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SOUTH AFRICA

Discipline Specific Training Guide for Registration as a Professional Technician in Mechatronic Engineering

R-05-TRONIC-PN

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ECSA

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DEFINITIONS

Engineering science: A body of knowledge based on the natural sciences and using mathematical formulation where necessary that extends knowledge and develops models and methods to support its application, to solve problems and to provide the knowledge base for engineering specialisations.

Engineering problem: A problematic situation that is amenable to analysis and solution using engineering sciences and methods.

Ill-posed problem: Problems for which the requirements are not fully defined or may be defined erroneously by the requesting party.

Integrated performance: An overall satisfactory outcome of an activity requires several outcomes to be satisfactorily attained. For example, a design requires analysis, synthesis, analysis of impacts, checking of regulatory conformance and judgement in decisions.

Level descriptor: A measure of performance demands at which outcomes must be demonstrated.

Management of engineering works or activities: The co-ordinated activities required to:

(a) direct and control everything that is constructed or results from construction or manufacturing operations
(b) operate engineering works safely and in the manner intended
(c) return the engineering works, the plant and the equipment to an acceptable condition by the renewal, replacement or mending of worn, damaged or decayed parts
(d) direct and control the engineering processes, systems, commissioning, operation and decommissioning of equipment
(e) maintain engineering works or equipment in a state in which it can perform its required function.

Outcome: A statement of the performance that a person must demonstrate to be judged competent at the *professional* level.

Over-determined problem: A problem for which the requirements are defined in excessive detail, making the required solution impossible to attain in all its aspects.

Practice area: A generally recognised or distinctive area of knowledge and expertise developed by an engineering practitioner by virtue of the path of education, training and experience followed.

Range statement: The required extent of or limitations on expected performance stated in terms of situations and circumstances in which outcomes are to be demonstrated.

Specified Category: A category of registration for persons registered through the Engineering Profession Act or through a combination of the Engineering Profession Act and external legislation who have specific engineering competencies at NQF Level 5 regarding an identified need to protect the safety, health and interest of the public and the environment in the performance of an engineering activity

Well-defined Engineering Work: This work is characterised by the following:

(a) Scope of practice area is defined by techniques applied; change by adopting new techniques into current practice.

(b) Practice area is located within a wider, complex context, with well-defined working relationships with other parties and disciplines.

(c) Work involves familiar, defined range of resources (including people, money, equipment, materials, technologies).

(d) Requires resolution of interactions manifested between specific technical factors with limited impact on wider issues.

(e) Is constrained by operational context, defined work package, time, finance, infrastructure, resources, facilities, standards and codes, applicable laws.

(f) Has risks and consequences that are locally important but not generally far reaching.

ABBREVIATIONS

CAD	Computer-aided Design
DCS	Distributed Control System.
HMI	Human–Machine Interface
PC	Personal computer.
PLC	Programmable Logic Controller.
SBC	Single Board Computer.
SCADA	Supervisory Control and Data Acquisition Control System.

BACKGROUND

The illustration below defines the documents that comprise the Engineering Council of South Africa (ECSA) system for registration in professional categories. The illustration also locates the current document.

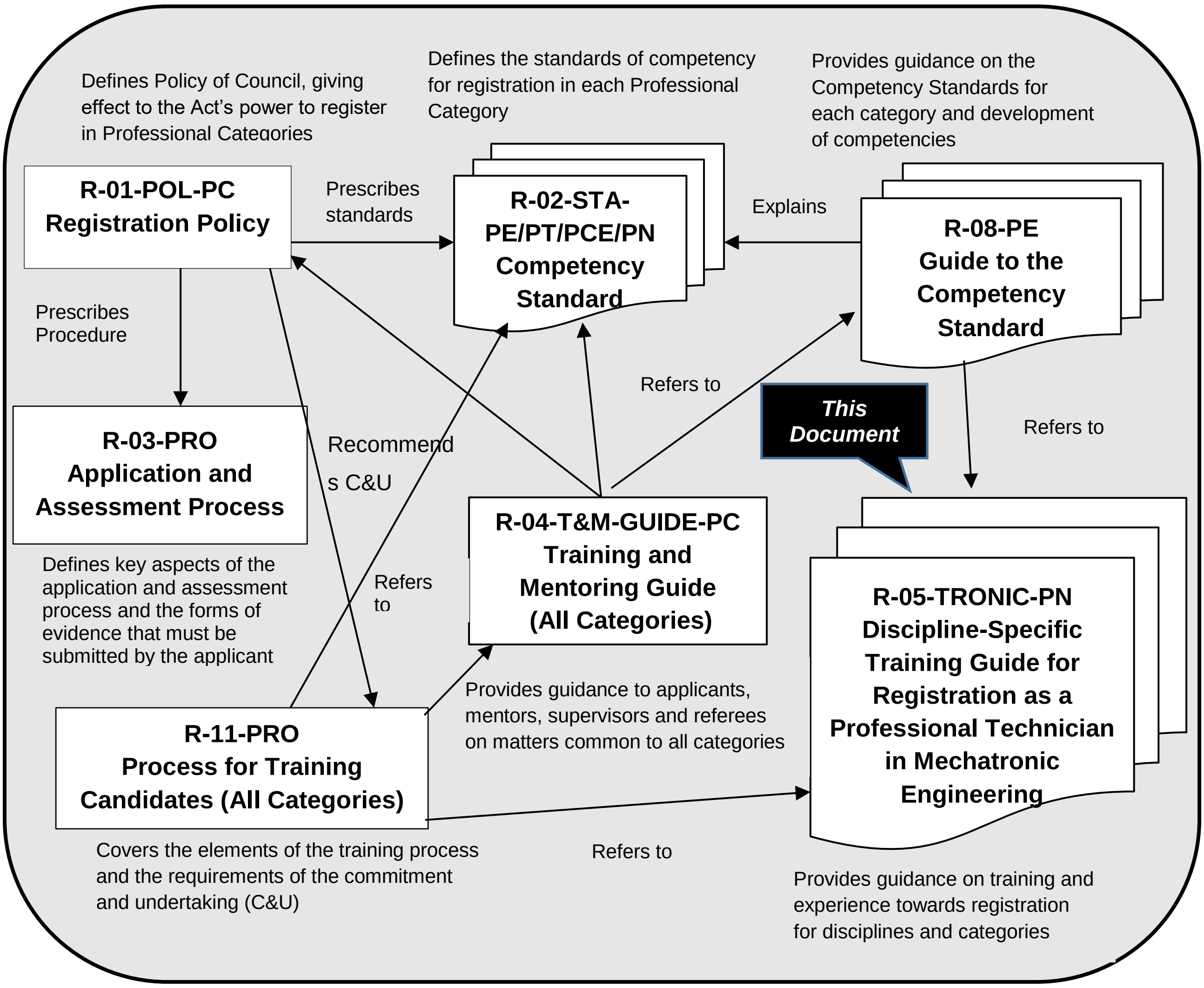

Figure 1: Documents defining the ECSA Registration System

1. PURPOSE OF THIS DOCUMENT

All persons applying for registration as a Professional Engineering Technician are expected to demonstrate the competencies specified in document **R-02-STA-PE/PT/PCE/PN** at the prescribed level though work performed by the applicant at the prescribed level of responsibility, irrespective of the trainee's discipline.

This document supplements the generic *Training and Mentoring Guide* (document **R-04-T&M-GUIDE-PC**) and the *Guide to the Competency Standards for Professional Engineering Technicians* (document **R-08-PN**).

In document **R-04-T&M-GUIDE-PC**, attention is drawn to the following sections:

- Duration of training and length of time working at level required for registration
- Principles of planning, training and experience
- Progression of training programme
- Documenting training and experience
- Demonstrating responsibility.

Document **R-08-PN** provides both a high-level and an outcome-by-outcome understanding of the competency standards that form an essential basis for this discipline-specific guide.

This guide and documents **R-04-T&M-GUIDE-PC** and **R-08-PN** are subordinate to the Policy on Registration in Professional Categories (document **R-01-POL-PC**), the Competency Standard for Registration in Professional Categories (document **R-02-PE/PT/PCE/PN**) and the Processing of Applications for Registration of Candidates and Professionals (document **R-03-PRO**).

2. AUDIENCE

This guide is directed towards candidates, their supervisors and mentors in the discipline of Mechatronic Engineering. The guide is intended to support a programme of training and experience, incorporating good practice elements.

This guide applies to persons who have:

- completed the educational requirements by obtaining an accredited NDip (National Diploma Engineering), Dip (Eng Tech), Adv. Cert Engineering type qualification, or by obtaining a Dublin Accord Recognised qualification, or through evaluation / assessment of prior learning

- registered as a Candidate Engineering Technician
- embarked on a process of acceptable training under a registered Commitment and Undertaking (C&U) with a mentor guiding the professional development process at each stage.

3. PERSONS NOT REGISTERED AS CANDIDATES OR NOT BEING TRAINED UNDER COMMITMENT AND UNDERTAKING

All applicants for registration must present the same evidence of competence and be assessed against the same standards, irrespective of the developmental path followed.

Application for registration as a Professional Engineering Technician is permitted without being registered as a Candidate Engineering Technician or without training under a C&U. However, mentorship and adequate supervision are key factors in effective development to the level required for registration. A C&U indicates that the company is committed to mentorship and supervision.

If the trainee's employer has no C&U, the trainee should establish the level of mentorship and supervision that the employer is able to provide. In the absence of an internal mentor, the services of an external mentor should be secured. The VA for the discipline should be consulted for assistance in locating an external mentor. A mentor should be in place at all stages of the development process.

This guide is for the recent graduate who is training and gaining experience towards registration. Mature applicants for registration may apply the guide retrospectively to identify possible gaps in their development.

Applicants who have not been through a mentorship programme are advised to request an experienced mentor (internal or external) to act as an application adviser while they prepare their applications for registration.

The guide may be applied in the case of a person moving at a later stage into a candidacy programme that is at a level below that required for registration (see Section 7.4 of this document).

Applicants who do not hold an NDip in Engineering may apply under an alternative route as indicated in document **E-18-PRO**. This alternative route considers number of years' experience, the well-defined engineering activities undertaken during this period and experience at the responsible level.

4. ORGANISING FRAMEWORK FOR OCCUPATIONS (21440)

Mechatronic Engineering is a multidisciplinary branch of engineering that focuses on the engineering of various systems, and includes a combination of robotics, electronics, computer, telecommunication, systems, control, and product engineering. The intention of mechatronics is to produce integrated solutions that are optimally controlled.

Mechatronic Engineering Technicians form a collective group of technicians who conduct well-defined research and design. They advise, plan and direct the construction and operation of automated devices and systems. They use their combined knowledge of and skills in mechanics, kinematics, pneumatics, hydraulics, electro-techniques / electronics, networking, programmable logic controllers and programming to enable connectivity between machines needed for systems operation. In addition, they use their knowledge of control algorithms, digital enterprise technologies, artificial intelligence, augmented reality, virtual reality and related technologies to optimise processes within various industries.

Other specialised disciplines in which Mechatronic Engineering Technicians may practise include:

- Aeronautical Engineering
- Agricultural Engineering
- Chemical Engineering
- Civil Engineering
- Electrical Engineering
- Industrial Engineering
- Metallurgical Engineering
- Information Technology
- Marine Engineering
- Biomedical Engineering.

Mechatronic Engineering Technicians also practise in combinations of the above specialties such as bio mechatronics, robotics, collaborative robots, prosthesis manufacturing and process control.

Various career paths are available to Mechatronic professionals:

4.1 FA: Factory Automation

Mechatronic Engineering Technicians perform automation of processes within a factory environment by using their knowledge, skills and experience to automate and or optimise production lines and other factory processes and systems.

Factory automation is mainly focused on complete modular discrete control consisting of sequential, speed control, packaging and batch control. Compared to process automation, it requires relatively faster response times.

4.2 PA: Process Automation

Mechatronic Engineering Technicians perform automation of processes within a process industry by using their knowledge, skills and experience to optimise production that usually consists of chemical, physical, or thermal processes.

Process automation is mainly focused on process control / monitoring (typically Distributed Control Systems – DCS) with relatively slower response time and safety instrumented systems along with high class faster response time PLCs and SIL certified components.

4.3 MD: Mechatronic Devices

Mechatronic Engineering Technicians perform automation of tasks by using their knowledge, skills and experience to automate and or optimise tasks.

Mechatronic devices/components/systems are mainly focused on complete modular discrete control consisting of mechanical devices using sequential, speed control, packaging and batch control.

Depending on the type of device/component/system the response times can vary from slow to very fast. Precision based mechanical engineering systems such as actuators, magnetic valves, on/off drives/motors, limit/proximity switches, sensors, etc. are typically used along with micro-controllers and modular PLCs as hardware and electronic/digital control algorithms for automation.

4.4 Industries

Industries in which mechatronic engineering technicians may practise include, among others, the following:

Possible Industry	FA	PA	MD
Agriculture			1
Construction	1	1	1
Custody Transfer and Tank Gauging		1	
Energy (including renewable energy and "green" technologies)	1	1	1
Finance			1
Food and Beverage	1	1	1
Fracking and Shale Gas Operations		1	
Healthcare			1
Manufacturing (such as Automotive, Chemicals, Metals, Textiles, Electronics etc.)	1	1	1
Maritime	1	1	1
Mining	1	1	1
Personal Services			1
Petrochemical (such as gas to liquids)		1	
Pipeline Operation and Monitoring		1	
Power Generation Automation		1	
Refinery automation		1	
Supply Chain (Warehousing & Distribution)	1		1
Terminal Automation and Storage		1	
Transport and Communication			1
Wholesale and Retail Trade	1		1

4.5 Technologies

Technologies used by Mechatronic Engineering Technicians may include, among others, the following:

Technologies	FA	PA	MD
Computation Systems			
Data Logging and Recording	1	1	1
Databases	1	1	1
DCS	1	1	
HMI	1	1	
Industrial Computer Hardware	1	1	
Micro-Controllers	1	1	1
Modular PLCs	1	1	1
OPC UA (OLE for Process Control)	1	1	
SCADA	1	1	
Single Board Computers (SBC) Automation (Raspberry Pi, Beagle Bone, Latte Panda. Etc.)	1	1	1
Traditional PC Based Automation	1	1	1
Integrated Devices such as Mobile Phones, Tablets etc.	1	1	1

Software	FA	PA	MD
Embedded Linux and Windows	1	1	1
Historians	1	1	
Understanding of Modern Automation Coding Languages such as C, C#, Python and SCL	1	1	1
Laboratory Information Management Systems	1	1	
Production Information Management Systems	1	1	

Network Technologies	FA	PA	MD
CAN Bus	1	1	1
Fibre	1	1	1

EtherCAT Ethernet		1	1
Foundation Fieldbus		1	1
Industrial Ethernet	1	1	1
Industrial Wireless and Telemetry	1	1	1
Modbus Network		1	1
Profibus	1	1	1
Profinet	1	1	1

The Digital Enterprise and Information Technology	**FA**	**PA**	**MD**
Artificial Intelligence	1	1	1
Augmented Reality	1	1	1
Cloud Storage/Services, Edge Computing, Industrial 5G	1	1	1
Digital Twins	1	1	1
Virtual Commissioning	1	1	1
Embedded Control Technologies	1		1

Process Control Technologies	**FA**	**PA**	**MD**
Alarm Management		1	
Anti-Surge Control		1	
Control Room Design and Lay-out		1	
Enclosures, Cabling and Accessories		1	
Process Measurement (incl. Temperature, Pressure, Level, Flow and Mass)		1	
Safety Systems (incl. Hazardous Area Equipment, Fail–safe Systems etc.)	1	1	
Vibration Monitoring		1	

Power Electronics and Drives	**FA**	**PA**	**MD**
Low to Medium Current Electrical Distribution	1	1	1
Motor Drives	1	1	1

Power Supply Systems	1	1	1
Power Amplifiers	1	1	1

Process Technology	**FA**	**PA**	**MD**
Gas Analysers		1	
Gas Detectors		1	
Product Sampling		1	
Mechanical Design	**FA**	**PA**	**MD**
Computer Aided Design and CNC	1		1
Mechanical Simulation and Finite Element Analysis	1		1
Robotics (Industrial, Mobile, Autonomous Systems	1		1

Manufacturing	**FA**	**PA**	**MD**
Additive Manufacturing and Nanotechnology	1		1
Subtractive Manufacturing (Traditional Machining)	1		1
CAM including Creating Toolpaths from CAD			1
CNC Machining			1
Machining Techniques			1
Material Science			1
Slicers			1

Mechanical Technology	**FA**	**PA**	**MD**
Actuators and Transmission Systems	1	1	1
Electromechanical Actuators	1	1	1
Hydraulics	1	1	1
Pneumatics	1	1	1
Control Valves	1	1	1

Other Technologies	FA	PA	MD
Energy Usage Optimization	1	1	
Green Buildings	1	1	
Renewable Energy Technologies	1	1	
Sensors	1	1	1
Vision Systems	1	1	1

5. NATURE AND ORGANISATION OF THE INDUSTRY

5.1 Group A: Engineering Problem Solving

5.1.1 Outcome 1 – Define, investigate and analyse well-defined engineering problems

Applicants are expected to be exposed to the technical investigation of equipment, plant and product failure. The intent is for applicants to be able to define the engineering problem and to investigate and analyse well-defined engineering problems.

They must also be able to demonstrate their ability to investigate a product or equipment failure.

Tasks

As seen above, typical tasks could include the following:

Table 1: Outcome 1

TASK	FA	PA	MD
Consulting	1	1	1
Analyse a problem	1	1	1
Research	1	1	1
Diagnose a fault	1	1	1
Area and equipment classification		1	
Calibration	1	1	1
Alarm Management		1	

5.1.2 Outcome 2 – Design or develop solutions to well-defined engineering problems

Research and development constitute the first stage of development of a potential new service, process or product or the first stages to improve existing services, process or product. Research and development technicians are responsible for assisting a researcher or research team with product development or improvement projects by doing research and development on well-defined areas.

Process designs typically use several tools including flowcharting, process simulation software, digital twins. This includes the design of new equipment, facilities or the modification or expansion of existing facilities. Organisations often introduce processes to standardise their designs and operations for efficiency purposes. Engineering Technicians operating in the various industries are expected to understand the process design of their industrial environment.

Applicants must be able to design a solution for a well-defined engineering problem and be able to demonstrate different options that were considered to develop the solution and the reason for the eventual design.

Tasks

As seen above, typical tasks could include:

Table 2: Outcome 2

TASKS	FA	PA	MD
Interactive design	1	1	1
Modelling and analysis (Cost effective automation)	1	1	1
Systems engineering (Integration and technical standards)	1	1	1
Inspection of product quality	1	1	1
Optimise system	1	1	1

5.1.3 Outcome 3 – Jurisdiction – specific knowledge and practices

Candidate Mechatronic Engineering Technicians must demonstrate the following:

- Ability to implement the solution, have a thorough understanding of the specific knowledge areas and engineering practices in the career path they are operating in.

Tasks

As seen above, tasks could include:

Table 3: Outcome 3

TASKS	FA	PA	MD
Implementing the solution	1	1	1
Identify and apply applicable technical standards	1	1	1
Data genealogy	1	1	

5.2 Group B: Managing Engineering Activities

5.2.1 Outcome 4 – Engineering project management

Areas in which Mechatronic Engineering Technicians work generally follow a conventional project or product development life cycle model:

- Research and development to develop new products or systems, solve problems, optimise a process or make changes due to obsolescence.
- System or product design to develop a new system or product, to solve a system or product problem, to achieve a particular desired result, or to select equipment for a particular purpose.
- Install, test and commission the necessary equipment or system for the desired result.
- Operation and maintenance of the system or network or support of the product.
- Decommissioning of the system or network.

It is expected that Candidate Technicians or persons wishing to register with the ECSA as Professional Engineering Technicians must get involved and gain experience in all generic engineering competencies of problem solving, implementation, operation, risk and impact mitigation and management.

Tasks

As seen above, tasks could include:

Table 4: Outcome 4

TASKS	FA	PA	MD
Project organising and technical inputs	1	1	1
Consulting (Cost effective automation)	1	1	1
Adjusting system parameters	1	1	1
Loop checking		1	
Maintenance	1	1	1
Procurement	1	1	1
Programming equipment	1	1	1
Start-up and commissioning	1	1	1
Repair	1	1	1
Testing	1	1	1
Training plant staff and operators	1	1	
Troubleshooting	1	1	1

5.2.2 Outcome 5 – Communication

Candidate Mechatronic Engineering Technicians must demonstrate:

- accurate communication techniques within the work environment
- accurate reporting regarding the activities within a well-defined environment
- how feedback was obtained from the resources at the Candidate's disposal
- how communication ensured the outcome of the tasks.

Tasks

As seen above, tasks could include:

Table 5: Outcome 5

TASKS	FA	PA	MD
Reference to education level applied to justify decisions	1	1	1
Take advice on matters outside Candidate's education / experience	1	1	1
Self-assessment	1	1	1

5.3 Group C: Impacts of Engineering Activities

5.3.1 Outcome 6 – Social, cultural and environmental impact

Candidate Mechatronic Engineering Technicians must demonstrate:

- which social, cultural and environmental impact assessments were considered during the tasks at hand
- how these impact assessments were considered and catered for.

Tasks

As seen above, tasks could include:

Table 6: Outcome 6

TASKS	FA	PA	MD
Documentation and communication	1	1	1
Impact assessment	1	1	1

5.3.3 Outcome 7 – Meet legal and regulatory requirements

Candidate Mechatronic Engineering Technicians must demonstrate:

- which legal and regulatory requirements were applicable to the tasks at hand
- actions that were taken to ensure these requirements were met.

Tasks

As seen above, tasks could include:

Table 7: Outcome 7

TASKS	FA	PA	MD
Identify and interpret applicable regulatory requirements	1	1	1
Documentation and communication	1	1	1
Certifications, functional safety etc.	1	1	1

5.4 Group D: Act Ethically, Exercise Sound Judgment and Take Responsibility

5.4.1 Outcome 8 – Ethical engineering activities

Due to work stresses, time constraints and management pressure, many Candidates must make choices that involve ethical considerations.

- Candidates are requested to recall any such an incident (if one took place) and the impact it had on the task.
- Regardless of whether Candidates can show such an example, Candidate must demonstrate that they know and understand ECSA's Code of Conduct.

Tasks

As seen above, tasks could include:

Table 8: Outcome 8

TASKS	FA	PA	MD
Documentation and communication	1	1	1

5.4.2 Outcome 9 – Exercise sound judgement

Mechatronic Engineering covers a wide range of industries and may, among other processes, include a single unit, a production line or even a chemical production process.

Judgment in decision making involves:

(a) taking diverse, wide ranging risk factors into account

(b) significant consequences in a range of contexts; or

(c) wide ranges of interested and affected parties with widely varying needs.

Tasks

As seen above, tasks could include:

Table 9: Outcome 9

TASKS	FA	PA	MD
Documentation and communication	1	1	1
Hazard identification and risk assessment	1	1	1

Reliability analysis	1	1	1
Modelling	1	1	1
Systems engineering (Integration)	1	1	1

5.4.3 Outcome 10 – Taking responsibility

Some decisions are based on the theory presented during the education process. Candidates need to document what education level theory they applied to justify the decisions made.

In other cases, if advice was required on matters falling outside the Candidate's education and experience, the Candidate needs to indicate how this advice was taken.

It is also important for Candidates to take responsibility for their own work. Candidates need to explain how they evaluated and identified any shortcomings in their output.

Tasks

As seen above, tasks could include:

Table 10: Outcome 10

TASKS	FA	PA	MD
Reference to education level applied to justify decisions	1	1	1
Take advice on matters outside Candidate's education / experience	1	1	1
Self-assessment	1	1	1

5.5 Group E: Initial Professional Development

Candidate Mechatronic Engineering Technicians must demonstrate:

- that they are in the habit of updating their personal knowledge and skills to stay up to date with the latest technologies, policies, procedures, etc. required in their field of work.

Tasks

As seen above, tasks could include:

Table 11: Outcome 11

TASKS	FA	PA	MD
Attend course / workshop	1	1	1
Additional qualifications	1	1	1
Documentation and communication	1	1	1

6. DEVELOPING COMPETENCY: DOCUMENT R-08-PN

6.1 Contextual knowledge

Candidates are expected to be aware of the requirements of the engineering profession. The Voluntary Associations (VAs) applicable to Mechatronic Engineering Technicians and their functions and services to members provide a broad range of contextual knowledge for Candidate Engineering Technicians through the registered Engineering Technician's full career path.

The profession identifies specific contextual activities that are considered essential in the development of competence of the Mechatronic Engineering Technician. These include the applicable basic analytical, process and fabrication activities and the competencies required for registration at the applicable category. Exposure to practice in these areas is identified in each programme within the employer environment.

The ECSA Registration Committee carries out the review of the Candidate's portfolio of evidence at the completion of the training period.

6.2 Functions performed

The functions required to a greater or lesser extent in all the areas of employment and in which all Mechatronic Engineering Technicians need to be proficient are listed below. The parallels with the well-defined generic competence elements required by the Competency Standard (document **R-02-STA-PE/PT/PCE/PN**) should be clear.

Special considerations in the discipline, sub-discipline or specialty must be given to the competencies specified in the following groups:

- Group A: Engineering problem solving (this should be a strong focus)

- Group B: Managing engineering activities
- Group C: Impacts of engineering activities
- Group D: Act ethically, exercise sound judgement and take responsibility
- Group E: Continuing professional development.

It is very useful to measure the progression of the Candidate's competency by using the scales regarding Degree of Responsibility, Problem Solving and Engineering Activity as specified in document **R-04-T&M-GUIDE-PC**.

Appendix A was developed against the Degree of Responsibility Scale. Activities should be selected to ensure that the Candidate reaches the required level of competency and responsibility. It should be noted that the Candidate working at Responsibility Level E carries the responsibility appropriate to that of a registered person except that the Candidate's supervisor is accountable for the Candidate's recommendations and decisions.

The nature of work and the degrees of responsibility defined in document **R-04-T&M-GUIDE-PC** are presented here and in **Appendix A.**

A: Being	B: Assisting	C: Participating	D: Contributing	E: Performing
Undergoes induction; observes processes and work of competent practitioners.	Performs specific processes under close supervision.	Performs specific processes as directed with limited supervision.	Performs specific work with detailed approval of work outputs.	Works in team without supervision; recommends work outputs; responsible but not accountable.
Responsible to supervisor.	Limited responsibility for work output.	Full responsibility for supervised work.	Full responsibility to supervisor for immediate quality of work.	Level of responsibility to supervisor is equivalent to that of a registered person; supervisor is accountable for applicant's decisions.

6.3 Statutory and regulatory requirements

Candidate Engineering Technicians must be aware of and understand the statutory and regulatory requirements for the tasks at hand and the environment that they are working in.

These could include the following:

- Council for the Built Environment Act, 43 2000
- Engineering Profession Act, 46 of 2000, including Rules and specifically the Code of Conduct
- ECSA Code of Conduct
- Occupational Health and Safety Act, 85 of 1993 (OHS Act) and Regulations
- Mine Health and Safety Act, 29 of 1996 (see www.dmr.gov.za)
- National Environmental Management Act, 107 of 1998 (Various measures relating to pollution of a water resource; Waterworks process controller)
- National Environmental Management Waste Act, 59 of 2008
- SANS Codes for Specification for Piping Design / Material (ANSI) (see www.sabs.co.za)
- SANS 10248, 1023: Waste Classification and Management Regulations from the Constitution of the Republic of South Africa, 1996
- Minerals and Energy Acts (e.g. Mineral and Petroleum Act, 28 of 2002)
- Project and Construction Management Professions Act, 48 of 2000
- Nuclear Energy Act, 46 of 1999
- National Water Act, 36 of 1998
- ISO 9001
- IEC61158 – Industrial communication networks
- IEC60654 – Industrial-process measurement and control equipment
- IEC60584 – Thermocouples – Part 1: EMF specifications and tolerances
- IEC61131 – Programmable Controllers
- IEC61326 – Electrical equipment for measurement, control and laboratory use – EMC requirements
- IEC60534 – Industrial-process control valves
- IEC62337 – Commissioning of electrical, instrumentation and control systems in the process industry

- IEC62381 – Automation systems in the process industry – Factory acceptance test (FAT), site acceptance test (SAT), and site integration test (SIT)
- IEC62382 – Control systems in the process industry – Electrical and instrumentation loop check
- IEC61512 – Batch control
- IEC62541 – OPC Unified Architecture
- IEC62264 – Enterprise-control system integration
- IEC62061 – Insulating liquids – Determination of acidity
- IEC61513 – Nuclear power plants – Instrumentation and control important to safety
- ISO 14971:2000 – Medical Devices Risk Management
- ISO 13485 – Medical devices – Quality Management Systems
- ISA-18 – Alarm Management
- ISA-88 – Batch Process Control
- ISA-95 – Enterprise Control System Integration
- ISA-101 – Human Machine Interfaces
- ISA-106 – Procedure Automation for Continuous Process Operations
- ISO12100 – Safety of Machinery – General Principles for Design – Risk Assessment and Risk Reduction.

5.5 Desirable formal learning activities

Attendance of relevant technical courses and conferences is recommended. Formal safety training should be mandatory, especially in the industry that they are operating in.

Candidate Engineering Technicians should register with the relevant VAs to access lists of training courses / conferences / seminars and other relevant information e.g.:

- Society for Automation, Instrumentation, Mechatronics and Control (SAIMC)
- South African Institution of Mechanical Engineering (SAIMechE)
- South African Institute of Electrical Engineers (SAIEE) etc.

Training / courses recommended include the following:

- Problem solving and analysis tools (e.g. brain storming, gap analysis, FMEA, Pareto Analysis, root cause analysis, problem tree analysis, trade-off tools)

- Risk assessment and analysis techniques
- Project management techniques and tools, including conditions of contract management, finance and economics, quality systems, stakeholder management and Project Management (planning, scheduling and project controls), tools and software (e.g. MS Project, Primavera, Project Risk Analysis tools, Earned Value Management [EVM] and other Tools)
- Modelling and simulation tools
- Occupation health and safety, including the OHS Act and 'safety in design'
- Formally registered CPD courses in Mechatronic Engineering and associated disciplines
- Financial competency such as finance for non-financial managers etc.
- Preparation of engineering design specifications
- Environmental aspects of projects and plant operations
- Professional skills such as report writing, presentations, facilitation and negotiation
- Courses intended to keep the Candidate updated on the latest technology
- Courses intended to increase the performance of the Candidate, which could include management techniques, time management, emotional intelligence etc.
- Updates on relevant equipment, its use, maintenance etc.
- Updates on applicable tools such as plant operations, performance monitoring etc.
- Maintenance and reliability engineering.

7. PROGRAMME STRUCTURE AND SEQUENCING

7.1 Best practice

Best practice is a developmental process that assists applicants to register as Professional Engineering Technicians. Best practice comprises the process used for the Candidate's continuous development. Several courses (technical and management) should be attended in order to gain Initial Professional Development (IPD) at the level required for registration as well as on-the-job- learning at the organisations in which the Candidate was / is employed.

Applicants are encouraged to join at least one VA registered with ECSA to gain access to courses, articles and relevant information for their development. Such registration may also present opportunities to meet with experts during seminars.

It is suggested that Candidates work with their mentors to determine appropriate projects for gaining exposure to elements of the asset lifecycle and to ensure that their designs are constructible, operable and are designed considering lifecycle costing and long-term sustainability. A regular reporting structure with suitable recording of evidence of achievement against the competency outcomes and level of responsibility needs to be in place.

The training programme should be such that Candidates progress through the levels of work capability described in document **R-04-T&M-GUIDE-PC** so that by the end of the training period, Candidates can perform as individuals and as team members at the level of problem solving and well-defined engineering activity required for registration, exhibiting a Degree of Responsibility Level E.

7.2 Realities

There is no ideal training programme structure or unique sequencing that constitutes best practice. Each Candidate's training programme depends on the work opportunities available at the time for the employer to assign to the Candidate. For ECSA registration in the fields in which the Candidates are employed, applicants must ensure that they undertake tasks that provide experience in the three generic engineering competence elements of problem investigation and analysis, problem solution and execution / implementation.

It should be possible by judicious selection of work task opportunities with the same employer to gain experience in all three elements. Candidate Engineering Technicians are advised that although three years is the minimum required period of experience following graduation, in practice, Mechatronic Engineering Technicians seldom meet the experience requirements in three years, and then only if they have followed a structured training programme.

7.3 Considerations for generalists, specialists, researchers and academics

To be able to become a Professional Engineering Technician, lecturers/researchers must become involved in the application of engineering knowledge by way of applied research and consulting work under the supervision of a Professional Engineering Technician, Technologist or Engineer.

For generalists and specialists, provided the applicant's specialist knowledge is at least at the level of the required academic qualification and provided the applicant has demonstrated the ability to identify engineering problems at a professional level and to produce well-defined- solutions that can be satisfactorily implemented, a degree of trade-off may be acceptable in assessing the experience. Where an applicant's experience is judged to be in a narrow specialist field, a minimum of five years' experience after obtaining the academic qualification may be required, but each application will be considered on merit.

Applicants who studied in other engineering disciplines may find themselves in a Mechatronics environment and can undertake mechatronics duties with the proviso that their experience has been in the Mechatronics field.

Candidates working towards becoming Professional Engineering Technicians while in the academic environment need to satisfy the requirements of paragraph 1 and be involved in well-defined engineering activities which could include the following:

Teaching / Lecturing / Facilitation

- Reading in applicable fields of knowledge
- Curriculum development
- Selection and development of teaching materials
- Compilation of lecture notes
- Compilation of examination papers
- Demonstration of application of theory in practice
- Service as supervisor for student projects.

Research or further studying

- Literature surveys
- Obtaining higher qualifications
- Advancement of the current state-of-the-art technology
- Theoretical research / development of analytical techniques
- Practical/experimental research
- Participation in international collaborative research.

Laboratory experimental activities

- Experimentation
- Design and building of laboratories
- Experimental equipment design / construction
- Experiment design
- Development of new manufacturing techniques.

Conferences / Symposia / Seminars

- Publishing papers (peer-reviewed journals and international conferences)
- Public speaking.

Consulting (exposure recommended for academics)

- Consulting to industry in solving real problems encountered in engineering practice
- Design of products / structures / systems / components
- Supervise applied post-graduate and final year projects.

Multi-disciplinary exposure

Interphase management between various disciplines needs to be formalised. Details of signed-off interface documents among different disciplines are essential.

Orientation requirements

- Introduction to company safety regulations
- Company code of conduct
- Company staff code and regulations
- Typical functions and activities in company
- Hands-on experience and orientation in each of the major company divisions.

7.4 Moving into or between candidacy training programmes

This guide assumes that the Candidate enters a programme after graduation and continues with the programme until ready to apply for registration. It also assumes that the Candidate is supervised and mentored by persons who meet the requirements indicated in document **R-04-T&M-GUIDE-PC**. In the case of a person changing from one candidacy programme to another or moving into a candidacy programme from a less structured environment, it is essential that the following steps are completed:

- The Candidate must complete the Training and Experience Summary (TES) and the Training and Experience Reports (TERs) for the previous programme or unstructured experience. In the latter case, it is important to reconstruct the experience as accurately as possible. The TERs must be signed off.
- On entering the new programme, the mentor and supervisor should review the Candidate's development, taking into consideration experience, opportunities and the requirements of the new programme and planning at least the next phase of the Candidate's programme.

REVISION HISTORY

Revision Number	Revision Date	Revision Details	Approved By
Rev. 0 Draft A	29 July 2020	First Draft	Working Group
Rev. 0 Draft B	07 Sept 2020	Final Draft	Working Group
Rev. 0 Draft C	21 October 2020	Review by the Executive	Executive: RPS - EL Nxumalo
Rev. 0 Draft D	02 November 2020	Stakeholder Consultation	RPS & Stakeholder Relations
Rev. 0 Draft E	29 January 2021	Review and recommendation for Approval	Executive: RPS - EL Nxumalo
Revision. 0	13 April 2021	Approval	RPSC

The Discipline-specific Training Guide for:

Candidate Professional Technician in Mechatronic Engineering

Revision 0 dated 13 April 2021 and consisting of 33 pages has been reviewed for adequacy by the Business Unit Manager and is approved by the Executive: Research Policy and Standards **(RPS).**

.... 15/04/2021

Business Unit Manager — Date

.... 19/04/2021

Executive: **RPS** — Date

This definitive version of this policy is available on our website

APPENDIX A: TRAINING ELEMENTS

Synopsis: Candidate Technicians should achieve specific competencies at the prescribed level during their development towards professional registration and at the same time should accept more responsibility as experience is gained. The outcomes achieved and established during the Candidacy Phase should form the template for all engineering work performed after professional registration regardless of the level of responsibility at any particular stage of the engineering career:

1. Confirm understanding of instructions received and clarify if necessary
2. Use theoretical training to develop possible solutions, thereafter selecting the best and presenting to the recipient
3. Apply theoretical knowledge to justify decisions taken and processes used
4. Understand role in the work team and plan and schedule work accordingly
5. Issue complete and clear instructions and report comprehensively on work progress
6. Be sensitive about the impact of the engineering activity and take action to mitigate this impact
7. Consider and adhere to legislation applicable to the task and the associated risk identification and management
8. Adhere strictly to high ethical behavioural standards and to the ECSA Code of Conduct
9. Display sound judgement by considering all factors, their interrelationship, consequences and evaluation when all evidence is not available
10. Accept responsibility for own work by using theory to support decisions, seeking advice when uncertain and evaluating shortcomings
11. Become conversant with employer's training and development programme and develop own lifelong development programme within this framework

Well-defined engineering work is usually restricted to applying standard procedures, codes and systems (i.e. work that was done before).

Responsibility Levels: A = Being Exposed; B = Assisting; C = Participating; D = Contributing; E = Performing

Competency Standards for Registration as a Professional Engineering Technician	Explanation and Responsibility Level
1. Purpose This standard defines the competence required for registration as a Professional Engineering Technician. Definitions of terms having particular meaning within this standard are presented in Appendix B.	Discipline-Specific Training Guides (DSTGs) give context to the purpose of the Competency Standards. Professional Technicians operate within the nine disciplines recognised by the ECSA. Each discipline can be further divided into sub-disciplines and finally, into specific workplaces as demonstrated in Clause 4 of the specific DSTG. Discipline-Specific Training Guides are used to facilitate experiential development towards ECSA registration and assist in compiling the required portfolio of evidence (specifically the Engineering Report in the application form). NOTE: The training period must be used to develop the competence of the trainee towards achieving the standards presented below at a Responsibility Level E (i.e. Performing). Refer to Section 7.1 of the specific DSTG.
2. Demonstration of Competence Competence must be demonstrated within ***well-defined engineering activities*** (defined below) by the integrated performance of the outcomes defined in Section 3 at the level defined for each outcome. Required contexts and functions may be specified in the applicable DSTG. **Level Descriptor: *Well-defined engineering activities (WDEA) have*** several of the following characteristics: a) *Scope* of practice area is defined by techniques applied; change is by adopting new techniques into current practice. b) Practice area is located within a wider, complex *context,* with well-defined working relationships with other parties and disciplines. c) Work involves a familiar, defined range of *resources,* including people, money, equipment, materials and technologies. d) Activities require resolution of *interactions* manifested between specific technical factors with limited impact on wider issues. e) Activities are *constrained* by operational context, defined work package, time, finance, infrastructure, resources, facilities, standards and codes, and applicable laws. f) Activities have *risks* and *consequences* that are locally important but are generally not far reaching ***Activities*** include design; planning; investigation and problem resolution; improvement of materials, components, systems and processes; manufacture and construction; engineering operations; maintenance; project management; research; development; and commercialisation.	Engineering activities can be approximately divided into 5% Complex (Professional Engineers) 5% Broadly Defined (Professional Technologists) 10% Well-Defined (Professional Technicians) 15% Narrowly Well-Defined (Registered Specified Categories) 20% Skilled Workman (Engineering Artisan) 55% Unskilled Workman (Artisan Assistant) The activities can be in-house or contracted out; evidence of integrated performance can be submitted irrespective of the situation. **Level Descriptor: *WDEA*** in the various disciplines are characterised by several or all of the following: a) *Scope* of practice area does not cover the entire field of the discipline (exposure limited to the sub-discipline and specific workplace). Techniques applied are largely well established, and change by adopting new techniques into current practice is the exception. b) Practice area varies substantially with unlimited location possibilities, resulting in the additional responsibility of identifying the need for complex and/or *broadly defined* advice to be included in the well-defined working relationships with other parties and disciplines. c) The bulk of the work involves a familiar, defined range of *resources* that includes people, money, equipment, materials and technologies. d) Most of the impacts in the sub-discipline are on wider issues and although occurring frequently, are *well-defined* and can be resolved by following established procedures. e) The work packages and associated parameters are *constrained* by operational context with variations limited to different locations only (cannot be covered by standards and codes). f) Even locally important minor risks can have far-reaching consequences. ***Activities*** include design; planning; investigation and problem resolution; improvement of materials, components, systems or processes; engineering operations; maintenance; and project management. For Engineering Technicians, research, development and commercialisation happen more frequently in some disciplines and are seldom encountered in others.

3. Outcomes to be satisfied	Explanation and Responsibility Level
Group A: Engineering Problem-Solving	
Outcome 1: Define, investigate and analyse *well-defined engineering problems*	**Responsibility Level E** Analysis of an engineering problem means the 'separation into parts, possibly with comment and judgement'.
Well-defined engineering problems have the following characteristics: (a) can be solved mainly by practical engineering knowledge underpinned by related theory; *and one or more of:* (b) are largely defined but may require clarification; (c) are discrete, focused tasks within engineering systems; (d) are routine, frequently encountered, may be unfamiliar but in a familiar context; *and one or more of:* (e) can be solved by standardised or prescribed ways; (f) are encompassed by standards, codes and documented procedures; authorisation required to work outside limits; (g) information is concrete and largely complete but requires checking and possible supplementation; (h) involve several issues (few of these impose conflicting constraints) and a limited range of interested and affected parties; *and one or both of:* (i) require practical judgement in the practice area in the evaluation of solutions and consideration of interfaces to other role players; and (j) have consequences that are locally important but not far reaching (wider impacts are dealt with by others).	(a) A practical problem for Engineering Technicians means the problem encountered cannot be solved by artisans because theoretical calculations and engineering decisions are necessary to substantiate the solution proposed. (b) Further investigation to identify the nature of the problem is seldom necessary. (c) The problem is discrete, meaning it is *individually distinct* and easily recognised as part of the larger engineering task, project or operation. (d) It is recognised that the problem occurred in the past or the possibility exists that it may have happened before; it is definitely and possibly occurred in the past therefore it is not a new problem. (e) The problem does not require the development of a new solution (determine how the problem was previously solved). (f) Encompassed means *encircled:* The standards, codes and documented procedures must be obtained to solve the problem, and authorisation from the Engineer or Technologist in charge must be obtained to waive the stipulations. (g) The responsibility lies with the Engineering Technician to check that the information received regarding the problem encountered is correct and is added to as necessary to ensure the correct and complete execution of the work. (h) The problem handled by the Engineering Technician must be limited to well-known matters and preferably requires standardised solutions without possible complications. (i) Practical solutions to problems include knowledge of the skills displayed by Practical Specialists and Engineering Artisans without sacrificing theoretical engineering principles and/or taking shortcuts to satisfy the parties involved. (j) Engineering Technicians must realise that their actions may appear to be of local importance only but may develop into problems for which support from Engineers and Technologists may be needed to deal with the consequences.
Assessment Criteria: A structured analysis of well-defined problems typified by the following performances is expected. 1.1 State how <u>you</u> interpreted the work instruction received, checking with your client or supervisor that your interpretation is correct. 1.2 Describe how <u>you</u> analysed, obtained and evaluated further clarifying information and indicate if the instruction was revised as a result.	To perform an engineering task, an Engineering Technician will typically receive an instruction from a senior person (customer) to perform the task and must 1.1 ensure that the instruction is complete, clear and within his/her capability and that the person who issued the instruction agrees with his/her interpretation; and 1.2 ensure that the instruction and information to do the work is complete and fully understood, including the engineering theory needed to understand the task and to carry out and/or check the calculations and the acceptance criteria. If needed, supplementary information must be gathered, studied and understood.

Range Statement: The problem may be part of a larger engineering activity or may stand alone. The design problem is amenable to solution by established techniques that are practised regularly by the candidate. Outcome 1 is concerned with the understanding of a problem; Outcome 2 is concerned with the solution.	**Please refer to Clause 4 of the specific DSTG.**
Outcome 2: Design or develop solutions to *well-defined engineering problems*	**Responsibility levels C and D** Design means 'drawing or outline from which something can be made'. Develop means 'come or bring into a state in which it is active or visible'.
Assessment Criteria: This outcome is normally demonstrated after the problem analysis defined in Outcome 1. Working systematically to synthesise a solution to a well-defined problem typified by the following performances is expected. 2.1 Describe how you designed or developed and analysed alternative approaches to do the work. Impacts checked. Calculations attached. 2.2 State your final solution to perform the work – client or supervisor in agreement.	After the task received is fully understood and interpreted, a solution to the problem posed can be developed (designed). To synthesise a solution means 'to combine separate parts, elements, substances, etc. into a whole or into a system'. 2.1 The development (design) of more than one way to solve an engineering task or problem should always be done and include the costing and impact assessment for each alternative. All the alternatives must meet the requirements set out by the instruction received, and the theoretical calculations to support each alternative must be done and submitted as an attachment. 2.2 In some cases, the Engineering Technician will not be able to support proposals with the complete theoretical calculation substantiating every aspect and must, in these cases, refer his/her alternatives to an Engineer or Technologist for scrutiny and support. The alternatives and the recommended alternative must be convincingly detailed to win customer support for the recommended alternative. Selection of alternatives may be based on tenders submitted with alternatives deviating from those specified.
Range Statement: The solution is amenable to established methods, techniques and procedures within the candidate's practice area.	Applying theory to *well-defined engineering* work is done in a way that has been used before. The process was probably developed by Engineers or Technologists in the past and documented in written procedures, specifications, drawings, models, examples, etc. Engineering Technicians must seek approval for any deviation from these established methods.
Outcome 3: Comprehend and apply knowledge embodied in established engineering practices and knowledge specific to the jurisdiction in which he/she practises.	**Responsibility Level E** Comprehend means to understand fully. The jurisdiction in which an Engineering Technician practises is given in **Clause 4 of the specific DSTG**.
Assessment Criteria: This outcome is normally demonstrated in the course of design, investigation or operations. 3.1 State which NDip-level engineering standard procedures and systems you used to execute the work and how NDip-level theory was applied to understand and/or verify these procedures. 3.2 Provide your own NDip-level theoretical calculations and/or reasoning on why the application of this theory is considered correct (actual examples required).	Design work for Engineering Technicians mainly involves utilising and configuring manufactured components. The design work is repetitive and uses an existing design as an example. Engineering Technicians apply existing codes and procedures in their design work. Investigation is on well-defined incidents. Condition monitoring and operations mainly involve controlling, maintaining and improving engineering systems and operations. 3.1 The understanding of well-defined procedures and techniques must be based on fundamental mathematical, scientific and engineering knowledge. Specific procedures and techniques applied to do the work accompanied by the underpinning theory must be given. 3.2 Calculations confirming the correct application and utilisation of equipment listed in Clause 4 of the specific DSTG must be done on practical *well-defined activities.* Reference must be made to standards and procedures used and how these were derived from NDip theory.

Range Statement: Applicable knowledge includes the following: (a) Technical knowledge that is applicable to the practice area irrespective of location and is supplemented by locally relevant knowledge, for example, established properties of local materials (b) A working knowledge of interacting disciplines and codified knowledge in related areas: financial, statutory, safety, management (c) Jurisdictional knowledge regarding legal and regulatory requirements and prescribed codes of practice	(a) The specific location of a task to be executed is the most important determining factor in the layout design and utilisation of equipment. A combination of educational knowledge and practical experience must be used to substantiate decisions taken and must include a comprehensive study of materials, components and projected customer requirements and expectations. (b) Regardless of having a working knowledge of interacting disciplines, Engineering Technicians must appreciate the importance of working with specialists such as Civil Engineers on structures and roads, Mechanical Engineers on fire protection equipment, Architects on buildings and Electrical Engineers on communication equipment. The codified knowledge in the related areas means working to and understanding the requirements set out by specialists in the areas mentioned. (c) Jurisdictional in this instance means 'having the authority', and Engineering Technicians must adhere to the terms and conditions associated with each task undertaken. The Engineering Technician may be appointed as the 'responsible person' for specific duties in terms of the OHS Act.

Group B: Managing Engineering Activities	Explanation and Responsibility Level
Outcome 4: Manage part or all of one or more *well-defined engineering activities*	**Responsibility Level D** Manage means 'control'.
Assessment Criteria: The display of personal and work process management abilities is expected: 4.1 State how <u>you</u> managed yourself, priorities, processes and resources in carrying out the work (e.g. bar chart). 4.2 Describe <u>your</u> role and contribution in the work team.	In engineering operations and projects, Engineering Technicians will typically be given the responsibility to carry out specific tasks and/or complete projects. 4.1 Resources are usually subdivided based on availability and are controlled by a work-breakdown structure and schedule to meet deadlines. Quality, safety and environmental management are important aspects. 4.2 Depending on the task, the Engineering Technician can be the team leader or a team member and can supervise appointed contractors.
Outcome 5: Communicate clearly with others in the course of his/her *well-defined engineering activities*	**Responsibility Level C**
Assessment Criteria: Demonstration of effective communication. 5.1 State how <u>you</u> presented your point of view and compiled reports after completion of the work. 5.2 State how <u>you</u> compiled and issued instructions to entities working on the same task.	5.1 Refer to the Range Statement for outcomes 4 and 5. Presentation of point of view mainly occurs in meetings and discussions with immediate supervisor. 5.2 Refer to the Range Statement for outcomes 4 and 5.

Range Statement for outcomes 4 and 5: Management and communication in *well-defined engineering* involves the following: (a) Planning *well-defined* activities (b) Organising *well-defined* activities (c) Leading *well-defined* activities (d) Controlling *well-defined* activities Communication relates to technical aspects and the wider impacts of professional work. Audience includes peers, other disciplines, clients and stakeholders. Appropriate modes of communication must be selected. The Engineering Technician is expected to perform the communication functions reliably and repeatedly.	(a) Planning means 'the arrangement for doing or using something; considering in advance'. (b) Organising means 'putting into working order; arranging in a system; making preparations for'. (c) Leading means 'guiding the actions and opinions of; influencing; persuading'. (d) Controlling means the 'regulating, restraining, keeping in order; checking'. Engineering Technicians write or participate in writing specifications for the purchase of materials and/or for work to be done; make recommendations on tenders received; place orders and variation orders; write work instructions; report back on work done; draw, correct and revise drawings; compile test reports; use operation and maintenance manuals to write work procedures; write inspection and audit reports; write commissioning reports; prepare and present motivations for new projects; compile budget reports; report on studies done and calculations carried out; report on customer requirements; report on safety incidents and risk analysis; report on equipment failure; report on proposed system improvement and new techniques; report back on cost control; etc.

Group C: Impacts of Engineering Activity	Explanation and Responsibility Level
Outcome 6: Recognise the general foreseeable social, cultural and environmental effects of *well-defined engineering activities*	**Responsibility Level B** Social means 'relating to people living in communities; relations between persons and communities'. Cultural means 'all the arts, beliefs, social institutions, etc. that are characteristic of a community'. Environmental means 'surroundings, circumstances, influences'.
Assessment Criteria: This outcome is normally displayed in the course of the analysis and solution of problems. 6.1 Describe the social, cultural and environmental impact of the engineering activity. 6.2 State how <u>you</u> communicated mitigating measures to affected parties and acquired stakeholder engagement.	6.1 Engineering significantly affects the environment (e.g. servitudes, expropriation of land, excavation of trenches with associated inconvenience, borrow pits, dust and obstruction, street and other crossings, power dips and interruptions, visual and noise pollution, malfunctions, oil and other leaks, electrocution of human beings, detrimental effect on animals and wild life, dangerous rotating and other machines, and demolition of structures). 6.2 Mitigating measures taken may include environmental impact studies, environmental impact management, community involvement and communication, barricading and warning signs, temporary crossings, alternative supplies (ring feeders and bypass roads), press releases and compensation paid.

Outcome 7: Meet all legal and regulatory requirements and protect the health and safety of persons in the course of his/her *well-defined engineering activities*	**Responsibility Level E**

Assessment Criteria: 7.1 List the major laws and regulations applicable to this particular activity and indicate how health and safety matters were handled. 7.2 State how <u>you</u> obtained advice in carrying out risk management for the work and elaborate on the risk management system applied.	7.1 The OHS Act is supplemented by a variety of parliamentary Acts, regulations, local authority by-laws, standards and codes of practice. Places of work may have standard procedures, instructions, drawings, and operation and maintenance manuals available. Depending on the situation (emergency, breakdown, etc.), these documents are consulted before commencing the work and during the activity. 7.2 It is advisable to attend a Risk Management (Assessment) course and to investigate and study the materials, components and systems used in the workplace. The Engineering Technician seeks advice from knowledgeable and experienced specialists if the slightest doubt exists that safety and sustainability cannot be guaranteed.
Range Statement for outcomes 6 and 7: Impacts and regulatory requirements include the following: (a) Impacts to be considered are generally those identified within the established methods, techniques and procedures used in the practice area. (b) Regulatory requirements are prescribed. (c) Prescribed risk management strategies are applied. (d) Effects to be considered and methods used are defined. (e) Safe and sustainable materials, components and systems are prescribed. (f) Persons whose health and safety are to be protected are both inside and outside the workplace.	(a) The impacts will vary substantially with the location of the task (e.g. the impact of laying a cable or pipe in the main street of a town will be entirely different to the impact of construction in a rural area). The methods, techniques and procedures will differ accordingly and are identified and studied by the Engineering Technician before starting the work. (b) The Safety Officer and/or the Responsible Person appointed in accordance with the OHS Act usually confirms or checks that the instructions are in line with regulations. The Engineering Technician is responsible for ensuring that this is done, and if not, for establishing which regulations apply and ensuring adherence. Usually, the people working on site are strictly controlled w.r.t. health and safety, but the Engineering Technician checks that this is done. Tasks and projects are mainly carried out where contact with the public cannot be avoided, and safety measures such as barricading and warning signs must be used and maintained. (c) Risks are mainly associated with elevated structures, subsidence of soil, electrocution of human beings and moving parts on machinery. Risk-management strategies are usually implemented by more senior staff but are understood and applied by the Engineering Technician. (d) Effects associated with risk management are mostly well known if not obvious, and methods used to address these risks are clearly defined. (e) Usually, the components and systems and the safe and sustainable materials are prescribed by Engineers, Technologists or other professional specialists. It is the responsibility of the Engineering Technician to use his/her knowledge and experience to check and interpret what is prescribed and to report if any dispute exists. (f) Health and safety of the staff working on the task or project as well as persons affected by the engineering work should be considered.

Group D: Exercise judgement, take responsibility and act ethically	Explanation and Responsibility Level
Outcome 8: Conduct engineering activities ethically	**Responsibility Level E** Ethics means 'science of morals; moral soundness'. Moral means 'moral habits; standards of behaviour; principles of right and wrong'.
Assessment Criteria: Sensitivity to ethical issues and the adoption of a systematic approach to resolving such issues are expected. 8.1 State how you identified the ethical issues in addition to the affected parties and their interests and indicate the actions you took when a problem arose. 8.2 Confirm that you are conversant and in compliance with the ECSA Code of Conduct and why this Code of Conduct is important in your work.	Systematic means 'methodical; based on a system'. 8.1 Ethical problems that can occur include tender fraud, payment bribery, alcohol abuse, sexual harassment, absenteeism, favouritism, defamation, fraudulent overtime claims, fraudulent expenses claimed, fraudulent qualifications and misrepresentation of facts. 8.2 The ECSA Code of Conduct as per the ECSA website is known and adhered to. Applicable examples given.

Outcome 9: Exercise sound judgement in the course of *well-defined engineering activities*	**Responsibility Level E** Judgement means 'good sense; ability to judge'.
Assessment Criteria: Judgement is displayed by the following performance: 9.1 State the factors applicable to the work and their interrelationship and indicate how you applied the most important factors. 9.2 Describe how you foresaw work consequences and evaluated situations in the absence of full evidence.	9.1 The extent of a project or task given to a junior Engineering Technician is characterised by the limited number of factors and their resulting interdependence. The Engineering Technician will seek advice if educational and/or experiential limitations are exceeded. Examples of the main engineering factors applied must be given. 9.2 Making risky decisions will lead to equipment failure, excessive installation and maintenance cost, damage to persons and property, etc. Give examples.
Range Statement for outcomes 8 and 9: Judgement in decision-making involves (a) accounting for limited risk factors, some of which may be ill-defined; **or** (b) accounting for consequences that are in the immediate work contexts; **or** (c) accounting for an identified set of interested and affected parties with defined needs.	In engineering, approximately 10% of the activities can be classified as *well-defined* and for these, the Engineering Technician uses standard procedures, codes of practice, specifications, etc. Judgement must be displayed to identify any activity that falls outside the *well-defined* range (defined above): (a) Advice is sought when risk factors exceed his/her capability. (b) Consequences outside the immediate work contexts (e.g. long-term) are not normally handled. (c) Interested and affected parties with defined needs outside the *well-defined* parameters are taken into account.

Outcome 10: Be responsible for making decisions on part or all of one or more *well-defined engineering activities*	**Responsibility Level E** Responsible means 'legally or morally liable for carrying out a duty; caring for something or somebody while being in a position where one may be blamed for loss, failure, etc.'
Assessment Criteria: Responsibility is displayed by the following performance: 10.1 Show how you used NDip theoretical calculations to justify decisions taken in carrying out the engineering work. Attach actual calculations. 10.2 State how you sought responsible advice on any matter falling outside your own education and experience. 10.3 Describe how you took responsibility for your own work and evaluated any shortcomings in your output.	10.1 The calculations (e.g. fault levels, load calculations, losses) are done to ensure that the correct material and components are used). 10.2 The Engineering Technician does not operate on tasks at a higher level than *well-defined* and consults professionals at engineer and/or technologist level if elements of the tasks to be done are beyond his/her education and experience (e.g. power system stability). 10.3 The Engineering Technician engages in continuous self-evaluation to ascertain that the task given is done correctly, on time and within budget. Continuous feedback to the originator of the task instruction with corrective action taken if necessary forms an important element.
Range Statement: Responsibility must be discharged for significant parts of one or more *well-defined engineering activities.*	The responsibility is mainly allocated within a team environment and with an increasing designation as experience is gathered.
Note 1: Demonstration of responsibility is under the supervision of a competent engineering practitioner but the Engineering Technician is expected to perform as if he/she is in a responsible position.	

Group E: Initial Professional Development (IPD)	Explanation and Responsibility Level
Outcome 11: Undertake independent learning activities sufficient to maintain and extend his/her competence	**Responsibility Level D**
Assessment Criteria: Self-development is displayed by the following performance: 11.1 Provide the strategy that you independently adopted to enhance professional development (IPD report) 11.2 Be aware of the philosophy of the employer in regard to professional development	11.1 If possible, a specific field of the sub-discipline is chosen, available developmental alternatives are established, a programme is drawn up (in consultation with the employer if costs are involved) and options that are open to expand knowledge into additional fields are investigated. 11.2 Record-keeping must not be left to the employer or any other person. The trainee must manage his/her own training independently, taking the initiative and being in charge of his/her experiential development towards Professional Engineering Technician level. Knowledge of the employer's policy and procedures on training is essential.

Range Statement: Professional development involves the following: (a) Taking ownership of own professional development (b) Planning own professional development strategy (c) Selecting appropriate professional development activities (d) Recording professional development strategy and activities while displaying independent learning ability	(a) This is your professional development, not the development of the organisation for which you are working. (b) In most places of work, training is seldom organised by a training department. The Engineering Technician must manage his/her own experiential development. Engineering Technicians frequently find themselves at a standstill and are left doing repetitive work. If self-development is not self-driven, success is unlikely. (c) Preference must be given to engineering development rather than developing soft skills. (d) Developing a learning culture in the workplace environment of the Engineering Technician is vital to his/her success. Information is readily available, and most senior personnel in the workplace are willing to mentor if approached.