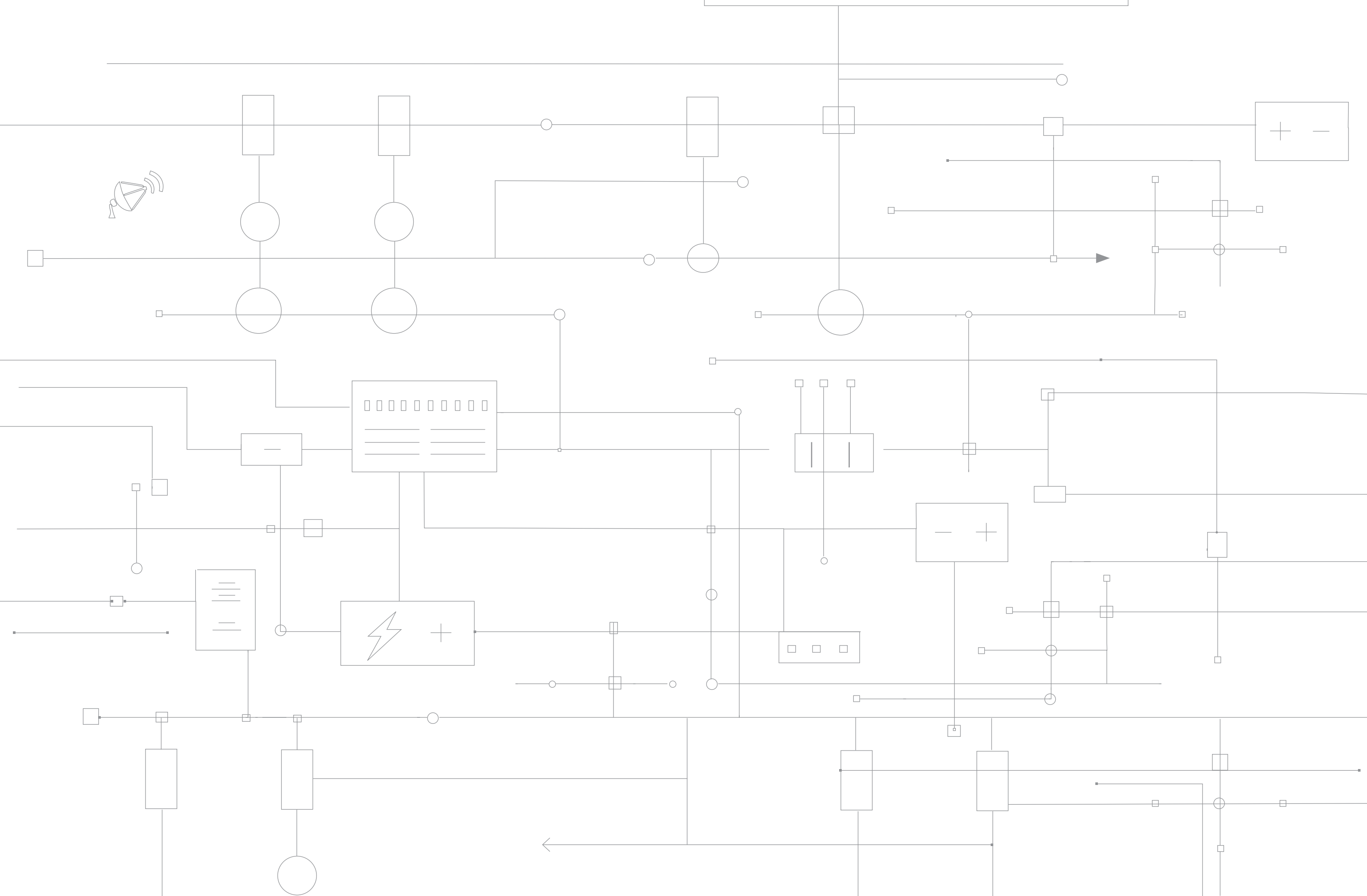
4. During emergencies, the ETO works alone and does not collaborate with the Chief Engineer.
5. Communication with shore-based technicians is sometimes required for advanced troubleshooting.
6. Navigation lights and battery backups are among the electrical components handled by the ETO.
7. Supporting the Chief Engineer in routine electrical maintenance is part of the ETO's responsibilities.
8. STCW 95 Basic Safety Training is one of the required certifications for becoming an ETO.
9. The role of the ETO is less important on large passenger ships because most systems are automated.
10. The demand for skilled ETOs is expected to grow as ships rely more on electrical and automated systems.

Vocabulary exercise 4: Use the correct form of the word in brackets.

The ETO's role requires a high level of technical ______________. (KNOW)

1. The Chief Engineer is responsible for overseeing the______________of all machinery and electrical systems. (OPERATION)
2. The ETO must regularly perform ______________of the ship's electrical systems to ensure they are functioning properly. (INSPECT)
3. The STCW certification ensures that the Electro-Technical Officer has received the necessary ______________ training. (SAFETY)
4. It is essential for the ETO to have ______________skills in problem-solving and electrical repairs. (ANALYZE)

Lesson 2



KEY ELECTRICAL RESPONSIBILITIES OF MARINE ENGINEERS ON BOARD SHIPS[2]

Objective

This lesson is designed to provide marine engineers with an overview of key electrical jobs and their maintenance procedures that are essential for ensuring safe and efficient ship operations. By the end of the lesson, you will understand the common electrical tasks marine engineers perform onboard, the tools involved, and the proper procedures to follow.

Introduction

Marine engineers are responsible for ensuring the proper functioning and maintenance of the ship's electrical systems. While there are numerous electrical tasks to be handled onboard, some are critical to the safe operation of the vessel and require special attention and expertise. This lesson outlines the most important electrical jobs a marine engineer must be proficient in.

1. Operation of Various Electrical Instruments

What It Involves:

Marine engineers regularly use electrical instruments and tools to operate and maintain the ship's electrical systems. These tools include:

- Multimeter
- Megger
- Clamp Meter

Skills Required:

Marine engineers must understand how to operate these instruments properly and interpret their readings accurately. Each tool serves a specific purpose:

- Multimeter: Used to measure voltage, current, and resistance.
- Megger: Used to test the insulation resistance of cables.
- Clamp Meter: Used for measuring current in a conductor without disconnecting it.

Importance:

Using these instruments correctly is crucial for troubleshooting and ensuring that electrical systems are safe and functional.

[2] https://www.marineinsight.com/marine-electrical/10-electrical-jobs-marine-engineers-must-know-board-ships/ (Accessed 14 April 2025)

2. Starter Panel Routine

What It Involves:

The starter panel controls the electrical systems of the ship. Regular maintenance of the starter panel is essential to ensure that the electrical equipment operates smoothly. Neglecting starter panel maintenance can lead to operational failures or hazards.

Skills Required:

Marine engineers must understand the procedure for maintaining the starter panel, including ensuring proper contact and safety measures before performing any work.

3. Insulation Resistance Maintenance

What It Involves:

The electrical wires and cables on a ship are encased in an insulation sheath. Over time, this insulation may wear down or become damaged.

Skills Required:

Marine engineers must regularly check the insulation resistance of wires and cables using a Megger. If the insulation resistance reading is too low, it can lead to:

- Short Circuits
- Earth Faults
- Equipment Damage

Maintaining proper insulation resistance helps prevent electrical hazards and damage to equipment.

4. Earth Fault Finding

What It Involves:

An earth fault occurs when an electrical current escapes its intended path, which can cause malfunctioning systems or even electrical fires.

Skills Required:

Finding and diagnosing an earth fault can be a challenging task that requires patience and precision. Marine engineers should be skilled in using instruments and techniques to identify the source of the fault.

Correctly identifying and resolving earth faults prevents electrical safety issues.

5. Motor Overhauling

What It Involves:

Electrical motors are widely used onboard ships to drive various machinery, such as pumps, fans, and purifiers. These motors require regular maintenance and overhauling.

Skills Required:

Marine engineers must know how to disassemble, inspect, and reassemble motors. The overhauling process includes understanding safety procedures and dealing with any breakdowns.

Proper motor maintenance ensures the continuous operation of critical shipboard systems.

6. Bus Bar Overhauling

What It Involves:

The bus bar is responsible for distributing electrical power from the ship's generator to the rest of the vessel. Overhauling the bus bar is typically done in dry dock.

Skills Required:

Marine engineers must be familiar with isolating and maintaining the bus bar, whether the ship is in operation or in dry dock.

Importance:

Proper maintenance of the bus bar ensures that the ship's electrical distribution system is reliable and safe.

7. Battery Charging Onboard

What It Involves:

Batteries provide emergency power for essential systems like emergency lighting, life-saving appliances (LSA), and the lifeboat.

Skills Required:

Marine engineers need to be knowledgeable about battery charging techniques and how to maintain the battery bank, ensuring that it is ready for emergency use. Maintaining the battery charging system is vital for emergency preparedness.

8. Adjusting the Load Sensor of the Mooring Winch

What It Involves:

The mooring winch is used for berthing a ship. It operates under high load conditions, and the load sensor monitors the pressure on the winch.

Skills Required:

Marine engineers must know how to adjust the load sensor to ensure that the winch operates within safe limits. If the load exceeds the sensor's threshold, it will trigger a shutdown to protect the machinery.

Proper adjustment of the load sensor ensures the safe operation of the mooring winch and prevents mechanical damage.

9. Shore Connection or AMP (Alternate Marine Power)

What It Involves:

Shore power allows ships to connect to land-based electricity sources, reducing fuel consumption and pollution during periods of inactivity (such as at port or in dry dock). The shore power parameters (voltage, frequency) may differ from the ship's electrical system.

Skills Required:

Marine engineers need to know how to correctly connect shore power to the ship's systems, often using transformers or frequency converters.

Proper shore power connection helps maintain energy efficiency and environmental compliance.

10. Engine Automation

What It Involves:

Engine automation refers to the automatic control and monitoring of ship engines and generators, including alarms and trips that protect the systems.

Skills Required:

Marine engineers must be familiar with the ship's automation system, be able to troubleshoot alarms, and solve any problems related to the automation equipment. Understanding engine automation is vital for the safe and efficient operation of the ship's propulsion and power generation systems.

Conclusion

The electrical tasks listed above are integral to ensuring the safety, reliability, and efficiency of a ship's operations. As a marine engineer, possessing a solid understanding of these tasks and the skills to perform them correctly is crucial for maintaining the vessel's electrical systems.

Exercises

Discussion questions:

1. Why is it important for marine engineers to be skilled in using instruments such as the multimeter, megger, and clamp meter?
2. What risks might occur if the starter panel is not properly maintained?
3. How can poor insulation resistance affect the ship's overall safety and operations?
4. Why do you think earth fault finding can be a challenging task for marine engineers?

5. What could happen if motors onboard are not regularly overhauled?
6. Why is bus bar overhauling usually performed in dry dock rather than at sea?
7. How do properly maintained batteries contribute to emergency preparedness on board?
8. What role does the load sensor of the mooring winch play in ensuring safe ship operations?
9. In what ways does shore power (AMP) benefit both the ship and the environment?
10. How does engine automation improve the safety and efficiency of shipboard operations?
11. Which of these ten electrical tasks do you think requires the most expertise and why?
12. How might technological advancements in marine electrical systems change the role of marine engineers in the future?

Vocabulary exercise 1: Match the terms with the definitions

1. Megger
2. Mooring Winch
3. Insulation Resistance
4. Bus Bar
5. Load Sensor
6. Earth Fault
7. Engine Automation
8. Starter Panel

a) A device used to measure the insulation resistance of electrical cables and equipment.
b) A machine used to secure the ship to the dock during berthing.
c) A panel that controls the operation of the ship's electrical systems, including safety devices.
d) A component that monitors the weight or force exerted on machinery, such as the mooring winch.
e) A fault in the electrical system where the current escapes from its intended path, usually causing malfunction.
f) A component that distributes electrical power generated by the ship's generator to other systems.
g) A system that controls and monitors the ship's engine and generator automatically to ensure optimal operation and safety.
h) The ability of an electrical system to resist leakage of current through its insulation, which helps prevent shorts and electrical hazards.

Vocabulary exercise 2: Fill in the blanks with the correct words from the list below.

Earth Fault / Megger / Starter Panel / Bus Bar / Insulation Resistance / Engine Automation / Load Sensor / Mooring Winch

1. The_______________ is responsible for controlling the electrical system of the ship, including the starting and stopping of equipment.
2. The marine engineer used a_______________to test the insulation resistance of the cables before starting the repairs.
3. The_______________ is vital in preventing electrical accidents by ensuring that the wires do not short-circuit due to damaged insulation.
4. The marine engineer noticed an _______________ in the electrical system, which was causing the equipment to malfunction.
5. The_______________ is an important component of the ship's power system, as it ensures the safe distribution of electrical power across the vessel.
6. A_______________ is used to safely measure the load on the mooring winch, ensuring that the winch does not operate beyond its safe limits.
7. The_______________ system automatically adjusts the engine's operation, including stopping the engine if necessary to prevent damage.
8. The marine engineer performed regular maintenance on the_______________ to ensure that the electrical system was operating safely and efficiently.

Vocabulary exercise 3: True / False

1. The starter panel is used to measure the insulation resistance of electrical cables.
2. Earth faults are not considered a major concern for marine engineers since they are easy to detect and fix.
3. The bus bar is responsible for distributing power from the generator to various parts of the ship.
4. The load sensor on the mooring winch ensures that the winch can handle an excessive load without triggering any safety mechanisms.
5. Engine automation systems help monitor and control ship engines automatically to optimize performance and ensure safety.
6. A Megger is used to measure the electrical load applied to the mooring winch during docking.
7. Insulation resistance is a measure of how well the electrical cables prevent leakage currents.

Vocabulary exercise 4: Use the correct form of the word in brackets.

1. The_______________of electrical systems is vital for ensuring that the ship operates safely and efficiently. (MAINTAIN)
2. The marine engineer performed an_______________to determine the current insulation resistance levels of the cables. (INSPECT)
3. The_______________ of the mooring winch must be monitored to prevent damage during docking. (LOAD)
4. The electrical engineer regularly checked the_______________to ensure the system was properly insulated and safe. (INSULATE)
5. The_______________system on the ship automatically shuts down the engine in case of an emergency. (AUTOMATE)
6. The marine engineer reviewed the_______________of the cables to make sure no faults had occurred. (RESIST)

Lesson 3

UNDERSTANDING MARINE ELECTRICITY AND COMPRESSED AIR SYSTEMS[3]

Objective

To understand how electricity is generated and distributed on ships, the main differences between shipboard and land-based electrical systems, and the importance of compressed air systems for ship operations.

Introduction

Electricity and compressed air are two vital utilities onboard ships. Unlike on land, where electricity comes from large power plants, ships generate their own electricity using onboard generators. They also rely on compressed air systems for essential operations such as starting engines, running pneumatic tools, and supporting auxiliary equipment. A solid understanding of these systems helps marine engineers ensure the safety, reliability, and efficiency of ship operations.

Marine Electricity

Electricity onboard is generated by diesel, shaft-driven, or steam-driven generators.

- Ship generators use an insulated neutral system (not grounded to the hull), which allows essential machinery to continue running even during an earth fault.
- Typical ship supply is 3-phase, 440V insulated neutral, while larger passenger or RORO vessels may operate with 3kV–11kV gensets.
- Unlike land systems (50 or 60 Hz depending on the region), ships adopt 60 Hz as a standard, which allows motors to run faster and more efficiently.
- Voltage is stepped down from 440V to 220V or 110V using transformers for lighting and small equipment.
- Electrical equipment onboard is designed to withstand humidity, vibration, high temperatures, and a salty atmosphere.

The ship's electrical system can be divided into four subsystems:

1. Generator System
2. Main Switchboard System
3. Emergency Switchboard System
4. Distribution System

Generator System details:

- Consists of an alternator and a driver (diesel or steam engine).
- Some ships use shaft generators, powered by the main engine.
- Power from generators is transmitted to switchboards via busbars, not wires, in high-voltage systems.

[3] https://www.marineinsight.com/marine-electrical/what-is-marine-electricity/ (Accessed 23 April 2025)

Compressed Air Systems

Compressed air is indispensable on ships.

- High-pressure air (30 bar): Mainly used for starting the main engine.
- Service air (7–8 bar): Used for auxiliary engine starting, emergency generator starting, hydrophores, fog horns, exhaust valve operation, turbocharger cleaning, sewage treatment, boiler soot blowing, pneumatic oil pumps, cleaning, painting, and operating pneumatic tools (grinders, chisels, etc.).
- Control air: A special, filtered branch of service air (oil- and moisture-free), used in pneumatic controllers to operate vital machinery.

Main Air Compressor:

Air compressors compress air by reducing its volume, increasing its pressure. Types include:

1. Centrifugal Compressors
2. Rotary Vane Compressors
3. Rotary Screw Compressors
4. Reciprocating Compressors

Exercises

Discussion questions

1. Why do ships use an insulated neutral electrical system instead of grounding it to the hull?
2. What are the advantages of using 60 Hz as the standard frequency on ships?
3. Why is voltage stepped down from 440V to 220V or 110V onboard?
4. How does shipboard electrical equipment differ from land-based equipment?
5. What are the four main subsystems of a ship's electrical network?
6. Why are busbars used instead of wires in high-voltage systems?
7. Why is high-pressure air essential for starting the main engine?
8. How does service air differ from control air, and why must control air be oil- and moisture-free?
9. Which shipboard operations depend most on compressed air, and why?
10. What might happen if the compressed air system fails during a critical operation?

Vocabulary exercise 1: Match the terms with the definitions

1. Shaft Generator
2. Busbar
3. Transformer
4. Earth Fault
5. Control Air
6. Reciprocating Compressor
7. Hydrophore
8. Turbocharger

a) A device that increases engine efficiency by forcing extra air into cylinders.
b) A generator powered by the ship's main engine.
c) A pressure vessel used to maintain water pressure in pipelines.
d) A compressor that works with piston action.
e) Thick conductors that distribute electrical power from the generator to switchboards.
f) A condition where electrical current escapes to the hull.
g) A device used to reduce or increase voltage.
h) Clean, filtered air used for pneumatic controllers.

Vocabulary exercise 2: Fill in the blanks

Generator / transformer / busbars / compressed air / 60 Hz / control air

1. Onboard electricity is produced by the ship's _______________system.
2. High-voltage current is transmitted through_______________instead of normal wires.
3. Ship systems usually operate at a frequency of _______________.
4. A _______________reduces 440V supply to 220V or 110V for lighting.
5. Ships rely on _______________for engine starting, cleaning, and pneumatic tools.
6. Specially filtered _______________ is used in pneumatic controllers.

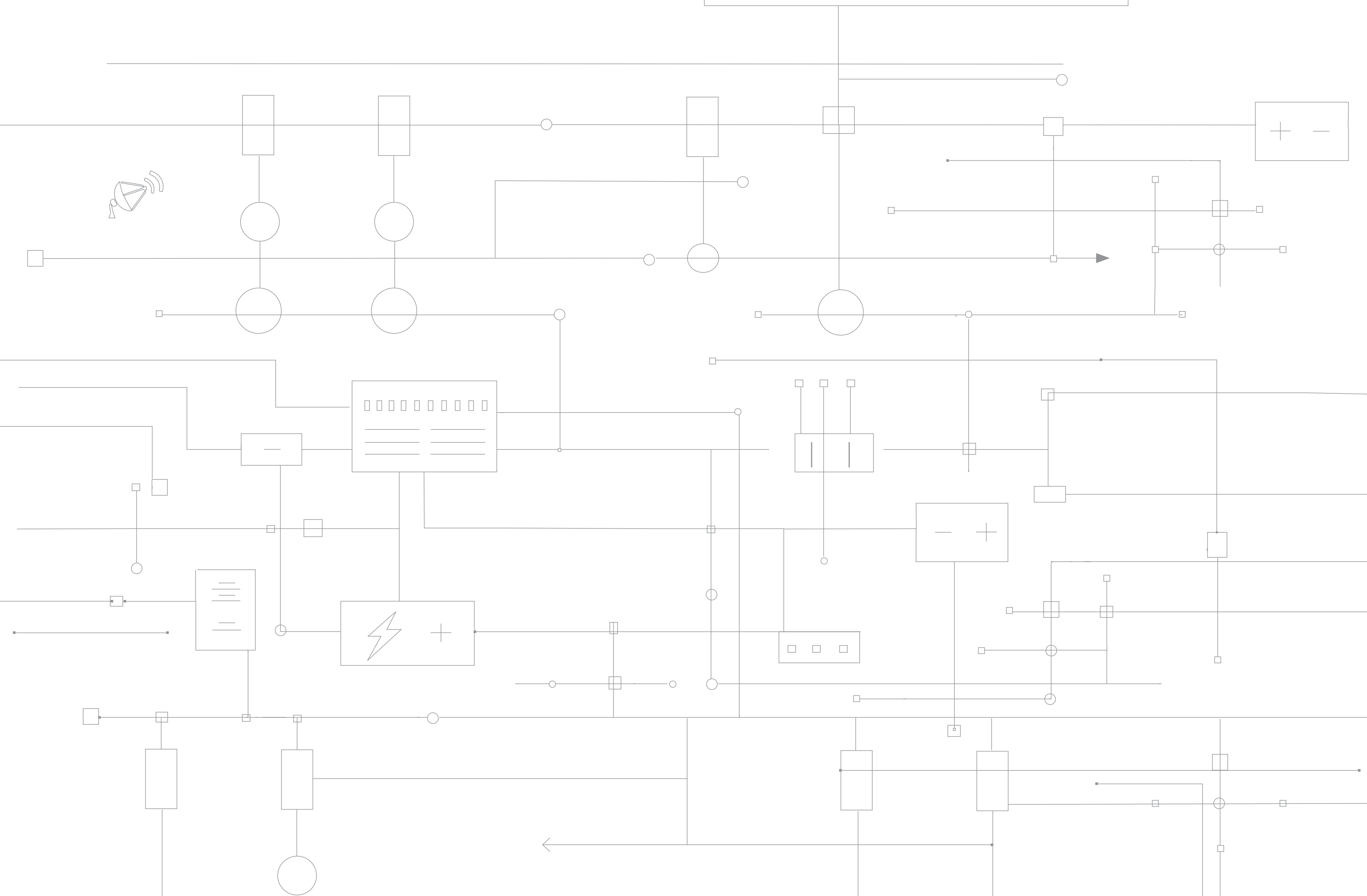
Vocabulary exercise 3: True / False

1. Ship generators normally have their neutral point grounded to the hull.
2. Some passenger ships operate with high-voltage gensets between 3kV and 11kV.
3. Control air must be filtered to remove oil and moisture.
4. Service air is maintained at a pressure of around 30 bar.
5. Busbars are used to carry high current between generators and switchboards.

Vocabulary exercise 4: Use the correct form of the word in brackets.

1. Regular _______________(MAINTAIN) of generators ensures reliable ship power.
2. The engineer carried out an _______________(INSPECT) of the compressor system.
3. An electrical _______________ (FAULT) was detected in the main switchboard.
4. Proper _______________(DISTRIBUTE) of electricity is achieved with busbars.
5. The compressor used a _______________(ROTATE) screw mechanism to compress air.

Lesson 4



ELECTRICAL PROPULSION OF SHIPS, ELECTRICAL MOTORS, AND CONTROL SYSTEMS[4]

Objective

To understand the concept of electrical propulsion in ships, the different types of propulsion systems (shaftline and pod propulsion), their advantages and disadvantages, and the role of electrical motors and control systems in modern shipping.

Introduction

With growing demand for cleaner and more efficient propulsion systems, the shipping industry is exploring alternatives to conventional diesel-mechanical propulsion. One such system is electrical propulsion, which has already proven successful in certain ship types like cruise ships and dynamic positioning (DP) vessels.

While electrical propulsion offers many advantages – such as flexibility, reduced emissions, and better maneuverability – it also comes with drawbacks, including higher installation costs and the need for specialized crew training.

What is Electrical Propulsion?

Electrical propulsion refers to systems in which electric motors drive the propellers, instead of direct mechanical shafts connected to diesel engines. Power is generated by prime movers (diesel engines, gas turbines, or fuel cells) driving generators, which then supply electricity to propulsion motors via control systems.

Types of Electrical Propulsion Systems

1. Shaftline Propulsion

As the name suggests, this system uses a shaft from a prime mover to rotate the propeller. The propeller may either be driven directly by a slow-speed motor or connected to a high-speed motor through reduction gears. Both asynchronous and synchronous motors are commonly employed in this type of system. The voltage of the motors and their drive systems, whether low or medium, depends on the propulsion power requirements of the ship.

2. Pod Propulsion

This type of propulsion combines both the steering and propeller systems into a single unit. The conventional propeller is replaced by a pod propulsion unit, which

[4] https://www.marineinsight.com/marine-electrical/electric-propulsion-system-for-ship-does-it-have-a-future-in-the-shipping/ (Accessed 23 April 2025)

contains an electric motor mounted inside the pod, with the propeller directly connected to the motor shaft. The entire pod assembly can rotate 360 degrees, allowing the ship to move ahead or astern without the need to reverse the motor or use a controllable pitch propeller. To enable the rotation of the pod, slip rings are employed to deliver power from the motor to the pod unit. The power supply is controlled through a variable-frequency drive or a cyclo-converter, which allows precise control of both the speed and the direction of the propulsion motors.

Advantages of the Electrical Propulsion System

- The system generates a significant amount of power, and the excess can be supplied to cargo pumps, fire pumps, and other important auxiliary machinery.
- The machinery for electrical propulsion requires much less space and is more compact compared to conventional systems.
- There is no direct connection between the propeller shaft and the prime mover; therefore, severe stresses such as torsional stress and vibration are minimized.
- Greater flexibility is available in the installation of machinery.
- It provides improved maneuverability and high redundancy.
- Payload capacity can be increased due to the flexible placement of machinery components.
- Environmental benefits include reduced fuel consumption and lower emissions.
- Excellent performance in harsh ice conditions is possible because maximum torque is available at zero speed.
- Life cycle costs are reduced owing to lower fuel consumption and reduced maintenance requirements.
- Standstill time for maintenance and service is minimal.
- Useful for vessels with potential trim problems (e.g., stern wheelers), where machinery can be placed forward to balance trim.
- Improved comfort is achieved due to reduced vibration and noise.
- Offers much better dynamic response, moving from zero to maximum propelling speed compared to other propulsion systems.
- Provides faster reversing time compared to conventional propulsion.
- Maximum torque is available across the entire speed range at the propeller.
- Reduced space requirements for the shaft system.
- The design and engineering of the propeller are independent of the drive system.
- Greater flexibility in choosing diesel engine speed.

Disadvantages of the Electrical Propulsion System

- The overall efficiency of the electrical plant is lower than that of a conventional mechanical system.
- Installation costs are significantly higher.

- Ship's crew require different and advanced training, as the system is highly automated and differs considerably from conventional mechanical systems.

Conclusion

Electrical propulsion is already established in certain sectors and aligns well with international regulations such as MARPOL Annex VI and Emission Control Areas (ECAs). While it has some limitations, its advantages strongly suggest that it will play a significant role in the future of shipping.

Exercises

Discussion questions

1. How does electrical propulsion differ from conventional diesel-mechanical propulsion?
2. What types of prime movers can be used to generate power in electrical propulsion systems?
3. What is the main difference between shaftline propulsion and pod propulsion?
4. Why can pod propulsion systems improve a ship's maneuverability?
5. What role do slip rings and variable-frequency drives play in pod propulsion?
6. Which advantages of electrical propulsion do you think are most important for passenger comfort?
7. How does electrical propulsion help reduce environmental impact?
8. What are the main disadvantages of electrical propulsion compared to mechanical systems?
9. Why might electrical propulsion require special crew training?
10. In which types of ships do you think electrical propulsion is most beneficial, and why?

Vocabulary exercise 1: Match the terms with the definitions

1. Shaftline Propulsion
2. Pod Propulsion
3. Asynchronous Motor
4. Slip Rings
5. Variable-Frequency Drive (VFD)
6. Redundancy
7. Dynamic Positioning (DP)
8. MARPOL Annex VI

a) A system that allows ships to maintain their position automatically using electric thrusters.

b) A propulsion system with a motor inside a pod that can rotate 360° for maneuverability.
c) A legal framework regulating air pollution from ships.
d) The use of multiple systems/components so that backup is available if one fails.
e) A motor that operates without synchronizing its speed to the supply frequency (commonly induction motors).
f) A propulsion system where the motor drives the propeller via a shaft (directly or with reduction gears).
g) A device used to transmit electrical power to rotating equipment.
h) An electronic system that controls motor speed by varying the supply frequency.

Vocabulary exercise 2: Fill in the Blanks

Use the vocabulary terms above to complete the sentences:

1. _______________ allows ships to maintain position automatically, which is crucial for offshore operations.
2. Cruise ships often use _______________for superior manoeuvrability in ports.
3. _______________propulsion uses a direct shaft connection from an electric motor to the propeller.
4. A_______________ is needed to transfer electrical power into a rotating pod.
5. _______________motors are widely used in electrical propulsion due to their rugged design and reliability.
6. Emissions from ships are regulated under_______________.
7. Using_______________in propulsion ensures that if one generator fails, another can take over.
8. A_______________ is used to control the speed of AC motors by changing supply frequency.

Vocabulary exercise 3: True / False

1. Pod propulsion eliminates the need for a reversing gear.
2. Electrical propulsion always requires more space than conventional propulsion.
3. Both synchronous and asynchronous motors can be used in shaftline propulsion.
4. MARPOL Annex VI is a key regulation influencing the adoption of electrical propulsion.
5. Electrical propulsion provides lower torque at low speeds compared to mechanical propulsion.

Vocabulary exercise 4: Use the correct form of the word in brackets.

1. Electrical propulsion improves vessel_______________in ports and narrow waters. (MANEUVER)
2. The_______________ of propulsion machinery is flexible in electric systems. (LOCATE)
3. MARPOL Annex VI regulates air_______________from ships. (EMIT)
4. Pod propulsion offers better_______________compared to shaftline propulsion. (CONTROL)
5. Ship crews need advanced_______________in automation to handle electric propulsion systems. (TRAIN)

Lesson 5

MAIN SWITCHBOARD SYSTEM ON SHIPS: STRUCTURE AND FUNCTION5

Objective

To understand the purpose and function of the main switchboard system on ships, its components, and the role of the emergency and distribution systems.

Introduction

The main switchboard is the central hub of a ship's electrical network. It receives power from the generators and distributes it to all consumers throughout the ship, ensuring that both essential and non-essential systems receive a continuous and reliable power supply.

Main Switchboard

The main switchboard provides power to all important shipboard machinery at 440V. A section of it also supplies 220V through a step-down transformer. This lower voltage is used for bridge equipment, navigation lights, radio communication equipment, and other smaller systems.

The auxiliary switchboard also plays a role by supplying power for charging the ship's batteries, which are used to maintain emergency lighting when needed.

Emergency Switchboard System

An emergency generator is required to operate automatically if the main generator fails. Once started, it supplies the emergency switchboard, which distributes power to essential emergency equipment.

Like the main switchboard, the emergency switchboard has both 440V and 220V sections, providing electricity to the necessary machinery and systems that must remain operational in critical situations.

Distribution System

After power is received from the switchboards, it is further distributed throughout the ship via several components.

The distribution boxes are enclosed metal units that channel electricity to specific areas of the vessel. The motor starter boxes are used to control the many motors on board that power mechanical equipment. Each box contains ON/OFF switches, protective devices, and gauges for monitoring current and temperature.

[5] https://www.marineinsight.com/marine-electrical/what-is-marine-electricity/ (Accessed 2 May 2025)

Finally, the shore connection boxes are used when the ship is in port or during dry-docking, situations in which the ship's generators may not be operating. In these cases, shore power is supplied to run the vessel's systems. Shore panels are usually installed near the accommodation entry or bunker station to make it easier to connect the shore power cable.

Exercises

Discussion questions

1. Why is the main switchboard considered the central hub of a ship's electrical system?
2. What voltage does the main switchboard supply to most shipboard machinery?
3. Why is a step-down transformer used, and what equipment typically requires lower voltage?
4. What role does the auxiliary switchboard play in relation to the ship's batteries?
5. When and how does the emergency generator operate?
6. Why is it important for the emergency switchboard to have both 440V and 220V sections?
7. What is the purpose of distribution boxes on board a ship?
8. How do motor starter boxes help in operating shipboard machinery?
9. In what situations is shore power used, and why is it important?
10. Why are shore connection panels usually located near the accommodation entry or bunker station?

Vocabulary exercise 1: Match the terms with the definitions

1. Main Switchboard
2. Step-down Transformer
3. Emergency Generator
4. Distribution Boxes
5. Motor Starter Boxes
6. Shore Connection Boxes

a) Provide power to localized areas of ship machinery.
b) Converts 440V supply into 220V for smaller shipboard equipment.
c) Automatically supplies power when the main generator fails.
d) Central unit that distributes power from the generator to ship systems.
e) Used to connect the ship to land-based electricity when in port.
f) Control and protect ship motors, also fitted with gauges for monitoring.

Vocabulary exercise 2: Fill in the Blanks

Use the vocabulary terms above to complete the sentences:

1. The main switchboard supplies power to the ship at ______________ volts.
2. The ______________ transformer reduces voltage for equipment such as navigation lights and radio communication systems.
3. The ______________ generator starts automatically when the main generator fails.
4. ______________ boxes are fitted with switches, safety devices, and gauges for operating motors.
5. When in port, ships rely on ______________ power instead of running their generators.

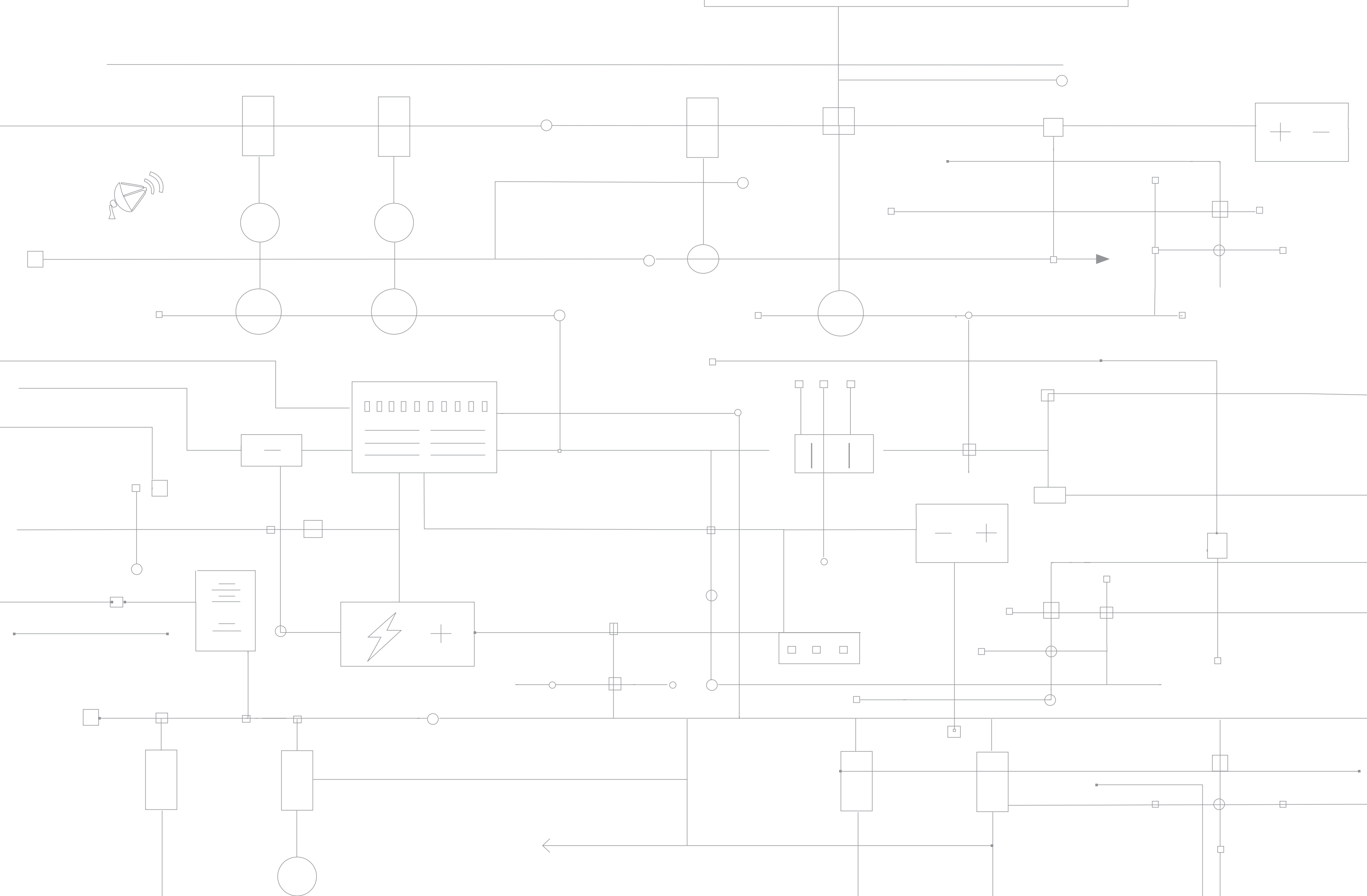
Vocabulary exercise 3: True / False

1. The main switchboard is the central hub of a ship's electrical network.
2. The main switchboard only supplies 220V power to the ship.
3. A step-down transformer is used to reduce 440V to 220V for smaller systems such as bridge equipment and navigation lights.
4. The auxiliary switchboard is responsible for charging the ship's batteries.
5. Ship batteries can be used for maintaining emergency lighting.
6. If the main generator fails, the emergency generator starts automatically.
7. The emergency switchboard supplies power only at 220V.
8. Distribution boxes are enclosed metal units that channel electricity to specific areas of the ship.
9. Motor starter boxes are used to start and stop shipboard motors and contain protective devices and gauges.
10. Shore connection boxes allow the ship to receive electricity from land when the ship's generators are not running.
11. Shore power panels are usually installed in the cargo hold for easy cable connection.
12. Both the main and emergency switchboards supply electricity at 440V and 220V.

Vocabulary exercise 4: Use the correct form of the word given in brackets.

1. The switchboard is the main point of power _______________ on the ship. (DISTRIBUTE)
2. The emergency generator ensures_______________ in case of power failure. (SAFE)
3. Shore panels allow the _______________of cables to supply land-based power. (CONNECT)
4. Batteries are charged through the auxiliary switchboard for_______________ lighting. (EMERGE)
5. Motor starter boxes contain _______________ devices to protect the motors. (SAFE)

Lesson 6



DISTRIBUTION PANEL ON SHIPS[6]

Objective

To understand the role of the distribution panel on ships, the principle of generator operation, and the safety measures used to protect both personnel and machinery.

Introduction

On ships, electrical systems are divided into different levels of distribution. While the main switchboard supplies power to the major shipboard systems, the distribution panel handles smaller circuits and equipment. Together with safety devices and emergency switch-off panels, these systems ensure the reliable and safe use of electricity on board.

The Distribution Panel

The distribution panel supplies power to smaller electrical consumers on board. These include lighting systems, accommodation systems, small heating appliances, circuits, and motors of 1/4 HP or less. By directing power to these essential but smaller units, the distribution panel plays a key role in the comfort and daily functioning of the ship.

Emergency Switch-Off Panel

For the protection of both ship machinery and crew, emergency switch-off panels are installed at various locations on board. These allow machinery and equipment to be shut down quickly in case of fire, malfunction, or any hazardous situation.

Distribution System and Protection

The main purpose of a distribution system is to provide operational, alarm, and safety functions for individual or groups of machinery. Large auxiliary machinery is powered through circuit breakers at high voltage, while smaller consumers use fuses or miniature circuit breakers. This ensures that equipment receives the correct level of protection, preventing damage and increasing reliability.

Principle of the Generator

The generator works on the principle that when the magnetic field around a conductor changes, an electric current is induced in the conductor.

It consists of a stator (a stationary set of conductors wound in coils on an iron core) and a rotor (a rotating magnet inside the stator). As the rotor turns, it produces a magnetic field which cuts across the conductors, generating an induced electro-magnetic force (EMF).

In modern ships, the magnetic field may be produced by induction, as in a brushless alternator, or by rotor windings supplied with DC current through slip rings and brushes.

[6] https://www.marineinsight.com/marine-electrical/what-is-marine-electricity/ (Accessed 2 May 2025)

Safety of Marine Electrical Systems

The safety of marine electrical systems has two goals:

1. To protect personnel from electrical shock.
2. To prevent damage to machinery due to faults such as overcurrent or overheating.

Depending on the equipment size and rating, protective devices such as relays, circuit breakers, or fuses are used.

In addition, local instruments like temperature gauges, RPM meters, direction indicators, and ammeters are used to monitor machinery performance and detect problems early, ensuring the safe and efficient operation of ship systems.

Exercises

Discussion questions

1. What is the main difference between the main switchboard and the distribution panel?
2. Which types of equipment are typically powered by the distribution panel?
3. Why are emergency switch-off panels installed at various locations on board?
4. In what situations might crew members need to use an emergency switch-off panel?
5. How do circuit breakers and fuses protect shipboard electrical systems?
6. Why is it important to provide different levels of protection for large and small consumers?
7. How does a generator produce electricity, and what roles do the stator and rotor play?
8. What is the difference between a brushless alternator and one that uses slip rings and brushes?
9. What are the two main goals of marine electrical system safety?
10. How do instruments such as temperature gauges and ammeters help ensure safe ship operations?

Vocabulary exercise 1: Match the terms with the definitions

1. Distribution Panel
2. Emergency Switch-Off Panel
3. Stator
4. Rotor
5. Brushless Alternator
6. Circuit Breaker
7. Fuse
8. Amperage Meter

a) A rotating magnet that produces a magnetic field inside a generator.
b) A protective device that disconnects circuits automatically in case of overload.
c) A device for measuring electrical current.
d) A protective device that melts to break a circuit when overloaded.
e) Supplies power to small appliances, lighting, and motors of 1/4 HP or less.
f) Generator type that produces a magnetic field without brushes.
g) Fixed part of the generator with coils wound on an iron core.
h) A panel used to shut down machinery quickly in case of emergency.

Vocabulary exercise 2: Fill in the Blanks

Rotor / Distribution / Miniature / Shock / Stator

1. The______________ panel supplies power to lighting and small motors on board.
2. In a generator, the______________is the stationary part with coils wound on an iron core.
3. The______________rotates inside the stator to produce a magnetic field.
4. To protect smaller circuits, ships use fuses or______________ circuit breakers.
5. The safety of marine electrical systems includes protecting people from electrical ______________.

Vocabulary exercise 3: True / False

1. The distribution panel supplies power to the ship's main propulsion motors.
2. Emergency switch-off panels are used to shut down equipment in case of an emergency.
3. A generator produces electricity when a changing magnetic field induces current in a conductor.
4. The rotor of a generator is stationary, and the stator rotates inside it.
5. Fuses, circuit breakers, and relays are used to protect equipment from damage.
6. Amperage meters measure the temperature of the motor.

Vocabulary exercise 4: Use the correct form of the word in brackets.

The generator produces electrical ______________ when the rotor turns. (ENERGY)

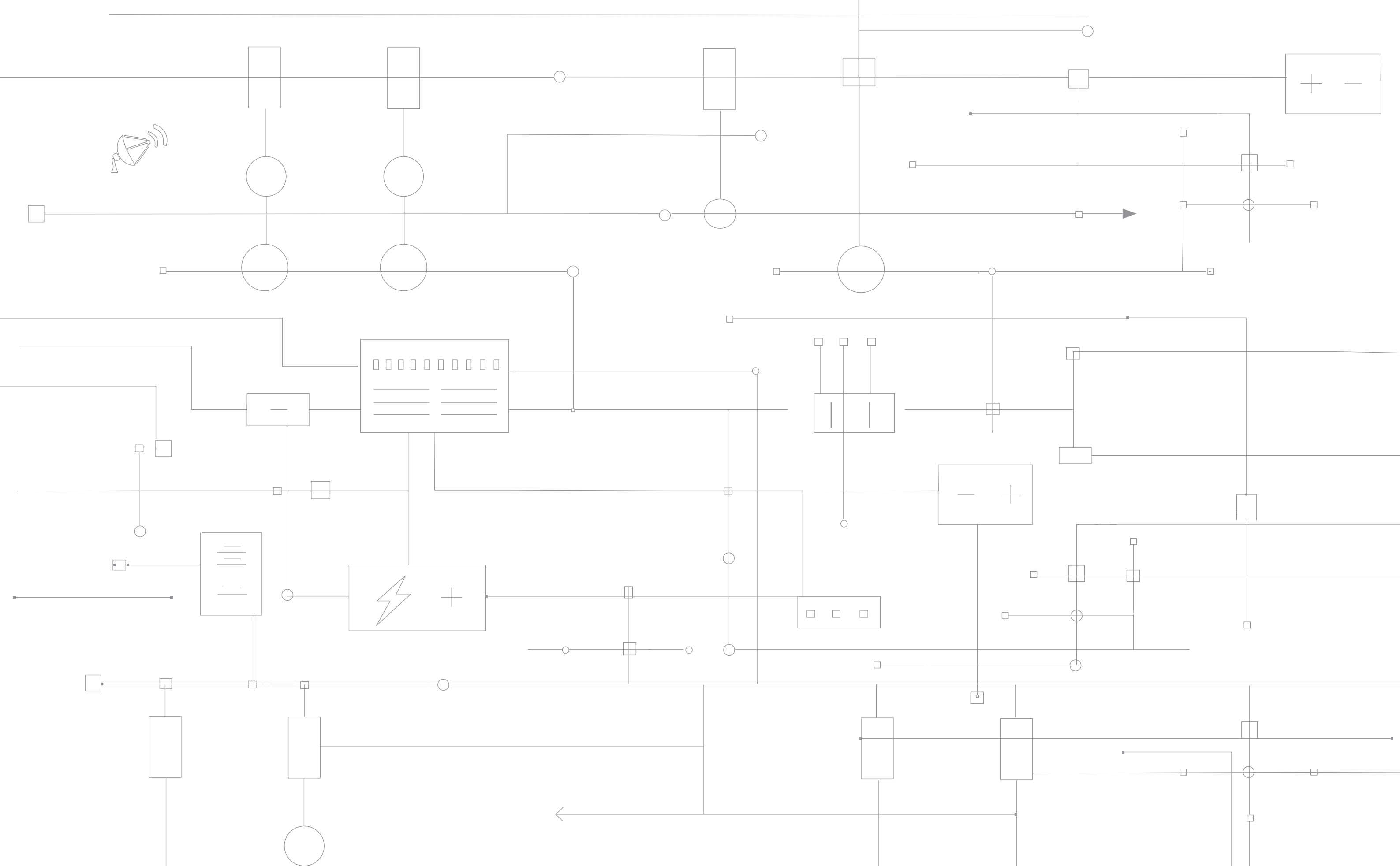
Fuses and circuit breakers are used for______________ against overcurrent. (PROTECT)

Emergency panels allow quick ______________ of dangerous machinery. (SHUT)

The rotor and stator are essential parts of a ship's electrical______________. (GENERATE)

Monitoring instruments help detect machinery ______________ at an early stage. (FAIL)

Lesson 7



ELECTRICAL DEVICES FOR POWER DISTRIBUTION (RELAYS)[7]

Objective

To understand the function of relays as protective devices in shipboard electrical systems, their working principle, and the basic maintenance procedures required to keep them in good condition.

Introduction

Relays are essential electromechanical safety devices used in ship electrical systems. Their primary role is to disconnect faulty circuits from the main power supply when an electrical fault occurs. Without properly functioning relays, the ship's electrical network could suffer power loss or severe equipment damage.

Relays are fitted in both the Main Switchboard and the Emergency Switchboard, where they serve as protective devices against faults such as overloads and short circuits. Ship engineers and electrical officers are responsible for ensuring that relays remain in good condition through regular maintenance and timely replacement when required.

Working Principle of a Relay

A relay operates using the principle of electromagnetism. When excess or high current passes through the coil wound on an iron core, the increased magnetic effect attracts an iron armature that is normally held in place by a spring. As soon as the armature is pulled, the relay trips the circuit, disconnecting it from the supply to prevent further damage.

Applications of Relays

The most common uses of relays on ships include:

- Overload protection
- Short circuit protection

Maintenance of Relays

To ensure reliable operation, relays must be inspected and maintained regularly. If a relay is found defective during inspection, it must be replaced immediately. Key maintenance checks include:

- Inspect relay contacts for arcing damage.
- Polish contacts with emery paper to remove rust and deposits.

[7] https://www.marineinsight.com/marine-electrical/maintenance-of-electrical-relay-on-ships-electrical-circuit/ (Accessed 5 May 2025)

- Check closing linkages for free movement.
- Use a multimeter to check contact continuity.
- Inspect arc chutes for burnout and replace if necessary.
- Check spring tension.
- Perform open-circuit and short-circuit tests on the coil with a multimeter.
- Test the continuity of the trip circuit.
- Check tightness of supply terminals.

Exercises

Discussion questions:

1. What is the primary role of relays in ship electrical systems?
2. Why is it important for both the Main Switchboard and the Emergency Switchboard to have relays installed?
3. What could happen to a ship's electrical system if relays were not functioning properly?
4. How does a relay use the principle of electromagnetism to disconnect a faulty circuit?
5. What is the function of the iron armature in a relay?
6. In what situations are relays most commonly used on ships?
7. Why is regular maintenance of relays necessary?
8. What maintenance checks are performed on relay contacts and linkages?
9. How is a multimeter used when maintaining relays?
10. What should engineers do if a relay is found to be defective during inspection?

Vocabulary exercise 1: Match the terms with the definitions:

1. Relay
2. Armature
3. Coil
4. Arc chute
5. Multimeter
6. Circuit breaker
7. Overload
8. Spring force

a) Device that measures voltage, current, and resistance in electrical circuits.
b) A movable iron piece attracted by a magnetic field inside the relay.
c) An electromechanical switch that disconnects faulty circuits.
d) A channel used to extinguish electrical arcing.

e) The wound conductor around the relay's iron core.
f) Excess current flowing beyond safe limits.
g) The mechanical resistance keeping the relay contacts in place.
h) A device used to manually disconnect electrical circuits under fault or maintenance conditions.

Vocabulary exercise 2: Fill in the Blanks

Coil / Emery / Open circuits / Armature / Relay

1. A _______________is an electromechanical safety device used to disconnect faulty circuits.
2. When excess current passes through the _______________, the magnetic field increases.
3. The iron _______________ is attracted by the magnetic field and trips the circuit.
4. During inspection, contacts must be polished with _______________paper.
5. A multimeter is used to test continuity and detect _______________ or short circuits.

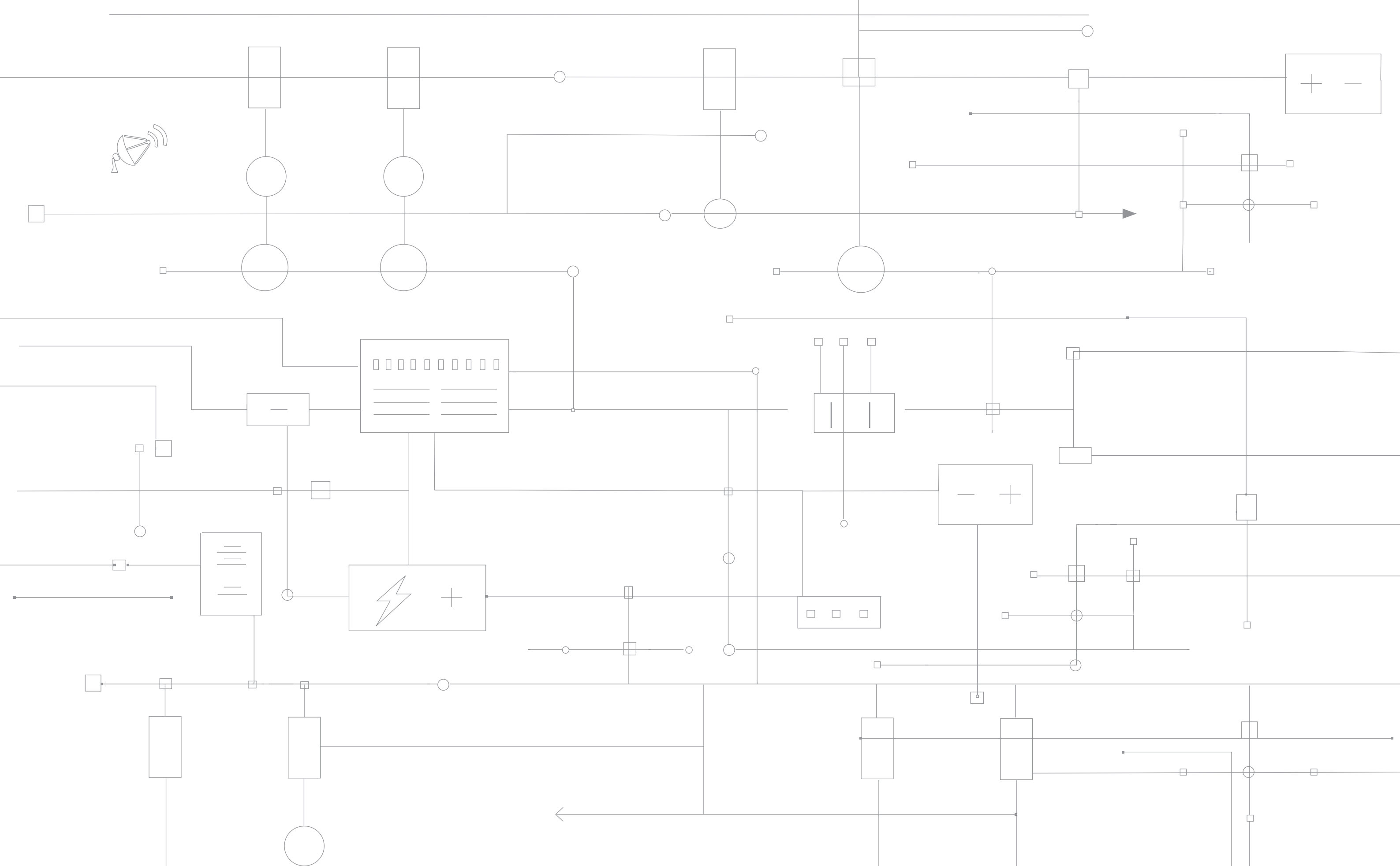
Vocabulary exercise 3: True / False

1. A relay is only used for lighting circuits on ships.
2. Relays are fitted in both the Main and Emergency switchboards.
3. The principle of electromagnetism is used in the operation of relays.
4. The iron armature is normally held by a spring force until a fault occurs.
5. Maintenance checks for relays include coil testing, arc chute inspection, and contact cleaning.
6. A defective relay can continue to be used until the next scheduled dry dock.

Vocabulary exercise 4: Use the correct form of the word in brackets.

1. Relays provide _______________ against electrical overloads. (PROTECT)
2. Regular _______________of relays is necessary to prevent failure. (INSPECT)
3. The relay trips the circuit to avoid equipment _______________. (DAMAGE)
4. Engineers must carry out relay tests with high _______________. (ACCURATE)
5. If a relay is _______________, it must be replaced immediately. (DEFECT)

Lesson 8



MARINE RADARS: FUNCTIONS AND APPLICATIONS IN THE SHIPPING INDUSTRY[8]

Objective

To understand the role of marine radar as an aid to navigation, its working principle, features, and importance for safe navigation at sea.

Introduction

Marine radar is one of the most frequently used pieces of equipment on a ship's bridge. It is an essential tool for the Officer of the Watch (OOW) in ensuring a safe navigational watch. Radar is used to identify, track, and position vessels, helping ships comply with the COLREGs and avoid collisions while navigating from one point to another.

What is Marine Radar?

Radar is a mandatory aid to navigation. With integrated ARPA (Automatic Radar Plotting Aid), it enables the identification and tracking of other vessels, including one's own, as well as buoys, shorelines, and navigational marks.

Marine radar operates on two main frequencies:

- X-band (10 GHz): Provides sharper images and higher resolution.
- S-band (3 GHz): More effective in rain or fog, suitable for identification and tracking in poor weather conditions.

According to SOLAS Chapter V, Regulation 19, ships of 3000 gross tonnage and above must be equipped with at least one 3 GHz radar and, where appropriate, a second 9 GHz radar or equivalent system. These radars must be functionally independent and capable of displaying the range and bearing of vessels, obstructions, buoys, and shorelines.

Functions of Marine Radar

Marine radar enhances safety by helping prevent collisions and monitor traffic. Its key functions include:

- Determining CPA (Closest Point of Approach) and TCPA (Time to CPA).
- Using EBL (Electronic Bearing Line) and VRM (Variable Range Marker) for precise navigation and distance measurement.
- Providing real-time information through the PPI (Plan Position Indicator) screen, which displays all targets within the radar's range.

[8] https://www.marineinsight.com/marine-navigation/marine-radars-and-their-use-in-the-shipping-industry/ (Accessed 5 May 2025)

Even when ships are docked, radar is used by VTS (Vessel Traffic Services), coast guards, and port authorities to monitor and control vessel movements in smaller ranges.

Main Features of Marine Radar

Marine radar works by transmitting electromagnetic waves from a parabolic antenna. These waves bounce off objects (targets) and return to the receiver. The radar processes the returning signal to display the object on the PPI screen.

- The distance of an object is determined by the time taken for the wave to travel to the target and back.
- The bearing of the target is measured relative to the ship's heading.
- Reflections displayed on the PPI allow officers to clearly identify targets and assess safe navigation routes.

How Marine Radar Works

The word RADAR is an acronym for *Radio Detection and Ranging*. It works on the principle of electromagnetic waves, transmitting high-speed pulses to determine an object's location, distance, velocity, direction, and sometimes altitude.

Electromagnetic energy travels at the speed of light (300,000 km/s). By calculating the travel time of the pulse and its return, the radar accurately determines the range and bearing of objects. Marine radar does not just show the presence of targets but also provides critical information about their distance and bearing, ensuring safer navigation in compliance with the COLREGs.

Exercises

Discussion questions

1. Why is marine radar considered one of the most important tools on a ship's bridge?
2. What role does radar play in helping ships comply with COLREGs?
3. What are the main differences between X-band and S-band radar?
4. According to SOLAS Chapter V, Regulation 19, what radar equipment is required on ships of 3000 GT and above?
5. How do CPA and TCPA help in preventing collisions?
6. What is the function of the EBL (Electronic Bearing Line) and VRM (Variable Range Marker)?
7. What information does the PPI (Plan Position Indicator) screen provide to the Officer of the Watch?
8. How does marine radar determine the distance and bearing of a target?
9. Why is radar still useful even when ships are docked?
10. In your opinion, what is the greatest advantage of marine radar for safe navigation?

Vocabulary exercise 1: Match the terms with the definitions

1. Radar
2. ARPA
3. X-band
4. S-band
5. PPI
6. CPA
7. VRM
8. EBL

a) A tool for marking distance on the radar display.
b) Plan Position Indicator, the radar display screen.
c) Marine radar frequency used in poor weather (rain/fog).
d) Closest Point of Approach.
e) A tool for marking bearing lines electronically.
f) Automatic Radar Plotting Aid used for tracking vessels.
g) High-frequency radar band for sharper images.
h) Acronym for Radio Detection and Ranging.

Vocabulary exercise 2: Fill in the Blanks

PPI / Detection / TCPA / Parabolic / S

1. The acronym RADAR stands for Radio ______________ and Ranging.
2. The ______________ is the radar display screen showing all targets in range.
3. The ______________ band radar is preferred in rain or fog.
4. The OOW uses CPA and ______________ to avoid collisions.
5. The ______________ antenna transmits and receives electromagnetic waves.

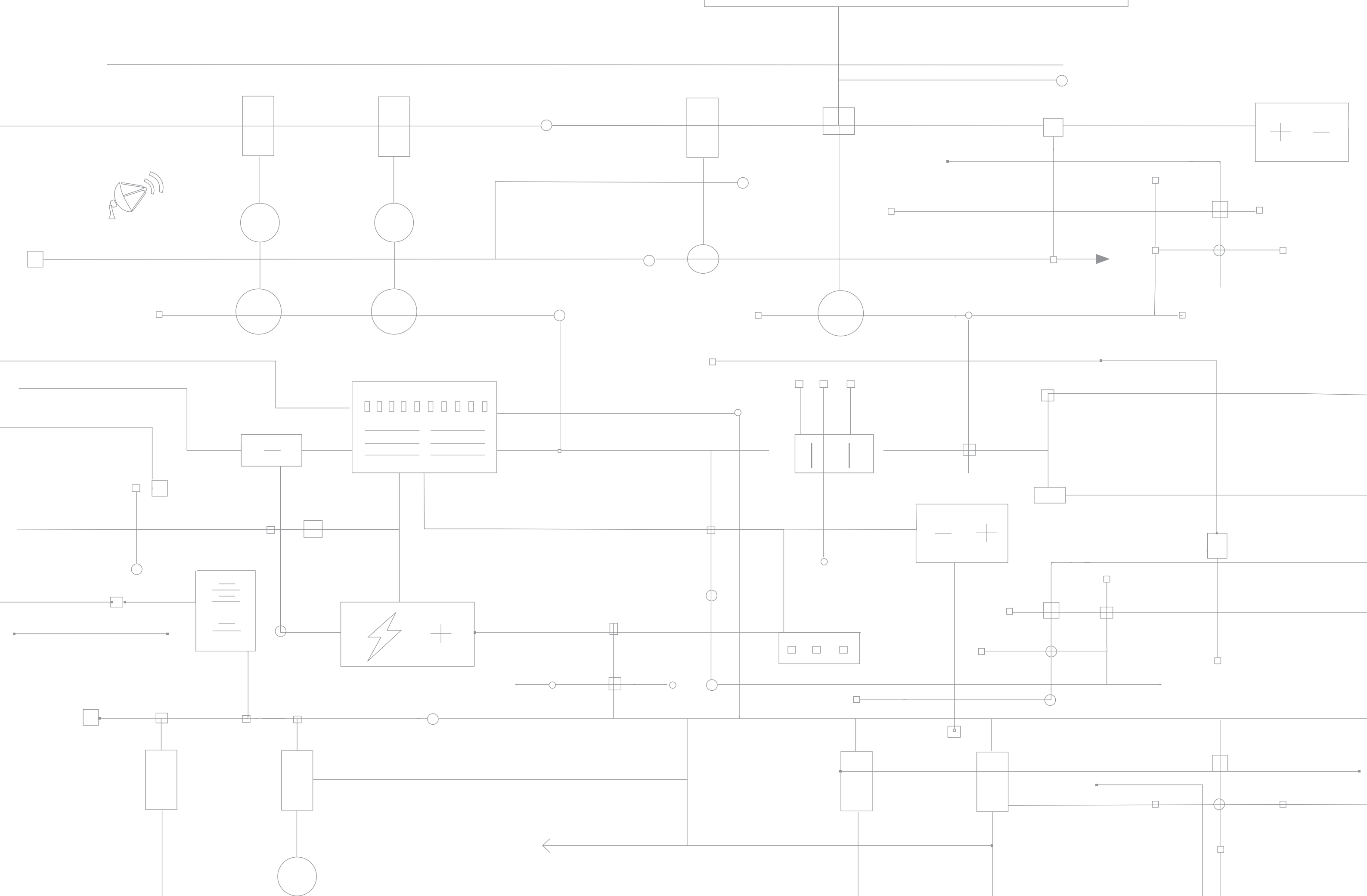
Vocabulary exercise 3: True / False

1. Marine radar is optional equipment under SOLAS for ships above 3000 GT.
2. The X-band radar provides sharper images and higher resolution.
3. The S-band radar is especially effective in poor weather conditions.
4. The CPA determines the distance of closest approach between two vessels.
5. The radar display screen is called the Plan Position Indicator (PPI).
6. Electromagnetic energy used by radar travels slower than sound.

Vocabulary exercise 4: Use the correct form of the word in brackets.

1. Radar is used for safe ship________________. (NAVIGATE)
2. The PPI provides a clear________________ of nearby vessels. (DISPLAY)
3. SOLAS makes radar equipment ________________ for certain ships. (MANDATE)
4. The officer must________________ the CPA and TCPA carefully. (ANALYSIS)
5. Electromagnetic waves travel at the speed of ________________ . (LIGHT)

Lesson 9



ESSENTIAL GUIDELINES FOR EMERGENCY GENERATOR MAINTENANCE ON SHIPS[9]

Objective

To understand the importance of emergency generators on ships and to learn the key maintenance practices that ensure their reliability during emergencies.

Introduction

The emergency generator is one of the most critical pieces of equipment on board a ship. It provides backup power when the main generators fail, ensuring that the ship can still operate safely in situations such as heavy traffic, narrow channels, rough weather, or during manoeuvring.

As a lifeline for the vessel and crew, the emergency generator must always be ready for immediate use. For this reason, it is kept on auto mode, allowing it to start automatically in case of power failure. To ensure reliability, regular testing and planned maintenance are required. Proper care reduces the risk of breakdowns during emergencies when the ship is already in a vulnerable situation.

Essential Maintenance Guidelines

1. Change of Engine Sump Oil

It is important to check the oil level in the sump regularly. Since the emergency generator is kept on auto mode, which ensures the generator starts and comes on load automatically, it is necessary that before starting the engine for operation, oil level is checked on a regular basis. The condition of the oil will also be known during this inspection, and if carbon or soot particles are present, the complete oil system needs to be changed. The running hours for changing engine oil depend on the manufacturer, the engine type, and the grade of oil in use, but normally oil is changed between 250–500 hours.

2. Clean Air Cleaner

The combustion air for the engine is passed through an air filter, which can be of two types: an oil bath air cleaner or a dry type air cleaner (cartridge or dust collector). It is important to clean the air filter at correct intervals of time as delays can lead to clogging and reduced airflow to the engine. This will reduce the efficiency of the engine and increase its thermal parameters. When using a dry cartridge, ensure replacement at intervals specified by the manufacturer. Normally, the replacement schedule is one year or after 5–7 cleanings.

[9] https://www.marineinsight.com/tech/generator/maintenance-of-emergency-generators-on-ship/ (Accessed 14 May 2025)

3. Check Water Separator

Some emergency generators are fitted with a water separator to prevent mixing of water with fuel. It is essential to check the level of water regularly, making sure it is below the marked level, and to drain it off as required. This prevents rust and corrosion of fuel line devices and ensures proper combustion.

4. Check Electrolyte in the Battery

A battery is used in one of the starting methods of the emergency generator. The electrolyte level in the battery must be checked at regular intervals either by inserting a level stick or by checking the water level in the tester cap, if provided. Distilled water should be used to make up for any low level.

5. Check Alarms and Shutdowns

All safety devices and alarms fitted to the emergency generator must be checked and tested regularly. Generators with V-belts also have an additional alarm that is activated in the event of belt failure, operated by an idler pulley.

6. Check V-Belt Tension

When a V-belt is fitted, it must be inspected for cracks and other damage. The belt should be renewed if it shows signs of excessive wear or cracking. To check the belt tension, press the belt midway between pulleys with your thumb and measure the inward deflection in millimetres. Depending on the generator make, this should not be more than 10–15 mm.

7. Clean Oil Filter Cartridge

The emergency generator is fitted with various oil filters, such as bypass filters, centrifuge filters, lube oil filters, and fuel feed pump filters. These filters need to be cleaned, or their cartridges renewed, as per the manufacturer's instructions or depending on the condition of the oil.

8. Check Valve Clearance

The tappet clearance of the inlet and exhaust valves should be checked at the running hours stated in the generator's maintenance manual. It is important to ensure that the engine is cold before taking the tappet clearance measurement.

Exercises

Discussion questions

1. Why is the emergency generator considered one of the most critical pieces of equipment on board a ship?
2. Why must the emergency generator always be kept in auto mode?
3. What risks could arise if the engine sump oil is not checked and changed regularly?

4. How can a clogged air cleaner affect the performance of the emergency generator?
5. Why is it important to monitor the water separator in the fuel system?
6. What role does the battery play in starting the emergency generator, and why must its electrolyte level be checked?
7. Why should alarms and shutdown devices be tested regularly on the emergency generator?
8. How can you check if a V-belt has the correct tension, and what could happen if it fails?
9. Why is it necessary to clean or replace oil filter cartridges at regular intervals?
10. What precautions should be taken before checking valve clearance on the emergency generator?

Vocabulary exercise 1: Match the terms with the definitions

1. Sump
2. Air Cleaner
3. Water Separator
4. Electrolyte
5. V-belt
6. Tappet Clearance
7. Oil Filter Cartridge
8. Alarm and Shutdown

a) Gap adjustment of inlet and exhaust valves.
b) Device to filter particles from lubrication oil.
c) A belt used to transmit power between pulleys.
d) Liquid inside a battery for electrical conduction.
e) Container at the bottom of an engine for collecting oil.
f) Device to remove water from fuel.
g) Safety system that warns and stops the generator in case of fault.
h) Device to clean combustion air before entering the engine.

Vocabulary exercise 2: Fill in the Blanks

water separator / sump / electrolyte / tappet / air cleaner

1. The engine _______________ collects oil and must be checked regularly.
2. A clogged_______________ reduces efficiency and raises engine temperatures.
3. To prevent rust and incomplete combustion, the ______________ should be drained of water.
4. Distilled water is used to maintain the_______________ level in the battery.
5. The_______________clearance must be checked on a cold engine.

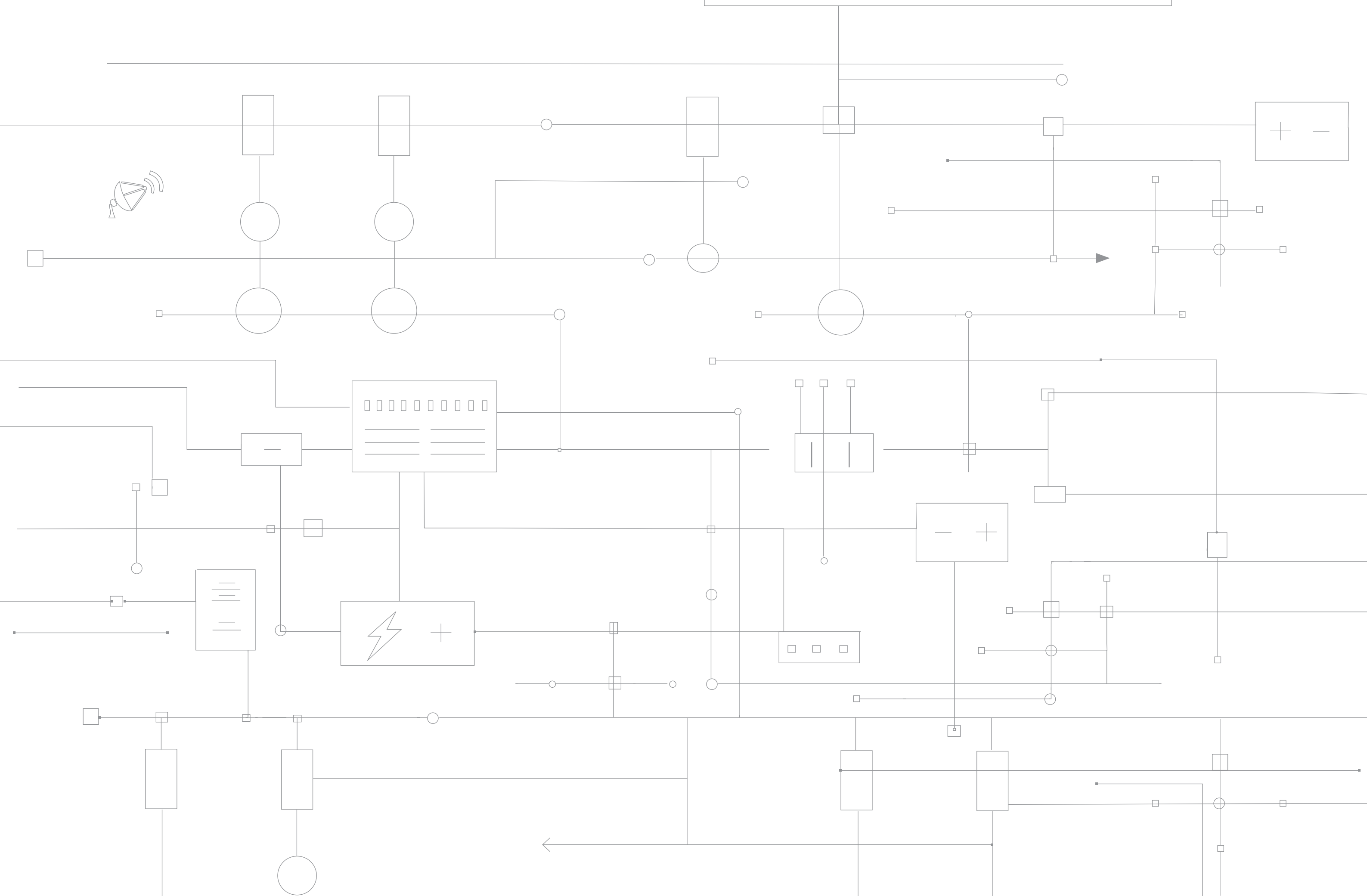
Vocabulary exercise 3: True / False

1. The emergency generator provides backup power only when the ship is in port.
2. Oil in the sump should be inspected for soot and carbon particles.
3. A clogged air filter increases efficiency and lowers thermal parameters.
4. V-belts should be replaced if cracks or damage are visible.
5. Battery electrolyte levels should be maintained using distilled water.
6. Valve clearance is checked when the engine is hot.

Vocabulary exercise 4: Use the correct form of the word in brackets.

1. Regular oil_______________ prevents damage to the engine. (CHANGE)
2. Dirty filters reduce engine _______________. (EFFICIENT)
3. Checking alarms ensures proper system _______________. (OPERATE)
4. Water in fuel causes _______________ and incomplete combustion. (CORRODE)
5. Valves must be checked at regular _______________ intervals. (MAINTAIN)

Lesson 10



SHIPBOARD HIGH VOLTAGE ELECTRICAL SYSTEMS: SAFETY AND FUNCTIONALITY[10]

Objective

To understand the importance of high voltage electrical systems on ships, their advantages and disadvantages, the hazards associated with arcing and short circuits, and the safety measures required for their operation.

Introduction

On ships, voltages up to and including 1000 V are considered low voltage systems, while voltages above 1000 V are defined as high voltage systems. Traditionally, ships operated mainly on low voltage systems, but with the growing demand for power due to heavy consumers such as bow thrusters, reefer containers, and cargo cooling machinery, the adoption of high voltage systems has become necessary. High voltage systems not only meet power demand but also reduce machinery size, weight, and overall costs, while improving efficiency.

Why are High Voltage Systems Used on Ships?

High voltage systems are preferred over low voltage systems for several reasons. First, heavy power consumers such as large bow thruster motors, reefer containers, and cargo cooling machinery require high power that cannot be efficiently handled by low voltage systems. Second, high voltage machinery is significantly smaller and lighter compared to low voltage equipment of the same capacity, reducing space and weight on board. This space saving increases cargo capacity and therefore profitability.

Additionally, the use of high voltage reduces conductor size due to lower current flow, which decreases copper requirements and costs. Copper and iron losses are also reduced, leading to better efficiency. Overall, cost savings of about one-third compared to low voltage systems can be achieved.

Disadvantages of High Voltage Systems

Despite their advantages, high voltage systems also present challenges. They require high-class insulation (generally F class or above) to handle higher voltages. There is an increased risk of accidents, demanding strict safety procedures and skilled personnel for operation. High voltage systems are prone to hazards such as arcing, arc flash, and arc blast, requiring the use of special switchgear designed to prevent these phenomena.

[10] https://marineengineeringonline.com/high-voltage-system-ships/ (Accessed 14 May 2025)

Why is Machinery Smaller in High Voltage Systems?

An electric motor operating on high voltage draws much lower current compared to a low voltage motor of the same power. Since the current-carrying capacity of conductors is reduced, smaller conductors can be used. This reduction in conductor size results in reduced machine dimensions and saves installation space.

Arcing, Arc Flash, and Arc Blast

Arcing occurs when an unintentional electric arc is formed while opening or closing a circuit breaker, isolator, or contactor due to discharge of electricity through the medium between contacts. Arcing also occurs during earth faults or short circuits caused by insulation failure.

- Temperatures at arc terminals can exceed 20,000 °C, four times the temperature of the sun's surface.
- The intense light produced is called an arc flash.
- The rapid heating of air and vaporisation of conductors creates a high-pressure wave. If released violently, this explosion is known as an arc blast.

Hazards of Arc Flash and Arc Blast

The hazards caused by arc events are severe:

- Permanent damage to electrical equipment.
- Severe burns and irreversible damage to human tissue.
- Eye damage from intense UV light and pressure waves.
- Hearing loss or ruptured eardrums due to noise levels above 140 dB.
- Explosions that eject parts at high velocity, causing injury or damage.
- Ignition of nearby flammable materials, leading to secondary fires.

Short Circuit and Short Circuit Level

A short circuit occurs when electrical current deviates from its normal path and flows through an alternative low-resistance path, causing the current to rise significantly above normal values.

The short circuit level (SCL) is the maximum possible current that flows through a circuit during a short circuit fault.

Effects of Short Circuit Faults in High Voltage Systems

Short circuits cause dangerously high current flow, resulting in elevated temperatures, damaged insulation, mechanical stresses, arcing, and potential arc flash or blast events.

Preventing the Effects of Short Circuit Faults

To protect systems from the effects of short circuits, protective relays are installed. These relays trip and isolate the equipment quickly, preventing prolonged exposure to fault currents. Furthermore, all associated components – generators, cables, equipment, and switchgear – are designed to withstand short-circuit currents for a limited duration until protection activates.

Exercises

Discussion questions

1. What is the difference between low voltage and high voltage systems on ships?
2. Why has the use of high voltage systems become more common on modern ships?
3. How do high voltage systems help reduce space and weight on board?
4. Why do high voltage systems require less copper in conductors compared to low voltage systems?
5. What are some disadvantages or risks associated with high voltage systems?
6. How does an electric motor's current requirement change when operated on high voltage instead of low voltage?
7. What is an electric arc, and under what conditions can arcing occur?
8. What is the difference between an arc flash and an arc blast?
9. What are some of the hazards to humans and equipment caused by arc events?
10. How do protective relays help prevent damage from short circuit faults in high voltage systems?

Vocabulary exercise 1: Match the terms with the definitions

1. High Voltage System
2. Bow Thruster
3. Conductor
4. Insulation
5. Arc Flash
6. Arc Blast
7. Short Circuit
8. Protective Relay

a) A device that trips and isolates equipment during a fault.
b) A sudden explosion caused by vaporised conductors and rapid air expansion.
c) Ship equipment requiring large amounts of power for manoeuvring.

d) Occurs when current deviates from its normal path to a low resistance path.
e) Electrical system operating above 1000 volts.
f) Protective covering preventing current leakage from conductors.
g) Intense light generated by electrical arcing.
h) A material or wire that carries electrical current.

Vocabulary exercise 2: Fill in the Blanks

copper / arc flash / high voltage systems / protective relay / arc blast

1. Electrical systems above 1000 volts are classified as_______________ .
2. Reduced conductor size in high voltage systems saves_______________ .
3. The intense light produced during arcing is known as_______________ .
4. The sudden explosion from arc events is called an _______________ .
5. A _______________ trips and isolates equipment during a short circuit fault.

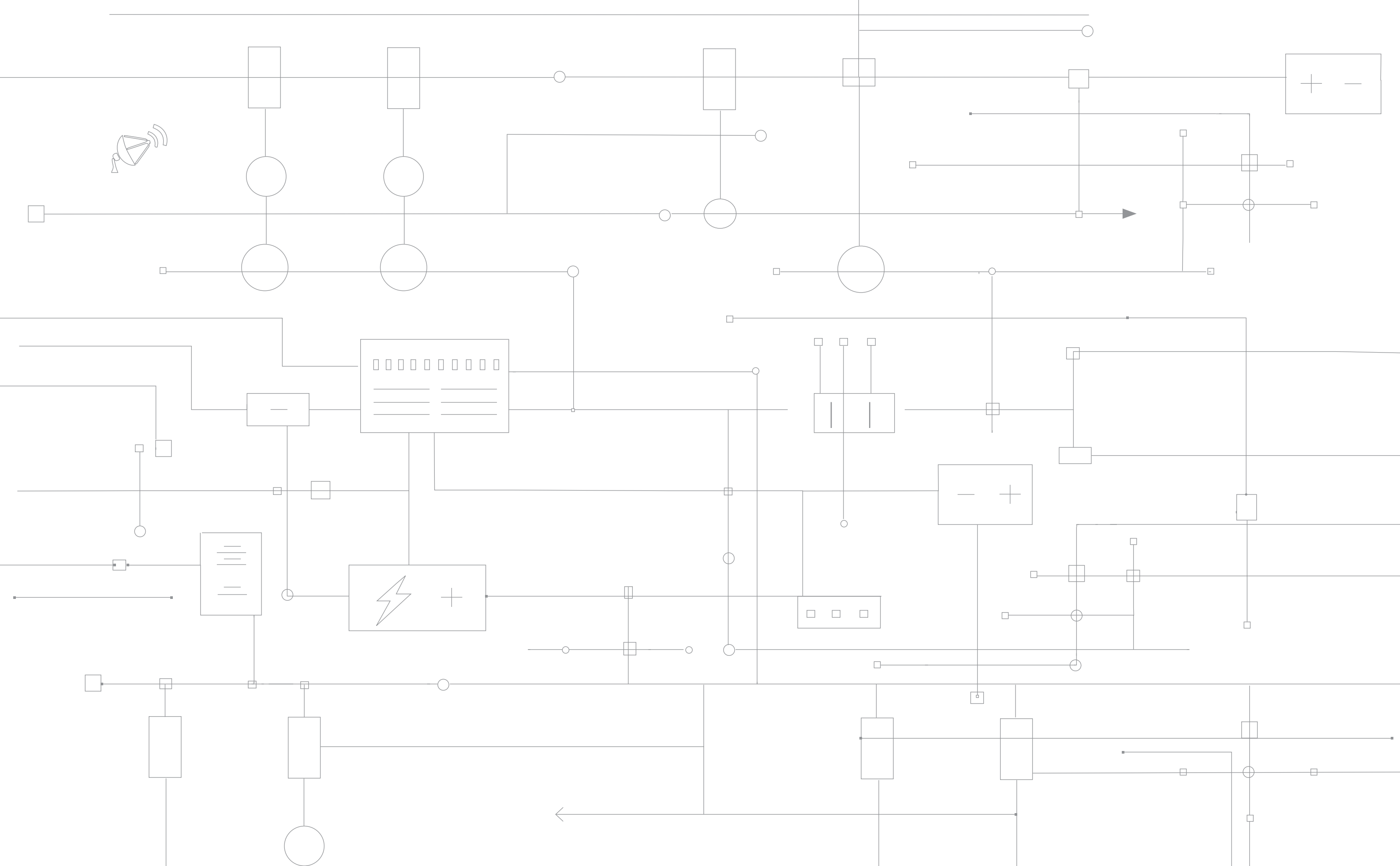
Vocabulary exercise 3: True / False

1. High voltage systems are used to reduce space, weight, and copper loss on ships.
2. Arcing only occurs during the closing of circuit breakers.
3. Temperatures during arcing can exceed four times the surface of the sun.
4. Short circuit level refers to the normal operating current of a system.
5. Protective relays are designed to isolate equipment quickly during faults.
6. High voltage systems can be handled safely by unskilled personnel.

Vocabulary exercise 4: Use the correct form of the word in brackets.

1. High voltage systems improve the_______________of shipboard electrical supply. (EFFICIENT)
2. Protective relays are an essential part of shipboard electrical _______________. (SAFE)
3. A short circuit causes severe thermal and mechanical _______________. (STRESSFUL)
4. Arc blast events can cause _______________ injuries to personnel. (PERMANENT)
5. Using high voltage systems reduces _______________ costs and copper use. (INSTALL)

Lesson 11



UNDERSTANDING MARINE ELECTRICAL CABLES[11]

Objective

To understand the role, types, construction, installation, and maintenance of marine electrical cables, and their importance in ensuring the safe and reliable operation of shipboard electrical systems.

Introduction

Marine electrical cables are essential for the safe and efficient functioning of ships. They are specifically designed to withstand harsh marine conditions such as saltwater, humidity, and constant exposure to mechanical stress. Without specialized cables, ships would be at great risk of electrical hazards, including corrosion, sparks, short circuits, and electrocution.

Choosing the right type of marine cable, installing it correctly, and maintaining it properly are critical for ensuring the safety of the crew and vessel, as well as for compliance with international standards.

Overview of Marine Electrical Cables

The sea environment is highly corrosive due to the combination of water and salt. Ordinary electrical cables are not suitable, as water may cause sparks and electrocution, while salt corrodes the conductor over time. Marine-grade cables are therefore essential for reliable power transmission, system safety, and efficient vessel operation.

Choosing the wrong type of cable, even if it is marine-grade, can result in inefficiency, increased fuel consumption, and potential safety hazards. Cables form the backbone of shipboard power distribution and control systems, making their correct selection and maintenance vital.

Types of Marine Electrical Cables

Marine electrical cables are classified according to their application:

Power Cables carry high voltage from the generator to distribute electricity across the ship. They are heavily insulated and protected to withstand harsh conditions. These cables power heavy machinery such as turbines, rudders, and propulsion systems.

Control Cables operate at low voltage and are used to manage mechanical operations like steering systems and engine control. They are flexible to accommodate frequent bending and movement.

[11] https://www.grandoceanmarine.com/types-of-marine-electrical-cables/ (Accessed 26 May 2025)

Communication Cables transmit information across the ship, including navigation data and GPS signals. Often twisted to reduce electromagnetic interference, they carry both analogue and digital signals and ensure effective communication throughout the vessel.

Instrumentation Cables handle low-level signals from sensors that measure parameters like temperature, pressure, and liquid levels. These cables are critical for safe ship operation in all weather conditions and are highly protected against marine exposure.

Construction and Components of Marine Electrical Cables

Marine cables are built with multiple layers of protection. Typical construction includes:

- Insulation (using XLPE or EPR) to prevent current leakage.
- Inner covering and shielding for added protection.
- Armor to withstand mechanical stresses.
- Outer sheath made of durable materials such as PVC, PCP, or PO, which protect against moisture, saltwater, UV radiation, and fire hazards.

Selecting the Right Marine Electrical Cables

When selecting cables, voltage and current ratings must match the system's requirements. Environmental challenges such as water, salt, UV exposure, fire risks, and chemicals must also be considered.

Compliance with international standards, particularly those of the International Electrotechnical Commission (IEC), ensures cable reliability, safety, and proper performance under marine conditions.

Installing Marine Electrical Cables

Proper planning is critical for installation. Cable routing, accessibility, and regulatory requirements must be considered. During installation, best practices include:

- Maintaining correct bending radius.
- Securing cables with proper supports.
- Using correct connectors and terminations.

After installation, thorough testing and verification (insulation resistance, continuity, and connection accuracy) ensures cables function safely and reliably.

Maintenance and Troubleshooting

Regular maintenance extends the lifespan of marine cables. Inspections should identify corrosion, wear, or damage. Cable connections must be cleaned and lubricated as necessary.

Troubleshooting is needed when faults occur, such as short circuits, insulation breakdowns, or connectivity failures. Using systematic testing methods, issues can be quickly identified and repaired to minimize downtime.

Upgrading Marine Electrical Cables

Over time, cables degrade due to seawater, marine life, or wear and tear. Signs such as frequent failures or reduced performance indicate the need for an upgrade. Upgrades should ensure compatibility with existing systems, meet future power demands, and comply with industry standards. Testing new cables before commissioning ensures safety and performance.

Conclusion

Marine electrical cables are the backbone of a ship's electrical system. Selecting the right cables, installing them properly, and maintaining them regularly ensures reliability, safety, and efficiency. By following best practices, shipowners and crew can guarantee safe voyages and long service life of onboard electrical systems.

Exercises

Discussion questions

1. Why are ordinary electrical cables unsuitable for use on ships?
2. What risks could arise if the wrong type of marine cable is used onboard?
3. How do power cables differ from control cables in terms of function and application?
4. Why are communication cables often twisted, and what purpose do they serve on ships?
5. What role do instrumentation cables play in ensuring safe ship operation?
6. What protective layers are typically included in the construction of marine electrical cables?
7. Why is it important for marine cables to comply with IEC (International Electrotechnical Commission) standards?
8. What best practices should be followed during cable installation?
9. What signs indicate that marine cables may need upgrading?
10. How does regular maintenance and troubleshooting help extend the lifespan of marine electrical cables?

Vocabulary exercise 1: Match the terms with the definitions

1. Power Cable
2. Control Cable
3. Communication Cable
4. Instrumentation Cable
5. Insulation
6. Outer Sheath
7. Continuity Test
8. IEC Standards

a) Ensures cable construction and performance meet international requirements.
b) Covers and protects the cable from saltwater, UV light, and fire.
c) Cable designed to monitor parameters such as temperature and pressure.
d) Test used to check that electricity flows without interruption.
e) Protective material around a conductor to prevent leakage.
f) Heavy-duty cable distributing electricity across the ship.
g) Low-voltage flexible cable used in steering and engine control.
h) Cable used for transmitting navigation data, GPS, and signals.

Vocabulary exercise 2: Fill in the Blanks

IEC / marine / power / outer sheath / communication

1. Marine electrical cables are designed to withstand harsh _______________ conditions.
2. _______________cables carry high voltage from the generator to distribute power.
3. To reduce interference, _______________ cables are often twisted.
4. The protective outer layer of a marine cable is called the _______________.
5. All marine cables should comply with _______________ standards.

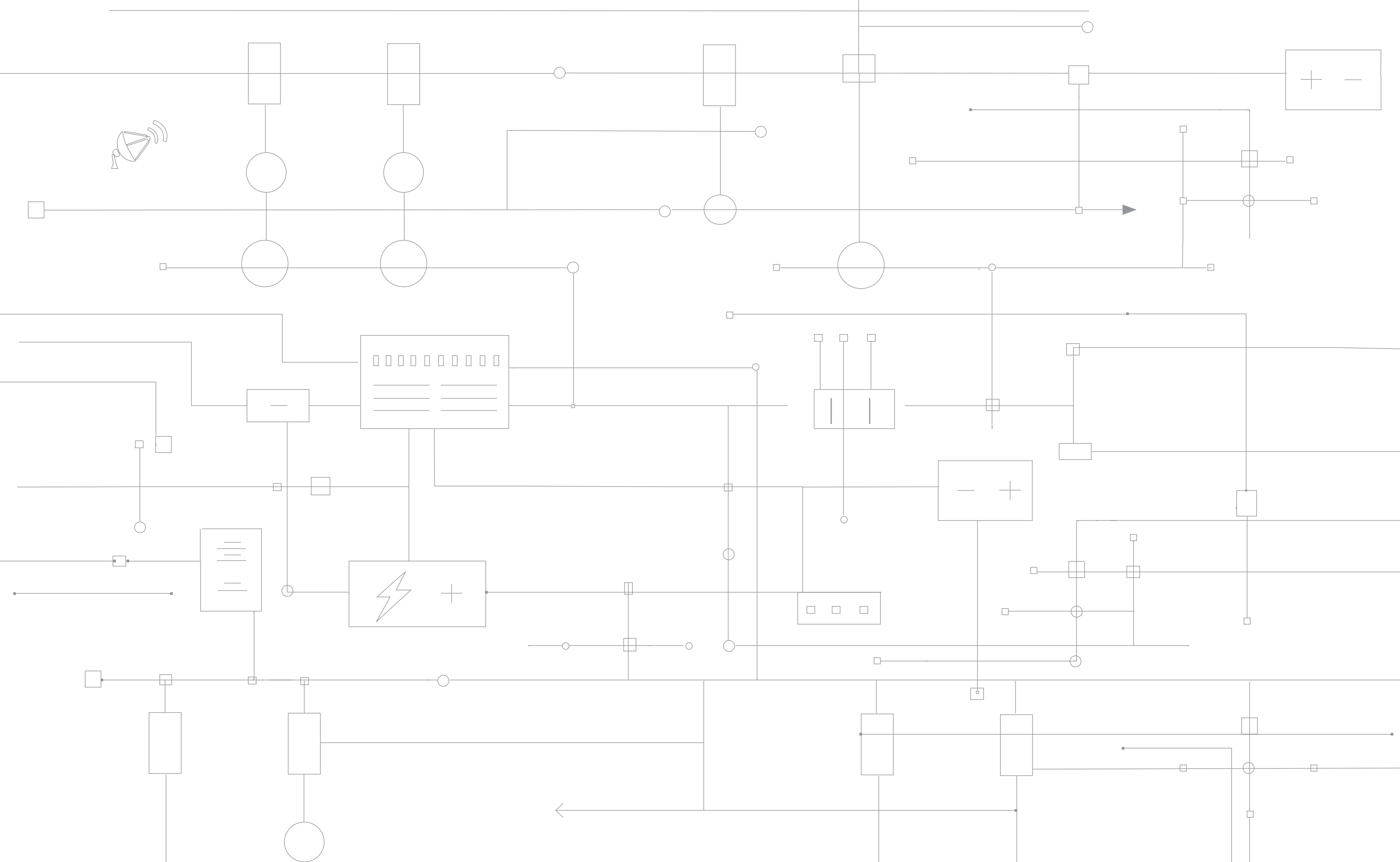
Vocabulary exercise 3: True / False

1. Saltwater and moisture have no effect on ordinary electrical cables.
2. Control cables are typically used for steering systems and engine controls.
3. Instrumentation cables carry high-voltage power across the ship.
4. IEC standards provide guidelines for safe cable construction and performance.
5. Testing and verification should always follow the installation of marine cables.

Vocabulary exercise 4: Use the correct form of the word in brackets.

1. Proper cable ______________ensures long-lasting performance. (INSTALL)
2. Cables are the backbone of marine electrical ______________. (SYSTEMATIC)
3. Regular inspections help detect cable ______________ early. (FAIL)
4. Marine cables require strong ______________ against fire and saltwater. (PROTECT)
5. Communication cables allow ships to ______________effectively. (COMMUNICATION)

Lesson 12



ENERGY EFFICIENCY MEASURES ON SHIPS: TECHNOLOGIES AND BEST PRACTICES[12]

Objective

The objective of this lesson is to understand how the International Maritime Organization (IMO) regulates ship energy efficiency, to explore the technologies and operational measures that reduce fuel consumption and greenhouse gas emissions, and to highlight the role of officers and ports in implementing best practices.

Introduction

The shipping industry has long been recognized as a major contributor to greenhouse gas emissions, and since the early 2000s the International Maritime Organization has worked on strategies to minimize this impact. In 2011, amendments to MARPOL Annex VI made technical and operational energy efficiency measures mandatory, and from January 2013 the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP) came into force. Together, these represent the first global mandatory greenhouse gas reduction regime for an international industry. By setting goal-based and technology-neutral standards, the regulations have encouraged the development and adoption of energy-efficient technologies such as hull air lubrication, wind-assisted propulsion, and waste heat recovery.

IMO's Regulatory Framework

The EEDI applies to all new ships and ensures that their design incorporates features that improve efficiency and reduce carbon emissions. At the same time, the SEEMP functions as a management tool for ships already in operation, requiring each vessel to adopt a plan to monitor energy use and implement strategies to reduce emissions. The combined purpose of these measures is not only to reduce harmful gases but also to decrease fuel consumption, improve operational practices, and promote innovation.

Technologies for Energy Efficiency

The transition towards greener ships has been driven by a variety of technological solutions. Improvements in hull design and propeller efficiency, such as the development of single-propeller twin-rudder systems, are aimed at reducing resistance and increasing overall performance. New paint technologies and hull

[12] https://www.imo.org/en/ourwork/environment/pages/improving%20the%20energy%20efficiency%20of%20ships.aspx (Accessed 26 May 2025)

cleaning systems are further examples of methods that reduce drag and improve efficiency. Other technologies include waste heat recovery systems that capture energy from exhaust gases, and wind-assisted propulsion devices that supplement engine power. The use of alternative fuels such as LPG also contributes to the reduction of carbon emissions.

Operational Best Practices

Energy efficiency is not only about design; it also depends heavily on operational measures carried out by officers. Passage planning and continuous route review are critical for reducing fuel use and preventing inefficiencies. Reducing speed under governor control when encountering headwinds and adverse currents is one of the most effective measures, yet it is often neglected until problems occur. Another key practice is operating generator engines at their optimum load, typically around seventy-five percent. However, poor communication or lack of involvement can lead to additional generators being run unnecessarily, wasting energy. Good teamwork and coordination among officers are therefore essential.

Regular maintenance of machinery also plays an important role. Deck cranes, for example, consume less power when properly maintained with good oil quality, correct brake adjustments, efficient greasing of pulleys, and minimal backlash in gears. Boilers should only supply steam when necessary, and smoke-side cleaning must not be neglected, as poor maintenance increases fuel consumption and emissions.

The Role of Ports in Energy Efficiency

Improving ship efficiency also requires cooperation from ports. Technologies such as cold ironing, or the provision of shore power, allow vessels to shut down auxiliary engines while berthed, significantly reducing emissions. Ports should not focus solely on collecting fees for berths, tugs, or cranes, but should actively assist vessels in carrying out maintenance and adopting greener practices. However, garbage disposal remains a challenge, since not all types of waste are accepted in every port. As a result, certain residues such as scavenge space scrapings are often burnt in incinerators, producing soot that undermines emission-reduction efforts. Greater cooperation between ships and ports is therefore vital for addressing these limitations.

Conclusion

Energy efficiency in shipping is the result of both regulatory frameworks and practical measures at sea and in port. The introduction of the EEDI and SEEMP has accelerated the adoption of greener designs and operational practices, while technological innovations such as hull improvements, waste heat recovery, and alternative fuels continue to evolve. At the same time, operational discipline – ranging from careful passage planning to efficient generator use and proper maintenance – is equally crucial. Ports also have an essential role to play in supporting ships with green infrastructure and waste management. Ultimately, collaboration across all levels of the industry is required to reduce emissions and promote sustainable shipping.

Exercises

Discussion questions

1. Why did the IMO introduce amendments to MARPOL Annex VI, and what was their main purpose?
2. What is the difference between the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP)?
3. How do goal-based and technology-neutral standards encourage innovation in ship design?
4. Which energy-efficient technologies are currently being used to reduce emissions on ships?
5. How can improvements in hull design and propeller efficiency reduce fuel consumption?
6. What role does waste heat recovery play in ship energy efficiency?
7. Why is operational discipline, such as proper passage planning and speed reduction, important for energy efficiency?
8. How does proper maintenance of machinery like deck cranes and boilers contribute to reducing fuel use and emissions?
9. What role do ports play in supporting energy efficiency in shipping, and how does shore power (cold ironing) help?
10. What are some challenges related to port waste management, and how do they affect emission reduction efforts?

Vocabulary exercise 1: Match the terms with the definitions

1. EEDI
2. SEEMP
3. Cold Ironing
4. Waste Heat Recovery
5. Passage Planning
6. Hull Air Lubrication

a) Use of bubbles along the hull to reduce resistance.
b) Ship-specific operational tool to improve energy efficiency.
c) Connecting to shore power while in port.
d) Designing new ships to meet efficiency standards.
e) Careful route planning to save fuel.
f) Using exhaust gases to generate additional energy.

Vocabulary exercise 2: Fill in the Blanks

shore / EEDI / hull / passage / SEEMP

1. The______________ is compulsory for all new ships and measures design efficiency.
2. The______________ requires ships to implement operational energy-saving practices.
3. Ports should support emission reduction by providing______________ power.
4. Cleaning the ship's ______________ reduces resistance and fuel consumption.
5. Using______________ planning helps ships avoid unnecessary fuel waste.

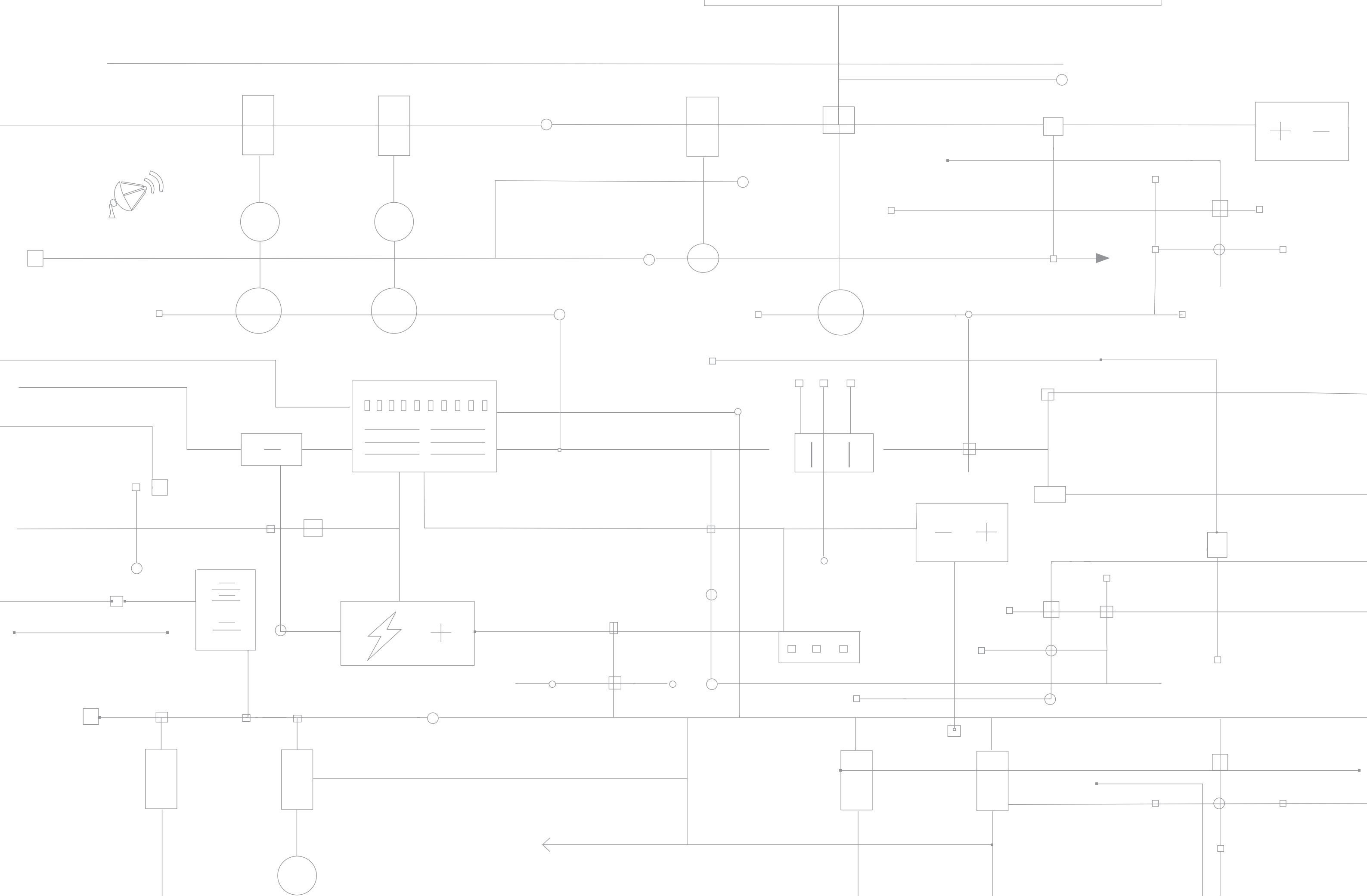
Vocabulary exercise 3: True / False

1. EEDI and SEEMP became mandatory in 2013.
2. Reducing speed in adverse conditions can decrease emissions.
3. Hull cleaning increases resistance and fuel use.
4. Ports play no role in ship energy efficiency.
5. Waste heat recovery is a technology used to improve energy efficiency.

Vocabulary exercise 4: Use the correct form of the word in brackets.

1. The IMO has made energy efficiency measures ______________ . (MANDATE)
2. Hull improvements lead to ______________ fuel consumption. (REDUCE)
3. Passage planning is an important______________ measure. (OPERATE)
4. Cold ironing helps ships to ______________ emissions while in port. (MINIMAL)
5. The SEEMP plan improves ship ______________ efficiency. (MANAGE)

Lesson 13



ADVANCED AUTOMATION AND CONTROL SYSTEMS IN MODERN SHIPS[13]

Objective

To understand the role of automation and control systems in modern ships, including engine room automation, programmable logic controllers (PLCs), alarm and monitoring systems, and the automation of auxiliary machinery, and to explore how these systems improve efficiency, safety, and operational reliability.

Introduction

Automation and control systems have become essential in modern ship operations. They increase efficiency, enhance safety, and improve precision in machinery management. By reducing the need for constant manual oversight, automation allows engineering officers to focus on troubleshooting and optimizing complex machinery. Ship engineers must therefore be proficient in operating, monitoring, and maintaining these systems, particularly when ships operate under demanding conditions.

Engine Room Automation

Automation in the engine room reduces the need for continuous manual monitoring and control. Sensors, controllers, and actuators are used to regulate engines, generators, and auxiliary machinery. These systems ensure that machinery operates within safe parameters without direct human intervention. Many vessels today employ centralized control rooms where engineers can monitor performance data, manage alarms, and adjust systems remotely. This centralization improves efficiency and allows engineers to respond quickly to anomalies.

Automation also extends to critical processes such as fuel injection, cooling, lubrication, and power generation. For example, optimized fuel injection timing increases engine efficiency while reducing emissions. Similarly, automatic control of cooling and lubrication systems ensures that engines operate within safe temperature and pressure ranges, minimizing the risk of failure and human error.

Safety and Emergency Systems

Automation systems contribute significantly to shipboard safety. They continuously monitor parameters such as temperature, pressure, and vibration, triggering alarms or automatic shutdowns if unsafe conditions arise. In the event of a serious malfunction, these systems can shut down machinery to prevent accidents or damage. For this reason, officers must ensure that alarms and shutdown

[13] https://maritimeducation.com/automation-and-control-systems-for-ship-engineers/ (Accessed 4 June 2025)

mechanisms are properly calibrated and regularly maintained to function effectively during emergencies.

Programmable Logic Controllers (PLCs)

PLCs are at the heart of ship automation systems. They are digital computers designed to control mechanical processes such as machinery start and stop functions, valve operations, and monitoring tasks. By receiving input from sensors and executing programmed logic, PLCs adjust machinery operation precisely. For example, a PLC controlling ballast water pumps can regulate pump speed in response to water level and pressure, ensuring stable vessel operation.

The advantages of PLCs include high reliability, flexibility, and scalability. They can be reprogrammed to suit changes in ship operations and are built to withstand the challenging marine environment of vibration, temperature extremes, and humidity. To keep them functioning effectively, officers must perform regular inspections, check sensors and actuators, and troubleshoot issues related to hardware or software. Training in PLC programming and diagnostics is vital for officers tasked with managing these systems.

Alarm and Monitoring Systems

Alarm and monitoring systems alert engineers to potential issues before they escalate. Alarms are typically classified by severity: minor deviations trigger warning alarms, while more serious faults trigger critical alarms that demand immediate attention. For instance, critically low oil pressure in the engine activates an alarm that requires urgent corrective action.

Monitoring systems continuously collect data from machinery sensors and present it in real time on control panels or integrated displays. This allows engineers to track performance indicators such as pressure, temperature, vibration, and fuel use. Data logging functions provide historical records that engineers can analyze to detect patterns, plan maintenance, and optimize system performance.

Automation of Auxiliary Machinery

Automation is not limited to propulsion but extends to auxiliary systems that support ship operations. Power generation is highly automated, with systems that regulate load sharing between generators, balancing fuel efficiency and machinery wear. Environmental control systems, including air conditioning and ventilation, are also automated. These systems maintain safe and comfortable conditions for both equipment and crew by adjusting airflow and temperature based on sensor feedback. Engineers must ensure these systems are calibrated and maintained to prevent overheating, excessive humidity, or energy waste.

Integrated Ship Systems

Modern ships increasingly use integrated systems that consolidate automation functions into a single control interface. This provides officers with a comprehensive view of the ship's operational status, allowing them to monitor and control propulsion, electrical supply, and auxiliary machinery from one location. Integration reduces complexity, prevents conflicting operations, and improves efficiency. However, it also introduces new challenges. Failures in integrated systems can disrupt multiple operations simultaneously, so officers must be prepared to isolate faulty components and, if necessary, revert to manual control. Training is therefore essential to ensure engineers can manage the complexity of integrated ship systems.

Conclusion

Automation and control systems have revolutionized ship operations, enabling safer, more efficient, and more reliable management of shipboard machinery. By automating processes such as fuel injection, power generation, and environmental control, ships minimize human error while optimizing performance. For engineering officers, mastery of automation systems, including PLCs, alarm monitoring, and integrated controls, is essential. As technology advances, automation will become even more central to maritime operations, requiring officers to continuously update their knowledge and skills to ensure smooth and sustainable ship management.

Exercises

Discussion questions

1. How has automation changed the role of engineering officers on ships?
2. What advantages does centralized control of the engine room provide?
3. How does automation improve the safety of fuel injection, cooling, and lubrication systems?
4. Why are alarms and automatic shutdowns critical for ship safety?
5. What are Programmable Logic Controllers (PLCs), and what role do they play in ship automation?
6. Why is training in PLC programming and diagnostics important for ship engineers?
7. How do alarm and monitoring systems help engineers detect and respond to problems?
8. What are the benefits of automating auxiliary systems such as generators and environmental controls?
9. What advantages do integrated ship systems provide, and what risks do they introduce?
10. In your opinion, how might advances in automation further change ship operations in the future?

Vocabulary exercise 1: Match the terms with the definitions

1. Centralized Control Room
2. Actuator
3. PLC (Programmable Logic Controller)
4. Ballast System
5. Alarm System
6. Data Logging
7. Load Sharing
8. Integrated Ship System

a) A device that converts electrical signals into mechanical action
b) Balances power distribution across multiple generators.
c) Records operational data for performance analysis and maintenance planning.
d) Digital computer used to automate machinery processes.
e) System used to control vessel stability by adjusting water levels in tanks.
f) Alerts engineers to deviations from safe operating parameters.
g) A centralized interface combining automation from multiple ship systems.
h) Location from which engineers can monitor and control ship systems.

Vocabulary exercise 2: Fill in the Blanks

Use the vocabulary terms above to complete the sentences:

1. Modern ships often use a _______________ to allow officers to control multiple automated systems from a single location.
2. A _______________ receives input from sensors and executes programmed logic to control machinery operations.
3. Automatic_______________of cooling water and lubrication oil ensures machinery remains within safe operating limits.
4. Historical performance data is preserved through_______________, which officers analyze for patterns and maintenance planning.
5. Generator_______________ensures that power is distributed efficiently across the ship's electrical system.

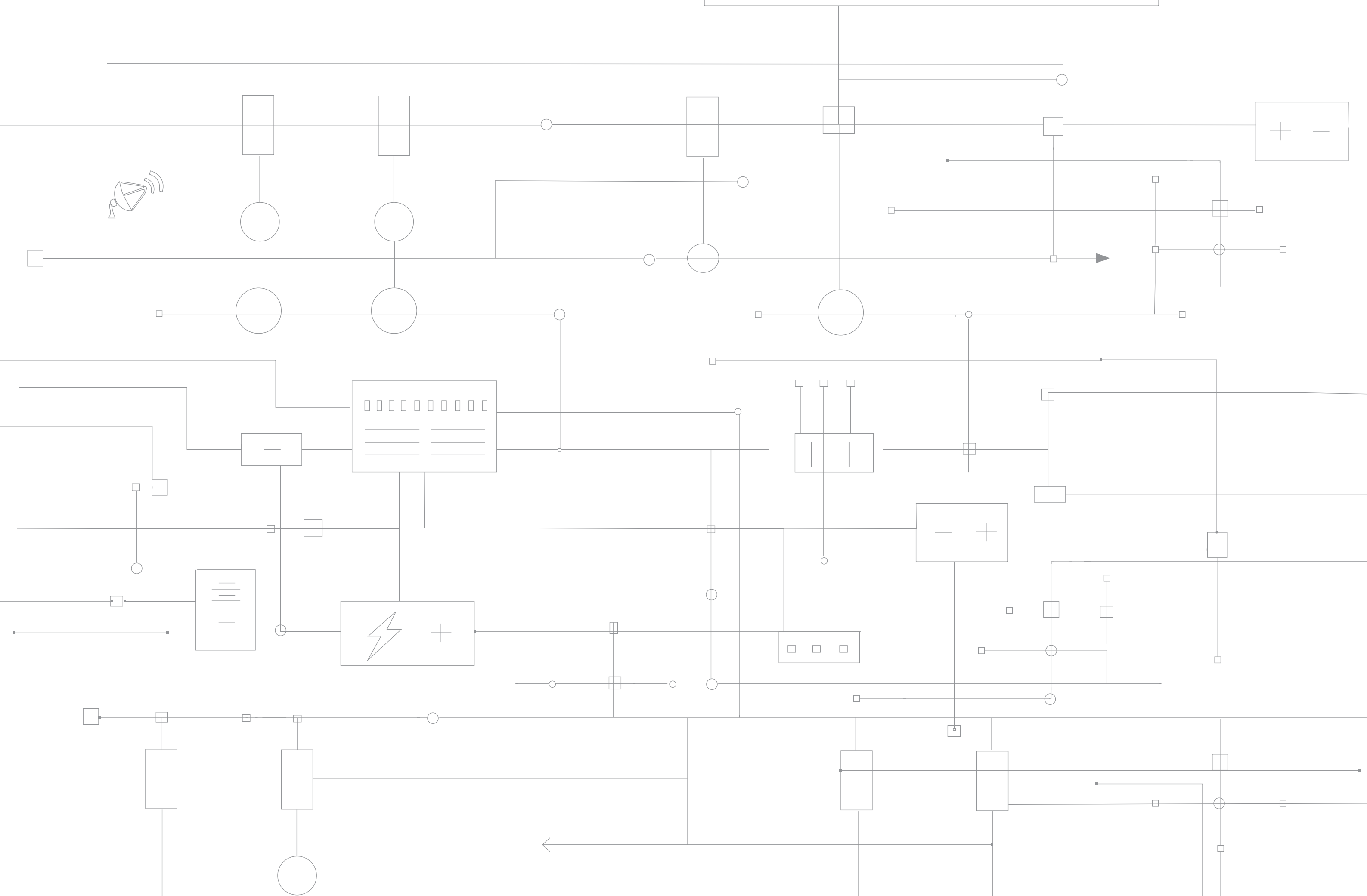
Vocabulary exercise 3: True / False

1. Engine room automation eliminates the need for engineers on board ships.
2. PLCs can be reprogrammed to adapt to different machinery configurations.
3. Alarm systems classify warnings and critical alerts based on severity.
4. Monitoring systems provide only real-time data and cannot record information for later use.
5. Integrated ship systems can improve efficiency but may increase the complexity of troubleshooting.
6. Automation reduces the likelihood of human error in ship operations.

Vocabulary exercise 4: Use the correct form of the word in brackets.

1. PLCs improve the ______________ of ship automation by providing precise control of machinery. (RELY)
2. Engineers must carry out regular ______________of sensors, actuators, and controllers. (INSPECT)
3. A sudden rise in vibration levels may indicate an ______________problem in the machinery. (OPERATE)
4. Integrated systems require engineers to have thorough______________of how subsystems interact. (KNOW)
5. Automation systems provide continuous______________of machinery conditions to ensure safety. (MONITOR)

Lesson 14



CYBERSECURITY IN MARITIME AUTOMATION[14]

Objective

To understand the challenges of balancing cybersecurity with operational efficiency and profitability in the maritime industry, to explore international guidelines and best practices, and to examine governance and risk management strategies for protecting maritime infrastructure and operations.

Introduction

The increasing automation and digitalization of maritime systems has transformed how ships and ports operate. Control systems for propulsion, cargo handling, environmental management, and communications now rely heavily on networked technologies. While this has improved efficiency and reduced manual oversight, it has also introduced new cybersecurity risks.

Cybersecurity in maritime automation is therefore critical not only for protecting vessels and ports but also for safeguarding the global economy that depends on the movement of goods, energy, medicine, and food. Because automation links both Information Technology (IT) and Operational Technology (OT) systems, a single vulnerability can affect the entire supply chain. One weak link in this interconnected ecosystem may disrupt trade, damage critical infrastructure, or even threaten national security.

Cybersecurity in the Maritime Sector

Maritime organizations create, process, store, and transmit vast amounts of data while engaging in major financial transactions and managing complex control systems for cargo, security, and ship operations. Many of these systems rely on older technologies without adequate updates, exposing them to vulnerabilities. A lack of cybersecurity awareness among personnel further increases risks. Since these systems are interconnected with port authorities, customs, vendors, and other stakeholders, a single breach can cascade through the supply chain.

International Guidelines and Best Practices

In recent years, several governments and organizations have issued guidelines to address these risks. The U.S. Coast Guard released NVIC 01-20 in 2020, highlighting the need for facility operators to secure cyber-dependent systems such as cargo control, communications, and environmental controls. The United Kingdom's *Good*

[14] https://www.maritime-cybersecurity.com/ (Accessed 4 June 2025)

Practice Guide: Cyber Security for Ports and Port Systems provides detailed advice for port authorities, system operators, and contractors. In the EU, the European Union Agency for Cybersecurity (ENISA) stresses the importance of securing an increasingly digitalized maritime sector. Conferences such as the 2nd Maritime Cybersecurity Conference in 2022 emphasized the rising risk of supply chain attacks and the cyber-physical vulnerabilities of port operations.

Governance of Cybersecurity in Maritime Transport

Strong governance is essential to manage cybersecurity across both Information Technology (IT) and Operational Technology (OT). Senior management must be directly involved in cybersecurity decisions, allocating resources and setting clear policies. Organizations should appoint a senior role responsible for both IT and OT security, while also clearly defining responsibilities and communication channels for shore-based and shipboard personnel. Cooperation across the supply chain—from manufacturers to service providers—is vital. Governance must also ensure compliance with relevant EU regulations and directives, such as those relating to port security and the ISM Code.

Risk Management in Maritime Cybersecurity

Effective risk management requires a comprehensive understanding of the hardware and software systems in use, and how they connect to shore-side infrastructure. Organizations must conduct cybersecurity risk assessments to identify vulnerabilities in key shipboard and port operations, as well as emerging threats. Risk assessments should also include risks arising from human behavior, such as social media use or unsafe information sharing. Treatment measures can include implementing Information Security Management Systems (ISMS) and Privacy Information Management Systems (PIMS), aligned with existing Safety Management Systems (SMS). This integrated approach helps mitigate threats and ensures resilience.

Conclusion

Balancing cybersecurity with operational efficiency and profitability remains a major challenge in the maritime sector. With the increasing digitalization of shipping and ports, the threat landscape continues to evolve, exposing vulnerabilities in both technology and human factors. Effective governance and risk management are essential to build resilience, supported by international guidelines, coordinated efforts across the supply chain, and ongoing training. By adopting these practices, the maritime industry can strengthen security without compromising the efficiency and profitability that underpin global trade.

Exercises

Discussion questions

1. How has automation and digitalization transformed ship and port operations?
2. Why is cybersecurity considered critical to the global economy in the maritime sector?
3. What risks arise from the interconnection of IT (Information Technology) and OT (Operational Technology) systems?
4. How can outdated technologies increase cybersecurity vulnerabilities in ships and ports?
5. Why is human behaviour, such as poor awareness or unsafe information sharing, a key cybersecurity risk?
6. What role do international guidelines (e.g., NVIC 01-20, ENISA, UK Good Practice Guide) play in improving maritime cybersecurity?
7. Why is senior management involvement important in maritime cybersecurity governance?
8. How does cooperation across the supply chain help strengthen cybersecurity?
9. What is the purpose of cybersecurity risk assessments, and what should they include?
10. How can the maritime industry balance cybersecurity with operational efficiency and profitability?

Vocabulary exercise 1: Match the terms with the definitions

1. NVIC 01-20
2. ENISA
3. IT
4. OT
5. ISMS
6. PIMS
7. Cold Ironing
8. Supply Chain Attack

a) Information Security Management System.
b) Attack that exploits vulnerabilities in interconnected suppliers and partners.
c) European Union Agency for Cybersecurity.
d) Information Technology.
e) Operational Technology, such as cargo and control systems.
f) Guidelines issued by the U.S. Coast Guard on maritime cyber risks.
g) Privacy Information Management System.
h) Supplying ships with shore-based electricity while in port.

Vocabulary exercise 2: Fill in the Blanks

Supply chain / U.S. Coast Guard / OT / ISMS / ENISA

1. The _______________ published NVIC 01-20 to provide guidelines on maritime cyber risks.
2. In Europe, _______________has emphasized the need to secure digitalized maritime infrastructure.
3. Systems such as sensors and cargo pumps belong to_______________rather than traditional IT.
4. Implementing an_______________helps organizations systematically manage information security.
5. Attacks on the_______________have become increasingly common, with cascading effects on ports and shipping.

Vocabulary exercise 3: True / False

1. Maritime cybersecurity risks affect only ships at sea, not port facilities.
2. The NIS 2 Directive identifies maritime operators as Operators of Essential Services.
3. Governance requires that senior management be excluded from cybersecurity decisions.
4. Risk assessments should include threats related to human behaviour.
5. ISMS and PIMS are management systems that support cybersecurity risk treatment.

Vocabulary exercise 4: Use the correct form of the word in brackets.

1. One weak link in the system can cause significant_______________to international trade. (DISRUPT)
2. Port facilities must develop clear_______________structures to manage cybersecurity responsibilities. (GOVERN)
3. Cybersecurity risk_______________should consider both technical and human factors. (ASSESS)
4. The introduction of digitalization has increased the_______________ profile of the maritime sector. (RISK)
5. Training and awareness are vital for_______________ personnel to respond to cyber threats. (MARITIME)

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INDEX OF TERMS