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Discipline Specific Training Guide (DSTG) for Registration as a Professional Technologist in Mechatronics Engineering

R-05-TRONIC-PT

ECSA

Discipline – Specific Training Guide for Candidate Engineering Technologists in Mechatronic Engineering

R-05-TRONIC-PT

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1. DEFINITIONS

Broadly Defined Engineering Work: This work is characterised by:

(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, has interfaces to other parties and disciplines;

(c) Involve the use a variety resources (including people, money, equipment, materials, technologies);

(d) Require resolution of occasional problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues;

(e) Are constrained by available technology, time, finance, infrastructure, resources, facilities, standards and codes, applicable laws; and

(f) Have significant risks and consequences in practice area and in related areas

Complex Engineering Work: This work is characterised by:

(a) Scope of activities may encompass entire complex engineering systems or complex subsystems;

(b) A context that is complex and varying, is multidisciplinary, requires teamwork, unpredictable, may need to be identified;

(c) Requires diverse and significant resources: including people, money, equipment, materials, technologies;

(d) Significant interactions exist between wide- ranging or conflicting technical, engineering or other issues;

(e) Are constrained by time, finance, infrastructure, resources, facilities, standards & codes, applicable laws; and

(f) Have significant risks and consequences in a range of contexts

CAD: Computer – Aided Design

DCS: Distributed Control System

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

HMI: Human – Machine Interface

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

(i) to direct and control everything that is constructed or results from construction or manufacturing operations;

(ii) to operate engineering works safely and in the manner intended;

(iii) to 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;

(iv) to direct and control the engineering processes, systems, commissioning, operation and decommissioning of equipment; and

(v) to 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 of its aspects

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

PC: Personal Computer

PLC: Programmable Logic Controller

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

SCADA: Supervisory Control and Data Acquisition Control System

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 characterized by:

(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) Require resolution of interactions manifested between specific technical factors with limited impact on wider issues;

(e) Are constrained by operational context, defined workpackage, time, finance, infrastructure, resources, facilities, standards and codes, applicable laws; and

(f) Have risks and consequences that are locally important but are not generally far reaching;

2. BACKGROUND

The illustration below defines the documents that comprise the Engineering Council of South Africa

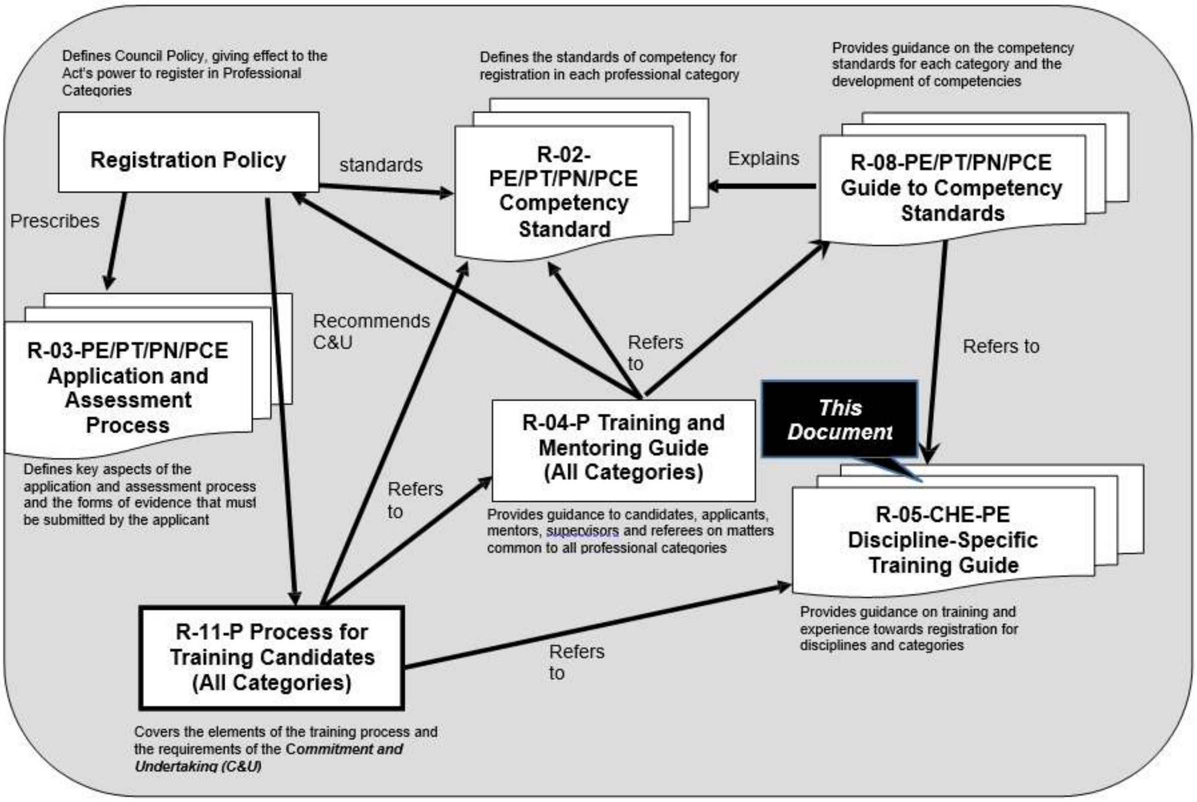

Figure 1: Documents defining the ECSA Registration System

3. 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-PT** 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-P**) and the *Guide to the Competency Standards for Professional Engineering Technologists* (document **R-08-PT**).

In document **R-04-P**, 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

The second document (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-P** and **R-08-PT** are subordinate to the Policy on Registration (document **R-01-POL**), the Competency Standard (document **R-02-PT**) and the application process definition (document **R-03-PRO**).

4. 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 Engineering type qualification, or by obtaining a Sydney Accord Recognized qualification, or through evaluation / assessment of prior learning
- registered as a Candidate Engineering Technologist and
- 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.

5. 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 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 application 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 appropriate theoretical qualification may apply under an alternative route and complete the additional form (C18). This alternative route considers number of years' experience, the broadly – defined engineering activities undertaken during this period and experience at the responsible level.

6. ORGANISING FRAMEWORK FOR OCCUPATIONS (OFO)

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 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 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 optimize processes within various industries.

Other specialized disciplines in which mechatronic engineering Technologists may practice include:

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

Mechatronic engineering Technologists also practice 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:

6.1. FA: Factory Automation

The automation of processes within a factory environment by using their knowledge, skills and experience to automate and or optimize 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.

6.2. PA: Process Automation

The automation of processes within a process industry by using their knowledge, skills and experience to optimize 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.

6.3. MD: Mechatronic Devices

The automation of tasks by using their knowledge, skills and experience to automate and or optimize tasks.

Mechatronic devices/components/systems are mainly focused on complete modular discrete control consisting of mechanical devices using sequential, speed control, packaging & 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 & modular PLCs as hardware and electronic/digital control algorithms for automation.

6.4. Industries

Industries in which mechatronic engineering Technologists may practice 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

6.5. 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			
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
Fiber	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 optimization	1	1	
Green buildings	1	1	
Renewable energy technologies	1	1	
Sensors	1	1	1
Vision Systems	1	1	1

7. NATURE AND ORGANISATION OF THE INDUSTRY

7.1. Group A: Engineering Problem Solving

7.1.1. 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) Gather, structure and evaluate a sufficient range of information relating to the problem;
d) Perform structured analysis;
e) Evaluate the result of the analysis and revise or refine as required;
f) Document and report 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:

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	

Table 1: Outcome 1

7.1.2. Design or develop solutions to broadly–defined engineering problems

The candidate is expected to work systematically to synthesize 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 develop chosen solution;

f) Evaluate the resulting solution;

g) Document the solution for approval and implementation

Tasks

As seen above, typical tasks could include:

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
Optimize system	1	1	1

Table 2: Outcome 2

7.1.3. 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:

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

Table 3: Outcome 3

7.2. Group B: Managing Engineering Activities

7.2.1. Engineering Project Management

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

a) Manage self;

b) Works 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:

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

Table 4: Outcome 4

7.2.2. Communication

The candidate demonstrates effective communication by:

a) Writes clear, concise, effective, technically, legally and editorially correct reports using a structure and style which meets communication objectives and user/audience requirements.

b) Reads and evaluate technical and legal matter relevant to the function of the Professional Engineering Technologist

c) Receives instructions, ensuring correct interpretation.

d) Issues clear instructions to subordinates using appropriate language and communication aids, ensuring that language and other communication barriers are overcome.

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

Tasks

As seen above, tasks could include:

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

Table 5: Outcome 5

7.3. Group C: Impacts of Engineering Activities

7.3.1. Social, Cultural and Environmental Impact

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

a) Identify interested and affected parties and their expectations;
b) Identify environmental impacts of the engineering activity;
c) Propose and evaluate measures to mitigate negative effects of engineering activity;
d) Communicate with stakeholders;
e) Adopt measures to mitigate negative effects of engineering activity.

Tasks

As seen above, tasks could include:

TASKS	FA	PA	MD
Documentation and Communication	1	1	1
Impact Assessment	1	1	1

Table 6: Outcome 6

7.3.2. 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:

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

Table 7: Outcome 7

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

7.4.1. 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:

TASKS	FA	PA	MD
Documentation and Communication	1	1	1

Table 8: Outcome 8

7.4.2. Outcome 9 – Exercise Sound Judgement

A candidate typically exhibits judgement by:

a) Considers several factors, some of which may not be well defined;

b) Considers the interdependence, interactions and relative importance of factors;

c) Foresees consequences of actions;

d) Evaluates a situation in the absence of full evidence;

e) Draw on experience and knowledge;

f) Justify judgements on risks associated with decisions

Tasks

As seen above, tasks could include:

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

Table 9: Outcome 9

7.4.3. Taking Responsibility

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

Tasks

As seen above, tasks could include:

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

Table 10: Outcome 10

7.5. Group E: Initial Professional Development

Candidate Mechatronic Engineering Technologists must demonstrate:

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

Tasks

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

Table 11: Outcome 11

8. DEVELOPING COMPETENCY: DOCUMENT R-08-PT

8.1. Contextual knowledge

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

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

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

8.2. Functions performed

The functions that are 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 well-defined generic competence elements required by the Competency Standard (document **R-02-PT**) 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 making use of the scales regarding Degree of Responsibility, Problem Solving and Engineering Activity as specified in the relevant documentation.

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-P** are presented here and in **Appendix A.**

A: Being Exposed	**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

8.3. Statutory and regulatory requirements

The Candidate Engineering Technologist 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:

- Council for the Built Environment Act 2000 (Act 43 of 2000)
- Engineering Profession Act, No. 46 of 2000, including Rules and specifically the Code of Conduct
- ECSA Code of Conduct
- Occupational Health and Safety Act, No. 85 of 1993 (OHS Act) and Regulations
- Mine Health and Safety Act, No. 29 of 1996 (see www.dmr.gov.za)
- National Environmental Management Act, No. 107 of 1998 (Various measures relating to pollution of a water resource; Waterworks process controller)
- National Environmental Management Waste Act, No. 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, No. 28 of 2002)
- Project and Construction Management Professions Act, No. 48 of 2000
- Nuclear Energy Act, No. 46 of 1999
- National Water Act, No. 36 of 1998
- ISO 9001: xxxx
- 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

8.4. 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.
The Candidate Engineering Technologist should register with the relevant volunteer associations 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:

- 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 performance of the candidate and 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

9. PROGRAMME STRUCTURE AND SEQUENCING

9.1. Best practice

Best practice is a developmental process that assists applicants in becoming 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 in order to gain Initial Professional Development (IPD) at the level required for registration as well as on-the-job- learning at the organizations in which the Candidate was / is employed.

Applicants are encouraged to join at least one Voluntary Association 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-P 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- and well-defined engineering activity required for registration, exhibiting a Degree of Responsibility Level E.

9.2. Realities

There is no ideal training programme structure or unique sequencing that constitutes best practice. The training programme for each Candidate will depend 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. Applicants are advised to gain at least five years of experience before applying.

9.3. 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 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 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 his / her 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 6 and be involved in well-defined engineering activities which could include:

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

9.4. 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-P**. 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 1			
Rev 2			

Discipline-specific Training Guideline for:

Candidate Engineering Technologists in Mechatronics Engineering

Revision ___ dated _______ and consisting of __ pages has been reviewed for adequacy by the Business Unit Manager and is approved by the Executive: Research, Policy and Standards **(RPS).**

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Business Unit Manager Date

....

Executive: **RPS** Date

This definitive version of this policy is available on our website.

APPENDIX A: TRAINING ELEMENTS

1	**Introduction**
1.1	***Induction programme (Typically 1–5 days)***
1.1.1	Company structure
1.1.2	Company policies
1.1.3	Company Code of Conduct
1.1.4	Company safety regulations
1.1.5	Company staff code
1.1.6	Company regulations
1.2	***Exposure to Practical Aspects of Engineering (Typically 6–12 months) and covers how***
1.2.1	(Experience in one or more of these sectors but not all) Manufacturing
1.2.2	Construction
1.2.3	Erection
1.2.4	Field installation
1.2.5	Testing
1.2.6	Commissioning
1.2.7	Operation
1.2.8	Maintenance
1.2.9	Fault location
1.2.10	Problem investigation

2	**Design**
2.1	*Experience in design and application of design knowledge (Typically 12–18 months) Focus is on planning, design and application (Responsibility level C & D)*
2.1.1	(In one or more of the above sectors) Analysis of data and systems
2.1.2	Planning of networks and systems
2.1.3	System modelling and integration
2.1.4	System design
2.1.5	Network/circuit design
2.1.6	Component/product design
2.1.7	Software design
2.1.8	Research and investigation
2.1.9	Preparation of specifications and associated documentation
2.1.10	Preparation of contract documents and associated documentation
2.1.11	Development of standards
2.1.12	Application of quality systems
2.1.13	Configuration Management

3	Engineering tasks
3.1	***Experience in the execution of engineering tasks (Rest of training period) Focus should be on projects and project management*** (Responsibility
3.1.1	(Working in one or more of these sectors but not all) Design
3.1.2 3.1.3	Manufacture Construction
3.1.4	Erection
3.1.5	Installation
3.1.6	Commissioning
3.1.7	Maintenance
3.1.8	Modifications
3.2	***Organising for implementation of 3.1*** (Responsibility Level E)
3.2.1	Manage resources
3.2.2	Optimisation of resources and processes
3.3	***Controlling for implementation or operation of 3.1*** (Responsibility Level E)
3.3.1	Monitor progress and delivery
3.3.2	Monitor quality
3.4	***Completion of 3.1*** (Responsibility Level E)
3.4.1	Commissioning completion
3.4.2	Documentation completion
3.4.3	Documentation handover
3.5	***Maintenance and repair of 3.1***
3.5.1	(Responsibility Level E) Planning and scheduling maintenance
3.5.2	Monitor quality
3.5.3	Oversee maintenance and repair

4	Risk and impact mitigation
4.1	***Impact and risk assessments***
4.1.1	(Responsibility Level E)
4.1.2	Risk assessments
4.2	***Regulatory compliance***
4.2.1	(Responsibility Level E) Health and safety
4.2.2	Codes and standards
4.2.3	Legal and regulatory

5	**Managing engineering activities**
5.1	***Self-management***
5.1.1	Manages own activities
5.1.2	Communicates effectively
5.2	***Team environment***
5.2.1	Participates in and contributes to team planning activities
5.2.2	Manages people