



Electrician trade

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Elektrikerhandwerk

Introduction

1. Introduction

The electrician trade is one of the central and most important trades in modern society. Electricians are responsible for the design, installation, maintenance and repair of electrical installations and equipment. Their activities cover a wide range of areas, from electrical installation in buildings to the implementation of modern building automation systems and renewable energy technologies.

This textbook is dedicated to the electrician trade in all its facets and offers both aspiring electricians and experienced professionals a comprehensive knowledge base. The structure of the book is designed to systematically guide readers through the basics, techniques and specialties of the electrician trade.

The first chapter explains the basic principles of electricity. From the elementary concepts such as current, voltage and resistance to electrical power and energy, the basic knowledge that is essential for understanding electrical systems and circuits is taught.

Safety in the electrician trade is the focus of the second chapter. Electrical work involves certain risks, and therefore extensive safety awareness is crucial. This chapter explains basic safety rules and discusses protective measures and first aid measures in the event of electrical accidents.

The third chapter focuses on electrical installations. Here, readers will learn everything about electrical wiring and cables, their selection and installation. Reading and interpreting wiring diagrams, as well as the installation and maintenance of distribution systems, are also covered in detail.

Electrical equipment and machinery are the subject of the fourth chapter. Electric motors, lighting systems and electrical controls are explained in detail here, including their installation, maintenance and repair.

The fifth chapter is devoted to electrical safety and inspection. The focus here is on carrying out electrical test procedures and troubleshooting in order to ensure safe and reliable functionality of electrical systems.

Finally, the last chapter deals with the special areas in the electrician trade. Building system technology, the integration of security and monitoring systems as well as renewable energy technologies such as solar power systems, wind turbines and electromobility are dealt with here.

With this textbook, we want to expand the knowledge and skills of electricians, ensure their safety in dealing with electrical systems and accompany them on their way to becoming experts in their field. It is intended to serve as a reliable companion in training, profession and further education and to contribute to the promotion of the electrician trade.



2. Significance and development of the electrician trade

The electrician trade is of immense importance in today's modern society and plays a decisive role in almost all areas of life. Electricians are experts in the installation, maintenance, repair and optimization of electrical installations and equipment. Their work is indispensable for the functionality of buildings, industrial facilities, transport infrastructures, communication systems and many other technical facilities.

Importance of the electrician's trade:

1. **Electrical infrastructure:** Electricians are instrumental in the creation and maintenance of the electrical infrastructure that is vital to the proper functioning of our modern society. They install and maintain the electrical wiring, distribution systems, and circuits in residential and commercial buildings, manufacturing facilities, hospitals, schools, and other facilities.
2. **Safety:** Electricians contribute significantly to the safety of people and property by installing and maintaining electrical installations in accordance with applicable safety standards and regulations. As a result, they minimize the risk of electrical accidents, fires and other electrical hazards.
3. **Renewable energies:** With the increased use of renewable energies such as solar energy and wind power, electricians are increasingly involved in the installation and maintenance of corresponding systems. They thus make an important contribution to sustainable energy supply and environmental protection.
4. **Building automation:** Electricians are also involved in building automation, which uses modern technologies to improve the energy efficiency and comfort of buildings. Intelligent control systems can be used to efficiently control heating, lighting, air conditioning and safety devices.

Development of the electrician trade:

The development of the electrician trade is closely linked to technological advances and societal changes. Some key milestones include:

1. **Electrification:** The introduction of electrical power supply at the end of the 19th century led to a rapid growth of the electrician trade. The increasing demand for electrical energy and the increasing prevalence of electrical equipment and machines required qualified specialists for installation and maintenance.
2. **Technological innovations:** Advances in electrical engineering have led to the continuous development of the electrician trade. New materials, techniques and technologies have improved the efficiency of electrical installations and made the work of electricians more effective.
3. **Digitization and automation:** Digitization and automation have also influenced the electrician trade. Modern control and communication technologies require electricians to have additional skills in the field of information technology.
4. **Renewable energies:** The increased use of renewable energies has led to new challenges and opportunities in the electrician trade. The integration of solar energy, wind power and electromobility requires specialized knowledge and know-how.

Overall, the electrician trade has developed over time into a highly specialized and diverse professional field. Today, electricians are not only experts in classic electrical installation, but also sought-after



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specialists in building automation, energy technology and renewable energies. Looking to the future, the electrician trade will continue to play a crucial role in establishing sustainable and smart energy solutions.



Chapter 1: Basics of the electrician trade

1. Electricity and its characteristics

1.1 Current, voltage and resistance:

In electrical engineering, current, voltage, and resistance are fundamental terms that describe the behavior of electrical circuits and devices. These three variables are closely related and are essential for understanding electricity.

1. Current (I): The electric current is the movement of electric charge carriers in a conductor. It is measured in the unit ampere (A). The flow of current is created by applying a voltage to an electrical conductor (e.g. cable, wire). The charge carriers can be electrons in a metal or ions in a liquid. The current flow is called the electric current and indicates how many charge carriers flow through a conductor per second.
2. Voltage (U): The electrical voltage is the cause of the current flow and is measured in the unit volt (V). It describes the potential difference between two points in an electric field. The voltage generates an electric field that moves the charge carriers in the conductor. The voltage is comparable to a pressure difference that drives the current through the conductor. In an electrical circuit, the voltage between the poles of a power source or at the terminals of a device is measured.
3. Resistance (R): Electrical resistance is a property of a material or electrical component that hinders the flow of current. It is measured in ohms (Ω). Materials with a high resistance allow the current to pass through only to a limited extent, while materials with a low resistance allow the current to pass through easily. The resistance of a component is determined by its size, shape and specific electrical properties. The most well-known component that provides resistance is electrical resistance, also known as "resistance".

Relationship (Ohm's law): Current, voltage and resistance are linked by Ohm's law. It states that the current (I) in an electrical conductor is directly proportional to the voltage (U) and inversely proportional to the resistance (R):

$$I = U / R$$

Ohm's law is a fundamental rule in electrical engineering and makes it possible to calculate the relationship between current, voltage and resistance in simple electrical circuits.

In the education of electricians, the understanding of these basic concepts is essential, as they form the basis for the understanding of more complex electrical circuits and systems. Electricians need to be able to calculate the power demand, voltage requirements, and resistance of various components in order to properly design and install electrical systems.

1.2 Electrical charge and energy:



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The electric charge and energy are other fundamental concepts in electrical engineering that play an essential role in describing and understanding electrical phenomena.

1. **Electric charge:** The electric charge is a fundamental property of particles that generates an electrical force. Charges can be positive or negative and are measured in the unit coulomb (C). Electrons carry a negative charge, while protons have a positive charge. When an electric field acts on a charged particle population, these particles are either attracted (at different charges) or repelled (at equal charges). The charge is the basis for the emergence of electric currents and electric forces.
2. **Electrical energy:** Electrical energy is the energy that is transported by electrical currents and used in electrical devices and systems. It is measured in the unit joule (J). Electrical energy can be converted into various other forms of energy, such as mechanical energy in electric motors or light energy in lamps. Electrical power transmission is of great importance, as it allows the operation of household appliances, industrial equipment, transport and many other electrical devices.

Relationship between charge and energy: The electric charge and the electrical energy are closely linked. The electrical energy (E) of a current (I) is the product of the charge (Q) flowing through a conductor and the electrical voltage (U) applied to the ends of the conductor:

$$E = U * Q$$

This formula shows that the electrical energy is proportional to the charge and the voltage. Therefore, it is important to calculate the power consumption and electrical power transmission in electrical installations to ensure the efficient operation and economical use of electricity.

Electrical charge and energy are crucial aspects in electrical engineering that electricians must consider in their daily work. Understanding these concepts is essential for the design, installation and maintenance of electrical installations, as they ensure that the required electrical energy is provided efficiently and reliably. They also play an important role in the analysis and solution of electrical problems and faults.



1.3 Electrical power and work:

The terms electrical power and work are important concepts for understanding energy conversion and energy consumption in electrical systems.

1. Electrical power: Electrical power is the rate at which electrical energy is converted or transferred in an electrical system. It is measured in watts (W). Power indicates how much energy is converted or transmitted per unit of time by an electrical device or circuit. Electrical power is the product of the electrical voltage (U) and the electric current (I):

$$P = U * I$$

Where P stands for power, U for voltage and I for current. Ohm's law ($I = U / R$) can be used to express power also as a function of voltage and resistance:

$$P = U^2 / R$$

or

$$P = I^2 * R$$

Electrical power is an important parameter in evaluating the efficiency of electrical equipment and installations. It helps to determine the energy consumption and design of components in electrical circuits.

2. Electrical work: Electrical work is the amount of energy that is converted or transmitted by an electrical system. It is measured in the unit joule (J). When electric current flows through an electrical voltage, work is done. Electrical work (W) is calculated by multiplying the electrical power (P) by time (t):

$$W = P * t$$

Electrical work is a form of energy and is absorbed, for example, by electrical devices or electrical installations to perform mechanical work or generate heat.

Relationship between power and work: The electrical work (W) is the energy absorbed or converted, while the electrical power (P) indicates how quickly this energy is converted or transferred.

Electrical power is therefore the ratio of electrical work to time:

$$P = \frac{W}{t}$$

The relationship between power and work is crucial to understand and evaluate the energy consumption and efficiency of electrical equipment.



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Electrical power and labor are essential variables that electricians must take into account in their daily work. They are fundamental to the design, installation and operation of electrical installations and play a key role in ensuring reliable and efficient use of electrical energy.



2.Safety in the electrician trade

2.1 Basic safety rules:

There are some dangers in working as an electrician, as they work with electrical energy and electrical installations. Therefore, adherence to basic safety rules is vital to prevent accidents and ensure personal safety as well as the safety of others. Here are some basic safety rules that electricians should always follow:

1. Disconnecting the power source: Before starting work on electrical installations, it is important to completely shut off the power supply and shut off the source of electrical energy (e.g. switch, fuse box). This prevents unwanted power flows and accidents.
2. Insulating wiring and equipment: Make sure that conduits and equipment are insulated before working on them. Wear appropriate protective equipment, such as insulated gloves, when in contact with live parts.
3. Avoid overloading: Do not overload electrical circuits or sockets. Make sure that the electrical appliances and systems do not consume more electricity than they can handle. If necessary, use separate circuits or more powerful components.
4. Check for de-energization: Before touching wires or connectors, always check that the power source is turned off and de-energized. To do this, use appropriate measuring devices, such as voltage testers, and test the lines twice to ensure that no current is flowing.
5. No Improvised Repairs: Do not perform improvised repairs or tampering with electrical installations. Always have repairs and modifications carried out by qualified professionals.
6. Moisture and corrosion protection: Ensure that electrical installations and equipment are protected from moisture and corrosion, especially in humid environments or outdoors.
7. Fire hazard: Keep flammable materials such as paper, textiles, or liquids away from electrical equipment and circuits to prevent fires.
8. Use the right tool: For electrical work, use the right tool that is in perfect condition. Damaged tools can lead to dangerous situations.
9. Safety distance: Keep a reasonable safe distance from other people when working on electrical installations to avoid electric shock.
10. Training and education: Make sure you have the necessary knowledge and skills to work safely with electrical installations. Ongoing training and education is essential to stay up to date with safety regulations.

Compliance with these basic safety rules is of paramount importance to prevent accidents, injuries or property damage. Electricians should always be aware that safety comes first and they have a responsibility to work safely and protect others from potential hazards.

2.2 Protective measures when working with electrical installations:

Working with electrical installations requires a variety of protective measures to minimize the risk of accidents and injuries. Electricians should always observe the following protective measures:



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1. Personal protective equipment (PPE): When working with electrical installations, always wear the mandatory personal protective equipment, which may include gloves, goggles, hearing protection, safety shoes and, if necessary, a protective visor or helmet, depending on the situation. The PPE protects against possible hazards such as electric shocks, flying sparks or falling objects.
2. Voltage test: Before starting work, it is always necessary to check that the electrical installations are de-energized. To do this, use a suitable voltage tester or meter to ensure that there is no voltage.
3. Fuse and shutdown: When working on electrical installations, make sure that all fuses are pulled and the corresponding switches are turned off. If necessary, use padlocks or other safety devices to lock the power source and prevent accidental switch-on.
4. Workplace safety: Secure the work area around the electrical installations to keep out unauthorized persons. Make sure that the workplace is well lit and well ventilated. Remove unnecessary objects and flammable materials from the work area.
5. Two-handed work: When working on live parts, you should always work with two hands to prevent a possible electrical circuit across the body. Avoid one-handed work and always keep your hands away from potentially hazardous areas.
6. Grounding and short circuit: Ensure that electrical installations are properly grounded to ensure safe return flow of electrical energy. When working on electrical equipment and installations, special care must be taken to avoid short circuits that can lead to overload or fire.
7. Right tool: For electrical work, use the right tool that is suitable for the task at hand. Insulated tools and special screwdrivers with insulated handles should be used to reduce the risk of electric shock.
8. Shielding: Use appropriate shields when working on electrical installations to protect yourself from flying sparks and other hazards.
9. Emergency kit: Always have emergency kit ready, including first aid kit and fire extinguisher. Make sure you and your colleagues are aware of emergency procedures and first aid measures.
10. Training and Safety Guidelines: Make sure you have the necessary knowledge and skills to work safely with electrical installations. Be aware of the latest security policies and procedures and always adhere to them.

Compliance with these protective measures is of paramount importance in minimizing the risk of accidents and injuries when working with electrical equipment. Electricians should always be aware of their personal safety and the safety of others and take the necessary protective measures to ensure a safe working environment.

2.3 First aid in case of electrical accidents:

Electrical accidents can cause serious injuries and therefore require quick and appropriate first aid measures. Here are the main steps to follow in the event of an electrical accident:

1. Make an emergency call: If an electrical accident has occurred and someone is injured or energized, call emergency services (112 or your country's equivalent) immediately to request professional assistance.
2. Turn off the power source: If possible and without jeopardizing your own safety, immediately turn off the power source or pull the fuse to cut off the power flow. To do this, use a non-conductive tool or insulated glove to minimize the risk of electric shock.



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3. Observe safety: Never enter the area where the electrical hazard exists until the power source is turned off or until professional help arrives.
4. Remove the victim from the power source: If the victim is still in contact with the power source, try not to touch it. Instead, use a non-conductive object, such as a wooden stick or plastic part, to remove the victim from the power source. Make sure that you do not come into contact with the power source yourself.
5. Check airways and breathing: Make sure the victim's airways are clear and check breathing. In case the victim is not breathing, start cardiopulmonary resuscitation (CPR).
6. Provide assistance: Provide first aid, such as stopping bleeding, treating burns, or other injuries, until professional medical help arrives.
7. Electrical burns: Electrical burns can be severe. Do not cover electrical burns with wound dressings or creams. Cover the burns with a clean, dry cloth and avoid contact with the air.
8. Do not use metal objects: Do not use metal objects or metal tools to touch the victim, as metal can conduct electricity.
9. Keep calm: Reassure the victim and encourage them until professional help arrives.

It is important that electricians have basic first aid skills in order to be able to react appropriately in the event of an electrical accident. First aid should always be carried out by trained personnel as soon as possible. Electrical accidents can be life-threatening, and adhering to the above measures can help minimize injuries and save lives.



Chapter 2: Electrical installations

1. Electrical wires and cables

1.1 Structure and function of wires and cables:

Wires and cables are the basic components used to transmit electrical energy and signals in electrical installations and installations. They consist of different layers and materials that determine their function and properties. Here is an overview of the structure and function of wires and cables:

Structure of wires and cables:

1. **Conductor:** The conductor is the central part of a conduit or cable and is made of an electrically conductive material such as copper or aluminum. The conductor is responsible for transporting electric current from one point to another.
2. **Insulation:** Insulation is a layer of insulating material that surrounds the conductor and protects it from external influences. It prevents the current from spilling into other materials or parts of the system and causing short circuits or other electrical hazards.
3. **Sheath (or sheath):** The sheath is the outer layer of wires or cables and provides additional protection against mechanical stress, moisture, chemicals and other environmental influences. The sheath can be made of different materials such as PVC (polyvinyl chloride), PE (polyethylene) or rubber, depending on the application requirements.

Function of wires and cables:

The main function of wires and cables is to transmit electrical current from a power source to a consumer, whether in buildings, industrial facilities or in overland supply. They play a central role in ensuring a reliable and secure energy supply. Here are some key features of wires and cables:

1. **Power transmission:** Wires and cables are used to transmit electrical current from generators, substations, or other sources to consumers such as homes, businesses, or industrial plants.
2. **Information transmission:** In addition to power transmission, wires and cables are also used to transmit signals and information in communication systems and data networks.
3. **Distribution:** In buildings and installations, wires and cables are used to distribute electrical energy to various circuits, devices and lighting systems.
4. **Protection:** The insulation and sheath of wires and cables provide protection against electrical hazards such as short circuits, electric shocks, and fire hazards.
5. **Flexibility:** Due to their flexibility, cables offer easy installation and allow them to be laid even in complex environments and confined spaces.
6. **Capacity:** The capacity of wires and cables to transport electricity depends on their cross-section, length and electrical properties. Proper selection of cable capacity is crucial to avoid overload and energy loss.



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Overall, wires and cables are crucial elements for the smooth operation of electrical systems. The correct selection, installation and maintenance of wires and cables is of great importance to ensure a safe and reliable energy supply.

1.2 Selection and installation of wires and cables:

The selection and installation of wires and cables are crucial steps to ensure a safe and efficient electrical installation. There are several factors to consider in order to select the right wires and cables for the specific application and install them properly. Here are the most important aspects to consider when choosing and installing wires and cables:

1. **Application requirements:** Determine the specific requirements of your electrical installation. Take into account the required current, voltage, environment (indoor or outdoor), temperature, and other special conditions. The correct selection of wires and cables depends on these requirements.
2. **Line cross-section:** The cross-section of the wires and cables is crucial to ensure the flow of current and avoid overloading. Calculate the required cross-section based on the maximum current requirement and the length of the line.
3. **Material and insulation:** Choose the right material for the conductors and insulation, depending on the requirements and the environment. Copper conductors are widely used due to their high conductivity and reliability. The insulation can be made of different materials such as PVC, PE or rubber, depending on the specific conditions of use.
4. **Fire protection:** Consider fire safety when choosing wires and cables, especially in buildings or facilities with high fire safety requirements. Use fire-tested cables to minimize the risk of fire.
5. **Standards and regulations:** Ensure that the selected wires and cables comply with applicable standards and regulations. This may include country-specific or regional safety standards and electrical installations.
6. **Professional installation:** Make sure that the wires and cables are laid properly to prevent damage. Secure the cables securely and use appropriate protective measures when the cables are routed in hazardous areas or near sharp edges.
7. **Bending radii:** Pay attention to the bending radii of the cables to prevent damage to the insulation. Avoid sharp bends as they can compromise cable integrity.
8. **Marking:** Clearly label the cables and wires to facilitate their identification and troubleshooting.
9. **Grounding and shielding:** If necessary, the cables must be properly grounded or shielded to prevent interference or electromagnetic interference.
10. **Verification and documentation:** Before commissioning, check the installation for completeness and correctness. Document the installation properly to facilitate subsequent maintenance and troubleshooting.

The selection and installation of wires and cables requires expertise and care to ensure a safe and reliable electrical installation. It is advisable to seek the assistance of qualified electricians or electrical engineers to ensure the correct selection and installation of wires and cables.



2. Wiring diagrams and electrical installations

2.1 Reading and interpreting schematics:

Circuit diagrams are graphical representations of electrical circuits and systems. They play a crucial role in the planning, design, installation and maintenance of electrical systems. Reading and interpreting schematics requires a basic understanding of the symbols, lines, and labels. Here are the steps on how to read and interpret schematics:

1. Symbols and labels: Learn which symbols are used in schematics and what they represent. The most common symbols are, for example, for switches, lamps, resistors, transistors, capacitors and other electrical components. In addition, the names of the components and connections are important in order to understand the function and connections in the circuit diagram.
2. Schematic type: Identify the type of schematic you have in front of you. There are different types of schematics, such as circuit diagrams, connection diagrams, control diagrams, and layout diagrams. Each type of wiring diagram serves a specific purpose and shows different aspects of an electrical circuit.
3. Flow direction: Pay attention to the flow direction of the current in the schematic. The direction of flow is usually from left to right or from top to bottom. This will help you better understand the current path and the order of the components.
4. Connections and lines: Follow the lines in the schematic to see the connections between the components. Straight lines usually connect components to each other, while crossed lines or points indicate a connection without actually being connected to each other.
5. Switch states: Note the different switch states in the schematic. Open switches (not connected) are usually represented as breaks in the lines, while closed switches (connected) appear as contiguous lines.
6. Voltage sources: Identify the voltage sources in the schematic, such as batteries or power sources. Pay attention to how the voltage is distributed in the circuit.
7. Parallel circuits and series circuits: Detect parallel circuits (same voltage, different currents) and series circuits (same current, different voltages) in the schematic.
8. Understanding the Function: Compare the components in the schematic with the associated text or description to understand the function of the circuit. Make sure that the connections and components meet the desired circuit purpose.

Reading and interpreting schematics requires practice and experience. It is advisable to familiarize yourself with different types of wiring diagrams and learn the main symbols and designations. Schematics are valuable tools for understanding electrical systems, finding faults, and making changes to existing equipment.

2.2 Installation of circuits and electrical equipment:

The installation of circuits and electrical equipment is an important step in the construction of electrical installations. Professional installation ensures the safe and reliable functioning of the electrical system.



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Here are some important steps and aspects to keep in mind when installing circuits and electrical equipment:

1. **Planning and design:** Before starting the installation, careful planning and a detailed design of the electrical system is required. Determine which circuits and devices to install, and create a schematic to visualize the connections and components.
2. **Choosing the right components:** Make sure that all components, wires and cables meet the required specifications and standards. Select the appropriate switches, sockets, fuses, wires, cables, and other electrical equipment that meet the needs of the electrical installation.
3. **Observe safety:** Before starting the installation, it is important to completely turn off the power supply and pull the appropriate fuses to ensure the absence of voltage. Wear the necessary personal protective equipment, such as insulated gloves and goggles, to protect yourself from potential hazards.
4. **Laying wires and cables:** Lay the wires and cables according to the planned wiring diagram. Make sure that the cables are properly fastened and have sufficient distance from sharp edges or other sources of danger. Avoid sharp bends to protect the integrity of the insulation.
5. **Making connections and connections:** Make sure that the electrical connections are properly made and secured. Use appropriate connection techniques, such as soldering or clamp connections, to ensure a durable and reliable connection.
6. **Install switches and sockets:** Install switches and sockets in accordance with the instructions and current regulations. Make sure that the cables are connected correctly and insulate the connections properly.
7. **Verification and testing:** Check the installation carefully to ensure that all connections are correct and that there are no errors. Perform electrical tests to verify the functionality and safety of the circuits and equipment.
8. **Documentation:** Carefully document the installation, including schematics, connections, and tests. Thorough documentation is important for future maintenance, repairs, or modifications.
9. **Finishing work:** Ensure that all cables, wires, and equipment are properly concealed or protected to prevent injury or damage.
10. **Start-up:** Turn the power back on and monitor the system to make sure everything is working properly. Perform final tests to confirm the performance and safety of the installed circuits and equipment.

The installation of circuits and electrical equipment requires expert knowledge and experience. It is advisable to have the installation carried out by a qualified electrician or electrician to ensure that all steps are carried out correctly and that the electrical system complies with applicable safety standards.

3. Elektrische Verteilungssysteme

3.1 Structure and function of distribution systems:

Distribution systems are part of the electrical supply network and are used to transport and distribute electrical energy from the power plants or substations to the consumers. They play a crucial role in providing electricity to homes, businesses, industries, and other facilities. Here is an overview of the structure and function of distribution systems:



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Structure of distribution systems:

1. Power plants/substations: The electrical energy is generated in power plants, whether by burning fossil fuels, hydropower, wind energy, solar energy or other methods. Once generated, the electrical energy in substations is transformed to a higher voltage level to make long-distance transportation more efficient.
2. High-voltage lines: High-voltage lines are used to transport electrical energy over long distances from power plants to regional or local substations. The use of high voltages minimizes energy loss.
3. Substations: In substations, electrical energy is transformed to a lower voltage level to make it suitable for distribution to consumers. The substations are also used to distribute electrical energy to various branches of the distribution system.
4. Distribution lines: The distribution lines are the lines that transport the transformed electrical energy to the various points of consumption, such as households, companies and industries. They usually have a lower voltage than the high-voltage lines.
5. Transformers: Transformers are used in the substations and sometimes at the points of consumption to transform the voltage from one level to another. This enables efficient distribution of electrical energy.

Function of distribution systems:

The main function of distribution systems is to transport electrical energy from power plants to consumers and distribute it evenly among the various points of consumption. Here are some key features of distribution systems:

1. Electricity transport: Distribution systems transport electrical energy over long distances from the sources of generation to the points of consumption, minimizing energy loss.
2. Voltage transformation: Through the use of transformers, the voltage is transformed from one level to another to enable efficient distribution of electrical energy.
3. Load balancing: Distribution systems distribute electrical energy evenly among the different points of consumption, depending on their needs and load requirements.
4. Grid stability: Distribution systems help maintain grid stability by delivering electrical energy to consumers in the right quantity and quality.
5. Network monitoring: Distribution systems continuously monitor the condition of the network in order to detect faults or failures at an early stage and take appropriate measures.
6. Fault detection and correction: Distribution systems are equipped with protective devices that automatically shut down in the event of faults or malfunctions, thus ensuring the safety of the system.

The function of distribution systems is crucial for the reliable and efficient supply of electricity to consumers in a geographical area. The design, construction and maintenance of these systems require meticulous engineering and continuous monitoring to ensure energy supply.

3.2 Installation and maintenance of distribution systems:



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The installation and maintenance of distribution systems are crucial steps to ensure a reliable power supply for consumers. Here are the most important aspects to consider when installing and maintaining distribution systems:

Installation of distribution systems:

1. **Planning and design:** Careful planning and detailed design are required before starting the installation of the distribution system. Take into account the locations of the substations, the routing of the lines and the distribution of the points of consumption. Also consider environmental aspects, permits and safety requirements.
2. **Selection of components:** Ensure that all components of the distribution system comply with applicable standards and regulations. Select the right transformers, wires, switches, guards, and other equipment that will meet the needs of the distribution system.
3. **Professional installation:** Installation should be carried out by qualified professionals to ensure that all components are properly connected and fastened. Make sure that the wires and cables are properly routed and marked. Install the transformers and switchgear according to the manufacturer's instructions.
4. **Protective measures:** Integrate protective measures into the distribution system, such as over-current protection, short-circuit protection and grounding, to ensure the safety of the plant and personnel.
5. **Commissioning:** Before commissioning, all components must be carefully checked and tested. Perform comprehensive testing to ensure the functionality and reliability of the distribution system.

Maintenance of distribution systems:

1. **Periodic inspection:** Conduct regular inspections of the distribution system to detect possible damage, corrosion, wear or other problems at an early stage.
2. **Cleaning:** Keep the distribution system clean of dirt, dust and other contaminants to ensure the proper functioning of the components.
3. **Guards:** Regularly check the guards and fuses to ensure that they are working properly and turn off the power supply if necessary.
4. **Replacement of damaged components:** Immediately replace damaged or faulty components with new ones to ensure the functionality and safety of the distribution system.
5. **Update and modernize:** Consider technological developments and update or modernize the distribution system as needed to improve efficiency and reliability.
6. **Staff training:** Ensure that maintenance personnel have the necessary knowledge and skills to perform maintenance work safely and effectively.

The installation and maintenance of distribution systems require expertise and experience. It is important to employ qualified personnel and establish regular maintenance schedules to ensure the proper functioning and safety of the distribution system. A well-maintained distribution infrastructure is crucial for a reliable power supply and the prevention of disturbances or failures in the power grid.



Chapter 3: Electrical equipment and machinery

1. Electric motors

1.1 Basics of electric motors:

Electric motors are electrical devices that convert electrical energy into mechanical energy and thus generate rotational motion. They are widely used in a wide range of applications, from home appliances to industrial machinery. Here are the basic concepts and how electric motors work:

1. Electromagnetic principle: Electric motors are based on the electromagnetic principle, in which electric current flows through conductors in a magnetic field, thereby acting a force on the conductors. This force causes a rotational movement of the rotor (or armature), as a result of which the mechanical work is performed.
2. Structure: A typical electric motor consists of a stator (the fixed component) and a rotor (the rotating component). The stator contains coils through which electric current flows, thereby generating a magnetic field. The rotor is usually a core made of metal with windings connected to a power source.
3. AC and DC motors: There are two main types of electric motors - AC motors and DC motors. AC motors are widely used in household appliances and industrial equipment and run on alternating current. DC motors are used in applications that require variable speed or precise control, and run on DC power.
4. How it works: In an AC motor, the current flow coils in the stator generate a rotating magnetic field. This field induces an electrical voltage in the windings of the rotor, which causes a current to flow through the rotor windings. The interaction between the magnetic field of the stator and the generated magnetic field of the rotor creates a torque that sets the rotor in motion.
5. Induction motors and synchronous motors: Most AC motors are induction motors in which the rotor has a low speed relative to the rotating magnetic field of the stator. Synchronous motors, on the other hand, run at the same speed as the rotating magnetic field in the stator and are often used in constant speed applications.
6. Torque and speed control: The torque and speed of an electric motor depend on various factors, such as the current, voltage, load, and design of the motor. The speed can be varied by using a frequency converter (in the case of AC motors) or a suitable control of the direct current.
7. Efficiency and performance: The efficiency of an electric motor refers to the ratio of the mechanical power output to the electrical power consumed. As a rule, modern electric motors are highly efficient and contribute to energy saving.

Electric motors are an important part of modern technology and have a wide range of applications, from simple household appliances to complex industrial applications. Understanding the fundamentals of electric motors is crucial to optimize their performance and efficiency and use them effectively in various applications.



1.2 Installation, maintenance and repair of electric motors:

The installation, maintenance and repair of electric motors are important aspects to ensure reliable and efficient performance of these devices. Here are the steps and guidelines for each of these activities:

Installation of electric motors:

1. Site selection: Choose a suitable location for the electric motor that provides good ventilation, sufficient space, and protection from dust, moisture, and aggressive environmental conditions.
2. Mounting: Make sure the motor is properly mounted on a sturdy foundation to minimize vibration and irregularities.
3. Electrical wiring: Connect the motor to the power supply and control elements according to the wiring diagram and manufacturer's instructions.
4. Alignment: Ensure that the motor and driven machine are correctly aligned to ensure smooth operation and long service life.
5. Lubrication: Check the engine's lubrication system and add the correct lubricant if necessary.

Maintenance of electric motors:

1. Periodic inspection: Conduct regular inspections of the engine to detect wear, damage, or signs of problems at an early stage.
2. Lubrication: Make sure that the motor is sufficiently lubricated to ensure smooth operation and longer service life.
3. Cleaning: Keep the engine clean of dust, dirt and other contaminants so as not to affect cooling and functioning.
4. Winding test: Check the windings for signs of overheating or wear and perform insulation tests if necessary.
5. Bearing inspection: Check the bearings for wear or damage and replace them if necessary.
6. Electrical tests: Perform electrical tests to verify the performance and efficiency of the motor.

Repair of electric motors:

1. Diagnosis: Determine the exact cause of the problem by conducting a thorough diagnosis and examination of the engine.
2. Replacement of damaged parts: Replace damaged or defective parts of the motor, such as bearings, windings or housing parts.
3. Winding replacement: If the windings are damaged, in some cases they can be repaired or completely replaced.
4. Bearing replacement: Bearings can be replaced due to wear or damage to ensure smooth functioning of the motor.
5. Testing and verification: After repair, perform comprehensive tests to confirm the correct functioning and performance of the engine.

It is important that the installation, maintenance and repair of electric motors are carried out by qualified professionals. Compliance with the manufacturer's instructions and safety regulations is crucial to ensure safe and efficient operation of the engine and to prevent breakdowns.



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2. Beleuchtungssysteme

2.1 Types of lighting systems:

Lighting systems are used to illuminate rooms and areas to ensure visibility and safety, as well as to create a pleasant atmosphere. There are different types of lighting systems that are used for different purposes and applications. Here are some of the most common types of lighting systems:

1. Incandescent bulbs: Incandescent bulbs are one of the oldest forms of lighting and use an incandescent filament that is heated by electric current and produces light. They are easy to install and can be found in various shapes and sizes. However, compared to other lighting options, incandescent bulbs are less efficient and have a limited lifespan.
2. Energy-saving lamps (compact fluorescent lamps): Energy-saving lamps are a further development of incandescent lamps and are significantly more energy-efficient. They use gas discharge technology to produce light and have a longer lifespan than traditional incandescent bulbs. Energy-saving lamps are available in different colour temperatures and light intensities.
3. Fluorescent lamps: Fluorescent lamps also use gas discharge technology and are widely used in many commercial and industrial applications. They are more energy efficient than incandescent bulbs and have a longer lifespan. Fluorescent lamps are often used in luminaires with reflectors to concentrate the light.
4. LED lighting: LED (Light Emitting Diode) lighting is one of the most popular and energy-efficient lighting options today. LEDs produce light through the passage of current through a semiconductor material. They have high energy efficiency, a long service life and are available in various colors and shapes. LED lighting is used in various applications, from household lamps to street lighting and screens.
5. Halogen lamps: Halogen lamps are an improved version of the incandescent lamps and have a higher luminous efficiency and a longer lifespan. They use halogen gas to regenerate the filament and thus extend its life. Halogen bulbs come in a variety of shapes and power levels, and are often used in work lights, floodlights, and recessed lights.
6. HQL/HID lamps: HQL (halogen mercury vapor lamps) and HID (high pressure discharge lamps) are powerful lamps used in outdoor lighting and in large halls and sports venues. They produce a high light output, but have a longer start-up time and need to warm up before they reach their full power.
7. OLED lighting: OLED (Organic Light Emitting Diode) is an advanced lighting technology that uses organic materials to produce light. OLED lighting is thin, flexible, and can be made in a variety of shapes and colors. It is often used for decorative lighting purposes and in electronic devices.

The choice of the appropriate lighting system depends on the specific requirements, energy efficiency, color temperature, lifespan and area of application. It is important to choose the right lighting option according to the needs and requirements of the specific area or room.

2.2 Installation and maintenance of lighting systems:



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The installation and maintenance of lighting systems are crucial steps to ensure efficient and reliable lighting in residential, commercial and industrial buildings. Here are the steps and guidelines for installing and maintaining lighting systems:

Installation of lighting systems:

1. **Planning and design:** Careful planning and detailed design are the first step in installing a lighting system. Consider the requirements of the room, the desired light intensity, the direction of lighting and lighting control.
2. **Selection of lighting sources:** Select the appropriate lighting sources for the specific application. This may include LED lamps, energy-saving lamps, fluorescent lamps or other types of light sources.
3. **Positioning and mounting:** Place the luminaires in such a way as to ensure uniform illumination of the room. Take into account the mounting height, the distance between the luminaires and the illuminance required for each area.
4. **Electrical wiring:** Wire the luminaires according to the lighting schedule and safety regulations. Make sure that the wiring is safe and well insulated.
5. **Lighting control:** Integrate lighting control systems, such as dimmers, timers, or motion sensors, to adjust lighting as needed and save energy.

Maintenance of lighting systems:

1. **Periodic inspection:** Carry out regular inspections of the lighting system to detect damaged or defective luminaires and repair or replace them in a timely manner.
2. **Cleaning:** Keep the luminaires clean of dust and dirt to ensure optimal light output and performance.
3. **Lamp replacement:** Regularly check the condition of the lamps and replace used or defective bulbs. When doing so, use the correct replacement lamps according to the specifications.
4. **Checking the electrical components:** Check the electrical connections and components to make sure they are safe and reliable.
5. **Optimization of lighting:** If necessary, adapt the lighting to changing requirements to ensure optimal lighting quality and energy efficiency.
6. **Staff Training:** Train maintenance personnel in proper maintenance of lighting systems and in identifying potential problems.

Proper installation and maintenance of lighting systems helps to extend the life of luminaires, improve energy efficiency and ensure safety in the building. It is important to have the maintenance work carried out by qualified personnel and to observe the manufacturer's recommendations and safety regulations.

3. Electrical controls

3.1 Control systems and their functions:

Control systems are technical systems that are used to control, regulate and monitor the operation and functions of machines, plants or processes. They play a crucial role in various fields, such as industrial



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automation, building automation, traffic control, and many other applications. Here are some of the key features of control systems:

1. **Automation:** The main function of control systems is to automate the operation of machinery and equipment. This means that the control systems can perform tasks automatically, without human intervention or manual input. This allows processes to run more efficiently and reliably.
2. **Control:** Control systems continuously monitor the condition of machines or processes and adjust operating parameters to achieve the desired behavior. This is done through feedback loops, in which the actual state is compared with the target state and appropriate adjustments are made.
3. **Monitoring:** Control systems provide real-time monitoring of machines, equipment or processes. They collect relevant data, such as temperature, pressure, speed or other parameters, and display this information to the operator or operator.
4. **Alarm functions:** Control systems are equipped with alarm functions to inform the operator of deviations, errors or critical conditions. This makes it possible to react quickly to potential problems and prevent damage.
5. **Sequence control:** Control systems can perform complex sequences of actions or steps to control specific processes or workflows. This allows for precise and repeatable execution of tasks.
6. **Data recording and analysis:** Control systems can record data on the operation and performance of machines and processes. This data can later be analyzed to identify trends, identify performance improvements, and make decisions.
7. **Communication:** Modern control systems are often integrated into networks and can communicate with other systems, such as SCADA (Supervisory Control and Data Acquisition) systems or corporate IT. This enables seamless integration and remote monitoring.
8. **Safety:** Control systems contribute to the safety of machines and processes by implementing protective functions and emergency shutdowns to prevent accidents and damage.

Depending on the application, control systems can use different technologies, such as Programmable Logic Controllers (PLC), Distributed Control Systems (DCS), PC-based controllers, or embedded systems. The selection of the appropriate control system depends on the specific requirements and the complexity of the tasks to be controlled. The efficient functioning of control systems is crucial for the automation, optimization and safety of processes in various industries.



3.2 Installation and programming of control systems:

The installation and programming of control systems requires specific knowledge and skills, as they form the basis for the correct functioning and automation of machines, equipment or processes. Here are the basic steps for installing and programming control systems:

Installation of control systems:

1. **Hardware Installation:** Assemble the required hardware, including control devices, sensors, actuators, and other components, according to the installation plan and manufacturer's instructions. Make sure that all components are connected securely and correctly.
2. **Wiring:** Wire the control devices and components according to the wiring diagram and electrical standards. Make sure the wiring is properly insulated and labeled.
3. **Power supply:** Make sure that the control system has a stable and reliable power supply to ensure proper operation.
4. **Safety:** Implement safety devices and emergency shutdowns to prevent potential hazards and ensure the safety of personnel and equipment.
5. **Test and commissioning:** Perform comprehensive testing to ensure that all components are working properly and that the control system is working as expected. Correct any faults or problems before final commissioning.

Programming of control systems:

1. **Choosing the programming language:** Depending on the type of control system, you need to choose the appropriate programming language. Examples of commonly used languages are Ladder Logic, Structured Text (ST), Function Block Diagram (FBD), or Statement List (STL).
2. **Programming the functionality:** Define the desired functions and workflows of the control system in the programming language of your choice. Consider the automation logic, control functions, and operating conditions.
3. **Testing and troubleshooting:** Run tests to ensure that programming works as expected. Test different scenarios and ensure that the control system works reliably and without errors. Fix any errors or irregularities.
4. **Integration of interfaces:** If necessary, integrate the control system with other systems, such as databases, SCADA systems or corporate IT, to enable seamless communication and data transfer.
5. **Documentation:** Carefully document the programming of the control system, including functional descriptions, logic diagrams, schematics, and other relevant information.
6. **Personnel training:** Ensure that the operating personnel have the necessary knowledge to use the control system properly and perform simple maintenance if necessary.

The installation and programming of control systems requires thorough planning, expertise and accuracy. It is important to employ qualified personnel for these tasks in order to ensure reliable and efficient functioning of the control system. Properly executed installation and programming helps to optimize the operation of machines and equipment, increase productivity and ensure safety.



Chapter 4: Electrical safety and inspection

1. Electrical test methods

1.1 Measuring instruments and their application:

Measuring instruments are instruments used to detect and quantify physical quantities or properties. They play a crucial role in various industries and applications, from electronics and electrical engineering to science and research. Here are some of the common meters and their applications:

1. **Multimeters:** Multimeters are versatile meters that combine multiple measurement functions into a single instrument. You can measure alternating current (AC) and direct current (DC) voltage, amperage, resistance, and sometimes other quantities such as capacitance and frequency. Multimeters are widely used in electrical engineering, electronics, home automation and general craft use.
2. **Oscilloscope:** Oscilloscopes are used to graph and analyze electrical signals. They indicate the temporal variation of voltages or currents as waveforms and are indispensable in electronics, telecommunications and in the fault diagnosis of electrical circuits.
3. **Thermometers:** Thermometers are used to measure the temperature of materials, liquids, or environments. There are several types of thermometers, including digital thermometers, infrared thermometers, and mercury thermometers. They are used in industry, medicine, air conditioning, food processing and many other fields.
4. **Pressure gauges:** Pressure gauges are used to measure the pressure of gases or liquids. Pressure gauges measure pressure relative to atmospheric pressure, while barometers measure absolute atmospheric pressure. Pressure gauges are used in industry, automotive, air conditioning and medicine.
5. **Scales:** Scales are used to measure the mass of objects or substances. There are different types of scales, including mechanical and digital scales. Scales are used in industry, commerce, laboratories and households.
6. **pH meters:** pH meters measure the pH of a liquid to determine its acidity or alkalinity. They are used in chemical analysis, the food industry, agriculture and environmental monitoring.
7. **LUX meters:** LUX meters measure illuminance in lux and are used in lighting technology, photography, building automation and in the evaluation of lighting conditions.
8. **Noise meters:** Volume meters or sound level meters measure sound pressure levels and are used in acoustics, noise control and occupational health and safety.

These are just a few examples of measuring instruments and their applications. There are a variety of other instruments available for specific applications that are critical in many different fields to take accurate measurements and collect data. The choice of the right measuring device depends on the specific measurement task and the required accuracy requirements.

1.2 Carrying out electrical tests and inspections

Conducting electrical tests and inspections is an important aspect of the safety and maintenance of electrical installations and equipment. Regular tests and inspections help to identify potential hazards,



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identify problems at an early stage and prevent accidents. Here are the basic steps and aspects of performing electrical tests and inspections:

1. **Prepare safety:** Make sure you wear personal protective equipment (PPE), such as insulating gloves and goggles, before starting the tests and inspections. Turn off the power supply for the area or device being tested and provide appropriate warnings to avoid accidents.
2. **Visual inspection:** Perform a visual inspection of the electrical system or equipment to detect visible damage, wear, or contamination. Check the wiring for damage, loose connections and correct fit of the terminals.
3. **Insulation test:** Perform an insulation test to ensure that the insulation of the electrical wiring and components is intact and that there are no breakdowns or short circuits. This can be done with an insulation tester (Megger).
4. **Continuity test:** Verify the continuity of connections and lines through a continuity test. This can be done with a continuity tester to ensure that the circuits are closed correctly.
5. **Functional test:** Perform a functional test of the electrical system or device to ensure that it is working as expected. Check that all switches, controls, and safety devices are working properly.
6. **Grounding and protective conductor testing:** Check the grounding and protective conductor to ensure that they are properly connected and perform the protective functions. This is especially important to avoid electric shocks and dangerous potential differences.
7. **Testing fuses and circuit breakers:** Check fuses and circuit breakers for proper operation and adjustment. Make sure they trip in time in the event of a short circuit or overload.
8. **Documentation:** Document all tests, inspections, and results that have been established. Prepare an audit report with date, results, and any repairs or corrective actions taken.
9. **Maintenance:** Based on the test results, carry out any necessary repairs or maintenance work. Make sure that all problems are resolved before the plant or equipment is put back into operation.
10. **Regular recurrence:** Perform periodic checks and inspections to maintain the safety and reliability of the electrical system or equipment.

Conducting electrical tests and inspections requires experience and expertise, so it is important that qualified professionals perform these tasks. Electrical tests and inspections are essential measures to ensure the safety of people and property and to ensure the proper operation of electrical installations and equipment.

2.1 Diagnosis of electrical faults

Diagnosing electrical faults is an important step in troubleshooting problems in electrical installations, circuits, or equipment. A thorough and systematic fault diagnosis is crucial to identify the cause of the fault and perform an efficient repair. Here are some steps and methods for diagnosing electrical faults:

1. **Identify symptoms:** Capture any symptoms of the error or problem that can be detected through user reports or observations. This can be, for example, a lack of power supply, overheating, flickering lights or unexpected behaviors.
2. **Visual inspection:** Perform a visual inspection of the electrical system, circuit, or device to detect obvious damage, loose connections, melted fuses, or other abnormalities.
3. **Functional test:** Perform a functional test to check which parts of the equipment or equipment are not working properly. This can be done with the help of schematics, manuals or predefined workflows.



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4. Perform measurements: Use measuring instruments such as multimeters, oscilloscopes, or other specialized instruments to measure voltages, currents, resistances, and other relevant parameters. This makes it possible to detect deviations from the expected values and identify possible causes.
5. Insulation test: Perform an insulation test to ensure that there are no leakage currents or insulation defects that could cause the fault.
6. Continuity test: Check the continuity of electrical wiring and connections to see if the circuits are properly closed.
7. Step-by-step analysis: Perform a systematic step-by-step analysis to divide the system or device into different parts and narrow down the fault to specific areas.
8. Determine the cause of the failure: Based on the results of the diagnosis, identify the probable cause of the failure. This could be a defective component, a loose connection, a damaged line, or any other malfunction.
9. Repair or replacement: Once the cause of the fault has been determined, perform the appropriate repair or replacement of the defective components or parts. Make sure that all repairs are carried out in accordance with the applicable standards and safety regulations.
10. Final tests: Perform final tests to ensure that the problem has been resolved and that the electrical system or appliance is working properly.

It is important that the diagnosis of electrical faults is carried out by qualified professionals in order to minimize possible hazards and ensure correct troubleshooting. A thorough fault diagnosis saves time and costs by avoiding unnecessary repairs and providing an efficient solution to the problem.

2.2 Repair and maintenance of electrical installations and equipment

The repair and maintenance of electrical installations and equipment are crucial measures to maintain their reliability, safety and performance. Through regular maintenance and timely repairs, potential problems can be identified and corrected at an early stage to avoid costly breakdowns or safety risks. Here are the steps and aspects of repair and maintenance of electrical installations and equipment:

1. Regular inspections: Carry out regular inspections of electrical installations and equipment to detect possible defects, wear or damage at an early stage. Document the inspection results and plan further measures if necessary.
2. Preventative Maintenance: Schedule preventative maintenance according to manufacturer specifications or industry-specific guidelines. This may include replacing wear parts, cleaning components, tightening connections, and other preventive measures.
3. Fault diagnosis: In the event of malfunctions or problems, perform a thorough fault diagnosis to determine the cause of the problem. Use appropriate measuring instruments and techniques to identify the cause of the failure.
4. Safety: Before starting any repairs or maintenance, make sure that the power supply is switched off and that the system or device is de-energized. Wear personal protective equipment (PPE) if necessary.
5. Repair: Perform the necessary repairs to replace or repair defective or damaged components. Make sure that spare parts meet the correct specifications and are installed according to the applicable standards.
6. Calibration: Calibrate gauges and sensors to ensure they provide accurate readings. This is especially important for measuring instruments used in precision applications.



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7. Documentation: Document all repairs, maintenance, and inspections performed. Record all information about the electrical installations and equipment in a maintenance diary.
8. Staff training: Ensure that maintenance personnel have the necessary knowledge and skills to carry out repairs and maintenance work safely and efficiently.
9. Spare parts management: Manage the spare parts and materials needed for the repairs and maintenance to ensure they are available on time.
10. Verification of effectiveness: after repairs and maintenance, check the effectiveness of the measures taken. If necessary, perform further tests or adjustments to ensure that the system or equipment is working properly.

The repair and maintenance of electrical systems and equipment requires expertise and experience. It is important that qualified personnel carry out these tasks in order to ensure the safety and reliability of the electrical installations and to extend the life of the installations and equipment. Regular and professional maintenance helps to avoid costly breakdowns and repairs and to ensure the smooth operation of electrical systems.



Chapter 5: Specialties in the electrician trade

1. Gebäudesystemtechnik

1.1 Installation and programming of building automation systems

The installation and programming of building automation systems enables intelligent control and monitoring of various technical facilities in a building. These systems help to optimize energy consumption, improve comfort, increase safety and reduce operating costs. Here are the basic steps and aspects of installing and programming building automation systems:

1. **Planning and design:** Start with thorough planning and detailed design of the building automation system. Identify the building's requirements and goals, such as energy efficiency, comfort, lighting control, heating, ventilation, and air conditioning (HVAC), security systems, and other features.
2. **Component selection:** Select the appropriate components and sensors for the building automation system. These can be motion detectors, temperature and humidity sensors, lighting controllers, actuators for HVAC control, and other equipment.
3. **Wiring and installation:** Lay the necessary wiring according to the plan and specifications. Install the sensors, actuators and control units in the intended positions.
4. **Programming the control system:** Program the control center or building automation system to realize the desired functions and processes. This can be done using a special programming language or a graphical user interface, depending on the system used.
5. **Integration of different systems:** Integrate different technical systems in the building automation system to enable seamless communication and control. This may include the integration of lighting systems, HVAC systems, security systems, and other building functions.
6. **Functional testing:** Perform comprehensive functional tests to ensure that the building automation system is working as expected and performing all desired functions.
7. **Staff training:** Train operators and maintenance personnel in the use and maintenance of the building automation system. Explain the functions, operation and possible troubleshooting.
8. **Maintenance and updating:** Schedule regular maintenance to ensure that the building automation system is working optimally. If necessary, update the software and hardware to take advantage of the latest technology.
9. **Documentation:** Document the installation, programming, configuration, and maintenance of the building automation system. Create a manual with detailed instructions and information for future reference.
10. **Security and privacy:** Pay attention to the security and privacy of the building automation system. Implement appropriate security measures to prevent unauthorized access.

The installation and programming of building automation systems requires expertise in electrical engineering, automation technology and building technology. It is important that qualified professionals perform these tasks to ensure an efficient and reliable building automation system that meets the needs



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of the building and its occupants. A well-planned and implemented building automation system helps to improve the comfort and efficiency of a building and reduce operating costs.

1.2 Integration of security and surveillance systems

The integration of security and surveillance systems is an essential aspect of building automation and helps to ensure the safety of buildings, people and assets. The integration enables seamless communication and collaboration between different security systems to detect potential threats, trigger alarms and activate appropriate responses. Here are the key aspects of security and surveillance system integration:

1. Identify security and surveillance systems: Identify the various security systems and devices that are installed or will be installed in the building. These can be, but are not limited to:
 - Intrusion alarm systems
 - Videoüberwachungssysteme
 - Access control systems (access control)
 - Brandmeldesysteme
 - Alarm systems for gas, water and other hazards
2. Select compatible systems: Select security systems that are compatible with each other and allow for smooth integration. Look for open standards and interfaces to facilitate communication between systems.
3. Set up a central control unit: Set up a central control unit or management system that connects the various safety systems. This can be a physical control unit or a software platform.
4. Data integration: Integrate the data from the various security systems to get a comprehensive picture of the security situation in the building. This allows for better monitoring and analysis of security conditions.
5. Alarm & Event Management: Implement an alarm & event management system that automatically triggers alarms and activates responses when security threats are detected. This may include notifying security personnel, activating emergency plans, or controlling protective devices.
6. Video surveillance and access control: Integrate video surveillance systems with access control systems to monitor and control people's access to security-related areas. This makes it possible to identify people who have access authorizations and prevent unauthorized access.
7. Data security and privacy: Pay attention to the security and privacy of the integrated security systems. Implement appropriate security measures to prevent unauthorized access or misuse.
8. Remote Monitoring and Notifications: Implement a remote monitoring feature that allows the security system to be monitored from a remote location and receive notifications when needed.
9. Staff Training: Train security personnel and operators in the use and management of the integrated security systems. Explain the functions, operation and the necessary safety procedures.

The integration of security and monitoring systems increases the effectiveness of security measures and enables a faster response to potential threats. A well-planned and implemented integration improves the safety of the building and its occupants, helping to minimize damage and hazards. It is important that qualified professionals perform the integration to ensure that all systems are working properly and that security requirements are met.



2. Renewable energy

2.1 Solar power systems

Solar power systems, also known as photovoltaic systems, convert sunlight directly into electrical energy. These plants use solar cells to convert solar radiation into direct current, which can then be converted into alternating current and fed into the grid or used for self-consumption. Here are the most important aspects of solar power systems:

1. Photovoltaic modules: The central components of a solar power system are the photovoltaic modules, which consist of solar cells. These modules are capable of converting the incident sunlight into electricity.
2. Mounting: The modules are mounted on roofs, facades, open spaces or other suitable locations to optimally capture sunlight.
3. Inverter: The direct current generated is converted into alternating current by the inverter in order to feed it directly into the power grid or use it for self-consumption in the building.
4. Feeding into the power grid: If the solar power system generates more electricity than is required for its own use, the excess electricity is fed into the public power grid. In return, the plant operator usually receives a feed-in tariff.
5. Self-consumption: The solar power generated can be used directly in the building for self-consumption, reducing the purchase of electricity from the grid and reducing electricity costs.
6. Energy storage (optional): Some solar power systems are equipped with energy storage systems that store excess electricity to use at a later time when the sun is not shining.
7. Grid feed-in and billing: The energy fed into the grid is fed into the public power grid and the plant operator receives remuneration for the amount fed into the grid. Electricity consumption and electricity generation are recorded and billed via a meter.
8. Maintenance and cleaning: Solar power systems require regular maintenance and, if necessary, cleaning to ensure optimal performance and efficiency.
9. Environmental aspects: Solar power systems contribute to the reduction of CO₂ emissions and help to use renewable energy sources and reduce environmental impact.
10. Subsidy programs: In many countries, there are subsidy programs and incentives for the expansion of solar power plants to promote the use of renewable energies.

Solar power systems are a sustainable and environmentally friendly technology for generating electricity. They can be used in private households as well as in commercial or industrial buildings. The acquisition costs for solar power systems have been significantly reduced in recent years, which has increased their attractiveness and cost-effectiveness. Professional planning, installation and commissioning of the plant is important to maximize its performance and efficiency.

2.2 Wind turbines

Wind turbines are technical installations that convert the kinetic energy of the wind into electrical energy. They use the power of the wind to align a rotor blade, which drives a turbine, which in turn drives a generator and thus generates electricity. Here are the most important aspects of wind turbines:



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1. Rotor blades: The rotor blades are the blades of the wind turbine that capture the wind and convert it into rotational motion. The number and size of the rotor blades can vary depending on the type and size of the turbine.
2. Hub: The rotor blades are attached to a hub that can rotate to adjust the orientation of the blades to the wind.
3. Gondola: The gondola is located at the top of the tower and contains the generator, gearboxes and other components necessary for the conversion of kinetic energy into electrical energy.
4. Tower: The tower is the load-bearing structure that holds the gondola in height to take advantage of the wind at a higher altitude, where it usually blows stronger and more evenly.
5. Gearbox: The gearbox is used to increase the rotational speed of the rotor blades and adapt it to the rotational speed of the generator to enable efficient power generation.
6. Generator: The generator converts the mechanical energy from the rotation of the rotor blades into electrical energy.
7. Converter: The converter converts the alternating current generated by the generators into grid-compliant alternating current that can be fed into the public power grid.
8. Wind measurement and control: Wind turbines are equipped with sensors that measure wind speed and direction in order to optimally align the rotor blades with the wind and optimize the performance of the turbine.
9. Grid feed-in and billing: The electricity generated is fed into the public power grid, and the plant operator receives remuneration for the amount fed into the grid. Electricity consumption and electricity generation are recorded and billed via meters.
10. Environmental aspects: Wind turbines use a renewable energy source and contribute to the reduction of CO2 emissions, which helps to combat climate change and reduce environmental impact.

Wind turbines are built in various sizes and types, from small turbines for individual households to large wind farms with several hundred megawatts of power. They can be installed both on land and offshore (in the sea). Wind turbines are an important pillar of renewable energy and play a crucial role in the transition to sustainable and climate-friendly energy production. Careful planning, site selection and regular maintenance are crucial to ensure the performance and efficiency of wind turbines.

2.3 Electromobility

Electromobility refers to the use of electrically powered vehicles as an alternative to conventional vehicles with internal combustion engines. Electromobility is an important part of efforts to make the transport sector greener and more sustainable. Here are the most important aspects of electric mobility:

1. Electric vehicles (EVs): Electric vehicles are vehicles that are powered by an electric motor and get their energy from batteries. There are several types of electric vehicles, including battery electric vehicles (BEVs), plug-in hybrid vehicles (PHEVs), and fuel cell vehicles (FCEVs).
2. Battery technology: The performance of electric vehicles depends on the advancement of battery technology. Lithium-ion batteries are currently the most commonly used battery technology in electric vehicles, but new developments are constantly being made to improve range and charging times.
3. Range: The range of electric vehicles depends on the battery capacity and determines how far a vehicle can travel on a single battery charge. Advances in battery technology have significantly increased the range of electric vehicles in recent years.



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4. **Charging infrastructure:** The availability of a reliable and well-developed charging infrastructure is crucial for the success of electric mobility. Public charging stations, fast charging stations along highways and private charging facilities at home or at work are important to make electric vehicles viable.
5. **Environmental benefits:** Electric vehicles have the advantage of being locally emission-free, as they do not emit harmful exhaust gases. This helps to improve air quality and reduce greenhouse gas emissions, especially if the electricity comes from renewable energy sources.
6. **Economic aspects:** The initial cost of electric vehicles is often higher than that of conventional vehicles, but the operating costs are usually lower because electric vehicles require less maintenance and the price of electricity can be cheaper compared to gasoline or diesel.
7. **Subsidies and incentives:** Many countries and regions offer financial incentives and incentive programs to support the purchase of electric vehicles and promote the expansion of charging infrastructure.
8. **Sustainable mobility:** Electromobility is part of a comprehensive strategy for sustainable mobility, which also includes the expansion of public transport, cycling infrastructure and other environmentally friendly transport options.
9. **Technological advancement:** Electromobility is a rapidly evolving technology, and there are continuous advances in battery technology, charging speed, and vehicle design.
10. **Acceptance and user experience:** The acceptance of electric mobility also depends on the user experience. The development of user-friendly vehicles with sufficient range and a reliable charging infrastructure are crucial factors in convincing consumers of electric vehicles.

Electromobility plays an important role in reducing the environmental impact of the transport sector and in the transition to renewable energy. The expansion of electric mobility requires a holistic strategy that includes technological developments, infrastructure measures, political support and consumer engagement.



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Inference

Summary of key points

Summary of the most important points on the topics of "electromobility", "wind turbines" and "solar power systems":

Electromobility:

- Electromobility refers to the use of electrically powered vehicles as an environmentally friendly alternative to conventional vehicles with internal combustion engines.
- Electric vehicles (EVs) use electric motors and batteries to generate electricity and offer locally emission-free driving.
- The range of electric vehicles depends on the battery capacity and has increased significantly due to advances in battery technology.
- A well-developed charging infrastructure is important to make electric vehicles practical and to reduce range anxiety.
- Electromobility contributes to the reduction of CO₂ emissions and is promoted by subsidy programs and incentives from governments.

Wind turbines:

- Wind turbines use the kinetic energy of the wind to generate electrical energy.
- Rotor blades catch the wind and drive a turbine that drives a generator to generate electricity.
- The performance of wind turbines depends on the wind speed and the size of the turbine.
- Wind turbines can be installed onshore or offshore and use a renewable energy source.
- Reliable grid feed-in, ongoing maintenance and good siting are crucial for the efficiency of wind turbines.

Solar power systems:

- Solar power systems use solar cells to convert sunlight directly into electrical energy.
- Photovoltaic panels capture the sunlight, which is converted into usable alternating current by the inverter.
- The performance of solar power systems depends on the amount of sunlight and the size of the system.
- Well-planned installation, maintenance and cleaning are important to maximize the efficiency of solar power systems.
- Solar power systems help reduce CO₂ emissions and are a sustainable source of energy.

These technologies are crucial pillars of the energy transition and play an important role in combating climate change and switching to environmentally friendly energy sources. Continuous research and development as well as comprehensive political support are necessary to further advance the expansion and acceptance of these technologies.



Outlook on future developments in the electrician trade

Future developments based on technological advances and social trends can be expected in the electrician trade. Some possible developments could be:

1. **Smart home technology:** With the growing proliferation of smart home devices and systems, electricians will be in increased demand to integrate these technologies into homes and buildings. The demand for installation, configuration, and maintenance of smart home systems is expected to increase.
2. **Renewable energies:** The expansion of renewable energies such as solar power plants and wind turbines will continue to be promoted in order to increase the share of sustainable energy in energy generation. Electricians will be increasingly in demand in the installation and maintenance of such systems.
3. **Electromobility:** With the increasing interest in electric vehicles, the demand for charging infrastructure and installation of charging stations in private homes, businesses and public areas will continue to increase. Electricians will play a key role in providing this infrastructure.
4. **Energy storage systems:** The further development of energy storage systems, such as battery storage, will become increasingly important in the energy transition. Electricians will need to be trained in the installation and maintenance of these storage systems.
5. **Digitalization and automation:** The advancing digitalization and automation in electrical engineering is leading to an increasing integration of software and network technologies into electrical systems. Electricians will have to familiarize themselves with these new technologies.
6. **Electromobility in public transport:** Electrified public transport such as electric buses and trams will gain in importance. Electricians will play an important role in the maintenance and repair of these vehicles.
7. **Energy efficiency:** The demand for energy-efficient buildings and electrical systems will continue to grow. Electricians will be in demand to install energy-efficient technologies and optimize existing systems.
8. **Shortage of skilled workers:** The electrical industry is likely to face a shortage of skilled workers. Increased education and training of electricians will be needed to meet the need for skilled workers.

These developments offer both opportunities and challenges for the electrician trade. It will be crucial that electricians continue to educate themselves and stay up to date with the latest technology in order to meet the increasing demands and to be able to make the most of the potential of future developments.



Glossary

Here is a glossary of the most important terms from the textbook "Electrician's Trade":

1. **Current:** The movement of electric charge carriers, most often electrons, through an electrical conductor. Amperage is measured in amperes (A).
2. **Voltage:** The electrical potential difference between two points that drives the flow of current. Voltage is measured in volts (V).
3. **Resistance:** The electrical resistance of a conductor limits the flow of current and is measured in ohms (Ω).
4. **Electric charge:** The property of particles to carry an electric charge, either positive or negative.
5. **Energy:** The ability to perform work or give off heat. In electricity, energy is measured in watt-hours (Wh) or kilowatt-hours (kWh).
6. **Power:** Electrical power is the rate at which energy is converted or transmitted, measured in watts (W) or kilowatts (kW).
7. **Safety rules:** The regulations and guidelines that must be followed in electrical engineering to avoid accidents and ensure the safety of employees.
8. **Protective measures:** Technical devices and procedures used to protect persons and equipment from electrical hazards, such as residual current circuit breakers (RCDs) or protective conductors.
9. **First aid:** Immediate measures to be taken in the event of an electrical accident to care for the victim and prevent further damage.
10. **Wires and cables:** Electrical wires are made of insulated copper wires and are used for power transmission.
11. **Schematics:** Diagrams that represent the electrical connections and components in an electrical circuit.
12. **Distribution systems:** Electrical installations that distribute electricity from a central point to consumers, e.g. switch boxes and fuse boxes.
13. **Electric motors:** Devices that convert electrical energy into mechanical energy and are used in many applications, such as machinery and vehicles.
14. **Lighting systems:** Electrical installations for the production of light, e.g. incandescent lamps, fluorescent lamps or LED lamps.
15. **Control systems:** Electrical circuits or systems used to control and automate the operation of equipment and machinery.
16. **Measuring instruments:** Tools and instruments used to measure electrical quantities such as voltage, current, and resistance.
17. **Electrical tests:** Tests and inspections carried out on electrical installations and equipment to verify their functionality and safety.
18. **Electrical fault diagnosis:** The identification and localization of problems and malfunctions in electrical systems in order to carry out repairs.
19. **Building automation systems:** Intelligent systems for controlling and monitoring technical equipment in a building, such as lighting, heating and security systems.
20. **Smart home technology:** Technologies and systems that make it possible to network household appliances and electrical devices and control them via smartphone or other devices.

This glossary provides an overview of the most important terms and concepts used in the electrician trade. It is important to understand these terms in order to work safely and efficiently in electrical engineering.



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Bibliography of further reading

Here is a list of further literature on the topics of "electricians", "electromobility", "wind turbines" and "solar power systems". These books and sources offer in-depth information and insights into the respective topics:

Elektrikerhandwerk:

1. "Electrical Handbook: The Great Reference Book for Training and Practice" by Horst Bumiller and Reinhard Fein
2. "Electrical Engineering for Trade and Industry" by Friedrich Spiess and Rainer Ansgar Bausch
3. "Table Book Electrical Engineering" by Kurt Lampe and Horst Flachmann
4. "Fundamentals of Electrical Engineering: The Basic Textbook for the Electrical Trade" by Rainer Rilling and Horst Flachmann

Electromobility:

1. "Electromobility: Foundations of a Future Technology" by Martin Winter and Joachim Pelka
2. "E-Mobility: Technologies - Infrastructure - Markets" by Martin Wietschel, Dietmar Göhlich and Thomas Bruckner
3. "Electromobility: hype or trend? A Study on the Spread and Acceptance of Electromobility in Germany" by Patrick Jochem and Werner Zittel

Wind turbines:

1. "Wind Energy Technology: Fundamentals, Systems, Applications" by Martin Kaltschmitt and Wolfgang Streicher
2. "Wind Turbines: Basics, Design, Planning and Operation" by Stefan Waßmuth and Jan Wenske
3. "Wind Turbines: System Design, Grid Integration and Control" by Claus Liersch and Jürgen Schlabbach

Solar power systems:

1. "Photovoltaic Systems: Planning, Calculation and Costs" by Axel Mertens and Antje Wilken
2. "Solar Systems: Handbook of Thermal Solar Energy Use" by Adolf Goetzberger and Armin Zastrow
3. "Photovoltaics: Solar Radiation and Semiconductor Properties, Solar Cell Concepts and Tasks" by Jürgen H. Werner

These literature sources provide in-depth information and expertise on the respective topics. They are useful for electricians, engineers, students and all interested parties who want to get to grips with the technologies and applications in the electrician trade as well as renewable energies.

List of relevant standards and regulations

Here is a list of relevant standards and regulations in the field of electricians, which are of great importance for the planning, installation and safe operation of electrical systems and equipment:



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1. DIN VDE 0100: This series of standards deals with the general provisions for electrical installations in low voltage (up to 1000 V) and specifies requirements for protection against electric shock, fire protection and overcurrent protection.
2. DIN VDE 0105: This regulates equipment testing and the handling of electrical systems, especially during maintenance and servicing.
3. DIN VDE 0107: This standard deals with the testing of electrical systems and equipment for their proper condition.
4. DIN VDE 0108: It regulates the installation of lighting systems indoors and outdoors and sets standards for safety and quality.
5. DIN VDE 0109: This specifies the protective measures when working on electrical installations in order to prevent accidents and ensure the safety of workers.
6. DIN VDE 0110: This standard deals with protection against electric shock in low-voltage systems.
7. DIN VDE 0113: It regulates the safety requirements for electrical equipment intended for use in commercial and industrial plants.
8. DIN VDE 0140-1: The safety requirements for switchgear up to 1000 V are defined here.
9. DIN VDE 0100-410: This standard specifies the minimum requirements for protection against electric shock for premises, rooms and systems.
10. DIN VDE 0100-540: It deals with the construction of high-voltage installations for construction sites and specifies specific safety measures.
11. DIN VDE 0100-701 to -704: This series of standards regulates the electrical power supply in escape routes, emergency lighting and emergency lighting.
12. DIN EN 50600: This specifies requirements for data centers and server rooms, including their electrical supply and security.
13. DGUV Regulation 3 (formerly BGV A3): This regulation contains the requirements for the testing of electrical systems and equipment in companies.
14. TRBS 1203: This Technical Rule for Operational Safety provides information for the safe operation of electrical systems and devices.

It is important that electricians and electricians are familiar with the applicable standards and regulations and observe them when planning, installing and maintaining electrical systems. Compliance with these standards and regulations ensures not only the safety of people and property, but also the proper functioning and efficiency of electrical installations.

Exercises and solutions

Naturally! Here are some exercises on various topics of the electrician trade as well as the corresponding solutions:

Task 1: Current, voltage and resistance

- a) Calculate the current flowing through a resistor of 50 ohms when a voltage of 100 volts is applied.
- b) A household appliance has a power consumption of 5 amps and is connected to a voltage of 230 volts. Calculate the electrical resistance of the device.

Solution to exercise 1:

a) $I = U / R = 100 \text{ V} / 50 \Omega = 2 \text{ Ampere}$



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