NATIONAL CERTIFICATE (VOCATIONAL)

SUBJECT GUIDELINES

ELECTRICAL SYSTEMS AND CONSTRUCTION

NQF LEVEL 4

IMPLEMENTATION: JANUARY 2015
INTRODUCTION

A. What is Electrical Systems and Construction?

At Level 2, *Electrical Systems and Construction* covers the basics of electrical systems and introduces this particular field of learning. Students learn basic construction skills commonly found in the field of electrical practice. Students come into contact with standard electrical systems and construction procedures. At Level 3 the subject covers the basics of electrical systems and construction procedures.

At Level 4 *Electrical Systems and Construction* covers some of the daily tasks of an electrical tradesperson and introduces the practical side of this field of learning. At Levels 3 and 4 students continue with the theoretical and practical implementation of the learning material. Some of the Level 2 theoretical knowledge is repeated in greater detail to deepen students' understanding.

B. Why is *Electrical Systems and Construction* important in the Electrical Infrastructure Construction programme?

*Electrical Systems and Construction* addresses the necessary trade-specific skills, knowledge, values and attitudes so that students can understand the construction and application of electrical systems in practice.

C. The link between the Learning Outcomes for *Electrical Systems and Construction* and the Critical and Developmental Outcomes

This subject covers a substantial portion of the practical knowledge component of electrical systems found in practice. With particular reference to electrical systems and construction procedures, students should be able to:

- **Identify and solve problems:**
  Recognise situations that require action and react appropriately.

- **Work effectively with others:**
  Construct and test projects in groups or teams.

- **Organise and manage themselves and their activities:**
  Apply the correct procedures for using, storing and looking after equipment, tools, test equipment, drawings and parts.

- **Collect, organise and evaluate information and take appropriate action:**
  Use media centres to collect information.

- **Communicate effectively:**
  Use common names for equipment, tools, test equipment, drawings and parts.

- **Use science and technology:**
  Use and apply science and technology principles in both theory and practice.

- **Demonstrate understanding of subject content through the application of acquired knowledge:**
  Solve problems by using subject content.
D. Factors that contribute to achieving the *Electrical Systems and Construction* Learning Outcomes

- An understanding of technical (electro-mechanical) principles
- Analytical ability
- An ability to do mathematical calculations and manipulations
- Practical skills
- Skill to interpret technical information
ELECTRICAL SYSTEMS AND CONSTRUCTION – LEVEL 4

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1  **DURATION AND TUITION TIME**
This is a one year instructional programme comprising 200 teaching and learning hours. The subject may be offered on a part-time basis provided all of the assessment requirements set out hereunder are adhered to. Students with special education needs (LSEN) must be catered for in a way that eliminates barriers to learning.

2  **SUBJECT LEVEL OUTCOMES AND FOCUS**
**SAQA Qualification ID: 50442**
On completion of this subject the student should be able to:
- Describe and explain electrical infrastructure in a South African context by referring to the South Africa power grid, coal fire power stations, a typical small town power grid and installation and termination of medium voltage overhead networks.
- Design, construct, test, fault-find and repair three-phase domestic and industrial/commercial installations in line with safety and regulatory/statutory requirements.
- Analyse a renewable energy circuit or system and calculate loads and ratings to assess the renewable energy resource.

**Associated Assessment Criteria:**
- Electrical infrastructure such as South Africa power grid, coal fire power stations, a typical small town power grid and installation and termination of medium voltage overhead networks are described and explained.
- Three-phase domestic and industrial/commercial installations are designed and constructed, tested for fault-finding and maintenance and repaired in line with safety and regulatory/statutory requirements.
- A renewable energy circuit diagram is sketched and loads and ratings are calculated to assess the renewable energy resource.

3  **ASSESSMENT**
Information provided in this document on internal and external assessment aims to inform, assist and guide lecturers to plan the effective teaching of the subject. The Assessment Guidelines accompanying this document provide detailed information for planning and conducting internal and external assessments.

3.1  **Internal assessment (50 percent)**
Detailed information regarding internal assessment and moderation is outlined in the current Internal Continuous Assessment (ICASS) Guideline document provided by the Department of Higher Education and Training (DHET).

3.2  **External assessment (50 percent)**
A national examination is conducted annually in October or November by means of a paper(s) set and moderated externally. A practical component, the Integrated Summative Assessment Task (ISAT), will be included in the external assessment. Detailed information regarding external assessment and moderation is outlined in the National Policy on the Conduct, Administration and Management of the Assessment of the National Certificate Vocational Gazette Number 30287, dated 12 September 2007.
4 WEIGHTED VALUES OF TOPICS

<table>
<thead>
<tr>
<th>TOPICS</th>
<th>WEIGHT %</th>
<th>*TEACHING HOURS</th>
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<tbody>
<tr>
<td>1. Electrical Infrastructure</td>
<td>20</td>
<td>22</td>
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<tr>
<td>2. Construction of a three phase circuit</td>
<td>15</td>
<td>16</td>
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<tr>
<td>3. Construction of a three phase medium voltage overhead supply to domestic houses</td>
<td>15</td>
<td>17</td>
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<tr>
<td>4. Inspection of a three phase industrial/commercial installation</td>
<td>20</td>
<td>22</td>
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<tr>
<td>5. Fault-finding and maintenance of three phase voltage electric circuits</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>6. Renewable energy system</td>
<td>15</td>
<td>17</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100</strong></td>
<td><strong>110</strong></td>
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</tbody>
</table>

*Teaching Hours refers to the minimum hours required for face to face instruction and teaching. This excludes time spent on revision, tests and internal and external examination/assessment. The number of allocated teaching hours is influenced by the topic weighting, complexity of the subject content and the duration of the academic year.

5 CALCULATION OF FINAL MARK

Continuous assessment: Student’s mark/100 x 50/1 = a mark out of 50 (a)
Examination mark: Student’s mark/100 x 50/1 = a mark out of 50 (b)
Final mark: (a) + (b) = a mark out of 100

All marks are systematically processed and accurately recorded to be available as hard copy evidence for, amongst others, purposes of moderation and verification.

6 PASS REQUIREMENTS

The student must obtain at least fifty (50) percent in ICASS and fifty percent (50) in the examination to achieve a pass in this subject.

7 SUBJECT OUTCOMES AND LEARNING OUTCOMES

On completion of Electrical Systems and Construction Level 4 the student should have covered the following topics:

Topic 1: Electrical infrastructure
Topic 2: Construction of a three phase circuit
Topic 3: Construction of a three phase medium voltage overhead supply to domestic houses
Topic 4: Inspection of a three phase industrial/commercial installation
Topic 5: Fault-finding and maintenance of three phase voltage electric circuits
Topic 6: Renewable energy system
Topic 1: Electrical infrastructure

Subject Outcome 1.1: Explain electrical infrastructure and construction.

Range: Includes but is not limited to knowledge of the layout of the South Africa power grid, operating principles of coal fired power stations, layout of a typical small town power grid and how to install and terminate medium voltage overhead networks.

Learning Outcomes:
The student is able to:
- Explain the concepts low, medium and high voltage networks
- Describe and explain the ratings on switchgear, transformers, control gear and instruments
- Explain how alternators can be switched into or out of the grid
- Describe with the aid of diagrams, the main components of a coal fired power station
- Describe with the aid of diagrams, the main components of a typical small town power grid
- Describe radial and ring feeds and explain the effects of faulty transmission lines
  Range: short circuit and open circuit
- List and explain components, parts and equipment required to install medium voltage overhead networks.
  Range: Overhead line structures may include but are not limited to steel/wood/concrete poles. Relevant equipment may include, but is not limited to medium voltage pole mounted isolators, fuses, breakers, sectionalisers, transformers, reclosers, surge arrestors and metering equipment.
  Hardware may include, but is not limited to cables, bare conductors, covered conductors, service cables, aerial bundle conductors, stays and struts, insulators, clamps, ferrules, lugs and bolts.
  Installation includes, but is not limited to building the line and carrying out pre-commission inspections and hand-over procedures.

Topic 2: Construction of a three phase circuit

Subject Outcome 2.1: Design and construct a three phase circuit

Range: includes but is not limited to identifying electrical symbols (ISO and IEC standard) and components; gathering relevant components and describing the functioning of circuits and components (including contactors, protection (fuses, circuit breakers, earth leakage and overload relays), controls (temperature, limits, pressure, level, proximity and time switches), loads (resistive and inductive) and power supplies (maximum 550 volt). Circuits to be constructed are in a simulated environment and tested under supervision.

Learning Outcomes:
The student is able to:
- Identify symbols (ISO and IEC standard) and components
- Design a three phase circuit diagram that will satisfy the requirements.
  Range: Circuits are limited to direct on line, forward and reverse, sequence and star-delta starting.
- List the components, tools and equipment needed for the construction of the circuit.
- Construct the three phase circuit using acceptable working procedures and construction
methods.
- Evaluate the operational functionality of the constructed circuit and address any shortcomings.
- Complete the task by compiling drawings, operating procedures and specifications of the design.

Topic 3: Construction of a three phase medium voltage overhead supply to domestic houses

Subject Outcome 3.1: Construct a three phase medium voltage overhead supply to domestic houses.

Range: Includes but is not limited to: 11kV/380V three phase 4-wire network; materials such as cables, conductors, aerial bundle conductors, poles, isolators and fuses, and pin and strain type insulators; a 220V single phase supply cable to a domestic house; connection to the consumer's meter box.

Excludes mounting of 11kV/380V transformer on structure (assumed to be in place); plans (will be provided); and connection to the 11kV supply.

Learning Outcomes:
The student is able to:
- List and describe all statutory requirements as prescribed by the OHS Act, SABS 1418, Local Authority requirements and ESKOM reticulation specifications
- From the plans and diagrams draw up a list of parts and equipment needed
- Assess the terrain and decide on work to be done
- Mark out the route according to diagrams and servitude specifications
- Prepare holes or foundations, erect structures or poles and connect the stays
- String the conductive elements and tension the line
- Connect the 220V cable to the overhead supply
- Connect the transformer, isolator, fuses and other parts as per statutory requirements.
- Remove and dispose of surplus material and restore the terrain according to environmental standards and the land owner's requirements.
- Conclude the task by completing the inspection sheets and pre-commissioning reports.

Topic 4: Inspection of a three phase industrial/commercial installation

Subject Outcome 4.1: Test and inspect a three phase industrial/commercial installation

Range: Conducting an electrical test and inspection of a three phase industrial/commercial installation to ensure compliance with all statutory requirements and their application to the installation, using appropriate test instruments and understanding the indicated results, using appropriate inspection documents; completing the appropriate inspection documents with correct and relevant information. Test equipment may include but is not limited to multimeters, insulation tester, clip on ammeter, impedance testing equipment, earth leakage testing devices, earth electrode resistance testing equipment, continuity testers, phase rotation meters and any others appropriate to three phase industrial/commercial installations.

Note: All work must be conducted under supervision.
Learning Outcomes:
The student is able to:

- Interpret and explain the building plans, electric schematic and wiring diagrams and their components identified

**Range:** switch-yards, cabling, wire-ways, distribution boards, circuit protection devices, sub-circuits and points of delivery

- Plan the tasks required for inspecting and testing the installation
- Identify and select appropriate tools, equipment and instruments to meet the requirements of the task according to statutory and environmental requirements
- Explain safety rules and regulations relevant to the task according to statutory requirements and safe work procedures
- Identify environmental hazards and safety risks according to environmental standards and safety risk analyses
- Inspect the installation and test for compliance according to statutory requirements of the wiring code
- Complete a test report / certificate of compliance (CoC) and hand it to the assessor

**Topic 5: Fault-finding and maintenance of three phase voltage electric circuits**

**Subject Outcome 5.1: Fault-find three phase voltage electric circuits**

**Range:** Includes but is not limited to 380V three phase; equipment such as transformers, motors and control gear, domestic appliances, cables, lighting, switch gear and metering. Safety policies must be adhered to.

*Note: Fault finding must be done under supervision and in a simulated environment.*

**Learning Outcomes:**
The student is able to:

- Explain the principles and procedures to be applied during fault finding on three phase AC systems.
- Plan and prepare for fault finding on three phase AC systems.
- Find faults on faulty three phase AC systems.
- Complete fault finding on three phase AC systems.

**Subject Outcome 5.2: Repair three phase voltage electric circuits**

**Range:** Includes but is not limited to 380V three phase; equipment such as transformers, motors and control gear, domestic appliances, cables, lighting, switch gear and metering. Safety policies must be adhered to. Repair procedures must be conducted in accordance with accepted practises.

*Note: Repair must be done under supervision and in a simulated environment.*

**Learning Outcomes:**
The student is able to:

- Explain the principles and procedures to be for repairing three phase AC systems.
- Plan and prepare for repairing three phase AC systems.
- Repair faulty three phase AC systems.
- Test and commission the repaired three phase AC system.
Subject Outcome 5.3: Maintain three phase voltage electric circuits

Range: Includes but is not limited to 380V three phase; equipment such as transformers, motors and control gear, domestic appliances, cables, lighting, switch gear and metering. Safety policies must be adhered to.

Note: Maintenance procedures must be conducted under supervision and in a simulated environment

Learning Outcomes:
The student is able to:
- Explain the principles and procedures to be applied during maintenance on three phase AC systems.
- Plan and prepare for maintenance on three phase AC systems.
- Maintain three phase AC systems.
- Record data and schedule next maintenance on the three phase AC systems.

Topic 6: Renewable energy system

Subject Outcome 6.1: Sketch a basic renewable circuit diagram

Learning Outcomes:
The student is able to:
- Interpret instructions according to work site procedures.
- Use symbols that conform to ISO standards.
- Describe the function of each component correctly.
- Sketch circuit diagrams neatly and symmetrically according to instructions.
- Ensure that circuit diagrams are functional according to instructions

Subject Outcome 6.2: Calculate a typical solar home or solar school load

Learning Outcomes
The student is able to:
- Identify appliance loads correctly as per data plates.
- Correctly determine approximate time of use for each appliance.
- Calculate the total kWhr load correctly for the system.

Subject Outcome 6.3: Assess renewable energy resource

Range: Wind and solar

Learning Outcomes
The student is able to:
- Identify data manuals correctly according to geographical location.
- Analyse data correctly for application.
- Carry out adjustments for height (wind data) correctly.
- Apply data correctly to determine the average available energy.
Subject Outcome 6.4: Calculate battery bank rating

Learning Outcomes
The student is able to:
- Convert KWhr load value correctly to Ahr value.
- Consider battery losses when calculating battery bank rating.
- Make the autonomy correction based on available data.

Subject Outcome 6.5: Calculate the solar array and/or wind turbine rating

Learning Outcomes
The student is able to:
- Calculate solar array and/or wind turbine rating correctly as per available resource and load data and manufacturers’ specifications.
- Calculate winter and summer variations for solar array and/or wind turbine rating.
- Describe and explain the effect of factors such as dirt build up and performance deterioration through aging on the calculations.
- Explain the effect of system losses in the calculations.

Subject Outcome 6.6: Select wire sizes correctly.

Learning Outcomes
The student is able to:
- Explain specifications in regard to minimum voltage drop.
- Identify and explain wire size tables.
- Select wire sizes correctly as per specifications and standards.

8. RESOURCE NEEDS FOR THE TEACHING OF ELECTRONIC CONTROL AND DIGITAL ELECTRONICS – LEVEL 3

8.1 Physical resources
Well equipped classrooms and workshops are essential for this practically orientated subject. If possible using the facilities of employers in the electrical field, for training, is preferred.

8.2 Human resources
- Lecturing staff must have appropriate electrical qualifications and must possess the necessary knowledge, skills and reflexive approach to ensure that students’ learning is kept up to date with the latest technologies and changing trends in their specialist field.
- Continuous staff development with exposure to an industrial environment is necessary for lecturers to acquire new skills and update their existing skills where new technologies have been introduced. Lecturers are required to spend a structured and routine period annually in an industrial environment for these purposes.
- Staff development in terms of updating teaching, learning and assessment skills is required on an ongoing basis, particularly for staff coming from industry into the educational environment of an FET college.
8.3 Other resources

The institution should have funding available to provide the following:

- consumables required to perform practical assignments and examinations
- maintenance of physical resources
- purchasing of new equipment.