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SOUTH AFRICA

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

R-05-TRONIC-PE

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E C S A

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DEFINITIONS

Complex engineering work: This work is characterised by the following:

(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, is unpredictable and may need to be identified.

(c) It requires diverse and significant resources: including people, money, equipment, materials, technologies.

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

(e) It is constrained by time, finance, infrastructure, resources, facilities, standards and codes, and applicable laws.

(f) It has significant risks and consequences in a range of contexts.

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

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

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

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

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

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

(a) direct and control everything that is constructed or results from construction or manufacturing operations

(b) operate engineering works safely and in the manner intended

(c) return the engineering works, the plant and the equipment to an acceptable condition by the renewal, replacement or mending of worn, damaged or decayed parts

(d) direct and control the engineering processes, systems, commissioning, operation and decommissioning of equipment

(e) maintain engineering works or equipment in a state in which it can perform its required function.

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 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.

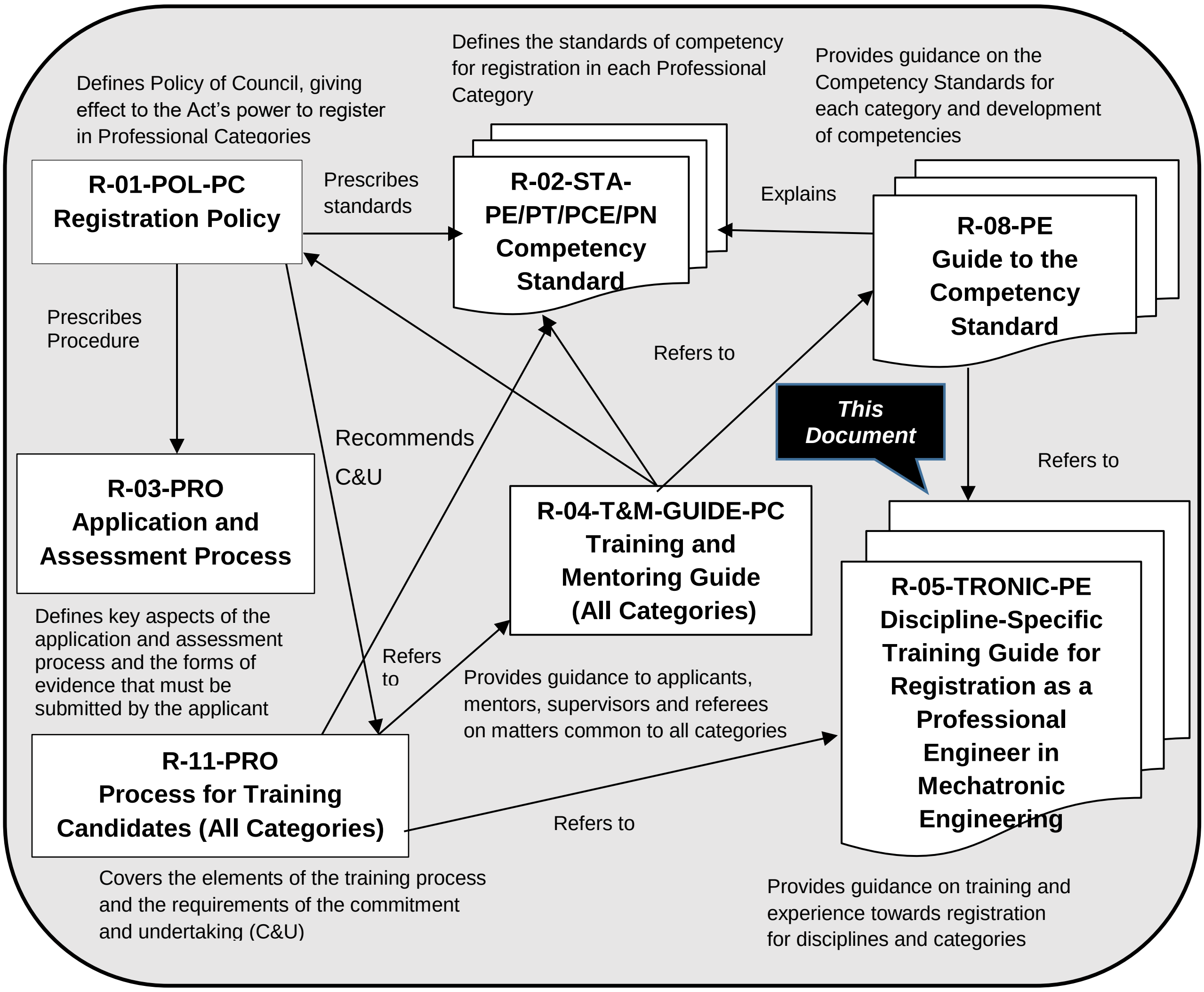

Figure 1: Documents defining the ECSA Registration System

1. PURPOSE OF THIS DOCUMENT

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

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

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-PE** 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-PE** 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:

- completed the educational requirements by obtaining an accredited Engineering Degree type qualification or by obtaining a Washington Accord Recognized qualification
- registered as a Candidate Engineer or who demonstrate training at an acceptable level of competence in specific elements relating to Mechatronics Engineering for at least three years after obtaining Bachelor of Science in Engineering or Bachelor of Engineering and Master of Engineering
- embarked on a process of acceptable training under a registered Commitment and Undertaking (C&U) with a mentor guiding the professional development process at each stage.

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

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

Application for registration as a Professional Engineer is permitted without being registered as a Candidate Mechatronics Engineer 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 7.4 of this document).

4. ORGANISING FRAMEWORK FOR OCCUPATIONS (21440)

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

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

Other specialised disciplines in which Mechatronic Engineers 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 Engineers 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 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 and 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 Engineers practise may 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 Engineers may include, among others, the following:

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

Software	FA	PA	MD
Embedded Operating Systems (Linux, Windows, Robot Operating Systems (ROS), etc)	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	

etwork Technologies	**FA**	**PA**	**MD**
CAN Bus	1	1	1
Fibre	1	1	1
EtherCAT Ethernet		1	1
Foundation Fieldbus		1	1
Industrial Ethernet	1	1	1
Industrial Wireless and Telemetry	1	1	1
Modbus Network		1	1
Profibus	1	1	1
Profinet	1	1	1

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

Process Control Technologies	**FA**	**PA**	**MD**
Alarm Management		1	
Anti-Surge Control		1	
Control Room Design and Lay-out		1	
Enclosures, Cabling and Accessories		1	
Process Measurement (incl. Temperature, Pressure, Level, Flow and Mass)		1	

Safety Systems (incl. Hazardous Area Equipment, Fail–safe Systems etc.)	1	1	
Vibration Monitoring		1	
Sensors	1	1	1
Power Electronics and Drives	**FA**	**PA**	**MD**
Low to Medium Current Electrical Distribution	1	1	1
Motor Drives	1	1	1
Power Supply Systems	1	1	1
Power Amplifiers	1	1	1

Process Technology	**FA**	**PA**	**MD**
Gas Analysers		1	
Gas Detectors		1	
Product Sampling		1	

Mechanical Design	**FA**	**PA**	**MD**
Computer Aided Design and CNC	1		1
Mechanical Simulation and Finite Element Analysis	1		1
Robotics (Industrial, Mobile, Autonomous Systems	1		1

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

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

Other Technologies	FA	PA	MD
Energy usage 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 complex engineering problems

Complex Engineering Problems have the following characteristics:

(a) Require in-depth fundamental and specialized engineering knowledge.

and one or more of:

(a) Are ill-posed, under- or over-specified, requiring identification and refinement.
(b) Are high-level problems including component parts or sub-problems.
(c) Are unfamiliar or involve infrequently encountered issues.

and one or more of:

(a) Solutions are not obvious, require originality or analysis based on fundamentals.
(b) Are outside the scope of standards and codes.
(c) Require information from variety of sources that is complex, abstract or incomplete.

(d) Involve wide-ranging or conflicting issues: technical, engineering and interested or affected parties.

and one or both of:

(a) Requires judgement in decision making in uncertain contexts.
(b) Have significant consequences in a range of contexts.

The problem may be a design requirement, an applied research and development requirement or a problematic situation in an existing component, system or process.

Tasks:

As seen above, typical tasks could include the following:

Table 1: Outcome 1

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

5.1.2 Design or develop solutions to ill–defined engineering problems

The solution may be the design of a component, system or process or a recommendation of the remedy to a problematic situation.

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

Applicable knowledge includes the following:

(a) Specialist knowledge that has depth in the practice area and is underpinned by the fundamental knowledge of an engineering discipline or cross disciplinary area. In-depth specialist knowledge in practice area supports a fundamentals-based, first principles analytical approach, building models as required.

(b) A working knowledge of interacting disciplines (engineering and other) to underpin teamwork.

(c) Jurisdictional knowledge, which 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.

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

Management is directed at achieving engineering results through management of people, resources, processes, systems and money and involves:

(a) planning of complex engineering activities

(b) organising complex engineering activities

(c) leading engineering activities

(d) controlling complex engineering activities.

Tasks

As seen above, tasks could include:

Table 4: Outcome 4

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

5.2.2 Communication

Communication involves strategic, managerial, technical and wider impacts of engineering work. Material communicated includes concepts, analyses, proposals and informative subjects. The audience includes peers, superiors, persons implementing designs and other work, persons in other disciplines, clients and wider stakeholders. Communication functions must be performed reliably and repeatably.

Tasks

As seen above, tasks could include:

Table 5: Outcome 5

TASKS	FA	PA	MD
Documentation and communication	1	1	1

5.3 Group C: Impacts of Engineering Activities

5.3.1 Social, cultural and environmental impact

Candidate Mechatronic Engineers must demonstrate:

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

Tasks

As seen above, tasks could include:

Table 6: Outcome 6

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

5.3.2 Meet legal and regulatory requirements

Candidate Mechatronic Engineers must demonstrate:

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

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

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

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

Tasks

As seen above, tasks could include:

Table 8: Outcome 8

TASKS	FA	PA	MD
Documentation and communication	1	1	1

5.4.2 Exercise sound judgement

Judgment in decision making involves:

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

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

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

Tasks

As seen above, tasks could include:

Table 9: Outcome 9

TASKS	FA	PA	MD
Documentation and communication	1	1	1
Hazard identification and risk assessment	1	1	1
Reliability analysis	1	1	1
Modelling	1	1	1
Systems engineering (Integration)	1	1	1

5.4.3 Taking responsibility

Responsibility exercised for outcomes of significant parts of one or more complex 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 Engineers 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-PE

6.1 Contextual knowledge

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

The profession identifies specific contextual activities considered essential to develop the Mechatronic Engineer’s competence. These include the applicable basic analytical, process and fabrication activities and the competencies required at the 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 Engineers need to be proficient are listed below. The parallels with the well-defined generic competence elements required in 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 the Candidate's competency by using the scales regarding Degree of Responsibility, Problem Solving and Engineering Activity as specified in document **R-04-T&M-GUIDE-PC**.

Appendix A was developed against the Degree of Responsibility Scale. Activities should be selected to ensure that the Candidate reaches the required level of competency and responsibility.

It should be noted that the Candidate working at Responsibility Level E carries the responsibility appropriate to that of a registered person except that the Candidate's supervisor is accountable for the Candidate's recommendations and decisions.

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

A: Being 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.

6.3 Statutory and Regulatory Requirements

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

These could include the following:

- Council for the Built Environment Act, 43 of 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 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 Mechatronic Engineer 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 CPD courses in Mechatronic Engineering and associated disciplines
- Financial competency such as finance for non-financial managers etc.
- Preparation of engineering design specifications
- Environmental aspects of projects and plant operations
- Professional skills such as report writing, presentations, facilitation and negotiation
- Courses intended to keep the Candidate updated on the latest technology
- Courses intended to increase the performance of the Candidate, which could include management techniques, time management, emotional intelligence etc.
- Updates on relevant equipment, its use, maintenance etc.
- Updates on applicable tools such as plant operations, performance monitoring etc.
- Maintenance and reliability engineering.

7. PROGRAMME STRUCTURE AND SEQUENCING

7.1 Best practice

Best practice is a developmental process that assists applicants to become registered Professional Engineers. 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 in which the Candidate was / is employed.

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

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

The training programme should be such that 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. Each Candidate's training programme depends on the work opportunities available at the time for the employer to assign to the Candidate. For ECSA registration in the fields in which the Candidates are employed, applicants must ensure that they undertake tasks that provide experience in the three generic engineering competence elements of problem investigation and analysis, problem solution and execution / implementation.

It should be possible by judicious selection of work task opportunities with the same employer to gain experience in all three elements. Candidate Mechatronic Engineers are advised that although three years is the minimum required period of experience following graduation, in practice, Mechatronic Engineers 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 Engineer, lecturers/researchers must become involved in the application of engineering knowledge by way of applied research and consulting work under the supervision of a Professional 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 complex 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 Engineers while in the academic environment need to satisfy the requirements of paragraph 1 and be involved in complex engineering activities which could include the following:

Teaching / Lecturing / Facilitation

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

Research or further studying

- Literature surveys

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

Laboratory experimental activities

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

Conferences / Symposia / Seminars

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

Consulting (exposure recommended for academics)

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

Multi-disciplinary exposure

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

Orientation requirements

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

7.4 Moving into or between candidacy training programmes

This guide assumes that the Candidate enters a programme after graduation and continues with the programme until ready to apply for registration. It also assumes that the Candidate is supervised and mentored by persons who meet the requirements indicated in document **R-04-T&M-GUIDE-PC**.

In the case of a person changing from one candidacy programme to another or moving into a candidacy programme from a less structured environment, it is essential that the following steps are completed:

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

REVISION HISTORY

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

The Discipline-specific Training Guide for:

Candidate Professional Engineer in Mechatronic Engineering

Revision 0 dated 13 April 2020 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).**

.... 15/04/2021
Business Unit Manager Date

.... 19/04/2021
Executive: **RPS** Date

This definitive version of this policy is available on our website

APPENDIX A: TRAINING ELEMENTS

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 things are:*** **(Responsibility level A & B)**
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 Level E)**
3.1.1	(Working in one or more of these sectors but not all) Design
3.1.2	Manufacture
3.1.3	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	Planning and scheduling maintenance (Responsibility Level E)

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	Health and safety (Responsibility Level E)
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