
**DRAFT NATIONAL OCCUPATIONAL STANDARD FOR
ELECTRICAL AND ELECTRONICS ENGINEER**

*Disclaimer: this document is for Sector Review and Commenting **only**.
It should **not** be used, or referred to, as a National Occupational
Standard*

APPROVING AUTHORITY

This National Occupational Standard has been prepared and published under the authority of the Zambia Qualifications Authority Board on [insert date when NOS was approved by the ZAQA Board].

ZAMBIA QUALIFICATIONS AUTHORITY

The Zambia Qualifications Authority Act No. 13 of 2011 was enacted by the Government of the Republic of Zambia to ***“provide for the development and implementation of a national qualifications framework; establish the Zambia Qualifications Authority; provide measures to ensure that standards and registered qualifications are internationally comparable; and provide for matters connected with, or incidental to the foregoing”***. Among other functions, ZAQA is responsible for ***determining national standards for any occupation***, through various sector specific National Occupational Standards Development Teams (NOSDTs).

REVISION OF NATIONAL OCCUPATIONAL STANDARDS

National Occupational Standards shall be revised every after **5 years**, or whenever necessary, by the issue of either amendments or of revised editions. It is important that users of National Occupational Standards (NOS) should ascertain that they are in possession of the latest amendments or editions.

NOS DEVELOPMENT TEAM RESPONSIBLE

This National Occupational Standard was prepared by the Manufacturing National Occupational Standards Development Team, upon which the following organisations were represented:

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2. Copperbelt University
3. Evelyn Hone College
4. Lafarge Cement (Z) Plc
5. Lusaka Business and Technical College
6. Trade Kings Group
7. University of Zambia
8. Zambia Association of Manufacturers
9. Zambian Breweries Plc
10. Zambia Bureau of Standards
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ACKNOWLEDGEMENT

The Zambia Qualifications Authority would like to acknowledge the invaluable support of the following stakeholders that participated in the development of this National Occupational Standard:

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DRAFT FOR SECTOR REVIEW AND COMMENTING

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FOREWORD

The Zambia Qualifications Authority (ZAQA) is a statutory body under the Ministry of Higher Education established by ZAQA Act No. 13 of 2011 to “**provide for the development and implementation of a national qualifications framework; provide measures to ensure that standards and registered qualifications are internationally comparable; and provide for matters connected with, or incidental to the foregoing**”.

Among other functions, ZAQA is responsible for “**determining national standards for any occupation**”, through various sector specific National Occupational Standards Development Teams (NOSDTs) of experts composed of representation from appropriate authorities, government departments, industry, academia, regulators, consumer associations and non-governmental organisations, etc.

This National Occupational Standard (NOS) has been developed by the Manufacturing National Occupational Standards Development Team in accordance with the procedures and guidelines of ZAQA. All users should ensure that they have the latest edition of this publication as National Occupational Standards are revised from time to time.

This NOS shall be used by, among others, industry, employers, quality assurance bodies, awarding and professional bodies and education and training institutions, as a benchmark to identify training needs, develop job profiles/descriptions, develop curricula and learning programmes, in various sectors where the occupation exists. In the Manufacturing sector, demonstration of competence against this NOS may be required in order to run a business or practice a craft or profession.

JUSTIFICATION

Electrical and Electronics Engineers play a vital role in the manufacturing sector. Every modern manufacturing industry uses electrical energy as the main energy source due to its portability, convenience, flexibility and cleanliness. As a consequence of its flexibility, electrical energy allows for ease of automation and control of manufacturing processes. To effectively utilise the electrical energy different components and systems need to be in place. These include: power equipment such as transformers, conductors, motors, variable speed drives and switchgear; control and instrumentation equipment such as sensors, actuators and programmable logic controllers (PLCs); communication equipment such as radios, modems, switching equipment, telephones and supervisory control and data acquisition (SCADA) systems.

Therefore, Electrical and Electronics Engineers are required in the manufacturing industry to design, maintain and repair among other things the equipment and systems required for the distribution of electrical energy, control of processes, protection of processes and equipment, and communication between different parts of the plant or system. Electrical and Electronics Engineers plan and implement strategies on the efficient use of electrical energy and ensure that they comply with national and international power quality standards.

Without Electrical and Electronics Engineers in the manufacturing sector, there will be no qualified personnel to design, maintain and repair the complex electrical and electronic systems used in various manufacturing processes. The sector would run very inefficiently because they would have to depend on less efficient energy sources than electrical energy. In addition, automation, control and communication would not be achieved easily without electrical energy.

This National Occupational Standard highlights core knowledge, skills, competences and personal attributes that Electrical and Electronics Engineers must possess to be successful in their jobs.

DRAFT FOR SECTOR REVIEW AND COMMENTING

ACRONYMS AND ABBREVIATIONS

CS	Core Skill
DNOS	Draft National Occupational Standard
EEE	Electrical and Electronics Engineer
EIZ	Engineering Institution of Zambia
EngRB	Engineering Registration Board
NOS	National Occupational Standard
NOSDT	National Occupational Standards Development Team
OK	Organisational Knowledge
PC	Performance Criteria
PLC	Programmable Logic Controller
PS	Professional Skill
RK	Regulatory Knowledge
RPL	Recognition of Prior Learning
SCADA	Supervisory Control and Data Acquisition
TK	Technical Knowledge
ZAQA	Zambia Qualifications Authority
ZQF	Zambia Qualifications Framework

GLOSSARY OF TERMS

For the purposes of this NOS, the following terms and definitions shall apply:

Core Skills/Generic Skills: are a group of skills that are key to learning and working in today's world. These skills are typically needed in any work environment. In the context of the NOS, these include communication related skills that are applicable to most job roles.

Function: is an activity necessary for achieving the key purpose of the sector, occupation, or area of work, which can be carried out by a person or a group of persons. Functions are identified through functional analysis and form the basis of NOS.

Job Title: defines a unique set of functions that together form a unique employment opportunity in an organisation.

Knowledge and Understanding: are statements which together specify the technical, generic, professional and organisational specific knowledge that an individual needs in order to perform to the required standard.

National Occupational Standards (NOS): are statements of the standards of performance individuals must achieve when carrying out functions in the workplace, together with specifications of the underpinning knowledge and understanding. They are precise descriptions of what an individual is expected to be able to do in his/her work role.

National Occupational Standards (NOS) Code: is a unique reference code that identifies a NOS.

National Occupational Standards Development Team (NOSDT): means an established group of national stakeholders/experts responsible for the development of National Occupational Standards within a specific economic sector or occupation.

Occupation: is a set of job roles, which perform similar/related set of functions in an industry.

Organisational Context: includes the way the organisation is structured and how it operates, including the extent of operative knowledge that managers have in their relevant areas of responsibility.

Performance Criteria: are statements that together specify the standard of performance required when carrying out a task.

Scope: is the set of statements specifying the range of variables that an individual may have to deal with in carrying out the function which have a critical impact on the quality of performance required.

Sector: is a conglomeration of different business operations having similar businesses and interests. It may also be defined as a distinct subset of the economy whose components share similar characteristics and interests.

Sub Sector: is derived from a further breakdown based on the characteristics and interests of its components.

Technical Knowledge: is the specific knowledge needed to accomplish specific designated responsibilities.

Unit Title: gives a clear overall statement about what the incumbent should be able to do.

DRAFT FOR SECTOR REVIEW AND COMMENTING

1. OVERVIEW

This is an introductory section providing a brief summary and specific information or commentary about the content of the NOS and the targeted sector and occupation to help the user judge whether it is relevant to them.

NOS Code	NOS.EEE.01
Occupation	Electrical and Electronics Engineering
Job Title	Electrical Engineer/ Electronics Engineer
Job Description	Electrical and Electronic Engineers design, install, and maintain electrical and electronic equipment and systems. These include but are not limited to electrical machines, inverters, communication equipment, control and automation systems etc.
Job Purpose	Electrical and Electronics Engineers design, install and maintain electrical and electronic equipment used in manufacturing industries.
ZQF Level	7
Sector	Manufacturing
Sub sector	All sub sectors of manufacturing.
Other Economic Sector(s) in which the Occupation is Practiced	Power utilities, water utilities, information and communication technology, mining, agriculture, education, construction industry, hospitality industry, transportation, etc.
Other Similar Jobs that can be performed by the Electrical and Electronics Engineer	Operations Engineer, Sales Engineer, Maintenance Engineer, Project Engineer, Instrumentation Engineer, Telecommunications Engineer, Electronics Engineer, etc.
Minimum Educational Job Entry Qualification(s)	Bachelor's Degree in Electrical and Electronics or Diploma in Electrical and Electronics, with substantial industrial experience, or equivalent.
Practicing License Requirements (if any)	Membership with the Engineering Institution of Zambia (EIZ) and Practicing Licence from the Engineering Registration Board (EngRB).
Training/RPL	<ol style="list-style-type: none"> 1. Electrical safety. 2. Use of ICTs (Internet, Microsoft word, Excel, PowerPoint, Email, Computer Software and Hardware necessary for the job, etc.). 3. 5S Workplace Organisation Method. 4. Previous experience in the same or similar occupation.
Minimum Job Entry Age	21
Prior Experience (Suggested)	<ol style="list-style-type: none"> 1. Bachelor's Degree holder – Minimum of 1 year internship. 2. Diploma holder – Minimum of 5 years industrial experience.
Performance Criteria	As described in the Units under Section 4

2. SCOPE

This National Occupational Standard specifies the fundamental knowledge and understanding, skills and competences that Electrical and Electronics Engineers must possess to be successful in their jobs.

3. PERSONAL ATTRIBUTES (VALUES, ETHICS AND ATTITUDES)

This job requires an individual to possess the following personal attributes:

- Good numerical analysis skills.
- Good oral and written communication skills.
- Good problem solving skills.
- Good interpersonal skills.
- Good leadership and managerial skills.
- Good decision making skills.
- Ability to work as part of a team.
- Ability to work under pressure.
- Ability to meet deadlines.
- High level of responsibility towards work.
- Honesty in work related matters.
- Integrity in all matters.
- Confidentiality when dealing with sensitive matters.
- High level of consciousness to safety for self, others and equipment.

4. UNITS AND ELEMENTS

This National Occupational Standard is divided into four (4) Units representing the tasks that a jobholder should undertake in his/her day to day work. Each unit is further broken down into elements depicting the number of activities to be carried out for the successful execution of a particular task.

UNIT 1 [This unit is about the skills and competence required by an Electrical and Electronic Engineer to carry out the design of electrical and electronic systems].

Unit No.	01
Unit Title	Design of Electrical and Electronic Systems
Description	This unit is about the skills and competence required by an Electrical and Electronics Engineer to carry out the design of electrical and electronic systems.
Scope	This unit covers the following: <ul style="list-style-type: none"> • Formulation of the design problem. • Electrical drawings. • Sizing of equipment. • Modeling and simulation. • Costing of the system.
Performance Criteria (PC) w.r.t. the Scope	
Element	Performance Criteria (PC)
Formulation of the design problem.	To be competent, the individual must be able to: PC1. Describe the existing problem. PC2. Break down the problem into smaller components. PC3. Identify competent individuals to be part of the design team. PC4. Identify the standards governing the design of electrical equipment. PC5. Identify power levels and voltage levels required in the design.
Electrical Drawings	To be competent, the individual must be able to: PC6. Produce functional block diagrams of the system. PC7. Produce schematic drawings such as single-line diagrams or ladder diagrams, as the case may be. PC8. Produce wiring diagrams.
Sizing of Equipment	To be competent, the individual must be able to: PC9. Carry out design calculations based on the information provided in the design description. PC10. Determine the power level required. PC11. Determine the voltage level required. PC12. Determine the current level required. PC13. Select equipment and components with suitable ratings for the design. PC14. Design protection circuits for various parts of the system.
Modeling and simulation	To be competent, the individual must be able to: PC15. Create a mathematical model of the system. PC16. Carry out simulations to verify the design. PC17. Compare the simulation results to standardized benchmarks. PC18. Verify that the design conforms to standards governing the operation of such equipment.
Costing of the system	To be competent, the individual must be able to: PC19. Categorize the key components of the cost estimate. PC20. Identify direct costs and indirect costs. PC21. Prepare a detailed cost estimate of the design.

Knowledge and Understanding (K)	
A. Organisational Context (Knowledge of the company/ organisation and its processes)	The individual on the job must demonstrate knowledge and understanding of: OK1. The organisational policy on design of electrical and electronic systems. OK2. Organisational processes such as project management, accounting and procurement. OK3. Standards adopted by the organisation on design of electrical and electronic systems.
B. Technical Knowledge	The individual on the job must demonstrate knowledge and understanding of: TK1. Basic Electrical circuit analysis. TK2. DC and AC Circuit analysis and design. TK3. Electrical symbols TK4. Single-line diagrams TK5. Ladder diagrams TK6. Schematic diagrams TK7. Wiring diagrams TK8. Control circuit design TK9. Power circuit design TK10. Electronic circuit design TK11. Computer aided drawing tools TK12. Mathematical modeling of electrical systems TK13. Simulation of electrical systems using Matlab, Multisim, or other suitable software. TK14. Project management TK15. Basic accounting
C. Regulatory context (Knowledge of Rules and Regulations)	The individual on the job must demonstrate knowledge and understanding of: RK1. Relevant Zambian standards governing the design work. RK2. Specific industry regulations e.g. power quality standards, electromagnetic interference standards as the case may be. RK3. Relevant international standards such as IEEE, IEC, ISO, NEMA, ANSI etc.
Skills (S)	
A. Core Skills/ Generic Skills	Reading Skills
	The individual on the job must be able to: CS1. Read and understand instructions in English with a very high proficiency. CS2. Read and interpret standard electrical symbols. CS3. Read and interpret single-line diagrams, block diagrams, schematic diagrams, and ladder diagrams.
	Writing Skills
	The individual on the job must be able to: CS4. Prepare reports in clear and easy to understand English. CS5. Prepare clear easy to understand instructions. CS6. Prepare a description of a process or system clearly. CS7. Prepare a budget for the design of Electrical and Electronic Systems.

	<p>Oral Communication (Listening and Speaking skills)</p> <p>The individual on the job must be able to:</p> <p>CS8. Communicate effectively with a high level of proficiency in English.</p> <p>CS9. Explain instructions clearly to subordinates.</p> <p>CS10. Provide oral progress reports to superiors.</p> <p>CS11. Make oral presentations to stake holders.</p>
<p>B. Professional Skills</p>	<p>Plan and Organise</p> <p>The individual on the job must be able to:</p> <p>PS1. Prepare a schedule of work to be carried out as part of the design.</p> <p>PS2. Select suitable team members for the design.</p> <p>PS3. Give time lines to the different components of the design.</p> <p>PS4. Ensure all necessary tools and material are available to the design teams.</p>
	<p>Judgment and Critical Thinking</p> <p>The individual on the job must be able to:</p> <p>PS5. Evaluate the complexity of the task and come up with an effective plan of action.</p> <p>PS6. Prepare a contingency plan in case of unforeseen occurrences.</p> <p>PS7. Prioritise safety of personnel in the design.</p>
	<p>Desire to Learn and Take Initiatives</p> <p>The individual on the job must be able to:</p> <p>PS8. Keep up-to-date with latest trends and changes in industry and the electrical and electronics field.</p> <p>PS9. Ensure that every team member is given an opportunity to make a contribution to new designs.</p> <p>PS10. Demonstrate strong leadership qualities and firm and fair treatment of all team members.</p>
	<p>Problem Solving and Decision Making</p> <p>The individual on the job must be able to:</p> <p>PS11. Solve problems as they arise.</p> <p>PS12. Evaluate different options before making a decision.</p> <p>PS13. Consult superiors and colleagues when making critical decisions.</p>

UNIT 2 [This unit is about safe installation of electrical and electronic equipment in the manufacturing industry].

Unit No.	02
Unit Title	Installation of Electrical and Electronic Equipment
Description	This unit is about the installation, testing and commissioning of Electrical and Electronic Equipment in both the formal and informal sector of the manufacturing industry.
Scope	<p>This unit covers the following:</p> <ul style="list-style-type: none"> • Equipment installation planning • Health and Safety • Resource mobilisation • Electrical Circuits and Systems Installations • Measurement and Testing • Commissioning.
Performance Criteria	
Element	Performance Criteria(PC)
Equipment Installation Planning	<p>To be competent, the individual must be able to:</p> <p>PC1. Determine the maximum demand of the final sub-circuits</p> <p>PC2. Determine the number and types of final sub-circuits</p> <p>PC3. Determine the current requirements of the final sub-circuits</p> <p>PC4. Interpret circuit drawings, conduit layouts and switching schedules</p> <p>PC5. Generate bill of quantities for the installation</p> <p>PC6. Articulate installation design procedures</p> <p>PC7. Determine equipment ratings</p> <p>PC8. Determine nominal protection settings</p> <p>PC9. Determine the current required by the various loads</p> <p>PC10. Select the correct cable sizes for specific loads</p> <p>PC11. Estimate transmission voltage drops of cables</p> <p>PC12. Foresee the shock risks expected during installation</p> <p>PC13. Select the Circuit Protection Conductor (CPC) using a standard table</p> <p>PC15. Suggest alternative installation methods</p> <p>PC16. State the work (work output) required from the job and discuss it with the supervisor.</p> <p>PC17. Refer all work instruction/related documents to understand requirements from electrical equipment/ electrical wiring or fixtures to the installation manual.</p> <p>PC18. Prepare sketches or follow blueprints to determine the location of wiring or equipment and to ensure conformance to safety codes</p>
Health and Safety	<p>To be competent, the individual must be able to;</p> <p>PC19. Demonstrate a thorough understanding of general safety rules applicable in the process of conducting his work.</p> <p>PC20. Interpret safety requirements for live conductors such as the need to fence off installation and putting warning signs at appropriate locations.</p>

	<p>PC21. Certify safety of personnel against rotating loads such as fans, compressors and other power tools.</p> <p>PC22. Make full use of PPEs (Personal Protective Equipment)</p> <p>PC23. Implement general safety rules during installation.</p> <p>PC24. Implement safety measures when handling lifting equipment such as cranes.</p> <p>PC25. Install and operate access equipment competently.</p> <p>PC26. Implement safety precautions when handling cable joining materials.</p> <p>PC27. Interpret the classification of different types of fires and the safest way of extinguishing them.</p> <p>PC28. Apply first aid when required.</p> <p>PC29. Take responsibility for personnel who experience electric shock during installation.</p>
<p>Resource Mobilisation</p>	<p>To be competent, the individual must be able to:</p> <p>PC30. Stipulate the electrical equipment requirements according to the specifications in the work instructions.</p> <p>PC31. Certify that the required electrical equipment is procured from the stores or vendor before starting the process.</p>
<p>Electrical Circuits and Systems Installation</p>	<p>To be competent, the individual must be able to:</p> <p>PC32. Install various types of electrical equipment.</p> <p>PC33. Install single-phase and three-phase power circuits.</p> <p>PC34. Install space heating systems.</p> <p>PC35. Install radiant or direct heating systems.</p> <p>PC36. Install thermostats.</p> <p>PC37. Install alarm and emergence systems.</p> <p>PC38. Install call systems.</p> <p>PC39. Install central heating systems.</p> <p>PC40. Install standby and emergency power systems.</p>
<p>Measurement and Testing</p>	<p>To be competent, the individual must be able to:</p> <p>PC41. Carry out measurement of electrical quantities such as voltage, current, power, and resistance.</p> <p>PC42. Interpret readings on measuring instruments.</p> <p>PC43. Select the correct measuring or test instruments</p> <p>PC44. Use approved test lamps and indicators.</p> <p>PC45. Calibrate, zero and take care of instruments</p> <p>PC46. Carry out continuity tests on conductors.</p> <p>PC47. Perform insulation resistance tests.</p> <p>PC48. Perform earth electrode resistance test.</p>
<p>Commissioning</p>	<p>To be competent, the individual must be able to:</p> <p>PC49. Explain the functions of the equipment or system with reference to the design specifications or operational requirements.</p> <p>PC50. Prepare a commissioning check list.</p> <p>PC51. Perform a visual inspection of the equipment or system.</p> <p>PC52. Accomplish an earth continuity test.</p>

	<p>PC53. Complete an insulation resistance test or a leakage current test.</p> <p>PC54. Execute a Residual Current Device (RCD) test.</p> <p>PC54. Apply the relevant commissioning standards when carrying out commissioning.</p>
Knowledge and Understanding (K)	
A. Organisation-al Context (Knowledge of the company/ organisation and its processes)	<p>The individual on the job must demonstrate knowledge and understanding of:</p> <p>OK1. The organisational policy on installation of electrical and electronic systems.</p> <p>OK2. Organisational processes such as project management, accounting and procurement.</p> <p>OK3. Standards adopted by the organisation on installation of electrical and electronic systems.</p>
B. Technical Knowledge	<p>The individual on the job must demonstrate knowledge and understanding of:</p> <p>TK1. Basic Electrical circuit analysis.</p> <p>TK2. DC and AC Circuit analysis.</p> <p>TK3. Electrical symbols.</p> <p>TK4. Single-line diagrams.</p> <p>TK5. Ladder diagrams.</p> <p>TK6. Schematic diagrams.</p> <p>TK7. Wiring diagrams.</p> <p>TK8. Electrical instruments.</p> <p>TK9. Project management.</p> <p>TK10. Electrical machines, types, characteristics, operation and installation.</p> <p>TK11. Substation equipment and installation.</p> <p>TK12. Installation and testing of electronic and communication equipment.</p>
C. Regulatory context (Knowledge of Rules and Regulations)	<p>The individual on the job must demonstrate knowledge and understanding of:</p> <p>RK1. Health and safety standards and regulations.</p> <p>RK2. Electrical safety regulations.</p> <p>RK3. Electrical wiring regulations.</p> <p>RK4. Personal protective equipment regulations.</p> <p>RK5. Building regulations.</p> <p>RK6. Commissioning regulations.</p>
Skills (S)	
A. Core Skills/ Generic Skills	Reading Skills
	<p>The individual on the job must be able to:</p> <p>CS1. Read and understand instructions in English with a very high proficiency.</p> <p>CS2. Read and interpret standard electrical symbols.</p> <p>CS3. Read and interpret single-line diagrams, block diagrams, schematic diagrams, and ladder diagrams.</p>
	Writing Skills
	<p>The individual on the job must be able to:</p> <p>CS4. Prepare reports in clear and easy to understand English.</p> <p>CS5. Prepare clear easy to understand instructions.</p>

	<p>CS6. Prepare a description of a process or system clearly. CS7. Prepare a budget for the installation of Electrical and Electronic Equipment.</p>
	<p>Oral Communication (Listening and Speaking skills)</p>
	<p>The individual on the job must be able to: CS8. Communicate effectively with a high level of proficiency in English. CS9. Explain instructions clearly to subordinates. CS10. Provide oral progress reports to superiors. CS11. Make oral presentations to stake holders.</p>
<p>B. Professional Skills</p>	<p>Plan and Organise</p>
	<p>The individual on the job must be able to: PS1. Prepare a schedule of work to be carried out. PS2. Select suitable team members for the tasks required. PS3. Certify that all necessary tools and material are available to the maintenance personnel.</p>
	<p>Judgment and Critical Thinking</p>
	<p>The individual on the job must be able to: PS4. Analyse the complexity of the task and come up with an effective plan of action. PS5. Prepare a contingency plan in case of unforeseen occurrences. PS6. Prioritise safety of personnel in the maintenance process.</p>
	<p>Desire to Learn and Take Initiatives</p>
	<p>The individual on the job must be able to: PS7. Keep up-to-date with latest trends and changes in industry and the electrical and electronics field. PS8. Ensure that every team member is given an opportunity to make a contribution to new designs. PS9. Demonstrate strong leadership qualities and firm and fair treatment of all team members.</p>
	<p>Problem Solving and Decision Making</p>
	<p>The individual on the job must be able to: PS10. Solve problems as they arise. PS11. Evaluate different options before making a decision. PS12. Consult superiors and colleagues when making critical decisions.</p>

UNIT 3 [This unit is about the skills and competence required by an Electrical and Electronic Engineer to carry out the maintenance and repair of electrical and electronic equipment and systems].

Unit No.	03
Unit Title	Maintenance and Repair of Electrical and Electronic Equipment and Systems
Description	This unit is about the skills and competence required by an Electrical and Electronic Engineer to carry out the maintenance and repair of electrical and electronic equipment and systems.
Scope	This unit covers the following: <ul style="list-style-type: none"> • Preventive maintenance. • Problem identification in a system or equipment. • Maintenance planning. • Work scheduling. • Allocation of tasks to specific people. • Work inspection.
Performance Criteria (PC) w.r.t. the Scope	
Element	Performance Criteria (PC)
Preventive maintenance	To be competent, the individual must be able to: PC1. Analyse the cause of major equipment and system failures. PC2. Select the type of preventive action to take to prevent recurrence. PC3. Follow manufacturers' guidelines on maintenance schedules for specific equipment. PC4. Utilise a computer maintenance management system (CMMS) to schedule preventive maintenance tasks for various equipment and systems.
Problem identification in a system or equipment	To be competent, the individual must be able to: PC5. Identify a malfunction of equipment by observing and listening. PC6. Identify a malfunction of equipment by checking readings on measuring instruments. PC7. Categorise equipment failure. PC8. Investigate the cause of failure. PC9. Predict the equipment downtime. PC10. Estimate the cost of maintenance or repair.
Maintenance planning	To be competent, the individual must be able to: PC11. Decide what needs to be done. PC12. Describe the sequence of activities. PC13. Determine which activities should be given priority. PC14. Determine what level of skill is required. PC15. Confirm that all required resources, material, labour, equipment and tools are available.
Work scheduling	To be competent, the individual must be able to: PC16. Decide when to do the work. PC17. Communicate with other parts of the company who will be affected by the work. PC18. Specify what work can be done within the company, and what work requires external contractors. PC19. Ensure that the work is done at a reasonable cost.

	PC20. Determine the tools needed to carry out the work.
Allocation of tasks to specific people	To be competent, the individual must be able to: PC21. Allocate maintenance personnel to specific areas and equipment. PC22. Ensure that the assigned personnel have the skills required to perform the assigned task. PC23. Carry out a risk assessment and ensure the people involved adhere to the required safety rules.
Work inspection	To be competent, the individual must be able to: PC24. Verify that the work meets the required quality standards. PC25. Verify that the equipment or system is restored to normal operation. PC26. Document the work and the results of the inspection.
Knowledge and Understanding (K)	
A. Organisational Context (Knowledge of the company/ organisation and its processes)	The individual on the job must demonstrate knowledge and understanding of: OK1. The organisational policy on maintenance of electrical and electronic systems. OK2. Organisational processes such as project management, accounting and procurement. OK3. Standards adopted by the organisation on maintenance of electrical and electronic systems.
B. Technical Knowledge	The individual on the job must demonstrate knowledge and understanding of: TK1. Basic Electrical circuit analysis. TK2. DC and AC Circuit analysis and design. TK3. Electrical symbols TK4. Single-line diagrams TK5. Ladder diagrams TK6. Schematic diagrams TK7. Wiring diagrams TK8. Control circuit design TK9. Power circuit design TK10. Electronic circuit design TK11. Mathematical modeling of electrical systems TK12. Simulation of electrical systems using Matlab, Multisim, or other suitable software. TK13. Project management TK14. Basic accounting TK15. Electrical machines, types, characteristics, operation and maintenance requirements. TK16. Power system operation and maintenance TK17. Communication systems operation and maintenance TK18. Power electronic systems operation and maintenance TK19. Electrical instruments.
C. Regulatory context (Knowledge of Rules and Regulations)	The individual on the job must demonstrate knowledge and understanding of: RK1. Maintenance standard operating procedures. RK2. Software based maintenance management systems.

Skills (S)	
A. Core Skills/ Generic Skills	Reading Skills
	The individual on the job must be able to: CS1. Read and understand instructions in English with a very high proficiency. CS2. Read and interpret standard electrical symbols. CS3. Read and interpret single-line diagrams, block diagrams, schematic diagrams, and ladder diagrams.
	Writing Skills
	The individual on the job must be able to: CS4. Prepare reports in clear and easy to understand English. CS5. Prepare clear easy to understand instructions. CS6. Prepare a description of a process or system clearly. CS7. Prepare a budget for the maintenance and repair of electrical and electronic equipment and systems
	Oral Communication (Listening and Speaking skills)
	The individual on the job must be able to: CS8. Communicate effectively with a high level of proficiency in English. CS9. Explain instructions clearly to subordinates. CS10. Provide oral progress reports to superiors. CS11. Make oral presentations to stake holders.
B. Professional Skills	Plan and Organise
	The individual on the job must be able to: PS1. Prepare a schedule of work to be carried out. PS2. Select suitable team members for the tasks required. PS3. Ensure all necessary tools and material are available to the maintenance personnel.
	Judgment and Critical Thinking
	The individual on the job must be able to: PS4. Evaluate the complexity of the task and come up with an effective plan of action. PS5. Prepare a contingency plan in case of unforeseen occurrences. PS6. Prioritise safety of personnel in the maintenance process.
	Desire to Learn and Take Initiatives
	The individual on the job must be able to: PS7. Keep up-to-date with latest trends and changes in industry and the electrical and electronics field. PS8. Ensure that every team member is given an opportunity to make a contribution to new designs. PS9. Demonstrate strong leadership qualities and firm and fair treatment of all team members.
	Problem Solving and Decision Making
	The individual on the job must be able to: PS10. Solve problems as they arise. PS11. Evaluate different options before making a decision. PS12. Consult superiors and colleagues when making critical decisions.

UNIT 4 [This unit is about the skills and competence required by an Electrical and Electronic Engineer to carry out the protection and control of electrical and electronic equipment and systems].

Unit No.	04
Unit Title	Protection and Control of Electrical and Electronic Equipment and Systems
Description	This unit is about the skills and competence required by an Electrical and Electronic Engineer to carry out the protection and control of electrical and electronic equipment and systems.
Scope	This unit covers the following: <ul style="list-style-type: none"> • Power system studies and analysis • Electrical system protection and control equipment • Coordination and integration of protective devices in the system • Sequential control and programming • Maintenance and repair of protective devices.
Performance Criteria (PC) w.r.t. the Scope	
Element	Performance Criteria (PC)
Power system studies and analysis	To be competent, the individual must be able to: PC1. Carry out detailed system studies and analysis. PC2. Comprehend generation, transmission and distribution systems of a power network. PC3. Conduct power system calculations, load flow studies and simulations. PC4. Demonstrate good knowledge of system operation under static, transient and dynamic state stability. PC5. Demonstrate good knowledge of symmetrical and unsymmetrical fault calculations. PC6. Demonstrate sound knowledge of switch gear operations. PC7. Demonstrate good knowledge of switching transients in a power system PC8. Comprehend the protection and control system principles applicable to all systems PC9. Identify all the elements of the protection system and the expected location in the system. PC10. Diagnose and resolve failures at any part of the system. PC11. Comprehend various faults prevalent in the system/plant.
Electrical system protection and control equipment	To be competent, the individual must be able to: PC12. Distinguish different types of relays. PC13. Install various protection and control equipment. PC14. Select a suitable communication protocol for the protection and control system.
Coordination and integration of protection and control devices in the system	To be competent, the individual must be able to: PC15. Comprehend the switching devices and schedules for distribution and supply. PC17. Coordinate the automated switching operations of a process from a control centre. PC18. Implement real time monitoring of a protection and control system using a SCADA system.

<p>Sequential control and programming</p>	<p>To be competent, the individual must be able to: PC19. Implement the principles of sequential and electric motor control. PC20. Demonstrate knowledge of standard symbols for various protection and control devices. PC21. Describe the operation of timers and counters PC22. Design sequential control systems. PC23. Translate relay logic diagrams to PLC logic control diagrams. PC24. Identify digital and analogue inputs and outputs of a PLC. PC25. Program a PLC using different PLC programming languages such as ladder logic, functional block diagrams, structured text, instruction list and sequential function chart.</p>
<p>Maintenance and repair of protective devices</p>	<p>To be competent, the individual must be able to: PC26. Analyse all data resulting from an inspection and ensure that it conforms to the set standards. PC27. Routinely calibrate and test instrument tests to ensure they operate within approved standards. PC28. Follow manufacturers' specifications on test values for specific protection and control devices.</p>
<p>Knowledge and Understanding (K)</p>	
<p>A. Organisational Context (Knowledge of the company/ organisation and its processes)</p>	<p>The individual on the job must demonstrate knowledge and understanding of: OK1. The organisational policy on the protection of electrical and electronic systems. OK2. Organisational processes and procedures. OK3. Standards adopted by the organisation on maintenance of protection and control systems equipment.</p>
<p>B. Technical Knowledge</p>	<p>The individual on the job must demonstrate knowledge and understanding of: TK1. DC and AC Circuit analysis and design. TK2. Electrical symbols TK3. Single-line diagrams TK4. Ladder diagrams TK5. Schematic diagrams TK6. Wiring diagrams TK7. Control circuit design and installation TK8. Protection circuit design and installation TK9. Electronic circuit design and installation TK10. Mathematical modelling of the protection system TK11. Simulation of electrical systems using Matlab, Multisim, or any other suitable software. TK12. Project management. TK13. Basic accounting. TK14. Electrical machines, relays and switching operation TK15. Power system operation and maintenance. TK16. Telecommunication systems operation and maintenance. TK17. Appreciable knowledge of Electrical instrumentation. TK18. Knowledge of SCADA systems application in protection and control systems engineering.</p>

C. Regulatory context (Knowledge of Rules and Regulations)	<p>The individual on the job must demonstrate knowledge and understanding of:</p> <p>RK1. Company's standard operating procedures for protection and control of electrical and electronic equipment and devices.</p> <p>RK2. International regulations on protection and control of electrical and electronic equipment and devices.</p> <p>RK3. Health and safety regulations of the company.</p>
Skills (S)	
A. Core /generic skills	Reading Skills
	<p>The individual on the job must be able to:</p> <p>CS1. Read and understand manufacturing process control documentation and diagrams.</p> <p>CS2. Read and understand instructions in English with a very high proficiency.</p> <p>CS3. Read and interpret standard electrical symbols.</p> <p>CS4. Read and interpret single-line diagrams, block diagrams, schematic diagrams, and ladder diagrams.</p>
	Writing Skills
	<p>The individual on the job must be able to:</p> <p>CS5. Prepare reports in clear and easy to understand English.</p> <p>CS6. Prepare clear easy to understand instructions.</p> <p>CS7. Prepare a description of a process or system clearly.</p> <p>CS8. Prepare an operational budget for the team.</p>
B. Professional Skills	Oral Communication (Listening and Speaking skills)
	<p>The individual on the job must be able to:</p> <p>CS9. Communicate effectively with a high level of proficiency in English.</p> <p>CS10. Explain instructions clearly to subordinates.</p> <p>CS11. Provide oral and written reports to superiors.</p> <p>CS12. Make oral presentations to stake holders.</p>
	Plan and Organise
	<p>The individual on the job must be able to:</p> <p>PS2. Prepare a schedule of work to be carried out.</p> <p>PS3. Select suitable team members for the tasks required.</p> <p>PS4. Ensure all necessary tools and materials are available to the personnel.</p>
	Judgment and Critical Thinking
	<p>The individual on the job must be able to:</p> <p>PS5. Evaluate the complexity of the task and come up with an effective plan of action.</p> <p>PS6. Prepare a contingency plan in case of unforeseen occurrences.</p> <p>PS7. Prioritize safety of personnel in the process.</p>
	Desire to Learn and Take Initiatives
	<p>The individual on the job must be able to:</p> <p>PS8. Keep up-to-date with latest trends and changes in industry and the electrical and electronics field.</p> <p>PS9. Ensure that every team member is given an opportunity to make a contribution to new designs.</p> <p>PS10. Demonstrate strong leadership qualities and firm and fair treatment of all team members.</p>

	Problem Solving and Decision Making
	The individual on the job must be able to: PS11. Solve problems as they arise. PS12. Evaluate different options before making a decision. PS13. Consult superiors and colleagues when making critical decisions. PS14. exhibit strong leadership qualities and firm and fair treatment of all team members

5. EQUIPMENT, TOOLS AND CONSUMABLE MATERIALS

These include, but not limited to:

- Personal Protective Equipment;
- Fault locator for underground cable installations;
- Earth resistance tester;
- Power lines and electric cable;
- Multimeter (voltage, current and resistance measurement);
- Current transformer analyser;
- Oscilloscope;
- Power quality analyser;
- Various portable hand tools;
- Batteries;
- Light bulbs and fluorescent lights.

6. DILEMMAS/CHALLENGES AND COMPLEXITIES FOR A JOB HOLDER

Dilemmas associated with the job of an Electrical and Electronics Engineer include;

- Exposure to live electrical power supply and high voltage;
- Working around and with machinery having moving parts;
- Working in dangerous areas with likelihood of sharp or falling objects;
- Working in confined spaces and at heights;
- Working in extreme weather such as hot and cold conditions;
- Working in noisy, wet and dusty environments;
- Exposure to fumes, dust, odours and chemical materials;
- Long working hours;
- Pressure from supervisors and colleagues;
- Pressure from government regulators and customers;
- Fast changing technology.

6.1 Alternative Choices (Solutions) to Dilemmas and Complexities

Solutions to dilemmas include:

- Wearing personal protective equipment (PPE) at all times.
- Not wearing loose clothing or jewelry when working near machine with moving parts.
- Following safety regulations and guidelines for working at height and in confined spaces.
- Following health guidelines when working in extreme weather environments, such as staying hydrated in very hot conditions.
- Wearing ear plugs or ear muffs in noisy places, and suitable masks or respirators for dusty environments, fumes, odours or chemicals.
- Taking regular breaks when working long hours.
- Good interpersonal and communication skills.
- Ensuring compliance with government regulations and standards.
- Keeping up-to-date with latest technology by continuous professional development (CPD).

7. WORKING CONDITIONS/ENVIRONMENT

The working conditions and work environment are highly dependent on the type of manufacturing industry under consideration. Some common conditions for all types of manufacturing industries include:

- Working mostly indoors, but sometimes outdoors on outdoor electrical and electronic installations such as outdoor substations and outdoor communication infrastructure.
- Exposure to high and uncomfortable noise levels.
- Risk of exposure to live electrical systems and electromagnetic fields.
- Regular communication by phone, email or other means with superiors, subordinates and clients.
- Spending a lot of time on their feet moving between different parts of a manufacturing plant.
- Having to meet strict deadlines.
- Ensuring work is done within budgetary allocations.
- Regularly working as part of an interdisciplinary team.
- Responsibility for the health and safety of other workers.
- Ensuring that all work is done correctly and completely to avoid endangering personnel and damage to equipment.
- Making decisions that affect other workers and the company at large.

8. PARTIES INVOLVED/INTERACTING WITH THE JOB HOLDER OR TRAINEE

8.1 Internal/Within the Organisation

Engineering Manager, Production Manager, Safety Health and Environment Coordinator, Quality Controller, Mechanical Engineers, Process Engineers, Plant Operators, Electricians, Planners, etc.

8.2 External/Outside the Organisation

Government regulators, suppliers of equipment/tools/consumables, training personnel, clients, etc.

9. PHYSICAL DEMANDS ON THE BODY

- Sitting or standing for long periods of time;
- Ability to see details of objects;
- Good hearing and should be able to distinguish different sounds and understand the speech of another person;
- Should be able to speak clearly and be understood by other people;
- Should be able to differentiate colours;
- Ability to use fingers, hands and feet with ease to complete the assigned task (dexterity).

ANNEX A

Criteria for Assessments based on this NOS

A.1 Guidelines for Assessment

A.1.1 Criteria for assessment for curricula and learning programmes based on this NOS will be created by curricula and programmes developers. Each Performance Criteria (PC) will be assigned marks proportional to its importance in the NOS. Curricula and programmes developers will also lay down proportion of marks for theory and practical skills for each performance criteria, giving more weight to practical skills.

There shall be allocated the 'Total Mark', which will be the sum of all marks in each Unit, distributed across the number of PCs in that particular Unit. The 'out of' mark will be the mark allocated to each PC, which will be shared between theory and skills practical assessments.

A.1.2 Individual awarding/assessment bodies or institutions and other users of the NOS will create unique question papers for the theory part and evaluations for skill practical part for their respective candidates.

ANNEX B NOS Version Control

This Annex gives details necessary for the tracking of the NOS versions based on the number of revisions.

NOS Code	DNOS.EEE.01		
ZQF Level	7	Version Number	01
Sector	Manufacturing	Date of Approval	
Sub Sector	All sub sectors of manufacturing	Date of Last Review	N/A
Occupation	Electrical and Electronics Engineering	Date of Next Review	

DRAFT FOR SECTOR REVIEW AND COMMENTING