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SOUTH AFRICA

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

R-05-TRONIC-PT

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ENGINEERING COUNCIL OF SOUTH AFRICA
Tel: 011 607 9500 | Fax: 011 622 9295
Email: engineer@ecsa.co.za | Website: www.ecsa.co.za

ECSA

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DEFINITIONS

Broadly defined engineering work: This work is characterised by the following:

(a) Scope of practice area is linked to technologies used and changes by adoption of new technology into current practice.
(b) Practice area is located within a wider, complex context, requires teamwork and has interfaces to other parties and disciplines.
(c) It involves the use of a variety resources (including people, money, equipment, materials, technologies).
(d) It requires resolution of occasional problems arising from interactions among wide-ranging or conflicting technical, engineering or other issues.
(e) It is constrained by available technology, time, finance, infrastructure, resources, facilities, standards and codes, applicable laws.
(f) It has risks and consequences in practice area and in related areas.

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 will require 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.

OPC UA: OPC Unified Architecture is a machine-to-machine communication protocol for industrial automation developed by the OPC Foundation.

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.

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

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.

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.

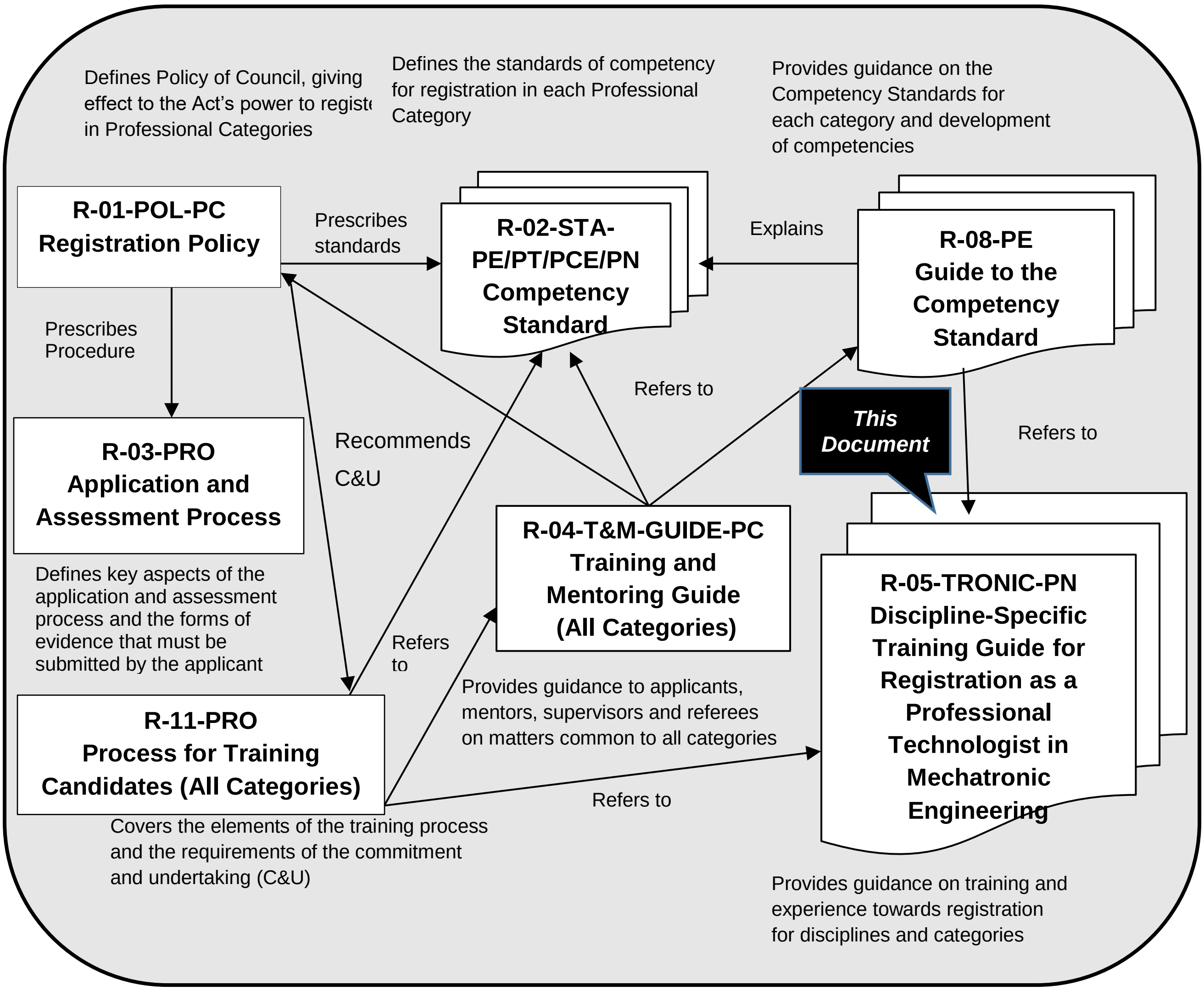

Figure 1: Documents defining the ECSA Registration System

1. PURPOSE OF THIS DOCUMENT

All persons applying for registration as a Professional Engineering Technologist are expected to demonstrate the competencies specified in document **R-02-STA-PE/PT/PCE/PN** 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 Technologists* (document **R-08-PT**).

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-PT** 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-PT** 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-STA-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:

- a relevant academic qualification recognised by the ECSA through accreditation or evaluation or who are in possession of a Sydney Accord recognised qualification
- registered as a Candidate Engineering Technologist or have demonstrated training to an acceptable level of competence in specific elements relating to Mechatronic Engineering

for at least three years after obtaining Advanced Diploma in Engineering or Bachelor of Engineering Technology

- 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 (C&U)

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 Technologist is permitted without being registered as a Candidate Engineering Technologist 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 Voluntary Association (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 5.4 of this document).

Applicants who do not hold an appropriate theoretical qualification may apply under an alternative route, as indicated in document **E-18-PRO**. This alternative route considers number of years' experience, the broadly 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, including 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 Technologists form a collective group of technologists who conduct broadly 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 among 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 Technologists may practise include:

- Aeronautical Engineering.
- Agricultural Engineering.
- Chemical Engineering.
- Civil Engineering.

- Electrical Engineering.
- Industrial Engineering.
- Mechanical Engineering.
- Metallurgical Engineering.
- Information Technology
- Marine Engineering
- Biomedical Engineering.

Mechatronic Engineering Technologists 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

The 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

The 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 & SIL certified components.

4.3 MD: Mechatronic Devices

The 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 Technologists 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 Technologists may include, among others, the following:

Technologies	FA	PA	MD
Computation Systems			
Data logging & recording	1	1	
Databases	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

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 & 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 & accessories		1	
Process measurement (incl. temperature, pressure, level, flow and mass)		1	
Safety systems (incl. hazardous area equipment, fail-safe systems etc.)		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

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 optimisation	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 Define, investigate and analyse broadly defined engineering problems

The Candidate is expected to perform a structured analysis of problems typified by the following performances:

(a) Interprets and clarifies requirements, leading to an agreed definition of the problem to be addressed

(b) Identifies interested and affected parties and their expectations

(c) Gathers, structures and evaluates a sufficient range of information relating to the problem

(d) Performs structured analysis

(e) Evaluates the result of the analysis and revise or refine as required

(f) Documents and reports, conveying outcome to the requesting party.

The problem may be a design requirement, an applied R&D requirement or a problematic situation in an existing component, system or process. The problem is one amenable to solution by technologies known to the Candidate.

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
Area and equipment classification		1	
Calibration	1	1	1
Alarm management		1	

5.1.2 Design or develop solutions to broadly defined engineering problems

The Candidate is expected to work systematically to synthesise a solution to a problem, typified by the following performances:

(a) Proposes potential approaches to the solution

(b) Conducts a preliminary synthesis following selected approaches

(c) Evaluates potential solutions against requirements and wider impacts

(d) Presents reasoned technical, economic and contextual arguments for the selected option

(e) Fully develops chosen solution

(f) Evaluates the resulting solution

(g) Document the solution for approval and implementation.

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)	1	1	1
Inspection of product quality	1	1	1
Optimise system	1	1	1

5.1.3 Jurisdiction – specific knowledge and practices

The Candidate typically:

(a) displays mastery of understanding of current and emerging technologies in the practice area
(b) applies general and underpinning engineering knowledge to support technologist activities
(c) displays working knowledge of areas that interact with the practice area
(d) applies related knowledge: financial, statutory, safety, management.

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 Engineering project management

The Candidate is expected to display personal and work process management abilities:

(a) Manage self
(b) Work effectively in a team environment
(c) Manage people, work priorities and resources
(d) Establish and maintain professional and business relationships.

Tasks

As seen above, tasks could include:

Table 4: Outcome 4

TASKS	FA	PA	MD
Project COORDINATION AND TECHNICAL INPUTS	1	1	1
Consulting	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 Communication

The Candidate demonstrates effective communication by:

(a) writing clear, concise, effective, technically, legally and editorially correct reports using a structure and style which meets communication objectives and user/audience requirements
(b) reading and evaluating technical and legal matter relevant to the function of the Professional Engineering Technologist
(c) receiving instructions and ensuring correct interpretation
(d) issuing clear instructions to subordinates using appropriate language and communication aids, ensuring that language and other communication barriers are overcome

(e) making oral presentations using structure, style, language, visual aids and supporting documents appropriate to the audience and purpose.

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 Social, cultural and environmental impact

This outcome is normally displayed in the course of analysis and solution of problems. The Candidate typically:

(a) identifies interested and affected parties and their expectations

(b) identifies environmental impacts of the engineering activity

(c) proposes and evaluates measures to mitigate negative effects of engineering activity

(d) communicates with stakeholders

(e) adopts measures to mitigate negative effects of engineering activity.

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

5.3.2 Meet legal and regulatory requirements

The Candidate is expected to:

(a) identify applicable legal, regulatory and health and safety requirements for the engineering activity
(b) select safe and sustainable materials, components and systems
(c) identify risk and apply defined, widely accepted risk management strategies
(d) communicate with parties involved in legal and regulatory aspects of work.

Tasks:

As seen above, tasks could include:

Table 7: Outcome 7

TASKS	FA	PA	MD
Documentation and communication	1	1	1
Identify and interpret applicable regulatory requirements	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 Ethical engineering activities

The Candidate is expected to be sensitive to ethical issues and adopt a systematic approach to resolving these issues. In this regard, the Candidate must be able to:

(a) identify the central ethical problem
(b) identify affected parties and their interests
(c) search for possible solutions for the dilemma
(d) evaluate each solution using the interests of those involved, accorded suitable priority
(e) select and justify the solution that best resolves the problem.

Tasks

As seen above, tasks could include:

Table 8: Outcome 8

TASKS	FA	PA	MD
Documentation and communication	1	1	1

54.2 Outcome 9 – Exercise sound judgement

A Candidate typically exhibits judgement by:

(a) considering several factors, some of which may not be well defined

(b) considering the interdependence, interactions and relative importance of factors

(c) Foreseeing the consequences of actions

(d) Evaluating a situation in the absence of full evidence

(e) Drawing on experience and knowledge

(f) Justifying judgements on risks associated with decisions.

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

5.4.2 Taking responsibility

Responsibility exercised for outcomes of significant parts of one or more broadly defined engineering activities.

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 Technologists 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-PT

6.1 Contextual knowledge

Candidates are expected to be aware of the requirements of the engineering profession. The VAs applicable to Mechatronic Engineering Technologists and their functions and services to members provide a broad range of contextual knowledge for Candidate Engineering Technologists through the full career path of the registered Engineering Technologist.

The profession identifies specific contextual activities considered essential to develop the Mechatronic Engineering Technologist's competence. These include the applicable basic analytical, process and fabrication activities and the competencies required for registration in applicable registration 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 Technologists need to be proficient are listed below. The parallels with the broadly 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 useful to measure the progression of a 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 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 Exposed	B: Assisting	C: Participating	D: Contributing	E: Performing
Undergoes induction;	Performs specific	Performs specific processes as	Performs specific work	Works in team without supervision;

observes processes and work of competent practitioners.	processes under close supervision.	directed with limited supervision.	with detailed approval of work outputs.	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 Technologists must be aware of and understand the statutory and regulatory requirements for the tasks at hand and the environment 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

6.4 Desirable formal learning activities

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

The Candidate Engineering Technologist 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 Continuing Professional Development (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 Candidate's performance, 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 become registered Professional Engineering Technologists. Best practice comprises the process used for the continuous development of the Candidate. Several courses (technical and management) should be attended to gain Initial Professional Development (IPD) at the level required for registration as well as on-the-job- learning at the organisations where 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 the Candidate progresses through the levels of work capability described in document **R-04-T&M-GUIDE-PC** so that by the end of the training period, the Candidate can perform as an individual and as a team member at the level of problem solving 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. The training programme for each Candidate 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 Technologists are advised that although three years is the minimum required period of experience following graduation, in practice, Mechatronic Engineering Technologists 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 Technologist, the lecturer/researcher must become involved in the application of engineering knowledge by way of applied research and consulting work under the supervision of a Professional Engineering 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 broadly 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 three years' experience after obtaining the academic qualification will 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 Technologists while in the academic environment need to satisfy the requirements of paragraph 1 and be involved in broadly 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.

Multi-disciplinary exposure

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

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
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Rev. 0	13 April 2021	Approval	RPSC

The Discipline-specific Training Guide for:

Candidate Professional Technologist in Mechatronic Engineering

Revision 0 dated 13 April 2021 and consisting of 32 pages has been reviewed for adequacy by the Business Unit Manager and is approved by the Executive: Research Policy and Standards **(RPS).**

[signature] ....
Business Unit Manager

15/04/2021 ....
Date

[signature] ....
Executive: **RPS**

19/04/2021 ....
Date

This definitive version of this policy is available on our website

APPENDIX A: TRAINING ELEMENTS

Synopsis: Candidate Engineering Technologists should achieve specific competencies at the prescribed level during their development towards professional registration, at the same time accepting more and 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 an engineering career:

1. Confirm understanding of instructions received and clarify if necessary.
2. Use theoretical training to develop possible solutions: select the best and present 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 ECSA's 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.

Broadly defined engineering work is usually characterised by the application of novel technology deviating from standard procedures, codes and systems, the deviation verified by research, modelling and/or substantiated design calculations.

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

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
1. Purpose This standard defines the competence required for registration as a Professional Engineering Technologist.	DSTGs give context to the purpose of the Competency Standards. Professional Engineering Technologists operate within the nine disciplines ECSA recognises. Each discipline can be further divided into sub-disciplines and finally into specific workplaces as given in section 4 of the specific DSTG. DSTGs 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 trainee's competence towards achieving the standards below at Responsibility Level E, i.e., Performing. (Refer to 7.1 in the specific DSTG.)
2. Demonstration of competence Competence must be demonstrated within *broadly defined* engineering activities, defined below, by 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 Discipline Specific Guidelines. **Level Descriptor:** Broadly defined engineering activities (BDEA) have several of the following characteristics: Scope of practice area is linked to technologies used and changes by adoption of new technology into current practice. Practice area is located within a wider, complex context, requires teamwork, has interfaces with other parties	Engineering activities can be divided into (approximately): (a) 5% Complex (Professional Engineers) (b) 5% Broadly Defined (Professional Engineering Technologists) (c) 10% Well-defined (Professional Engineering Technicians) (d) 15% Narrowly Well-defined (Registered Specified Categories) (e) 20% Skilled Workman (Engineering Artisan) (f) 55% Unskilled Workman (Artisan Assistants) Activities can be in-house or contracted out; evidence of integrated performance can be submitted irrespective of the situation. **Level Descriptor:** BDEA in the various disciplines are characterised by several or all of: a) Scope of practice area does not cover the entire field of the discipline (exposure limited to the sub-discipline and specific workplace). Some technologies used are well established and adoption of new technologies needs investigation and evaluation. b) Practice area varies substantially with unlimited location possibilities and an additional

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
and disciplines. Involve the use of a variety resources, including people, money, equipment, materials, technologies. Require resolution of occasional problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues. Are constrained by available technology, time, finance, infrastructure, resources, facilities, standards and codes, applicable laws. Have significant risks and consequences in the practice area and in related areas.	responsibility to identify the need for advice on complex activities and problems. Broadly defined activities in the sub-discipline needs interfacing with professional engineers, professional technicians, artisans, architects, financial staff, etc. as part of the team. c) The bulk of the work involves familiar, defined range of resources, including people, money, equipment, materials, but new technologies are investigated and implemented. d) Most of the impacts in the sub discipline are on wider issues, but some arise from conflicting technical and engineering issues that have to be addressed by the application of broadly defined non-standard engineering principles. 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 but are not limited to design, planning, investigation and problem resolution, improvement of materials, components, systems or processes, manufacture or construction, engineering operations, maintenance, project management, research, development and commercialisation.	**Activities** include but are not limited to design, planning, investigation and problem resolution, improvement of materials, components, systems or processes, engineering operations, maintenance, project management. For Engineering Technologists, research, development and commercialisation happen more frequently in some disciplines but 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 *broadly defined engineering problems*	**Responsibility level E** Analysis of an engineering problem means the “separation into parts possibly with comment and judgement”. *Broadly* means “not minute or detailed” and “not kept within narrow limits”.

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
Broadly defined engineering problems have the following characteristics: a) require coherent and detailed engineering knowledge, underpinning the technology area *and one or more of:* are ill-posed, under- or over-specified, require identification and interpretation into the technology area encompass systems within complex engineering systems; belong to families of problems which are solved in well-accepted but innovative ways *and one or more of:* can be solved by structured analysis techniques may be partially outside standards and codes must provide justification to operate outside require information from practice area and sources interfacing with practice area that is complex and incomplete involves a variety of issues which may impose conflicting constraints: technical, engineering and interested or affected parties *and one or both of:*	a) Coherent and detailed engineering knowledge for Engineering Technologists means the problem encountered cannot be solved without the combination of all the relevant detail including engineering principles applicable to the situation. b) The nature of the problem is not immediately obvious, and further investigation to identify and interpret the real nature of the problem is necessary. c) The problem is not easily recognised as part of the larger engineering task, project or operation and may be obscured by the complexity of the larger system. d) It is recognised that the problem can be classified as a falling within a typical solution requiring innovative adaptation to meet the specific situation. e) Solving the problem needs a step-by-step approach adhering to proven logic. f) The standards, codes and documented procedures must be analysed to determine to what extent they are applicable to solve the problem and justification must be given to operate outside these. g) The responsibility lies with the Engineering Technologist to verify that some information received as part of the problem encountered may remain incomplete and solutions to problems may need justified assumptions. h) The problem handled by an Engineering Technologist may be solved by alternatives that are unaffordable, detrimental to the environment, socially unacceptable, not maintainable, not sustainable, etc; the Technologist will have to justify his/her recommendation. i) Practical solutions to problems include knowledge and judgement of the roles displayed by the multi-disciplinary team and impact of own work in the interactive environment. j) Engineering Technologists must realise that their actions might seem to be of local importance only

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
require judgement in decision-making in practice area, considering interfaces to other areas have significant consequences that are important in practice area but may extend more widely.	but may develop into significant consequences extending beyond their own ability and practice area.
Assessment criteria: A structured analysis of broadly defined problems typified by the following performances is expected: 1.1 Performed or contributed in defining engineering problems leading to an agreed definition of the problems to be solved. 1.2 Performed or contributed in investigating engineering problems including collecting, organising and evaluating information. 1.3 Performed or contributed in analysis of engineering problems using conceptualisation, justified assumptions, limitations and evaluation of results.	To perform an engineering task an Engineering Technologist will typically receive an instruction from a senior person (customer) to do a specific task, and must involve the following: 1.1 Ensure the instruction is complete, clear and within his/her capability and that the person who issued the instruction agrees with his/her interpretation. 1.2 The engineering problem and related information must be segregated from the bulk of the information, investigated and evaluated. 1.3 Ensure the instruction and information to do the work is fully understood and complete, including engineering theory needed to understand the task and acceptance criteria, and to carry out and/or check calculations. If needed supplementary information must be gathered, studied and understood. Concepts and assumptions must be justified by engineering theory and calculations, if applicable.
Range statement: The problem may be a design requirement, an applied Research and Development requirement or a problematic situation in an existing component, system or process. The problem is one amenable to solution by technologies known to the Candidate. This outcome is concerned with the understanding of a problem: Outcome 2 is concerned	**Please refer to section 4 of the specific DSTG.**

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
with the solution.	
Outcome 2: Design or develop solutions to broadly defined engineering problems	**Responsibility level 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 a problem analysis as defined in Outcome 1. Working systematically to synthesise a solution to a broadly defined problem, typified by the following performances is expected: 2.1 Designed or developed solutions to broadly defined engineering problems. 2.2 Systematically synthesised solutions and alternative solutions or approaches to the problem by analysing designs against requirements, including costs and impacts on outside parameters. (requirements). 2.3 Drawing up of detailed specification requirements and design documentation for implementation to the satisfaction of the client.	After the task received is fully understood and interpreted, a solution to the problem posed can be developed (designed). To synthesise a solution is "the combination of separate parts, elements, substances, etc. into a whole or into a system" by the following: 2.1 The development (design) of more than one way to solve an engineering task or problem should always be done, including 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 The Engineering Technologist will in some cases not be able to support proposals with the complete theoretical calculation to substantiate every aspect and must in these cases refer his / her alternatives to an engineer for scrutiny and support. The alternatives and alternative recommended must be convincingly detailed to win customer support for the alternative recommended. Selection of alternatives might be based on tenders submitted with alternatives deviating from those specified. 2.3 The best complete and final solution selected must be followed up with a detailed technical specification, supporting drawings, bill of quantities, etc. for the execution of work to meet customer requirements.
Range Statement: Solutions are those enabled by the	Applying theory to do *broadly defined engineering* work is mostly done in a way that has been used

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
technologies in the Candidate's practice area.	before, probably developed by engineers in the past, and documented in written procedures, specifications, drawings, models, examples, etc. Engineering Technologists must seek approval of any deviation from these established methods, but must also initiate and/or participate in the development and revision of these norms.
Outcome 3: Comprehend and apply the knowledge embodied in widely accepted and applied engineering procedures, processes, systems or methodologies and those specific to the jurisdiction in which he/she practices.	**Responsibility level E** Comprehend means "to understand fully". The jurisdiction in which an Engineering Technologist practices is given in **section 4 of the specific Discipline Specific Training Guideline.**
Assessment criteria: This outcome is normally demonstrated in the course of design, investigation or operations. 3.1 Applied engineering principles, practices, technologies, including the application of BTech theory in the practice area. 3.2 Indicated working knowledge of areas of practice that interact with practice area to underpin teamwork. 3.3 Applied related knowledge of finance, statutory, safety and management.	Design work for Engineering Technologists is based on BTech theory and is mostly the utilisation and configuration of manufactured components and selected materials and associated novel technology. Engineering Technologists develop and apply codes and procedures in their design work. 3.1 Calculations at BTech theoretical level confirming the correct application and utilisation of equipment, materials and systems listed in section 4 of the specific DSTG must be done on broadly defined activities. 3.2 The understanding of broadly defined procedures and techniques must be based on fundamental mathematical, scientific and engineering knowledge, as part of personal contribution within the engineering team. 3.3 The ability to manage the resources within legal and financial constraints must be evident.
Range Statement: Applicable knowledge includes: a) Technological knowledge that is well-established and	a) The specific location of a task to be executed is the most important determining factor in the layout

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
applicable to the practice area irrespective of location, supplemented by locally relevant knowledge, for example, established properties of local materials. Emerging technologies are adopted from formulations of others. b) A working knowledge of interacting disciplines (engineering and other) to underpin teamwork. **c)** Jurisdictional knowledge includes legal and regulatory requirements as well as locally relevant codes of practice. As required for practice area, a selection of law of contract, health and safety, environmental, intellectual property, contract administration, quality management, risk management, maintenance management, regulation, project and construction management.	design and utilisation of equipment. A combination of educational knowledge and practical experience must be used to substantiate decisions taken including a comprehensive study of systems, materials, components and projected customer requirements and expectations. New ideas, materials, components and systems must be investigated, evaluated and applied accompanied by complex theoretical motivation. b) In spite of having a working knowledge of interacting disciplines, Engineering Technologists take responsibility for the multidisciplinary team of specialists like civil engineers on structures and roads, mechanical engineers on fire protection equipment, architects on buildings, electrical engineers on communication equipment, etc. c) Jurisdictional in this instance means “having the authority”, and Engineering Technologists must be aware of and decide on the relevant requirements applicable to each specific project that he/she is responsible for. They are usually appointed as the “responsible person” for specific projects 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 *broadly defined engineering* activities.	**Responsibility level D** Manage means “control”.
Assessment criteria: The Candidate is expected to display personal and work process management abilities: 4.1 Managed self, people, work priorities, processes and resources in broadly defined engineering work.	In engineering operations, Engineering Technologists will typically be given the responsibility to carry out projects. 4.1 Resources are usually subdivided based on availability and controlled by a work breakdown structure and scheduling to meet deadlines. Quality, safety and environment management are

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
4.2 Role in planning, organising, leading and controlling broadly defined engineering activities evident. 4.3 Knowledge of conditions and operation of contractors and the ability to establish and maintain professional and business relationships evident.	important aspects. 4.2 The basic elements of managements must be applied to broadly defined engineering work. 4.3 Depending on the project, Engineering Technologists can be the team leader, a team member or can supervise appointed contractors. To achieve this, maintenance of relationships is important and must be demonstrated.
Outcome 5: Communicate clearly with others in the course of his/her broadly defined engineering activities.	**Responsibility level C**
Assessment criteria: Demonstrates effective communication by the following: 5.1 Ability to write clear, concise, effective technical, legal and editorially correct reports shown. 5.2 Ability to issue clear instructions to stakeholders using appropriate language and communication skills evident. 5.3 Oral presentations made using structure, style, language, visual aids and supporting documents appropriate to the audience and purpose.	5.1 Refer to Range Statement for Outcome 4 and 5 below. 5.2 Refer to Range Statement for Outcome 4 and 5 below. 5.3 Presentation of point of view mostly occurs in meetings and discussions with immediate supervisor.
Range Statement for Outcomes 4 and 5: Management and communication in broadly-*defined engineering* involves: a) Planning broadly defined activities	a) Planning means “the arrangement for doing or using something, considered in advance”. b) Organising means “put into working order, arrange in a system, make preparations for”. c) Leading means to “guide the actions and opinions of, influence, persuade”.

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
b) Organising broadly defined activities c) Leading broadly defined activities d) Controlling broadly defined activities.	d) Controlling means the "means of regulating, restraining, keeping in order, check". Engineering Technologists write specifications for the purchase of materials and/or work to be done, recommendations on tenders received, place orders and variation orders, write work instructions, report 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 on cost control, etc.
Group C: Impacts of Engineering Activity	**Explanation and Responsibility Level**
Outcome 6: Recognise the foreseeable social, cultural and environmental effects of *broadly defined* engineering activities generally	**Responsibility level B** Social means "people living in communities; of relations between persons and communities". Cultural means "all the arts, beliefs, social institutions, etc. characteristic of a community". Environmental means "surroundings, circumstances, influences".
Assessment criteria: This outcome is normally displayed in the course of analysis and solution of problems. The candidate typically shows the following: 6.1 Ability to identify interested and affected parties and their expectations in regard to interactions between technical, social, cultural and environmental considerations shown. 6.2 Measures taken to mitigate the negative effects of	6.1 Engineering impacts heavily on 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, demolishing of structures, etc. 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,

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
engineering activities evident.	compensation paid, etc.
Outcome 7: Meet all legal and regulatory requirements and protect the health and safety of persons in the course of his/her broadly defined engineering activities.	**Responsibility level E**
Assessment criteria: 7.1 Identified applicable legal and regulatory requirements including health and safety requirements for the engineering activity. 7.2 Circumstances stated where applicant assisted in or demonstrated awareness of the selection of safe and sustainable materials, components and systems and have identified risk and applied risk management strategies.	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 might have standard procedures, instructions, drawings and operation and maintenance manuals available. These documents, depending on the situation (emergency, breakdown, etc.) are consulted before work is commenced and during the activity. 7.2 It is essential to attend a Risk Management (Assessment) course, and to investigate and study the materials, components and systems used in the workplace. The Engineering Technologist 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) Requirements include both explicit regulated factors and those that arise in the course of particular work. b) Impacts considered extend over the lifecycle of the project and include the consequences of the	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 town will be entirely different to construction in a rural area. The methods, techniques or procedures will differ accordingly and may be complex. It is identified and studied by the Engineering Technologist 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

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
technologies applied. Effects to be considered include direct and indirect, immediate and long-term related to the technology used. Safe and sustainable materials, components and systems. Regulatory requirements are explicit for the context in general.	Technologist is responsible to see that this is done, and if not, establish which regulations apply, and ensure that they are adhered to. Usually the people working on site are strictly controlled w.r.t. health and safety, but the Engineering Technologist checks that this is done, but may authorise unavoidable deviation after setting conditions for such deviations. Projects are mostly carried out where contact with the public cannot be avoided, and safety measures like barricading and warning signs must be used and maintained. Effects associated with risk management are mostly well known if not obvious, and methods used to address, clearly defined. Risks are mostly associated with elevated structures, subsidence of soil, electrocution of human beings and moving parts on machinery. The Engineering Technologist needs to identify, analyse and manage any long-term risks and develop strategies to solve these by using alternative technologies. The safe and sustainable materials, components and systems must be selected and prescribed by the Engineering Technologists or other professional specialists must be consulted. It is the Engineering Technologist's responsibility to use his/her knowledge and experience to confirm that prescriptions by others are correct and safe. Application of regulations associated with the particular aspects of the project must be carefully identified and controlled by the Engineering Technologist.
Group D: Exercise judgment, take responsibility, and act ethically	**Explanation and Responsibility Level**
Outcome 8: Conduct engineering activities ethically.	**Responsibility level E** Ethically means "science of morals; moral soundness". Moral means "moral habits; standards of behaviour; principles of right and wrong".

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
Assessment Criteria: Sensitivity to ethical issues and the adoption of a systematic approach to resolving these issues is expected, typified by the following: 8.1 Conversance and operation in compliance with ECSA's Rules of Conduct for registered persons confirmed. 8.2 How ethical problems and affected parties were identified, and the best solution to resolve the problem selected.	Systematic means "methodical; based on a system". 8.1 ECSA's Code of Conduct, as per ECSA's website, is known and adhered to. 8.2 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, misrepresentation of facts, etc.
Outcome 9: Exercise sound judgement in the course of *broadly defined* engineering activities.	**Responsibility level E** Judgement means "good sense: ability to judge".
Assessment criteria: Judgement is displayed by the following performance: 9.1 Judgement exercised in arriving at a conclusion within the application of technologies and their interrelationship to other disciplines and technologies. 9.2 Factors taken into consideration given, bearing in mind, risk, consequences in technology application and affected parties.	9.1 The extent of a project given to a junior Engineering Technologist is characterised by the several *broadly defined* and a few well-defined factors and their resulting interdependence. He/she will seek advice if educational and/or experiential limitations are exceeded. 9.2 Taking risky decisions will lead to equipment failure, excessive installation and maintenance cost, damage to persons and property, etc. Evaluation includes engineering calculations to substantiate decisions taken and assumptions made.

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
Range Statement for Outcomes 8 and 9*:* ***Judgement* in decision making involves: a) taking several risk factors into account b) significant consequences in technology application and related contexts; **or c) ranges of interested and affected parties with widely varying needs.	In Engineering, about 5% of engineering activities can be classified as *broadly defined* where the Engineering Technologist uses standard procedures, codes of practice, specifications, etc, but develops variations and completely unique standards when needed. Judgement must be displayed to identify any activity falling inside the *broadly defined* range, as defined above: a) Getting the work done in spite of numerous risk factors needs good judgement and substantiated decision-making. b) Consequences are part of the project e.g. extra cost due to unforeseen conditions, incompetent contractors, long-term environmental damage, etc. c) Interested and affected parties with defined needs that may be in conflict, e.g. need for a service irrespective of environmental damage, local traditions and preferences, etc. needs sound management and judgement.
Outcome 10: Be responsible for making decisions on part or all of all of one or more *broadly defined* engineering activities.	**Responsibility level E** Responsible means “legally or morally liable for carrying out a duty; for the care of something or somebody in a position where one may be blamed for loss, failure, etc.”.
Assessment criteria: Responsibility is displayed by the following performance: 10.1 Engineering, social, environment and sustainable development taken into consideration in discharging responsibilities for significant parts of one or more activities. 10.2 Advice sought from a responsible authority on matters outside your area of competence.	10.1 All interrelated factors taken considered are indicative of professional responsibility accepted working on broadly defined activities. 10.2 The Engineering Technologist does not operate on tasks at a higher level than broadly defined and consults professionals at engineer level if elements of the project to be done are beyond his/her education and experience, e.g. power system stability. 10.3 This is in the first instance 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

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
10.3 Academic knowledge of at least BTech level combined with past experience used in formulating decisions[1].	instruction and corrective action, if necessary, forms an important element. The calculations, for example fault levels, load calculations, losses, etc. are done to ensure that the correct material and components are utilised.
Range Statement: Responsibility must be discharged for significant parts of one or more *broadly defined* engineering activity.	The responsibility is mostly allocated within a team environment with an increasing designation as experience is gathered.
Note 1: Demonstrating responsibility would be under supervision of a competent engineering practitioner but the Candidate 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 or her competence.	**Responsibility level D**
Assessment criteria: Self-development managed typically as follows: 11.1 Strategy independently adopted to enhance professional development evident. 11.2 Awareness of philosophy of employer in regard to professional development evident.	11.1 If possible, a specific field of the sub-discipline is chosen, available developmental alternatives established, a programme drawn up (in consultation with employer if costs are involved) and options open to expand knowledge into additional fields investigated. 11.2 Record keeping must not be left to the employer or anybody else. The trainee must manage his/her own training independently, taking initiative and being in charge of experiential development towards Professional Engineering Technologist level.
Range Statement: Professional development involves	a) In most places of work training is seldom organised by some training department. It is up to the

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
the following: a) Planning own professional development strategy. b) Selecting appropriate professional development activities. c) Recording professional development strategy and activities, while displaying independent learning ability.	Engineering Technologist to manage his/her own experiential development. Engineering Technologists frequently end up in a 'dead-end street' being left behind doing repetitive work. If self-development is not driven by him/herself, success is unlikely. b) Preference must be given to engineering development rather than developing soft skills. c) Developing a learning culture in the workplace environment of the Engineering Technologist is vital to his / her success. Information is readily available, and most senior personnel in the workplace are willing to mentor, if approached.