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| **ENGINEERING COUNCIL OF SOUTH AFRICA**  ***Standards and Procedures System*** | | |  |
| **Discipline-specific Training Guideline for Candidate**  **Engineering Technicians in Aeronautical Engineering** | | |
| **Status: Approved by the Central Registration Committee** | | |
| **Document : R-05-AER-PN** | **Rev-1** | **17 July 2014** |

**Background: ECSA Registration System Documents**

The documents that define the Engineering Council of South Africa (ECSA) system for registration in professional categories are shown in **Figure 1** which also locates the current document.

**R-01-P**

**Registration Policy**

Prescribes

Prescribes Standards

**R-02-PN**

**Competency**

**Standard**

Explains

**R-08-PN Guide to the Competency Standards**

Procedures

**R-03-PN**

**Application and Assessment Process**

Refers to

**R-04-P Training and Mentoring Guide (All Categories)**

***This Document***

Refers to

**R-05-AER-PN**

**Discipline-specific**

**Training Guide**

**Figure 1: Documents defining the ECSA Registration System**

# Purpose

All persons applying for registration as Professional Engineering Technician are expected to demonstrate the competencies specified in document R-02-PN at the prescribed level, irrespective of the trainee’s discipline, through work performed by the applicant at the prescribed level of responsibility.

This document supplements the generic *Training and Mentoring Guide* (R-04-P) and the *Guide to the Competency Standards for Professional Engineering Technicians* (R-08-PN). In document R-04-P attention is drawn to the following sections:

* + 1. Duration of training and period working at level required for registration
    2. Principles of planning training and experience
    3. Progression of Training programme
    4. Documenting Training and Experience

7.4 Demonstrating responsibility

The second document R-08-PN provides both a high-level and outcome-by-outcome understanding of the competency standards as an essential basis for this discipline specific training guide.

This Guide, as well as R-04-P and R-08-PN, are subordinate to the Policy on Registration document R-01-P, the Competency Standard (R-02-PN) and the application process definition (R-03-PN).

# Audience

This guide is specifically for engineering technicians who have studied aeronautical engineering and practice as aeronautical engineering technicians. It is also applicable to engineering technician who studied in other disciplines, but whose work is primarily in the aeronautical field and who wish to be assessed for professional registration based on their work in an aeronautical environment. The Guide is intended to support a programme of training and experience incorporating good practice elements. See footnote regarding Marine Engineering and Naval Architecture1.

This guide applies to persons who have:

* 1. Completed the education requirements by obtaining either an accredited Dip (Engineering), Dip (Eng Tech), Adv Cert (Engineering) type qualification, or a Dublin-Accord Recognised qualification or through evaluation/assessment;
  2. Registered as Candidate Engineering Technicians;
  3. 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;

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

# Persons not Registered as a Candidate or not Training under a C&U

All applicants for registration must present the same evidence of competence and be assessed against the same standards, irrespective of the development path followed. Application for registration as a Professional Engineering Technician is permitted without being registered as a Candidate Engineering Technician and without training under a C&U. Mentorship and adequate supervision are, however 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 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.

Any applicant who has not enjoyed mentorship is advised to request an experienced mentor (internal or external) to act as an application adviser while they prepare their application for registration.

1 Because of the small number of candidates in the field of Marine Engineering and Naval Architecture, the Mechanical Sub-committee of the Professional Technician Registration Committee will evaluate applications in this field. ECSA does not have discipline-specific training guideline in Marine Engineering and Naval Architecture. Candidates and their mentors may make use of the guidelines given in this document with the appropriate transpositions of subject matter.

# The guide may be applied in the case of a person moving into a candidacy programme at a later stage that is at a level below that required for registration (see section 7.3).

# Aeronautical Engineering (OFO214403)

An *Aeronautical Engineering Technician* performs and supervises well-defined engineering work concerned with the design, development, manufacture, operation and maintenance of aircraft and spacecraft of all types based on the engineering sciences underlying flight dynamics, aerospace structures and propulsion systems.

Practicing *Aeronautical Engineering Technicians* generally concentrate in one or more of the following areas:

* Aeronautical Design Engineering Technician
* Aeronautical Systems Engineering Technician
* Aeronautical Certification Engineering Technician
* Aeronautical Flight Test Engineering Technician
* Aeronautical Research Engineering Technician or Academic

# Training Implications of Industry Structure

Many engineering technicians in the aerospace industry, particularly those working in a technical environment, tend to become specialists. Those working in areas such as manufacture, maintenance and project management tend to be generalists. Specialists, through their interaction on projects with persons from other specialist areas, should as a consequence also gain practical experience also outside their specialist area.

Those aeronautical engineering technicians whose training has been more general should demonstrate that they have acceptable experience in a number of specialist areas (typically 5) for a minimum period of three years. Specialist aeronautical engineering technicians, however, should demonstrate that they have had experience, of typically five years, in at least one area of aerospace engineering and acceptable experience in a number of other areas.

Typical aerospace specialist areas are:

* Aircraft design
* Aircraft structures
* Aircraft propulsion systems
* Aerodynamics
* Avionics
* Aero-elasticity
* Stability and control
* Aircraft systems including hydraulic, pneumatic and avionics systems
* Wind tunnel testing
* Flight testing
* Aircraft performance monitoring
* Airport/Airfield management
* Certification and system safety programmes

Because of the complex nature of aeronautical systems, any given product or system will usually have components designed by engineers assisted by engineering technicians in many of the specialist areas. Work done by any engineering technicians in the field may cross the boundaries between disciplines and specialist areas or at least will be influenced by interfaces with other disciplines.

Because of the complex nature and long life cycles of aeronautical systems, Candidate Engineering Technicians are expected typically to have gained experience in at least one of the lifecycle phases (such as development, design, manufacturing or operation & maintenance) of aeronautical systems. Even though it is not required that all Candidate Engineering Technicians have had design experience, it is required that all Candidates must have demonstrated their ability to solve well-defined aeronautical problems, as explained in document R-08-PN. Solving such problems would typically require the application of aeronautical engineering sciences and the application of engineering judgement.

Since the aeronautical industry routinely involves significant risks, it is a highly regulated industry. All Candidate Engineering Technicians are, therefore, expected to have gained exposure to the regulatory aspects relevant to the work they have been involved in. Candidates are further expected to have demonstrated making sound judgements to address and mitigate risks in an aeronautical environment, and thereby not unnecessarily endanger users of their systems or the general public. Such considerations of risks should particularly include situations where technologies (such as materials and control systems) are rapidly developing and the software used for design and operations is increasingly complex.

Candidates are expected to demonstrate appreciation that practicing as a professional engineering technician is a life-long process of learning and improvement. Candidates are, therefore, expected to show how, during their training period, they improved their abilities to make sound judgements and manage risks in the presence of rapidly developing technologies.

In assessing the suitability of a Candidate, the cross-disciplinary nature of their work will be examined, as well as the degree to which they have been able to work effectively in such contexts. The degree to which they have demonstrated that they are able to know their own limits and call in the help of specialists, for example, illustrates their ability. Candidates must demonstrate that they also know enough about other disciplines/specialist areas influencing their work to properly understand and manage the risks arising from those influences.

# Good Practice in Training in Aeronautical Engineering

In order to assist Candidates in gaining the necessary training and experience/exposure, the following guidelines are given of the type of activities that should be engaged in during the time prior to registration.

These guidelines are illustrative and candidates will not be expected to do all of the suggested training activities before registration, but should do many of them to ensure that adequate experience is obtained.

# 6.1 Aeronautical Design Engineering Technicians

Aeronautical design engineering technicians are those involved with the well-defined aspects of design of aircraft or aircraft systems. Engineering technicians would be performing actual design, such as preliminary design, performance predictions, aerodynamic design, structural design, power plant trade-off studies, control system design, etc. Products/systems are designed to meet particular needs/specifications/standards.

The following types of activities are recommended for training of Aeronautical Design Engineering Technicians

:

|  |  |
| --- | --- |
| **Type of Experience** | **Specific Well-defined Activities** |
| Problem/Requirements Definition | * Formulation of User Requirement Statements (URS) * Generate performance specifications (Specs) * Qualification/verification matrix design   *(Use Standards/Specifications/Handbooks to guide in preparation of above documents.)* |
| Project Planning (for design) | * Resource Planning (computing/drafting/manufacturing, etc.) * Timescales, Critical Path, identification of bottlenecks/critical milestones, etc. |
| Examination of Alternatives | * Literature Study * Identifying potential techniques/technologies/materials * Generation of concepts * Elimination of unsuitable alternatives * Preliminary performance prediction |
| Trade-off Studies | * Using decision making tools to select between viable alternatives * Examining impacts of alternatives on ability to meet URS/Specs * Negotiate with customers w.r.t. requirement trade-offs and reformulation of URS/Specs |
| Detailed Design | * Material selection * Aerofoil & high lift devices selection * Selection of components/sub-systems * Structural/aerodynamic/mechanical design * Performance prediction * Stress analysis * Aerodynamic analysis * Stability and control analysis and design * Hazard and Operability (HAZOP) studies * Failure Modes Effects and Criticality Analysis (FMECA) * Updating of specifications * Maintenance requirements design |
| Design Documentation | * Generation of drawings * Generation of design reports * Updating of documents/specifications as design progresses * Configuration control |
| Supervision of Production | * Design of processes/tests * Handling of engineering queries/concessions/deviations * Design & implementation of quality control methods * Handling of materials * Handling of scrap/rework able items, etc. |
| Verification Testing | * Qualification/verification test planning * Qualification/verification testing * Test report writing * Commissioning of plants/equipment |
| Product Support | * Support during production testing * Support during operational testing & evaluation * Management of upgrades/repairs |

**6.2 Aeronautical System Engineering Technicians**

Aeronautical system engineering technicians are those involved with the specification, in-service management and fleet engineering of aircraft or aircraft systems. These would typically be engineering technicians in organisations who operate fleets of aircraft and who are responsible to ensure continued airworthiness of the fleet and addressing obsolescence issues. These engineering technicians operate subject to regulations and regulating bodies such as the Civil Aviation Authority.

The following types of activities are recommended for training of Aeronautical System Engineering Technicians:

|  |  |
| --- | --- |
| **Type of Experience** | **Specific Well-defined Activities** |
| Maintaining Airworthiness | * Identification & implementation of relevant Service Bulletins * Implementation of Airworthiness Directives * Implementation of Ageing Aircraft Programmes * Health and Utilisation Monitoring * Failure Reporting and Corrective Action (e.g. FMECA/FRACAS) |
| Maintenance Optimisation | * Staggering (Fleet Utilisation & Maintenance Scheduling) * Negotiation with Original Equipment Manufacturers to adapt servicing for fleet specific requirements * Trend monitoring and maintenance adaptation * Engineering management of suppliers and sub-contractors |
| Fleet Optimisation | * Fleet redesign and adaptation * Route planning for optimal fleet utilisation |
| Maintaining Fleet Currency | * Aircraft Configuration Currency Analysis * Trade-off studies between cost and return of upgrades/retrofits vs fleet replacements * Aircraft Configuration Control |
| Acquisition/Procurement Projects | * Requirements definition for new products & systems * Integration of new weapons/equipment on existing aircraft * Design review activities * Selection and implementation of upgrades (typically such as would be covered under Supplemental Type Certificates) * Management of flight test and other acceptance testing activities * Oversight of suppliers during development activities (e.g. weapons development) * Monitoring compliance with Certification Compliance Matrixes Commissioning of ground systems and support equipment (simulators, new maintenance equipment, etc.) |

# 6.3 Certification Engineering Technicians

Certification engineering technicians are those involved with ensuring that aircraft systems meet the requirements of Airworthiness Regulations. These would typically be engineering technicians employed by the Civil Aviation Authority or within companies requesting certification of their products and whose responsibility it is to ensure compliance with certification requirements.

The following types of activities are recommended for training of Certification Engineering Technicians:

|  |  |
| --- | --- |
| **Type of Experience** | **Specific Well-defined Activities** |
| Compliance Testing | * Consultation with clients and other aviation authorities w.r.t. airworthiness requirements and regulations. * Setting up Compliance Matrixes * Oversight of flight test and other acceptance testing activities * Oversight of suppliers during development activities (eg weapons development) |
| Systems Background | * Training in systems on one or more aircraft types * Troubleshooting & fault analysis * Use of design specifications during design or certification planning * Floor level exposure to all aspects of aircraft maintenance * Participation in software development and certification |
| System Safety Analysis | * Training in and application of the system safety process * Application of fault tree, HAZOP, FMEA / FMECA and equivalent safety procedures |
| Organisational Audits | * Advising organisations in creating and implementing their Manuals of Procedures * Quality systems and special process audits * Periodic auditing of approved manufacturing and maintenance organisations |
| Monitoring Compliance with Airworthiness Directives, etc. | * Ensuring approved organisations and fleet operators implement applicable Airworthiness Directives * Auditing/monitoring correct implementation of Service Bulletins/ Ageing Aircraft Programmes |
| Accident Investigations | * Serving as part of accident investigation teams * Overseeing accident investigations * Review & analysis previous accident investigation reports for similarities/trends * Writing accident investigation reports |
| Generation of Regulations | * Review existing regulations * Generate or update regulations |

**6.4 Flight Test Engineering Technicians**

Flight Test engineering is a specialist field requiring first an engineering qualification and then additional training as Flight Test Engineering Technician at one of the Test Pilot/Engineering schools. Flight Testing forms part of product development as well as verification testing towards certification of aircraft and systems.

The following types of activities are recommended for training of Flight Test Engineering Technician:

|  |  |
| --- | --- |
| **Type of Experience** | **Specific Well-defined Activities** |
| Flight Testing and Ground Testing | * Determination of relevant and necessary tests * Compilation of Test Objectives and Test Plans * Development of new testing techniques & equipment * Modifications to test aircraft * Performance testing and data analysis * Flutter Clearance testing and data analysis * Cockpit evaluation |
| Client Liaison | * Negotiations w.r.t. flight testing * Writing of Flight Test Report * Presentation of test results |

# 6.5 Research Engineering Technicians and Engineering Academics

Research Engineering Technicians and Academics are those employed by universities and research organisations. Their focus is on development of new knowledge/techniques/technologies and in teaching students.

The following types of activities are recommended for training of Aeronautical Research Engineering Technicians and Engineering Academics:

|  |  |
| --- | --- |
| **Type of Experience** | **Specific Well-defined Activities** |
| Teaching | * 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 * Serve as supervisor for student projects |
| Study & Research | * Literature study * Obtaining higher qualifications * Advancement of the current state of the art of technology * Theoretical research/development of analytical techniques * Practical/experimental research * Participating in international collaborative research |

|  |  |
| --- | --- |
| Laboratory/experimental work | * Experimentation * Design and building of laboratories * Experimental equipment design/construction * Experiment design * Development of new manufacturing techniques * Development of Non-Destructive Testing techniques * Ground vibration testing * Wind-tunnel testing * Material/structural testing |
| Conferences, Symposia, etc. | * Publishing papers (peer-review journals and international conferences) * Public peaking, etc. |
| Consulting | * Consulting to industry in solving real problems encountered in engineering practice * Design of products/components/systems for clients |

**7. Programme Structure and Sequencing**

* 1. **Best Practice**

There is no ideal training programme structure or a 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

It is suggested that the candidate works with their mentors to determine appropriate projects to gain exposure to elements of the asset cycle, to ensure that their designs are constructible, operable, and are designed considering life cycle costing and long-term sustainability

The training programme should be such that candidate progresses through levels of work capability, which is described in 7.3.4 of R-04-P, such that by the end of the training period, the candidate must perform individually and as a team member at the level of problem solving and engineering activity required for registration and exhibit degree of responsibility E.

The nature of work and degrees of responsibility defined in document R-04-P, Table 4, are used here (and in **Appendix A** below)**:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| A: Being Exposed | B: Assisting | C: Participating | D: Contributing | E: Performing |
| Undergoes induction, observes processes, 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 appropriate to a registered person, supervisor is accountable for applicant’s decisions |

The Mentor and Candidate must identify at which level of responsibility an activity provides the compliance with and demonstration of the various Outcomes. The evidence of the candidate’s activities and acceptance by the Mentor will be recorded on the appropriate system such that it meets the requirements of the Training Elements **Appendix A**. ECSA will specify the applicable recording system.

**7.2 Orientation requirements**

Introduction to Company

Company Safety Regulations

Company Code of Conduct

Company Staff Code and Regulations

Typical functions and activities

Hands on experience and orientation in each of the major company divisions

# 7.3 Realities

Generally, irrespective of the discipline, it is unlikely that the period of training will be three years, the minimum time required by ECSA. Typically, it will be longer and would be determined amongst others by the availability of functions in the actual work situation.

Each candidate will effectively undertake a unique programme where the various activities carried out at the discipline specific level are then linked to the generic competency requirements of R-08-PN.

# 7.4 Considerations for generalists, specialists, researchers and academics

Section 10 of document R-08-PN adequately describes what would be expected of persons whose formative development has not followed a conventional path, for example academics, researchers, specialists and those who have not followed a candidate training programme.

The overriding consideration is that, irrespective of the route followed, the applicant must provide evidence of competence against the standard.

# 7.5 Moving into or Changing Candidacy Programmes

This Guide assumes that the candidate enters a programme after graduation and continues with the programme until ready to submit an application for registration. It also assumes that the candidate is supervised and mentored by persons who meet the requirements in document R-04-P section 7.2. In the case of a person changing from one candidacy programme to another or moving into a candidacy programme from a less structure environment, it is essential that the following steps be completed:

* The candidate must complete the Training and Experience Summary (TES) and Training and Experience Reports (TER or TEO) 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 in the light of the past experience and opportunities and requirements of the new programme and plan at least the next phase of the candidate’s programme.

|  |  |  |  |
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| **ENGINEERING COUNCIL OF SOUTH AFRICA**  ***Standards and Procedures System*** | | |  |
| **Discipline-specific Training Guideline for Candidate**  **Engineering Technicians in Agricultural Engineering** | | |
| **Status: Approved by the Central Registration Committee** | | |
| **Document : R-05-AGR-PN** | **Rev-1** | **17 July 2014** |

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Prescribes Standards

**R-02-PN**

**Competency**

**Standard**

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**R-08-PN Guide to the Competency Standards**

Procedures

**R-03-PN**

**Application and Assessment Process**

Refers to

**R-04-P Training and Mentoring Guide (All Categories)**

***This Document***

Refers to

**R-05-AGR-PN**

**Discipline-specific**

**Training Guide**

**Figure 1: Documents defining the ECSA Registration System**

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# Purpose

All persons applying for registration as Professional Engineering Technician are expected to demonstrate the competencies specified in document R-02-PN at the prescribed level, irrespective of the trainee’s discipline, through work performed by the applicant at the prescribed level of responsibility.

This document supplements the generic *Training and Mentoring Guide* R-04-P and *the Guide to the Competency Standards for Professional Engineering Technicians*, document

R-08-PN. In document R-04-P attention is drawn to the following sections:

* + 1. Duration of training and period working at level required for registration
    2. Principles of planning training and experience
    3. Progression of Training programme
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7.4 Demonstrating responsibility

The second document R-08-PN provides both a high-level and outcome-by-outcome understanding of the competency standards as an essential basis for this discipline specific guide.

This Guide, as well as R-04-P and R-08-PN, are subordinate to the Policy on Registration, document R-01-P, the Competency Standard (R-02-PN) and the application process definition (R-03-PN).

# Audience

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

This guide applies to persons who have:

2.1 Completed the education requirements by obtaining an accredited Dip (Engineering), Dip (Eng Tech), Adv Cert (Engineering) type qualification, or a Dublin-Accord Recognised qualification or through evaluation/assessment;

2.2 Registered as Candidate Engineering Technicians;

2.3 Embarked on a process of acceptable training, preferably under a registered Commitment and Undertaking (C&U), with a Mentor guiding the professional development process at each stage;

2.4 Follow a program of training and experience incorporating the good practice elements described in this guide.

1. **Persons not Registered as a Candidate or not Training under a C&U**

All applicants for registration must present the same evidence of competence and be assessed against the same standards, irrespective of the development path followed. Application for registration as a Professional Engineering Technician is permitted without being registered as a Candidate Engineering Technician or without training under a C&U.

Mentorship and adequate supervision are however 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 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 written for the recent graduate who is training and gaining experience toward registration. Mature applicants for registration may apply the guide retrospectively to identify possible gaps in their development.

Any applicants who have not enjoyed mentorship 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 into a candidacy programme at a later stage that is at a level below that required for registration (see **Section 7.3**).

# Agricultural Engineering

**Agricultural Engineering Technician**

The expertise of Agricultural Engineering Technicians, who have unique skills to connect the living world of plants, soil, water and animals with the technology of engineering (i.e. systems, structures and machines), are required to ensure sustainable environments with adequate water supplies, energy and food production and processing systems. Agricultural engineering technicians thus operate at the interfaces between engineering science and practice, agricultural production and processing and rural environmental management. The implication is that agricultural engineering technicians must be aware of the factors that are important in agricultural production and processing and environmental sustainability. This is promoted by including introductory agricultural courses in the tertiary education of the agricultural engineering technician. In the case of candidates who have diplomas in engineering specialities other than agricultural, they will have to show that they have attained this knowledge through practical experience in at least one of the many diverse areas of sustainable agricultural production and processing if they are to be registered as agricultural engineering technicians.

An Agricultural Engineering Technician plans, performs and supervises well-defined engineering work related to the development and/or improvement of infrastructure, machinery and processes for agricultural production, the post- harvest handling and processing of agricultural produce, and similar engineering processes in associated environmental and biological contexts. This may include the use and development of agricultural land, environment, infrastructure (buildings, roads, river crossings, dams, irrigations systems, electrification etc.), machines, equipment and processes.

Due to the multi-disciplinary nature of Agricultural Engineering, practicing Agricultural Engineering Technicians generally concentrate in one or more of the following areas:

* Agricultural Energy Engineering
* Agricultural Renewable Energy Engineering
* Agricultural Product Processing Engineering
* Agricultural Structures and Facilities Engineering
* Agricultural Waste Handling and Management
* Aquaculture Engineering
* Mechanisation Engineering
* Irrigation Engineering
* Hydrology and Agricultural Water Use
* Management Natural Resources Engineering
* Food Engineering
* Environmental Engineering
* Rural Infrastructure Engineering

Potential fields of work for Agricultural Engineering Technicians include the following:

* Advising on and/or conducting well-defined research and development of new or improved theories and methods related to Agricultural Engineering (i.e. soil and water, power and machinery, processing and handling of agricultural /biological products, structures and environment, energy – particularly renewable energy, and biological systems).
* The design, management and/or advising on well-defined technology for food, fibre and energy production systems including the design, sizing, selection and management of agricultural machinery, implements and equipment for field operations (e.g. for soil preparation, planting, harvesting, storage and transport of produce), testing and evaluation of new agricultural machinery and equipment, the use of precision agriculture technologies (e.g. GIS, GPS) to ensure optimal and sustainable agricultural production systems which takes due consideration of the environment, and the design and operation of transportation systems to move produce from fields to storage facilities, factories and consumers.
* The design and management of well-defined irrigation systems to irrigate plants efficiently in order to obtain optimal yield per unit of water applied and the design and installation of drainage systems for land conservation and optimal crop production.
* The design and management of well-defined agricultural and rural water resource systems by the design of dams, canals, boreholes, extraction works and pipe networks for water supply to agriculture and humans, the assessment of the availability of water resources in order to meet demands for water in a highly variable climate in South Africa, the management of water resources by reconciling demands for water with the available supplies, the design of well-defined soil and water conservation systems to control runoff and thus minimise erosion and maximise agricultural production, and by sustaining the environment by minimising any negative impacts of agricultural practices.
* The design and operation of well-defined agricultural structures and infrastructure (e.g. farm buildings, farm roads, minor river crossings and bridges, animal handling facilities, agricultural waste handling and management facilities, spray races and dips).
* The design and management of well-defined food processing and storage systems in order to add value to raw products by the use of technology to preserve and process food and animal feed, and ensuring products are safe for human consumption (e.g. structures, cold stores, pack houses, factories and plants for agricultural produce value addition, cooling, heating, dehydration and pasteurisation facilities, grain handling-, storage- and silo facilities, fish processing plants, abattoirs, marketing structures).
* The design and management of well-defined intensive animal and plant production structures and control systems which may have controlled environments for optimal plant (e.g. greenhouses) and animal (e.g. housing structures, broiler units, dairy plants, milking parlours) production.
* The use of renewable sources of energy by the design and development of well-defined technology to grow and utilise sustainable sources of energy (e.g. hydro, bio-fuels, solar, wind) and the processing of agricultural products and biomass into bio-energy (e.g. anaerobic digesters).
* Design, management and advising on well-defined power and energy systems for agricultural production, including design, sizing, selection and management of agricultural machinery and equipment (e.g. engines, motors, pumps, fans, pipes), testing and evaluation of new agricultural machinery and equipment.
* Determining and specifying construction methods, materials and quality standards and directing construction work.
* Establishing control systems to ensure efficient functioning of infrastructure as well as safety and environmental protection.
* Organising and directing operation, maintenance and repair of agricultural production structures and facilities.
* Analysing the stability of structures, machinery and implements and testing the behaviour and durability of materials used in their construction.

# Training Implications of the Nature and Organisation of the Industry

## 5.1 Diverse Fields of Specialisation

Agricultural Engineering encompasses a diverse range of fields, and it would be unrealistic to expect a Candidate Engineering Technician to achieve exposure to the full range of fields during the training period, or even throughout his career. However, it is important that the Candidate Engineering Technician:

* is exposed to and demonstrates a good understanding of the context within which he is applying his knowledge, skills and engineering judgement;
* gains experience across the full spectrum of tasks in the typical lifecycle of engineering projects; and
* is familiar with the statutory requirements related to his field of operation.

## 5.2 The Need for Strong Contextual Knowledge

By nature, work in the Agricultural Engineering sector is very closely integrated with biological systems and the natural environment. Furthermore, it requires of the engineering technician a thorough understanding of the range of people and circumstances that an agricultural engineering solution would need to be suited to, which may vary from ultramodern agro-industrial factories and complex multi-faceted commercial farming enterprises, through to robust pro-poor rural food security systems within complex multi-user social structures.

The strong contextual nature of Agricultural Engineering solutions holds specific implications for the training of the Candidate Engineering Technician. It is strongly recommended that the Candidate Engineering Technician also acquires first-hand exposure to and experience of the non-engineering context (farms, rural communities, agri-businesses) within which Agricultural Engineering solutions need to be relevant. Adequate first-hand exposure will enable the Candidate Engineering Technician to:

* Understand that he is working with the uncertainties of economy, climate, different social contexts and farming environments;
* Understand, respect and be able to collaborate with related disciplines in a well-defined environment, including specialists in crops, soils, food science, health, chemical suppliers, environmental aspects; and
* Appreciate the economic realities in agriculture, including low margins in agriculture; resource-poor communities; and socio-economic impacts of, and on, engineering interventions.

## 5.3 Tasks/Functions in the Engineering Project Lifecycle

The Candidate Engineering Technician should ensure that the work he/she engages in during the training period is relevant to his/her progression towards registration, and gradually increases his/her degree of responsibility. He/she should further ensure that he/she gains experience in all the typical tasks in the lifecycle of agricultural engineering projects, specifically including practical site work and engineering design. The tasks in the engineering project lifecycle are further elaborated in “**Appendix A**: Training Elements”, namely:

1. Solving well-defined engineering problems, using engineering & contextual knowledge;
2. Planning/implementing/operating engineering projects/systems/products/processes;
3. Mitigating risk & impact; and
4. Managing engineering activities.

The Candidate Engineering Technician can develop further insight into the typical stages in the implementation of engineering projects by studying the Guideline Scope of Services and Tariff of Fees for Persons Registered in terms of the Engineering Profession Act, 2000 (Act No.46 of 2000) (see Engineering Council of South Africa Board Notice No 208 of 2011 in the Government Gazette No.34875 of 20 December 2011).

The six stages for implementation of normal services in an engineering project are:

* **Stage 1** - Inception (including assessment of needs and resources)
* **Stage 2** - Concept and Viability (often called Preliminary Design)
* **Stage 3** - Design Development (also termed Detail Design)
* **Stage 4** - Documentation and Procurement (developing of tender documentation including drawings, specifications, quantities and tenders/contracts, and procurement, including tendering process)
* **Stage 5** - Contract Administration and Inspection (requiring adequate first-hand practical experience of the Candidate Engineering Technician in site work, such as fabrication, construction, manufacturing, installation; construction administration and inspection)
* **Stage 6** - Close-Out (project close-out and handover, including commissioning, operating documentation and as-built plans)

For continuing projects in an operational environment, the Agricultural Engineering Technician may be responsible for project management such as ongoing operation and maintenance, asset management and renewal, and optimisation, including:

* post-implementation/ operation/ management;
* shut-down, preventative maintenance;
* ongoing optimisation;
* repair, refurbishment, upgrading; and
* decommissioning, safe disposal/ re-use/ recycling.

Both practical experience in site work (Stage 5) and engineering design (Stages 2 and 3) are essential in the training of an Agricultural Engineering Technician. It should be noted that design is not restricted to physical infrastructure and artifacts, but may also produce new processes or operating systems.

## 5.4 Industry-related statutory requirements, risk and impact mitigation

The close association of Agricultural Engineering with biological and environmental systems requires specific attention to risk and impact mitigation, and requires the Candidate Engineering Technician to develop a good working knowledge of specific laws and regulations, including but not limited to the following:

1. Atmospheric Pollution Prevention Act, No. 45 of 1965
2. Conservation of Agricultural Resources Act. No. 43 of 1983 (CARA)
3. Land Reform legislature
4. Land Use Planning Ordinance, No. 15 of 1985 (LUPO)
5. National Environmental Management Act, 1998 (Act no. 107 of 1998)
6. National Environmental Management Biodiversity Act, No. 10 of 2004
7. National Environmental Management Waste Act, No. 59 of 2008
8. National Water Act, No. 36 of 1998
9. Occupational Health and Safety Act, No. 85 of 1993

# Developing competency: Elaborating on sections in the Guide to the Competency Standards, document R-08-PN

**6.1 Portfolio of Evidence**

The Candidate Engineering Technician can demonstrate competency in his or her field by compiling a portfolio of evidence, structured according to the eleven outcomes mentioned in R-02-PN and further described in R-08-PN. The eleven outcomes are organised in five groups (Groups A-E), and nested as shown below:

The competency standard defines eleven outcomes, conveniently grouped as follows and in nested form in **Figure 2**:

**Group A:** Knowledge-based Engineering Problem Solving (**Outcomes 1, 2, 3**)

**Group B:** Managing Engineering Activities (**Outcomes 4, 5**)

**Group C:** Risk and Impact Mitigation (**Outcomes 6, 7**)

**Group D:** Exercising Judgement and Taking Responsibility (**Outcomes 8, 9, 10**)

**Group E:** Developing Own Competency (**Outcomes 11**)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | | | | **Maintaining and Extending Competence**  **11:** Undertake professional development activities sufficient to maintain and extend his or her competence. |
|  | **Essential Activities of Professional Engineering Technicians**  **1**: Define, investigate and analyse *well-defined* engineering problems.  **2:** Design or develop solutions to *well-defined* engineering problems. | **Using Enabling Knowledge**  **3:** Comprehend and apply the knowledge embodied in established engineering practices and knowledge specific to the jurisdiction in which he/she practices. | **Taking Account of Consequences**  **6:** Recognise the reasonably foreseeable social, cultural and environmental effects of *well-defined* engineering activities.  **7:** Meet all legal and regulatory requirements and protect the health and safety of persons in the course of his or her *well-defined* engineering activities. | **Exercising Personal Attributes**  **8:** Conduct engineering activities ethically.  **9:** Exercise sound judgement in the course of *well-defined* engineering activities.  **10:** Be responsible for making decisions on part or all of *well-defined* engineering activities. |
|  |
|  |
|  | **4:** Manage part or all of one or more *well-defined* engineering activities.  **5:** Communicate clearly with others in the course of his or her engineering activities. |
|  |
|  |  |  |  |  |

**Figure 2: Nesting of the outcomes specified for registration as a Professional Engineering Technicians**

### A Knowledge based problem solving (this should be a strong focus)

The Candidate Engineering Technician may develop and demonstrate competency in Outcomes 1, 2 and 3 by providing evidence of well-defined problem identification and analysis which successfully interpreted a diversity of factors in farming, rural development or agro-industrial contexts affecting possible engineering solutions; examples of identification, evaluation, selection, design and implementation of suitable engineering solutions (which may include infrastructure and/or processes); and application of engineering and non- engineering knowledge and insight to achieve workable solutions.

### B Management and Communication

Evidence for the Candidate Engineering Technician’s competency in Outcomes 4 and 5, management and communication in Agricultural Engineering, can include examples of planning, organising and human resource management, funds, machinery, methods and materials in site work and agricultural engineering office contexts. This may also include professional and effective communication with farmers, rural communities, contractors, persons engaged in agro-industry, relevant government departments, clients and peers.

### C Identifying and mitigating the impacts of engineering activity

Examples demonstrating competency in Outcome 6, identifying and mitigating the impacts of agricultural engineering activity may include the responsible development, utilisation and protection of natural resources related to agriculture, including water, soil, biodiversity and air quality. It may further include mitigation of non-regulated impacts, such as disturbances to social and economic stability through ill-considered engineering developments, particularly in remote rural areas.

Evidence of competency in Outcome 7 may include examples of protection of human, animal and plant health, in farming and agro-industrial contexts, in addition to compliance with relevant regulatory requirements in the design of engineering solutions.

### D Judgement and responsibility

For Outcomes 8, 9 and 10, the Candidate Engineering Technician should demonstrate that he or she is willing and able to take responsibility for well-defined decisions, and is competent in judgement and responsible conduct in accordance with the ECSA Code of Conduct.

### E Independent learning

Towards achievement of Outcome 11, the Candidate Engineering Technician should develop the ability and habit for independent and lifelong learning, and can provide evidence of relevant Continuous Professional Development (CPD) activities completed during the training period, using the CPD guidance documentation available on the ECSA website.

## 6.2 Recommended Practical and Formal Learning Activities

The following practical and formal learning activities/objectives are recommended for inclusion in the training period for a Candidate Engineering Technician in Agricultural Engineering:

* Practical exposure to non-engineering skills, and underlying background experience in farming, rural development and/or agro-industry contexts. If possible, it is strongly advised that candidate agricultural engineering technicians work in a farming or agro-industrial environment for at least three months to a year upon graduation;
* Getting into the habit of CPD in functions related to the discipline;
* Networking and getting to know peers and related disciplines;
* Developing targeted soft skills, to act effectively with respect for social realities and management contexts;
* Attendance of industry-related conferences/ presentations / seminars / workshops; IT/software applications relevant to the discipline;
* Project planning and management;
* Engineering management; and
* Entrepreneurship and business management.

# Programme Structure and Sequencing

**7.1 Level of Responsibility**

The Candidate Engineering Technician, with his supervisor and mentor, should ensure that his work is structured and sequenced to enable systematic progression towards registration. Progress can be planned and measured using the scales for degree of responsibility, engineering activity and engineering problem solving as described in R-04-P: Training and Mentoring Guide and R-08-PN: Guide to the Competency Standard.

In particular, “Table 4: Progression throughout the candidacy period” in R-04-P refers to the gradual increase in the degree of responsibility that a Candidate Engineering Technician is expected to acquire and exhibit during his/her engineering training. Specific examples and outcomes appropriate to training in Agricultural Engineering are given below:

|  |  |  |
| --- | --- | --- |
| **Degree of Responsibility** | **Nature of work. The candidate …** | **(Activities/duties to be undertaken during training in Agricultural Engineering)** |
| A: Being Exposed | … undergoes induction, observes processes and work of competent practitioners | While working under close supervision of a competent/professional and senior colleagues in the firm/organization, the trainee should:   * Be directed to read the various Acts and regulations that affect the work of a professional engineering technician; * Be exposed to the firm or organisation’s work environment, including the organisational structure; * Read materials about the firm/organisation; * Be exposed to field work and engineering office work environment and culture; * Attend and participate in meetings, including office, field/site meetings, seminars, workshops, etc.; * Be sensitised about the importance of CPD and relevant vocational society meetings; * Be exposed and/or trained in the use of both the general and specialised computer software packages used by the firm/ organisation in its delivery of day-to-day work; |

|  |  |  |
| --- | --- | --- |
|  |  | * Be part of a team comprising competent engineering personnel and Candidate Engineering Technicians working on engineering projects in a sub-discipline of agricultural engineering; * If possible, the trainee should be attached/exposed to different well-defined projects in the known sub-disciplines of agricultural engineering; and * Be personally committed to his/her development and training by gaining experience in the full range of engineering activities available in the firm/organisation. |
| B: Assisting | … performs specific processes under close supervision | While working under close supervision of a professional person, the trainee should:   * Be engaged in well-defined engineering tasks under close supervision of a competent person; * Develop and display an appreciation of the numerous resources at the disposal of an agricultural engineering technician; * Be engaged in conducting well-defined special studies or research to solve customer service problems; * Assist in the selection of outside consultants and contractors; * Assist in the preparation of and issuance of proposals to consultants and contractors; * Be assigned the well-defined responsibilities of assisting/ supervising new staff at the „ A – Being Exposed‟ level and other lower level technical staff; * Assist in the review of bid proposals and assist in making recommendations and forward his/her report to the supervising professional; and * Be personally committed to his/her development and training by gaining experience of the whole range of well-defined engineering activities available in the firm/organisation. |
| C:  Participating | … performs specific processes as directed with limited supervision | While working under reduced supervision compared to the Degree of Responsibility at levels A and B, the trainee should:   * Administer assigned well-defined contracts and provide administrative support in the preparation of well-defined construction and maintenance contracts; * Participate in the preparation of budgets for assigned well-defined projects, submit budget recommendation and monitor expenditure; |

|  |  |  |
| --- | --- | --- |
|  |  | * Assist in monitoring outside consultants’ work and progress of well-defined projects and disbursement of payments; * Compile engineering and other relevant data for use by other engineering project team members for assigned projects; * Participate in minor well-defined engineering design work as directed by a competent person; * Be personally committed to his/her development and training by gaining experience of the whole range of engineering activities available in the firm/organisation; and * Remain committed to CPD. |
| D:  Contributing | … performs specific work with detailed approval of work outputs | While working under minimum supervision, the trainee applies well-defined engineering technology and knowledge of biological sciences to agricultural problems concerned with power and machinery, electrification, structures, soil and water conservation, and processing of agricultural products, in order to:   * Develop well-defined criteria for design, manufacture, or construction of equipment, structures, and facilities; * Design and use sensing, measuring, and recording devices and instrumentation to study such problems as effects of temperature, humidity, and light, on plants or animals, or relative effectiveness of different methods of applying insecticides; * Design and direct manufacture of well-defined equipment for land tillage and fertilisation, plant and animal disease and insect control, and for harvesting or transport of commodities; * Design and supervise erection of well-defined structures for crop storage, animal shelter, and human dwelling, including light, heat, air-conditioning, water supply, and waste disposal; * Plan and direct construction of well-defined irrigation, drainage, and flood-control systems for soil and water conservation; * Design and supervise installation of well-defined equipment and instruments used to evaluate and process farm products, and to automate agricultural operations groups, and related farm cooperatives; and * Remain committed to CPD.   It should be noted that the trainee need not contribute/work in all the said areas because the firm/organisation may not be involved in engineering work covering all the agricultural engineering sub- disciplines. |

|  |  |  |
| --- | --- | --- |
| E: Performing | … works in team without supervision, recommends work outputs, responsible but not accountable | While working under no supervision, the trainee applies well-defined engineering technology and knowledge of biological sciences to agricultural problems concerned with power and machinery, electrification, structures, soil and water conservation, and processing of agricultural products, in order to:   * Develop well-defined criteria for design, manufacture, or construction of equipment, structures, and facilities; * Develop and implement well-defined production, processing and management systems; * Design and use sensing, measuring, and recording devices and instrumentation to study such problems as effects of temperature, humidity and light on plants or animals, or relative effectiveness of different methods of applying insecticides; * Design and direct manufacture of well-defined equipment for land tillage and fertilisation, plant and animal disease and insect control, and for harvesting or transport of commodities; * Design and supervise erection of well-defined structures for crop storage, animal shelter, and human dwelling, including light, heat, air-conditioning, water supply, and waste disposal; * Plan and direct construction of well-defined irrigation, drainage, and flood-control systems for soil and water conservation; * Design and supervise installation of well-defined equipment and instruments used to evaluate and process farm products, and to automate agricultural operations groups, and related farm cooperatives; * Assume technical responsibility and coordinate the work of his/her juniors; * Manage multi-disciplinary well-defined engineering projects; * Be required to exercise well-defined engineering judgment and take responsibility, the output of which must be confirmed by a professional person; and * Remain committed to CPD.   It should be noted that the trainee need not contribute/work in all the said areas because the firm/organisation may not be involved in engineering work covering all the agricultural engineering sub- disciplines. |

## 7.2 Best-practice programmes

Recognition of prior engineering training outside the realm of ECSA training requirements guide should be used to determine at what level of responsibility a late entrant or one who has changed employment should join the candidacy programme. The onus is placed on the trainee applicant to provide verifiable evidence that the engineering work they were involved in, in the past indeed meets the requirements of the degree of responsibilities contained in this DSTG.

## 7.3 Considerations for generalists, specialists, researchers and academics

Persons whose formative development has not followed a conventional path, for example academics, researchers, and specialists, are enabled to register. The overriding consideration is that to be registered, a person, irrespective of the route followed, must provide evidence of competence against the standard. The onus is on such applicants to provide verifiable evidence that the degree of responsibility and competence required in this DSTG have been met.

## 7.4 Moving into or between Candidacy Programmes

This Guide assumes that the candidate enters a programme after graduation and continues with the programme until ready to submit an application for registration. It also assumes that the candidate is supervised and mentored by persons who meet the requirements in document R-04-P section 7.2. In the case of a person changing from one candidacy programme to another or moving into a candidacy programme from a less structure environment, it is essential that the following steps be completed:

* The candidate must complete the Training and Experience Summary (TES) and Training and Experience Reports (TER) 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 in the light of the past experience and opportunities and requirements of the new programme and plan at least the next phase of the candidate’s programme.

|  |  |  |  |
| --- | --- | --- | --- |
| **ENGINEERING COUNCIL OF SOUTH AFRICA**  ***Standards and Procedures System*** | | |  |
| **Discipline-Specific Training Guideline for Candidate Engineering Technicians in Chemical Engineering** | | |
| **Status: Approved by the Central Registration Committee** | | |
| **Document : R-05-CHE-PN** | **Rev-1** | **17 July 2014** |

# Background: ECSA Registration System Documents

The documents that define the Engineering Council of South Africa (ECSA) system for registration in professional categories are shown in **Figure 1** which also locates the current document.

**R-01-P**

**Registration Policy**

Prescribes

Prescribes Standards

**R-02-PN**

**Competency**

**Standard**

Explains

**R-08-PN Guide to the Competency Standards**

Procedures

**R-03-PN**

**Application and Assessment Process**

Refers to

**R-04-P Training and Mentoring Guide (All Categories)**

***This Document***

Refers to

**R-05-CHE-PN**

**Discipline-specific**

**Training Guide**

**Figure 1: Documents defining the ECSA Registration System**

# 1. Purpose

All persons applying for registration as Professional Engineering Technicians are expected to demonstrate the competencies specified in document R-02-PN at the prescribed level, irrespective of the trainee’s discipline, though work performed by the applicant at the prescribed level of responsibility.

This document supplements the generic *Training and Mentoring Guide* R-04-P and *the Guide to the Competency Standards for Professional Engineering Technicians*, document R-08-PN. In document R-04-P attention is drawn to the following sections:

7.3.2 Duration of training and period working at level required for registration

7.3.3 Principles of planning training and experience

7.3.4 Progression of Training programme

7.3.5 Documenting Training and Experience

7.4 Demonstrating responsibility

The second document R-08-PN provides both a high-level and outcome-by-outcome understanding of the competency standards as an essential basis for this discipline specific guide.

This Guide, as well as R-04-P and R-08-PN, are subordinate to the Policy on Registration, document R-01-P, the Competency Standard (R-02-PN) and the application process definition (R-03-PN).

# 2. Audience

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

This guide applies to persons who have:

2.1 Completed the education requirements by obtaining an accredited Dip (Engineering), Dip (Eng Tech), Adv Cert (Engineering) type qualification, or a Dublin-Accord Recognised qualification or through evaluation/assessment;

2.2 Registered as Candidate Engineering Technicians;

2.3 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 a Candidate or not Training under a C&U

All applicants for registration must present the same evidence of competence and be assessed against the same standards, irrespective of the development path followed. Application for registration as a Professional Engineering Technician is permitted without being registered as a Candidate Engineering Technician or without training under a C&U. Mentorship and adequate supervision are however 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 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 pace at all stages of the development process.

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

Any applicants who have not enjoyed mentorship 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 into a candidacy programme at a later stage that is at a level below that required for registration (see **Section 7.4**).

# 4. Chemical Engineering

**Chemical Engineering:** The planning, design, development, operation and maintenance of industrial- scale processes to convert raw and recycled materials to products through chemical and physical processes using engineering science such as thermodynamics, fluid mechanics and transfer processes.

Typical tasks that a Chemical Engineering Technician may undertake include the following (note that this is not an exhaustive list):

* Conducting research, advising on and developing well-defined commercial-scale processes to produce substances and items such as petroleum derivatives, chemicals, food and drink products, pulp and paper, pharmaceuticals or synthetic materials such as polymers and plastics
* Specifying well-defined chemical production methods, equipment, materials and quality standards and ensuring that they conform to specifications and accepted industry practices and standards
* Establishing well-defined control standards and procedures to ensure safety of production operations and safety of workers operating equipment or working in close proximity to on-going chemical reactions or processes
* Designing well-defined chemical plant and equipment and devising well-defined processes for manufacturing chemicals and other products while meeting targeted efficiencies
* Performing well-defined tests throughout stages of production to determine degree of control over process variables including composition, temperature, density, specific gravity and pressure
* Developing operating procedures to be employed during well-defined design and operating phases (including start-up, shutdown and emergency)
* Preparing estimates of production costs (capex, opex and lifecycle) and production progress reports for management
* Performing laboratory studies of steps in manufacture of new products and testing proposed process(es) in small scale operation such as a pilot plant
* Plant operation and/or management
* Optimising of well-defined processes for improvement of prescribe performance indices such as profitability, sustainability, energy, environmental and carbon efficiency.
* Develop well-defined process control philosophies and/or advanced process control (APC) systems.
* Evaluate environmental and legal considerations
* Participate in and lead risk assessment studies (such as hazard and operability studies) during the design or operations phase

# 5. Training Implications of the Nature and Organisation of the Industry

**5.1 Areas within Chemical Engineering**

The areas where chemical engineering technicians work follow the conventional stages of the project life cycle:

* Research and development to develop a new product or process, or fix a process problem.
* Process design to solve a process-related problem, or achieve a particular desired result, or to select equipment for a particular purpose (including conceptualisation, examination of alternatives, trade-off studies, basic and detailed design)
* Project management to install the necessary equipment for the desired process (including project planning, project controls (budgets, resources, schedules) etc.)
* Plant operation to manufacture the product and make process improvements

It is not expected that applicants will have to change jobs in order to work in all four areas (although that is often a good way, followed by many candidate engineering technicians, of being sure of getting the broadest possible experience). What is expected for ECSA registration is that in whatever area they are employed, applicants ensure that they undertake well-defined tasks that provide experience in the 3 generic engineering competence elements: of problem investigation and analysis; problem solution and execution/ implementation. It should not take too much thought to realise that problem investigation; problem solution; execution/ implementation are all required in every one of the areas above, to a greater or lesser extent. It should be possible, by judicious selection of well-defined work task opportunities with the same employer, to gain experience in all three elements, as expanded in the functions described in **Section 5.2**.

It is also important that the applicants be able to demonstrate that they have gained experience at increasing levels of responsibility ultimately operating at the level expected of a professional engineering technician within the areas of problem investigation and analysis; problem solution and execution/ implementation. To this end, it is important for candidate engineering technicians to work closely with their mentors and employers to plan well-defined workplace opportunities in order to gain the necessary experience and expertise.

# 5.2 Engineering Lifecycle Considerations

The typical engineering industry lifecycle is depicted in **Figure 2** below:

**Develop new brief**

**Projects**

**& Design**

**Operations & Maintenance**

**Management**

**Construction or Manufacturing**

Figure 2 Typical Engineering Industry Life Cycle

The Chemical Engineering professional will generally work in one of two broadly defined working environments:

* Projects and design
* Operations

In **Appendix A**, a generic scheme is presented for the outcomes applicable to all disciplines that a candidate must become competent to do in each of the phases of a project or task:

1. Solving problems based on well-defined engineering and contextual knowledge;
2. Managing engineering activities;
3. Impacts of the engineering activity;
4. Judgement, responsibility and ethical behaviour during an engineering activity; and
5. Further professional development since graduation.

**Appendix A** details the types of evidence of performance that would be appropriate.

# 6. Developing competency: Elaborating on sections in the Guide to the Competency Standards, document R-08-PN

**6.1 Contextual Knowledge**

Candidates are encouraged to familiarise themselves with the Process Industries in general by reading journals, joining industry associations, attending training courses and conferences. This includes gaining knowledge of industry standards and specifications (such as ASME, TEMA, NFPA) and industry practices (such as API).

# 6.2 Functions Performed

The functions in which all chemical engineering technicians need to be proficient, and are required to a greater or lesser extent in all the areas of employment, are listed below. The parallels with the well-defined generic competence elements required by the competency standard R-02-PN should be clear.

* Investigation/trouble-shooting
* Process plant and equipment design
* Process safety and environmental considerations
* Project management
* Plant construction support, hand-over and commissioning/de-commissioning
* Plant operation

Applicants need to gain experience in these functions, even if it is not their core job function.

# 6.2.1 Investigation/ trouble-shooting (i.e. thinking about or evaluating a problem)

* Identification of the cause(s) of process problems in a systematic manner
* Identification of opportunities for improving current operations, extending the product range/yield, changing the feed source, developing new methods for processing, developing new applications for products, developing new methods/technologies to address shortfalls in currently available methods/technologies or evaluation of processing alternatives
* Planning and carrying out well-defined experimental investigations in a scientific manner on a laboratory, pilot plant or industrial plant scale
* Evaluation of well-defined experimental or theoretical results, or evaluation of a proposed project (techno-economic evaluation); deriving conclusions in a logical way and formulating recommendations based on these conclusions
* Motivating research, development or plant modification projects based on technical, economic, safety and environmental considerations

# 6.2.2 Process plant design (i.e. doing something about the problem)

* Preparation of a well-defined design basis, process flow sheets, mass and energy balances (can involve simulation and/or computational fluid dynamics)
* Optimization of well-defined plant system design; using models (normally computerised) to determine configuration options
* Selection, design and specification of equipment and service requirements, with reference to the applicable codes and consideration of the suitability of materials used, costs and lifecycle requirements
* Checking the reliability of data on the properties of materials to be processed or produced, economics, instrumentation, quality control, logistics, safety, spillage/containment management and the effect on the environment
* Definition and development of well-defined process control and operating philosophies
* Checking of working drawings for suitability with respect to the process, space, accessibility, maintenance etc.

# 6.2.3 Process safety and environmental considerations

* Consideration of the process safety aspects of projects, which arise from the use of hazardous materials
* Consideration of process safety when selecting the materials of construction
* Assessing the environmental impact of process industry activities, and compliance with legal requirements (including requirements for final de-commissioning, shutdown and/or facility closure)
* Use of risk assessment and HAZOP techniques to improve plant design safety
* Application of process safety management systems to ensure safe operation and contingency measures

# 6.2.4 Project management

* Project management during all phases of project development, including conceptual design, basic and detailed engineering, EPCM – engineering procurement, construction management and commissioning/hand-over
* Responsibility for or involvement in project controls – including cost control, estimating (resources, capital, operating and/or lifecycle costs), planning and scheduling
* Liaison and responsibility for communication and overall control of part of the engineering team and resulting interfacing with client/legal entities

# 6.2.5 Plant construction support, hand-over and commissioning/de-commissioning

* Plant hand-over: including „as-built‟ documentation, construction punch-out, planning and execution of punch-out and hand-over
* Assisting in plant commissioning: measurement and analysis of plant performance versus design data; responsibility for acceptable plant performance; elimination of operability and other problems and unacceptable bottlenecks; checking on compliance with safety standards
* Preparation of operating, start up, shutdown and emergency procedures
* Plant de-commissioning and consolidation for shutdown or closure

# 6.2.6 Plant operation

* Management of production resources : raw materials, manpower, energy, maintenance
* Quality control; monitoring quality and meeting specifications;
* Assist in measurement analysis and evaluation of performance data; on-going plant monitoring and plant optimization, performance and operating costs
* Involvement in budgets, cost control, planning and production scheduling

# 6.3 Industry-related statutory requirements

The candidate engineering technician should become familiar with the legal requirements of the process industries including those acts that are generally applicable such as the OHS Act, and the Engineering Profession Act. The candidate engineering technician will be expected to have knowledge and understanding of the statutory requirements pertaining to the work and projects that are included in the experience report.

# 6.4 Recommended Formal Learning Activities

The following list of formal learning activities is by no means extensive and is purely a sample of some useful courses:

* Risk assessment and analysis techniques (including HAZOPs)
* Project management techniques and tools, including conditions of contract, finance and economics and quality systems
* Simulation tools, e.g. Aspen, SimSci, ChemCAD, AFT, Metsim
* Occupation Health and Safety including the OHS Act and “safety in design”
* Formally registered CPD courses in Chemical/Process Engineering and associated disciplines
* Value Engineering and other Value Improvement Practices (VIPs)
* Preparation of Specifications
* Environmental aspects of projects
* Professional skills such as report writing, presentations, review meeting facilitation and negotiation skills
* Project and Operations planning methods

# 7. Programme Structure and Sequencing

**7.1 Best Practice**

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. This means that each candidate will effectively undertake a unique programme where the various activities carried out at the discipline specific level must then be linked to the generic competency requirements of R-08-PN.

# 7.2 Realities

Candidate Engineering Technicians are advised that although 3 years is the minimum period of experience following graduation, in practice it is found that very seldom do chemical engineering technicians meet the experience requirements in this time, and then only if they have followed a structured training program. Applicants are advised to gain at least 5 years of experience before applying. Furthermore, as the application procedure only allows deferral for 1 year (plus a possible additional 1 year extension of

deferral in specific circumstances), applicants will lose their application fee if they cannot achieve the necessary competency within that deferral time period.

# 7.3 Considerations for generalists, specialists, researchers and academics

Chemical Engineering Technicians often work in areas such as academia, Research & Development or highly specialised fields where it is often difficult to gain the breadth of experience required for registration. These candidates must still obtain the necessary experience to enable them to demonstrate that they have met the competencies specified in document R-02-PN at the level expected of a professional engineering technician. It is expected that this will take longer than it would for candidates working in more general areas.

# 7.4 Moving into or between Candidacy Programmes

This Guide assumes that the candidate enters a programme after graduation and continues with the programme until ready to submit an application for registration. It also assumes that the candidate is supervised and mentored by persons who meet the requirements in document R-04-P section 7.2. 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 be completed:

* The candidate must complete the Training and Experience Summary (TES) and Training and Experience Reports (TER) 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 in the appropriate manner.
* On entering the new programme, the Mentor and Supervisor should review the candidate’s development in the light of the past experience and opportunities and requirements of the new programme and plan at least the next phase of the candidate’s programme.

|  |  |  |  |
| --- | --- | --- | --- |
| **ENGINEERING COUNCIL OF SOUTH AFRICA**  ***Standards and Procedures System*** | | |  |
| **Discipline-specific Training Guideline for Candidate**  **Engineering Technicians in Civil Engineering** | | |
| **Status: Approved by the Central Registration Committee** | | |
| **Document : R-05-CIV-PN** | **Rev-1** | **17 July 2014** |

# Background: ECSA Registration System Documents

The documents that define the Engineering Council of South Africa (ECSA) system for registration in professional categories are shown in **Figure 1** which also locates the current document.

**R-01-P**

**Registration Policy**

Prescribes

Prescribes Standards

**R-02-PN**

**Competency**

**Standard**

Explains

**R-08-PN Guide to the Competency Standards**

Procedures

**R-03-PN**

**Application and Assessment Process**

Refers to

**R-04-P Training and Mentoring Guide (All Categories)**

***This Document***

Refers to

**R-05-CIV-PN**

**Discipline-specific**

**Training Guide**

**Figure 1: Documents defining the ECSA Registration System**

# 1. Purpose

All persons applying for registration as Professional Engineering Technician are expected to demonstrate the competencies specified in document R-02-PN at the prescribed level, irrespective of the trainee’s discipline, through work performed by the applicant at the prescribed level of responsibility.

This document supplements the generic *Training and Mentoring Guide* R-04-P and *the Guide to the Competency Standards for Professional Engineering Technicians*, document

R-08-PN. In document R-04-P attention is drawn to the following sections:

* + 1. Duration of training and period working at level required for registration
    2. Principles of planning training and experience
    3. Progression of Training programme
    4. Documenting Training and Experience

7.4 Demonstrating responsibility

The second document R-08-PN provides both a high-level and outcome-by-outcome understanding of the competency standards as an essential basis for this discipline specific guide.

This Guide, as well as R-04-P and R-08-PN, are subordinate to the Policy on Registration, document R-01-P, the Competency Standard (R-02-PN) and the application process definition (R-03-PN).

# 2. Audience

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

This guide applies to persons who have:

* 1. Completed the education requirements by obtaining an accredited Dip (Engineering), Dip (Eng Tech), Adv Cert (Engineering) type qualification, or a Dublin-Accord Recognised qualification or through evaluation/assessment;
  2. Registered as Candidate Engineering Technicians;
  3. 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 a Candidate or not Training under a C&U

All applicants for registration must present the same evidence of competence and be assessed against the same standards, irrespective of the development path followed. Application for registration as a Professional Engineering Technician is permitted without being registered as a Candidate Engineering Technician or without training under a C&U. Mentorship and adequate supervision are however 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 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 written for the recent graduate who is training and gaining experience toward registration. Mature applicants for registration may apply the guide retrospectively to identify possible gaps in their development.

Any applicants who have not enjoyed mentorship 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 into a candidacy programme at a later stage that is at a level below that required for registration (see **Section 7.3**).

# 4. Civil Engineering

## Civil Engineer Technician

A *Civil Engineer Technician* plans, designs, organises and oversees the construction and operation of civil engineering projects such as but not limited to:

Structural: buildings, dams, bridges, roads, highways, runways, harbours, railways; Geotechnical: township services earthworks, excavations, soil conservation and geotechnical processes;

Transportation systems;

Hydraulic Engineering systems: water resources and supply, pipelines, canals, water treatment, stormwater and drainage, sewerage systems; sanitation waste disposal, coastal engineering.

Typical Tasks that a *Civil Engineering Technician* may undertake include:

* Assistance in conducting research and developing new or improved theories and methods related to civil engineering
* Advising on and designing *well-defined* infrastructure such as bridges, dams, harbours, roads, airports, railways, canals, pipelines, treatment works, waste-disposal and flood-control systems, and residential, commercial, industrial and other buildings
* Determining and specifying *well-defined* construction methods, materials and quality standards and directing construction work
* Applying control systems to ensure efficient functioning of infrastructure as well as safety and environmental protection
* Organising and directing maintenance and repair of existing civil engineering infrastructure
* Analysing the behaviour of founding material when subjected to super-imposed loading
* Analysing the stability of structures and testing the behaviour and durability of materials used in their construction
* Analysing earth retaining structures

Practising *Civil Engineering Technicians* generally concentrate in one or more of the following areas:

* Structural Engineering
* Geotechnical Engineering
* Hydraulic Engineering and Water Resources (Pipelines, Sewage and Water Treatment Works)
* Construction Engineering including Site Supervision and Control
* Road Design, and
* Services Reticulation (Water/Sewage)

More specialised Civil Engineering Technicians may be in fields such as: Transportation and Urban Planning; Bio Systems Engineering, GIS and Land Use Management.

# 5. Training Implications of the Nature and Organisation of the Industry

Engineering technicians may be employed in both the private and public sector.

Typically in the private sector they would be involved in consulting, contracting, or in supplier or manufacturing organisations. Engineering consultants are responsible for planning, designing and documentation, as well as supervising the construction of projects on behalf of their clients. Engineering contractors are responsible for project implementation and activities include planning, construction, and labour and resource management. Those working in supply or manufacturing companies could be involved in research and development, and would be involved in production, supply and quality control.

The public sector is responsible for service delivery and is usually the client, though in some departments design and construction is also carried out. Engineering technicians are required at all levels of the public sector, including at national, provincial and local government level, state owned enterprises (SOEs), and public utilities. The public sector largely handles planning, specifying, overseeing implementation, operations and maintenance of infrastructure.

An extension of the public sector would include tertiary academic institutions and research organisations.

Depending on where the candidate is employed, there may be situations where the opportunities in-house are not sufficiently diverse to develop all the competencies required in all the groups A and B noted in document R-02-PN. For example the opportunity for developing problem solving competence (including design or developing solutions) and for managing engineering activities (including implementing or constructing solutions) may not both be available to the candidate. In such cases employers are encouraged to put a secondment system in place.

It has been fairly common practice that where an organisation is not able to provide training in certain areas that secondments are arranged with other organisations, so that the candidate is able to develop all the competencies required for registration.

These secondments are usually of a reciprocal nature so both employers and their respective employees get the mutual benefit from the other party. Secondments between consultants and contractors and between the public and private sector should be possible.

In **Appendix A**, a generic scheme is presented for the outcomes applicable to all disciplines that a candidate should become competent to do in the various phases of a project or task:

1. Solving problems based on well-defined engineering and contextual knowledge;
2. Managing engineering activities;
3. Impacts of the engineering activity;
4. Judgement, responsibility and ethical behaviour during an engineering activity; and
5. Further professional development since graduation.

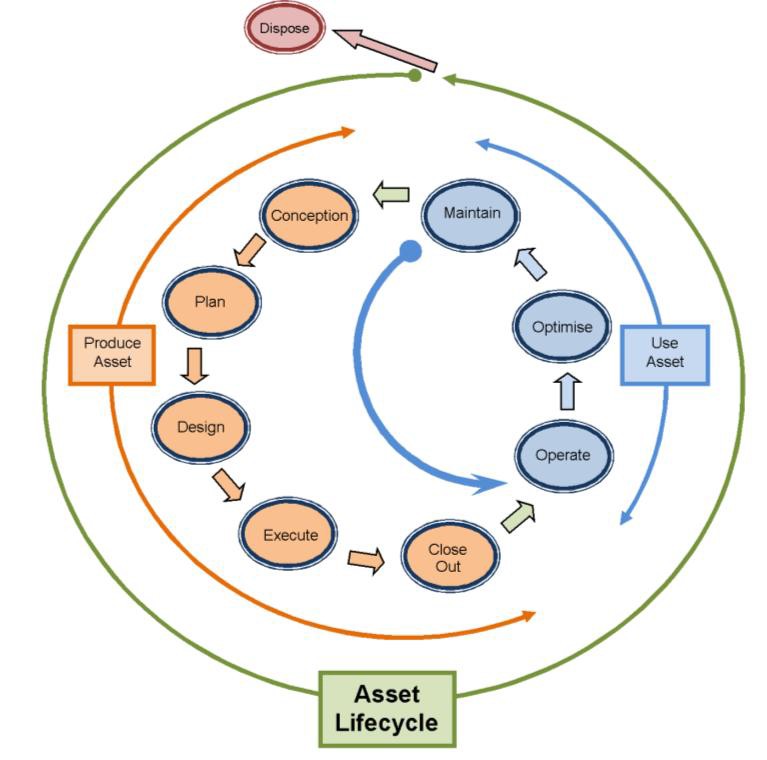
**Appendix A** details the types of evidence of performance that would be appropriate.

# 6. Developing competency: Elaborating on sections in the Guide to the Competency Standards, document R-08-PN.

## 6.1 Engineering Lifecycle Considerations.

The civil engineering technician is involved in activities associated with the asset life cycle as shown in **Figure 1**.

#### Figure 1: Asset Lifecycle



**6.2 Functions Performed**

A conventional path to registration will usually involve the candidate carrying out the functions described in **Table 1**. Generally these functions, as described in the Asset Lifecycle above, would be related to the “producing an asset” portion, but could also relate to the “use of an asset” portion.

In the case of “producing an asset”, the functions are expanded from the conventional sequence of an engineering project; conceive, design, implement, and operate, and usually the candidate will experience them in this order.

In the case of “use of an asset”, where the work involves operations and maintenance, the candidate may experience them differently, but the functions may be similar.

It is very useful to measure the progression of the candidate’s competency by making use of the Degree of Responsibility, Problem Solving and Engineering Activity scales as specified in the relevant documentation.

**Appendix A** has been 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 Candidates supervisor is accountable for the Candidates recommendations and decisions.

#### Table 1: Functions

|  |  |
| --- | --- |
| **1.** | **ORIENTATION** |
|  | Be exposed to, observe and understand a range of processes, material and products that are relevant to your employer and typical clients. |
| **2** | **DEVELOPING AN ENGINEERING BRIEF** |
| **2.1** | **Accurate identification and definition:**  Take an active part, probably in a supporting role, in researching, compiling and assessing basic data, background information and the meaning and purpose of an assignment.  Record your involvement in a report to your mentor and demonstrate the process by which the assignment was finally and properly defined. |
| **2.2** | **Systems Approach**  It is generally accepted that to ensure a holistic (all encompassing) solution to a problem, all relevant aspects are to be taken into account.  In reports to your mentor, record how, out of your own experience, you were involved in adopting the wider approach in defining problems. |
| **2.3** | **Standards and Codes**  List the National and International standards, Codes of Practice, Environmental Requirements documents you have used. Discuss their relevance to your work in your reports to your mentor. |
| **3** | **DESIGNING A SOLUTION** |
| **3.1** | **Resolution of an engineering brief**  This will involve compiling all relevant data acquired during the investigation period and a statement of the analytical work completed.  **Finding Alternative Solutions**  This will involve the technical and financial evaluation of alternatives by, for example, assisting with a feasibility study covering aspects such as:   * Concepts and precedents * Sources of information * Estimates and budget quotations * Quick design methods * Writing, production and interpretation of feasibility reports * Briefs for detailed design   In a report to your mentor produce your preferred solution, with justification, showing throughout (or by an accompanying statement) how this work contributed to the solution of the problem and identify the major factors on which the solution depended for accuracy or completeness. |
| **3.2** | **Present the solution to a problem**  This will involve producing documentation on the solution including diagrams, charts and/or detailed drawings using acceptable standards.  In a report to your mentor present the example for discussion and approval. |
| **3.3** | **Choice of construction material when deciding on a solution**  Read supplier’s instructions for use of patent materials. Read SABS specifications on civil engineering materials (naturally occurring processed and manufactured). List all references. Discuss the choice and use of prescribed materials for a specific solution with your mentor. |

**Table 1: Continued**

|  |  |
| --- | --- |
| **4** | **DOCUMENTATION** |
| **4.1** | **Purpose of Documentation**  This involves acquiring an appreciation that technical specifications are an essential part of a solution to the problem. Select or write a specification and/or amend an existing specification for a particular item of work.  Discuss a specification used in your work with your mentor. |
| **4.2** | **Costing of solutions**  Cost solutions to problems by taking off quantities and doing cost estimates. Present examples to the mentor for discussion and comment. |
| **4.3** | **Safety**  State in a quarterly report which regulations apply and what safety criteria you have followed in the course of implementing solutions. |
| **5** | **IMPLEMENTATION** |
| **5.1** | **Know how all parties to a contract exercise their duties and responsibilities**  In a report to your mentor, demonstrate your knowledge of the duties and responsibilities of all parties to a contract and discuss the practical application of the various documents forming a particular contract, with your mentor. |
| **5.2** | **Know the procedure for the issuing and/or receipt, registration and filing work instructions and/or drawings and amendments**  Gain practical experience of these procedures and demonstrate this experience in a report to your mentor. |
| **5.3** | **Keep an accurate daily record of events and instructions**  Keep an up-to-date, accurate daily diary for inspection by your mentor |
| **5.4** | **Read and co-ordinate drawings and/or implement work instructions** by being involved on a day-to-day basis in the process.  Demonstrate your competence by the quality of your work and discuss this with your mentor. |
| **5.5** | **Participate in the dimensional control and accuracy of the work you are implementing or controlling.**  Demonstrate your competence by the quality of your work and discuss this process with your mentor. |
| **5.6** | **Know the use, performance and cost of equipment plant and/or labour resource**.  Include in a report to your mentor a list of all major items of which you have first-hand knowledge. Discuss your experience with your mentor. |
| **5.7** | **Plan and programme section of work and be involved in progress monitoring and reporting**.  Discuss programme with your mentor. |
| **5.8** | **Measure and record or independently check work done for payment purposes.**  Take part in this work for the preparation of checking of Interim Valuations and/or Final Accounts.  Demonstrate your involvement to your mentor. |
| **5.9** | **Have a critical approach to safety matters in the implementation process and to the observance of safe working practices.**  Know your responsibilities relating to safety and be familiar with legislation relating to your particular work. Appreciate good safety practices relevant to your work by reference to your company safety manual.  Emphasize your involvement in safety matters in a report to your mentor |

**6.3 Contextual Knowledge**

Candidates are expected to have knowledge of the following topics:

#### General appreciation of engineering procedures applicable to civil engineering

Read the information brochures provided by:

South African Institution of Civil Engineering (SAICE) Consulting Engineers South Africa (CESA)

South African Federation of Civil Engineering Contractors (SAFCEC) Discuss the procedures with your mentor at a quarterly interview

#### Show a working knowledge of the SAICE Constitution and By-laws

Read all these documents

Discuss the documents with your mentor at a quarterly interview

#### Relationships between Organisations

Display a working knowledge of the roles of and interaction between Organizations such as:

Engineering Council of South Africa (ECSA)

SA Institution of Civil Engineering (SAICE)

Consulting Engineers South Africa (CESA)

SA Federation of Civil Engineering Contractors (SAFCEC)

Building Industries Federation South Africa (BIFSA)

The Construction Industry Development Board (CIDB)

#### Knowledge of General Conditions of Contract

Display a working knowledge of GCCs used in civil engineering such as SAICE GCC, FIDIC, NEC:

#### Structure of Organisation where candidate is employed

Study all available organization charts. Write a report on the management structure of your organization/project team, defining your roles and responsibilities

## 6.4 Industry-related statutory requirements

### Candidates are expected to have a working knowledge of the following Acts:

* Engineering Profession Act, 2000, (Act 46 of 2000), its Rules, specifically the Code of Conduct
* Occupational Health and Safety Act, 1993 (Act No. 85 of 1993), as amended by Act No. 181 of 1993

Candidates may, depending on their area of practice, need to have a working knowledge of the following Acts:

* National Building Regulations and Building Standards Act, 1977 (Act No. 103 of 1977), as amended by Act No. 49 of 1995
* Environment Conservation Act, 1989 (Act No. 73 of 1989), as amended by Act No. 52 of 1994 and Act No. 50 of 2003
* Water Services Act, 1997 (Act No. 108 of 1997), as amended by Act No. 30 of 2004
* National Water Act, 1998 (Act No. 36 of 1998), as amended by Act No. 45 of 1999

There are many Acts, not listed in this document, which may be pertinent in the work functions of the candidate. Candidates will be expected to have some basic knowledge of these Acts where applicable.

## 6.5 Recommended Formal Learning Activities

Candidates may find many of the following list of formal learning activities, which is by no means extensive, useful in developing their competencies:

Discipline Specific Courses relating to areas of practice Report Writing

Project Management

Conditions of Contract

Standard Specifications

Preparation of Specifications

Negotiation Skills

Engineering Finance

Risk Analysis Quality Systems

Occupation Health and Safety Quality Systems

Environment Impacts

# 7. Programme Structure and Sequencing

**7.1 Best Practice Programmes**

Generally, no matter the discipline, it is unlikely that the period of training will only be three years, the minimum time required by ECSA. Typically, it will be longer and would be determined amongst others by the availability of functions in the actual work situation.

There is no ideal training programme structure or a 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

Best practice programmes will be those that address the development of the competencies needed for each candidate to be able to successfully register as a professional engineering technician.

It is suggested that the candidate works with their mentors to determine appropriate projects to gain exposure to elements of the asset life cycle, to ensure that their designs are constructible, operable, and are designed considering life cycle costing and long-term sustainability. A regular reporting structure with suitable recording of evidence of achievement against the competency outcomes and responsibility need to be put in place

The training programme should be such that candidate progresses through levels of work capability, which is described in 7.3.4 of R-04-P, such that by the end of the training period, the candidate must perform individually and as a team member at the level of problem solving and engineering activity required for registration and exhibit at the degree of responsibility E.

The nature of work and degrees of responsibility defined in document R-04-P, Table 4, are used here (and in **Appendix A** below)**:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| A: Being Exposed | B: Assisting | C: Participating | D: Contributing | E: Performing |
| Undergoes induction, observes processes, 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 appropriate to a registered person, supervisor is accountable for applicant’s decisions |

Depending on the nature of the work undertaken by an employer, it may be possible to develop a training programme which provides opportunities to the candidate to undertake the work functions described in section 5.2, **Table 1**. In some cases an employer may only cover some functions described in section 5.2, **Table 1**. In such cases, the employer and the candidate should make appropriate arrangements as described in section 4.

It is suggested that the candidate works with their mentors to determine appropriate projects to gain exposure to elements of the asset cycle, to ensure that their designs are constructible, operable, and are designed considering life cycle costing and long-term sustainability.

## 7.2 Considerations for Special Cases

Section 10 of document R-08-PN adequately describes what would be expected of persons whose formative development has not followed a conventional path, for example academics, researchers, and specialists.

The overriding consideration is that, irrespective of the route followed, the applicant must provide evidence of competence against the standard.

**7.3 Moving into or Changing Candidacy Training Programmes**

This Guide assumes that the candidate enters a programme after graduation and continues with the programme until ready to submit an application for registration. It also assumes that the candidate is supervised and mentored by persons who meet the requirements in document R-04-P section 7.2. 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 be completed:

 The candidate must complete the Training and Experience Summary (TES) and Training and Experience Reports (TER) 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 by the relevant supervisor.

 On entering the new programme, the Mentor and Supervisor should review the candidate’s development in the light of the past experience and opportunities and the requirements of the new programme and plan at least the next phase of the candidate’s programme.

|  |  |  |  |
| --- | --- | --- | --- |
| **ENGINEERING COUNCIL OF SOUTH AFRICA**  ***Standards and Procedures System*** | | |  |
| **Discipline-specific Training Guideline for Candidate**  **Engineering Technicians in Electrical Engineering** | | |
| **Status: Approved by the Central Registration Committee** | | |
| **Document : R-05-ELE-PN** | **Rev-1** | **17 July 2014** |

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**R-08-PN Guide to the Competency Standards**

Procedures

**R-03-PN**

**Application and Assessment Process**

Refers to

**R-04-P Training and Mentoring Guide (All Categories)**

***This Document***

Refers to

**R-05-ELE-PN**

**Discipline-specific**

**Training Guide**

**Figure 1: Documents defining the ECSA Registration System**

# 1. Purpose

All persons applying for registration as Professional Engineering Technician are expected to demonstrate the competencies specified in document R-02-PN at the prescribed level, irrespective of the trainee’s discipline, through work performed by the applicant at the prescribed level of responsibility.

This document supplements the generic *Training and Mentoring Guide* R-04-P and *the Guide to the Competency Standards for Professional Engineering Technicians*, document

R-08-PN. In document R-04-P attention is drawn to the following sections:

* + 1. Duration of training and period working at level required for registration
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The second document R-08-PN provides both a high-level and outcome-by-outcome understanding of the competency standards as an essential basis for this discipline specific guide.

This Guide, as well as R-04-P and R-08-PN, are subordinate to the Policy on Registration, document R-01-P, the Competency Standard (R-02-PN) and the application process definition (R-03-PN).

# 2. Audience

This Guide is directed to candidates and their supervisors and mentors in the discipline of Electrical Engineering including bio-engineering, computer engineering, control engineering, electronic engineering, power engineering, software engineering, information engineering, telecommunications engineering and others. The Guide is intended to support a programme of training and experience incorporating good practice elements.

This guide applies to persons who have:

* 1. Completed the education requirements by obtaining an accredited Dip (Engineering), Dip (Eng Tech), Adv Cert (Engineering) type qualification, or a Dublin-Accord Recognised qualification or through evaluation/assessment;
  2. Registered as Candidate Engineering Technicians;
  3. 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 a Candidate or not Training under a C&U

All applicants for registration must present the same evidence of competence and be assessed against the same standards, irrespective of the development path followed. Application for registration as a Professional Engineering Technician is permitted without being registered as a Candidate Engineering Technician or without training under a C&U. Mentorship and adequate supervision are however 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 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 written for the recent graduate who is training and gaining experience toward registration. Mature applicants for registration may apply the guide retrospectively to identify possible gaps in their development.

Any applicants who have not enjoyed mentorship 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 into a candidacy programme at a later stage that is at a level below that required for registration (see **Section 7.5**).

**4. Electrical Engineering**

Electrical engineering technicians form a collective group who conduct research on and design, advise, plan and direct the construction and operation of electronic, electrical and telecommunications systems, computer and software systems, components, motors and equipment. They organise and establish control systems to monitor the performance and safety of electrical and electronic components, assemblies and systems.

Electrical engineering technicians perform some of the following well-defined functions: planning, design, construction, operation and maintenance of materials, components, plant and systems for generating, transmitting, distributing and utilising electrical energy; electronic devices, apparatus and control systems for industrial systems, bio-medical, robotics and consumer products; computing, communication and software for critical applications, instrumentation and control of processes, through the application of electrical, electromagnetic and information engineering sciences.

Within the broad collective field of electrical engineering, engineering technicians generally practice in areas of their specialities:

**Electrical Power Engineering:** covers electrical systems, components, motors and equipment, electrical engineering materials, products and processes.

**Electronic Engineering:** covers electronic systems, electronic engineering materials, products or processes

**Telecommunications Engineering:** is a broad specialisation of electrical engineering encompassing the design, construction and management of systems that carry out the transmission, processing and storage of information as electrical or optical signals and the control services based on this capability.

**Computer and Software Engineering:** addresses the relationship and interactions between software, hardware and external systems in solving real engineering problems. Computer engineering concentrates its effort on the ways in which computing ideas are mapped into working physical systems. Computer engineering rests on the intellectual foundations of electrical engineering, computer science, the natural sciences and mathematics.

Engineering technicians also practise in combinations of the above specialities as well as in areas involving other disciplines, for example Mechatronics Engineering-involving robotic, prosthesis and process control.

**Electrical power engineering technicians:** assist in conducting research and advise on, design and direct the construction and operation of electrical systems, components, motors and equipment, advise on and direct their functioning, maintenance and repair and study and advice on well-defined technological aspects of electrical engineering materials, products and processes.

Typical tasks that an Electrical Power Engineering Technician may undertake include:

* Conduct well-defined research and development of new or improved theories and methods related to Electrical Power Engineering
* Advising on and design of well-defined aspects of power stations and systems which generate, transmit and distribute electrical power
* Specifying well-defined aspects of instrumentation, measurement and control of equipment for the monitoring and control of electrical generation, transmission and distribution systems
* Supervising, controlling, developing and monitoring aspects of the operation and maintenance of electrical generation, transmission and distribution systems
* Advising on and designing well-defined aspects of systems for electrical motors, electrical traction and other equipment or electrical domestic appliances
* Specifying standard electrical installation and application in industrial and other buildings and objects
* Implementing and improving control standards and procedures to monitor performance and safety of electrical generating and distribution systems, motors and equipment.
* Implementing and improving manufacturing methods for electrical systems as well as the maintenance and repair of existing electrical systems, motors and equipment
* Design and development well-defined aspects of electrical apparatus
* And other

Practising Electric Power Engineering Technicians may concentrate on one or more of the following areas:

Mining, Plant and Factories, Power Generation, Power Transmission, Power Distribution, Power Systems Protection, Metering, Illumination, Railway Signalling, Signalling and Communications, Control and Instrumentation, Product Sales, Power Electronics, Electrical Drives, Energy Management, Infrastructure Maintenance, Construction Projects, Teaching, etc.

**Electronics engineering technicians** assist in conducting research and advise on design and direct the construction, maintenance and repair of electronic systems and study and advice on well-defined technological aspects of electronic engineering materials products or processes.

Typical tasks that an Electronics Engineering Technician may undertake include:

* Conducting well-defined research and developing new or improved theories and methods related to Electronics Engineering
* Advising on and design of well-defined electronic devices or components, circuits, semi- conductors and systems
* Specifying well-defined aspects of production or installation methods, materials and quality standards and directing well-defined production or installation work of electronic products and systems
* Supervising, controlling, developing and monitoring aspects of the operation and maintenance of electronic equipment and systems
* Implementing and improving control standards and procedures to ensure efficient functioning and safety of electronic systems and equipment
* Organising and directing maintenance and repair of existing electronic systems and equipment
* Designing well-defined electronic circuits and components for use in fields such as aerospace, guidance and propulsion control, acoustics or instruments and control
* Determining well-defined manufacturing methods for electronic systems as well as the maintenance and repair of existing electronic systems and equipment
* Assist in doing research and advising on radar, telemetry and remote control systems, microwaves and other electronic equipment
* Assist in designing and developing signal processing algorithms and implementing these through appropriate choice of hardware and software
* Developing well-defined apparatus and procedures to test electronic components, circuits and systems
* Designing, specifying and implementing well-defined Control and Instrumentation of plant and processes
* Designing, specifying, control and monitoring of well-defined equipment for fire and safety in plant and factories
* Well-defined robotics and process control of manufacturing plant
* Assist with Energy Efficiency PV
* And other

Practising Electronics Engineering Technicians may concentrate on one or more of the following areas:

Communications (Army), Mechatronics, Designer, Information, SCADA, Control, Instrumentation, Television, Bio-medical, Clinical, Fire and Safety, Rail Network Control, Aircraft electronic systems, Electronic Warfare, etc.

**Telecommunications engineering technicians** assist in conducting research and advise on, design and direct the construction, maintenance and repair of telecommunication systems and equipment. They study and advise on well-defined technological aspects of telecommunication engineering, materials products or processes. Plans, designs and monitors well-defined telecommunications networks and associated broadcasting equipment.

Typical tasks that a Telecommunication Engineering Technician may undertake include:

* Conduct well-defined research and developing new or improved theories and methods related to Telecommunications Engineering
* Advising on and design well-defined telecommunications devices or components, systems, equipment and distribution centres
* Specifying well-defined aspects of production or installation methods, materials, quality and safety standards and directing production or installation work of telecommunications products and systems
* Supervising, controlling, developing and monitoring aspects of the operation and maintenance of telecommunication systems. networks and equipment
* Determining well-defined manufacturing methods for telecommunication systems as well as the maintenance and repair of existing telecommunication systems, networks and equipment
* Organizing and directing maintenance and repair of existing telecommunication systems, networks and equipment
* Assist in doing research and advising on telecommunications equipment
* Planning and designing well-defined communications networks based on wired, fibre optical and wireless communication media
* Assist in the design and development of signal processing algorithms and implementing these through appropriate choice of hardware and software
* Designing well-defined telecommunications networks and radio and television distribution systems including both cable and over the air
* And other

Practising Telecommunications Engineering Technicians may concentrate on one or more of the following areas:

Broadcasting, Digital Signal Processing Design, Communications, Fibre Optics, Radio Frequency Design, Radar, Radio, Radio and Telecommunications, Mobile Radio, Satellite Transmission, Signal Processing Systems, Communications Consulting, Communications Specialist (ICT), Telecommunications Consulting, Telecommunications Network Planning, Telecommunications Specialist, Microwave, etc.

**Computer and software engineering technicians** assist in conducting research and advise on design and direct the construction, maintenance and repair of computer-based systems, software and equipment. They study and advise on the well-defined technological aspects of computer-based systems, software, products or processes. They assist in performing system analysis on computer-based system requirements, software and the specification of the systems required. They plan, design and monitor well-defined computer-based systems, software, networks and associated communication equipment.

Typical tasks that a Computer Engineering Technician may undertake include:

* Conducting well-defined research and developing new or improved theories and methods related to Computer and Software Engineering
* Advising on and design of well-defined computer-based systems or components, systems equipment, software and distribution centres
* Specifying well-defined production or installation methods, materials, quality and safety standards and directing production or installation work of computer-based products, software and systems
* Supervising, controlling, developing and monitoring the operation and maintenance of computer-based systems, software, networks and equipment
* Organising and directing maintenance and repair of existing computer-based systems, programmes and equipment
* Assist in doing research and advising on computer-based equipment and software
* Planning and designing well-defined computer-based communications networks based on wired, fibre optical and wireless communication media and ultra-high speed data networks
* System Analysis, designing and developing well-defined computer-based systems and implementing these through appropriate choice of hardware and managing the development the necessary software
* Determining well-defined manufacturing methods for computer-based systems as well as the maintenance and repair of existing computer-based systems, networks and equipment
* And other

Practising Computer Engineering Technicians may concentrate on one or more of the following areas:

Computer Hardware, Computer Systems Analysis, Computer Systems Design, Computer Communication Specialisation, Computer Network Design, Computer Network Sales, Software Systems, etc.

This guide first presents information that is relevant to all candidate Engineering Technicians whose area is in the broad field of electrical engineering. Information specific to sub-disciplines is given in later sections. Special considerations for training in different environments, for example consulting and contracting, are also given.

# 5. Training Implications of the Nature and Organisation of the Industry

Engineering technicians may be employed in both the private and public sector. Typically in the private sector they would be involved in consulting, contracting, or in supplier or manufacturing organisations. Engineering consultants are responsible for planning, designing, documenting, and supervising the construction of projects on behalf of their clients. Engineering contractors are responsible for project implementation and activities include planning, construction, and labour and resource management. Those working in supply or manufacturing companies could be involved in research and development, and would be involved in production, supply and quality control.

The public sector is responsible for service delivery and is usually the client, though in some departments design and construction is also carried out. Engineering technicians are required at all levels of the public sector, including at national, provincial and local government level, state owned enterprises (SOEs), and public utilities. The public sector largely handles planning, specifying, overseeing implementation, operations and maintenance of infrastructure.

An extension of the public sector would include tertiary academic institutions and research organisations.

Depending on where the candidate is employed, there may be situations where the opportunities in-house are not sufficiently diverse to develop all the competencies required in all the groups noted in document R-02-PN. For example the opportunity for developing problem solving competence (including design or developing solutions) and for managing engineering activities (including implementing or constructing solutions) may not both be available to the candidate. In such cases employers are encouraged to put a secondments system in place.

It has been fairly common practice that where an organisation is not able to provide training in certain areas that secondments are arranged with other organisations, so that the candidate is able to develop all the competencies required for registration.

These secondments are usually of a reciprocal nature so both employers and their respective employees get the mutual benefit from the other party. Secondments between consultants and contractors and between the public and private sector should be possible.

# 5.1 Location of training in overall engineering lifecycle and functions performed.

The areas where electrical engineering technicians work generally follow the conventional stages of the project (or product) life cycle:

* + 1. Research and development to develop well-defined new products or systems or solve some well-defined system problem or obsolescence.
    2. Well-defined system or product design to develop a new system or product, or to solve a well-defined system or product problem, or to achieve a particular desired result, or to select equipment for a particular purpose.
    3. Project engineering to install and test and commission the necessary equipment or system for the desired result.
    4. Operation and maintenance of the system or network, or support of the product.
    5. Decommissioning of a system or network

**Develop new brief**

**Projects**

**& Design**

**Operations & Maintenance**

**Management**

**Construction or Manufacturing**

It is not expected that candidates will have to change work in order to work in all the areas as listed above. Candidates however must ensure that in whatever area they are employed they undertake tasks that provide experience in all the generic well-defined engineering competencies of problem solving, implementation or operation, risk and impact mitigation and management of engineering activities.

In **Appendix A**, a generic scheme is presented for the outcomes applicable to all disciplines that a candidate should become competent to do in the various phases of a project or task:

1. Solving problems based on well-defined engineering and contextual knowledge;
2. Managing engineering activities;
3. Impacts of the engineering activity;
4. Judgement, responsibility and ethical behaviour during an engineering activity; and
5. Further professional development since graduation.

**Appendix A** details the types of evidence of performance that would be appropriate.

# 6. Developing competency: Elaborating on sections in the Guide to the Competency Standards, document R-08-PN.

**6.1 Contextual Knowledge**

Candidates are expected to be aware of the engineering profession, the Voluntary Associations applicable to the Electrical Engineering Technician and their functions and services rendered to members

**6.2 Functions Performed**

It is very useful to measure the progression of the candidate’s competency by making use of the Degree of Responsibility, Problem Solving and Engineering Activity scales as specified in the relevant documentation.

**Appendix A** has been 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 Candidates supervisor is accountable for the Candidates recommendations and decisions.

**6.3 Special industry and statutory requirements**

Candidates are expected to have a working knowledge of the following regulations and Acts and how they affect their working environment:

 ECSA – Engineering Profession Act, 2000, (Act No. 46 of 2000)’ its Rules and the Code of Conduct

 OHSAct – Occupation Health and Safety Act, 1993 (Act No. 85 of 1993), as amended by Act No. 181 of 1993 – Latest Revision.





Building Regulations – National Building Regulations and Building Standards Act, 1977 (Act No. 103 of 1977), as amended by Act No. 49 of 1995, SANS 10400 Factory Regulations







Machinery and Works Regulations

Labour Relations Act – Act, 1995, (Act No.66 of 1995)

 Environment Conservation Act, 1989 (Act No. 73 of 1989), as amended by Act No. 52 of 1994 and Act No. 50 of 2003.

Mine Health and Safety Act. 1996 (Act No. 29 of 1996) Industry Specific Work Instructions







Others

Many other Acts not listed here may also be pertinent to a candidates work environment. Candidates will be expected to have a basic knowledge of the applicable Acts

**6.4 Desirable Formal Learning Activities**

The following list of formal learning activities is by no means extensive and is purely a sample of some useful courses

Project Management

Conditions of Contract\Value Engineering – NEC, JBCE etc. Standard Specifications

Preparation of Specifications Negotiation Skills

Engineering Finance

Risk Analysis Quality Systems

Occupation Health and Safety Discipline Specific Courses Quality Systems

Energy Efficiency

Electrical Tariffs

Maintenance Engineering

Environment Impacts

Management

Report Writing Planning Methods System Engineering Industrial Relations Public Speaking

# 7. Programme Structure and Sequencing

**7.1 Best Practice**

There is no ideal training programme structure or a 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

It is suggested that the candidate works with their mentors to determine appropriate projects to gain exposure to elements of the asset life cycle, to ensure that their designs are constructible, operable, and are designed considering life cycle costing and long-term sustainability. A regular reporting structure with suitable recording of evidence of achievement against the competency outcomes and responsibility need to be put in place

The training programme should be such that candidate progresses through levels of work capability, which is described in 7.3.4 of R-04-P, such that by the end of the training period, the candidate must perform individually and as a team member at the level of problem solving and engineering activity required for registration and exhibit at the degree of responsibility E.

The nature of work and degrees of responsibility defined in document R-04-P, Table 4, are used here (and in Appendix A below)**:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| A: Being Exposed | B: Assisting | C: Participating | D: Contributing | E: Performing |
| Undergoes induction, observes processes, 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 appropriate to a registered person, supervisor is accountable for applicant’s decisions |

**7.2 Orientation requirements**

* Introduction to Company;
* 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.

**7.3 Realities**

Generally, irrespective of the discipline, it is unlikely that the period of training will be less than three years for candidates with a Dip (Engineering), Dip (Eng Tech), or four years for candidates with an Adv Cert (Engineering), the minimum time required by ECSA. Typically, it will be longer and would be determined amongst others by the availability of functions in the actual work situation.

**7.4 Considerations for generalists, specialists, researchers and academics**

Section 10 of document R-08-PN adequately describes what would be expected of persons whose formative development has not followed a conventional path, for example academics, researchers, and specialists.

The overriding consideration is that, irrespective of the route followed, the applicant must provide evidence of competence against the standard

**7.5 Moving into or Changing Candidacy Training Programmes**

This Guide assumes that the candidate enters a programme after graduation and continues with the programme until ready to submit an application for registration. It also assumes that the candidate is supervised and mentored by persons who meet the requirements in document R-04-P section 7.2. 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 be completed:

 The candidate must complete the Training and Experience Summary (TES) and Training and Experience Reports (TER) 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 by the relevant supervisor.

 On entering the new programme, the Mentor and Supervisor should review the candidate’s development in the light of the past experience and opportunities and the requirements of the new programme and plan at least the next phase of the candidate’s programme.

|  |  |  |  |
| --- | --- | --- | --- |
| **ENGINEERING COUNCIL OF SOUTH AFRICA**  ***Standards and Procedures System*** | | |  |
| **Discipline-specific Training Guideline for Candidate Engineering Technicians in Industrial Engineering** | | |
| **Status: Approved by the Central Registration Committee** | | |
| **Document : R-05-IND-PN** | **Rev-1** | **17 July 2014** |  |

# Background: ECSA Registration System Documents

The documents that define the Engineering Council of South Africa (ECSA) system for registration in professional categories are shown in **Figure 1** which also locates the current document.

**R-01-P**

**Registration Policy**

Prescribes

Prescribes Standards

**R-02-PN**

**Competency**

**Standard**

Explains

**R-08-PN Guide to the Competency Standards**

Procedures

**R-03-PN**

**Application and Assessment Process**

Refers to

**R-04-P Training and Mentoring Guide (All Categories)**

***This Document***

Refers to

**R-05-IND-PN**

**Discipline-specific**

**Training Guide**

**Figure 1: Documents defining the ECSA Registration System**

# 1. Purpose

All persons applying for registration as Professional Engineering Technicians are expected to demonstrate the competencies specified in document R-02-PN at the prescribed level, irrespective of the trainee’s discipline, though work performed by the applicant at the prescribed level of responsibility.

This document supplements the generic *Training and Mentoring Guide* R-04-P and *the Guide to the Competency Standards for Professional Engineering Technicians*, document

R-08-PN. In document R-04-P attention is drawn to the following sections:

7.3.2 Duration of training and period working at level required for registration

7.3.3 Principles of planning training and experience

7.3.4 Progression of Training programme

7.3.5 Documenting Training and Experience

7.4 Demonstrating responsibility

The second document R-08-PN provides both a high-level and outcome-by-outcome understanding of the competency standards as an essential basis for this discipline specific guide.

This Guide, as well as R-04-P and R-08-PN, are subordinate to the Policy on Registration, document R-01-P, the Competency Standard (R-02-PN) and the application process definition (R-03-PN).

# 2. Audience

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

This guide applies to persons who have:

* 1. Completed the education requirements by obtaining an accredited Dip (Engineering), Dip (Eng Tech), Adv Cert (Engineering) type qualification, or a Dublin-Accord Recognised qualification or through evaluation/assessment;
  2. Registered as Candidate Engineering Technicians;
  3. 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 a Candidate or not Training under a C&U

All applicants for registration must present the same evidence of competence and be assessed against the same standards, irrespective of the development path followed. Application for registration as a Professional Engineering Technician is permitted without being registered as a Candidate Engineering Technician or without training under a C&U. Mentorship and adequate supervision are however 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 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 written for the recent graduate who is training and gaining experience toward registration. Mature applicants for registration may apply the guide retrospectively to identify possible gaps in their development.

Any applicants who have not enjoyed mentorship 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 into a candidacy programme at a later stage that is at a level below that required for registration (see **Section 7.4**).

# 4. Industrial Engineering

## 4.1 Origins

Industrial Engineering has its roots in the work of Fredrick Taylor, and Gillian and Frank Gillbreth, all of whom focused on the improvement of worker productivity in the latter part of the nineteenth centuryi.

## 4.2 SAIIE Definition

Since then, the discipline has grown to encompass any methodical or quantitative approach to optimizing how a process, system, or organization operatesii. This is reflected in the more specific definition of Modern Industrial Engineering that has been adopted by the Southern African Institute for Industrial Engineering:

The science of integrating resources and processes into cohesive strategies, structures and systems for the effective and efficient delivery of quality goods and services. It draws upon specialized knowledge and skills in the mathematical, physical, behavioral, and economic and management sciences, and combines them with the principles and methods of engineering analysis and design, to find optimal and practical solutions which contribute to the success and sustainability of a venture, thus making a fundamental contribution to the creation of wealth.

## 4.3 OFO Definition

The Organising Framework for Occupations (OFO) 2012iii, offers a similar, though more simplified definition of our Profession:

An Industrial Engineer *(or Engineering Technician)* investigates and reviews the utilisation of personnel, facilities, equipment and materials, current operational processes and established practices, to recommend improvement in the efficiency of operations in a variety of commercial, industrial and production environments.

## 4.4 Specialisation

The OFO also offers the following alternative Titles and Specialisations, which give an indication of the various areas of specialisation, many of which are industry specific:

* Agri Produce Process Engineering Technician
* Automation and Control Engineering Technician
* Clinical Engineering Technician
* Enterprise Resource Management Engineering Technician
* Fabrication Engineering Technician
* Industrial Efficiency Engineering Technician
* Industrial Machinery Engineering Technician
* Manufacturing Logistics Engineering Technician
* Manufacturing Technology Engineering Technician
* Operations Research Engineering Technician
* Plant Engineering Technician
* Process Design Engineering Technician

*The OFO is a coded occupational classification system, adopted by the Department of Higher Education and Training for identifying, reporting and monitoring skills demand and supply in the South Africa labour market.*

*It provides a common language when talking about occupations, captures jobs in the form of occupations and groups occupations into successively broader categories and hierarchical levels based on similarity of tasks, skills and knowledge.*

* Process Engineering Technician
* Production Engineering Technician
* Quality Management Engineering Technician
* Robotics and Production Automation Engineering Technician
* Safety Engineering Technician
* Supply Chain Management Engineering Technician
* Value Engineering Technician

## 4.5 Skills Perspective

A further dimension of specialisation and sub disciplines is revealed when one views the Profession from a Skills Perspective.

A skill is defined as the ability to carry out the tasks and duties of a given job. The OFO considers skill specialisation in terms of four themes. Examples of specialised Industrial Engineering Skills in each of the four themes are listed below:

1. The field of knowledge required, which could include

* Knowledge of the area of specialisation, and associated problem solving methods e.g. Value Engineering, Quality Assurance
* Skills associated with phases in the life cycle of a business, programme, project, product or service, e.g. Asset and Maintenance Management, Project and Programme Management,
* Industry specific knowledge, in as far as it presents the context in which a problem needs to be understood and ultimately solved, e.g. Fast Moving Consumer Goods, Warehousing & Transportation, Capital Investment

1. The tools and machinery used, which could be interpreted to include

* Manufacturing, processing and fabrication techniques
* Techniques and models, e.g. Operations Research
* Modelling tools, e.g. Simulation and Optimisation Tools
* System tools, e.g. Enterprise Resource Planning Systems
* Philosophies, e.g. Just in Time

1. The materials worked on or with, which is typically closely related to Industry, e.g.

* Agri-produce and Agri-processing
* Petrochemical and Processing industries
* Steel, and other Metals and Beneficiation,
* Smelters, Metal Works
* Precision Manufacturing,
* Steel Fabrication

1. The kinds of goods and service produced, e.g.

* manufacturing, processing, assembly, fabrication, construction and engineering contracting
* complex systems
* service industries
* professional and management consulting services

It is evident from the above that, unlike many of the other engineering disciplines, Industrial Engineering is not limited to any one or more of the four dimensions of specialisation. It is therefore no surprise that a growing number of industries are benefiting from an Industrial Engineering skill set. The list of such **industries** includes, but is not limited to:

* Primary industries and its downstream beneficiation industries, including mining, fisheries, forestry and agriculture
* Manufacturing industries, ranging from highly specialized capital and goods manufactured on order, to mass produced and fast moving consumer goods
* Chemical, petrochemical, agriculture, food, cosmetics and other processing industries
* Construction and engineering contracting
* Logistics and transport
* Medical and health industries
* Services industries, including banking, insurance and the various spheres of government
* Engineering consulting
* Information and Communication Technology, including business management systems, artificial intelligence, virtual reality, simulation and other decision support mechanisms

## 4.6 Problem Solving Methods

Industrial Engineering also continues to evolve in its response to the typical optimisation challenges of particular industries. As knowledge and technology evolves, Industrial Engineering has embraced as sub-disciplines many problem solving techniques, methodologies, approaches and even philosophies. Some examples are:

* The Lean and Just in Time philosophies and associated techniques typically applied in manufacturing and construction supply chains
* Supply Chain Management and its associated disciplines in the areas of procurement, inventory and materials management, warehouse and logistics management, manufacturing management, production and process control, and sales and distribution management
* Methodologies and techniques associated with the planning and control of primary conversion processes, and the associated accounting practices
* Re-engineering of primary and support processes
* Total Quality Management, Six Sigma and other approaches to Quality Assurance and Management
* Theory of Constraints, and associated techniques
* Simulation and stochastic processes, statistical analysis, operations research and other associated quantitative problem solving techniques
* Maintenance Management, including Total Preventative Maintenance
* Systems design and systems engineering, including systems support over its entire life cycle
* System dynamics, policy planning and process design
* Cost and value engineering
* Facilities design and management
* Project Management
* Engineering economics

# 5. Implications for Industrial Engineering Training

Considering the dynamic nature of the profession, the diverse range of industries which Industrial Engineering Technicians could find themselves in, and the diverse range of sub-disciplines and specialised skills characterising the Profession, it is evident that it is virtually impossible to define a set of predetermined training paths for the Industrial Engineering Technician Candidacy Phase.

Instead of predetermined paths, a set of guiding principles is proposed, whereby Candidates should shape the course of their own Candidacy Phase. The list of guiding principles is:

* To be involved with the solution of at least one well-defined problem, through its entire life cycle, starting with problem definition, continuing to evaluation and selection of proposed solutions, solution design, as well as its implementation and post implementation support.
* To seek a fair balance between width of exposure and depth of specialisation, and not to compromise the one for the other
* To actively seek diversity across well-defined assignments, in terms of
* the types of underlying complexity of problems exposed to
* the management and leadership style of business leaders, managers and mentors exposed to
* teams involved with, as well as team work and individual work
* To seek a level of continuity across at least one area of specialisation, e.g. industry, discipline or problem solving technique

# 6. Developing Competency: Elaborating on sections in the Guide to the Competency Standards, document R-08-PN

In this section, we elaborate on the discipline-independent competency standards outlined in R-08-PN, highlighting specific competencies across the respective areas that are most relevant to Industrial Engineering.

## 6.1 Contextual Knowledge

Any successful solution or intervention takes the context in which it exists into consideration. The integrative nature of Industrial Engineering, the fact that it draws from a variety of specialised knowledge and skills, and the requirement to satisfy multiple objectives simultaneously place an added emphasis on the understanding and consideration of context.

Contextual knowledge includes, but is not limited to the following:

* Organisation vision, mission, aspirations, objectives and core strategy
* Business model
* Industry dynamics
* Risk, compliance and governance framework
* Legal and regulatory framework
* Cultural and social value systems
* Political and economic context
* Historic context
* Stakeholder and role player expectations, limitations and aspirations
* Behaviour, mindset, skills and capabilities context
* Physical environment
* Support context

Any successful Professional has developed the art and skill to discern which contexts are most important in the situation at hand, and makes an effort to understand the opportunities, limitations and rules of engagement associated with the particular environment and context he or she find themselves in.

## 6.2 Functions Performed

There are no particular requirements related to Functions Performed in addition to the stipulations of R-08-PN.

## 6.3 Industry Related Statutory Requirements

There is no public liability associated with the typical activities of Industrial Engineering Technicians, as outlined in the sections above.

The Generally Applicable legislation, listed in Appendix A of R-08-PN also applies to Industrial Engineering Technicians. This list does not necessarily include industry specific legislation and regulation which forms part of the contextual knowledge required of Industrial Engineering Technicians.

## 6.4 Recommended Formal Learning Activities

Possible formal learning activities for candidate engineering technicians include all post graduate programs in Industrial Engineering and related fields such as Supply Chain Management and Project and Technology Management offered by Universities of Technology with accredited engineering diploma programs.

There also is a variety of continued education programmes in the broad field of Industrial Engineering offered by the various academic institutions as well as commercial entities that offer formal training. These programs have various degrees of accreditation and the Candidate Engineering Technician should verify the status of the educational programme before enrolling.

The Southern African Institute for Industrial Engineering offers an annual conference as well as specialist group meetings through which Candidate Engineering Technicians can pursue Continuous Professional Development (CPD). The Institute also provide a listing of possible CPD activities for which CPD points will be awarded.

Short courses offered by Training Institutions, accredited by SAIIE in terms of CPD, include courses of both a generalist and specialist nature.

Examples of courses that offer specialist skill are:

* Systems Engineering
* Project Management
* Change and Transformation Management
* Maintenance Management
* Strategic Sourcing

Examples of courses that offer generalist skills are:

* Negotiation and influencing
* Industrial relations
* Public speaking
* Professional writing

The learning activities listed above are normally augmented by in house training in the workplace.

# 7. Programme Structure and Sequencing

## 7.1 Degree of Responsibility

**Table 4: Progression throughout the candidacy period** of *R-04-P Training and Mentoring Guide* refers to the gradual increase in degree of responsibility that the Candidate Engineering Technician is exposed to during his professional training. Considering the nature of work listed in this table, specific examples and outcomes appropriate to training in Industrial Engineering are given below:

|  |  |  |
| --- | --- | --- |
| **Degree of Responsibility** | **Nature of work The candidate …** | **Training in Industrial Engineering** |
| A: Being Exposed | … undergoes induction, observes processes and work of competent practitioners | * Understand the business environment and the dynamics that shape the business and industries it operates in. * Understand the business model, its key conversion processes and critical outcomes * Understand the value added by Industrial Engineering Technicians and by other professions in the business |
| B: Assisting | … performs specific processes under close supervision | * Develop insight and understanding of the different well-defined processes and systems in the transformation of inputs into goods and services * Develop an appreciation of the numerous resources at the disposal of the industrial engineer * Obtain experience in the day to day operations of the business, in order to gain insight and understanding of the different well-defined processes and systems in the transformation of inputs into goods and services, with specific emphasis on productivity and quality measurements |
| C: Participating | … performs specific processes as directed with limited supervision | * Gain first-hand experience of a broad range of well-defined industrial engineering activities, for example process design and re-engineering, planning and control, work study, value engineering, materials and information management, people management skills, logistics, specialists’ inputs, tools and equipment and quality assurance * The problems and limitations of particular well-defined philosophies, methods and techniques should be noted, with emphasis on cost / effort and relative benefit |
| D: Contributing | … performs specific work with detailed approval of work outputs | * Involvement in for example the planning of production, the control of quality and costs of process study and work study and good materials handling and workplace layout, activity based costing, bench marking, business cases, process re-engineering, maintenance practice and procedures, project management and system specification, all working together in the economic use of people, materials and machines, is of particular importance. * Specific attention should also be given to human aspects concerning communication, interpersonal relationships and teamwork, training and cost analysis, budget control and profit accountability. These should proceed in parallel, applying well-defined industrial engineering techniques and by utilising computers in problem solving |

|  |  |  |
| --- | --- | --- |
| E: Performing | … works in team without supervision, recommends work outputs, responsible but not accountable | * Assume increasing well-defined technical responsibility and increasingly co-ordinate the work of others * Exposure to and development of skill in management areas such as in labour relations, management accounting, business law and general business management are important in order to develop a fully rounded industrial engineering technician * Assignments that require well-defined judgment to be made, even when full information is not available leading to a position of professional responsibility is of great value and should be pursued. |

## 7.2 Realities

The minimum period for the Candidacy Phase is stated as three years. The likelihood however is that it will take between three and five years to gain the required width and depth of experience required for Registration.

Whilst many Companies, including those who have signed a Commitment and Undertaking with ECSA, offer structured Engineering Technician in Training Programmes, workplace realities may imply limited opportunities for rotation or even promotion, or it may imply the requirement to fulfil a specific role with less than ideal access to in-house mentors and to Industrial Engineering. This may have consequences in terms of the quality and rate of one’s development as a Candidate Engineering Technician.

What distinguishes people who achieve success in life and in their careers is their ability to understand the choices, albeit limited, open to them. Courses and other opportunities to develop one’s professional skills outside of the work place may ultimately lead to access to other opportunities within the workplace. The investment made in one’s own development offers a sense of empowerment, and virtually always has multiple returns on the medium to long term.

Candidate Engineering Technicians should evaluate their readiness for Registration by comparing their own development against the standards of competency for registration in R-02-PN. It will also be helpful to consult with a mentor and/or supervisor as to their readiness to apply for Registration.

## 7.3 Considerations for generalists, specialists, researchers and academics

It is highly recommended that researchers and academics make use of part time assignments and/or sabbaticals to gain exposure to projects outside of Academia. The Competency Standard as defined in R-02-PN applies to generalists, specialists, researchers and academics alike.

## 7.4 Moving into or Changing Candidacy Programmes

This Guide assumes that the Candidate enters a programme of Industrial Engineering work after graduation and continues with the programme until ready to submit an Application for Registration. It also assumes that the Candidate is supervised and mentored by persons who are qualified to provide mentoring in accordance with this document.

Candidate Engineering Technicians should ensure that their career development continues to be aligned with **Table 4** of paragraph 7.1 above. Candidate Engineering Technicians from disciplines other than Industrial Engineering will have to demonstrate their competencies in Industrial Engineering in accordance with the Training and Mentoring Guide 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 be completed:

* The candidate must complete the Training and Experience Summary (TES) and Training and Experience Reports (TER) for the previous programme or unstructured experience. In the latter instance 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 in the light of the past experience and opportunities and requirements of the new programme and plan towards the next phase(s) of the Candidate’s programme.

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| --- | --- | --- | --- |
| **ENGINEERING COUNCIL OF SOUTH AFRICA**  ***Standards and Procedures System*** | | |  |
| **Discipline-specific Training Guideline for Candidate**  **Engineering Technicians in Mechanical Engineering** | | |
| **Status: Approved by the Central Registration Committee** | | |
| **Document : R-05-MEC-PN** | **Rev-1** | **17 July 2014** |

# Background: ECSA Registration System Documents

The documents that define the Engineering Council of South Africa (ECSA) system for registration in professional categories are shown in **Figure 1** which also locates the current document.

**R-01-P**

**Registration Policy**

Prescribes

Prescribes Standards

**R-02-PN**

**Competency**

**Standard**

Explains

**R-08-PN Guide to the Competency Standards**

Procedures

**R-03-PN**

**Application and Assessment Process**

Refers to

**R-04-P Training and Mentoring Guide (All Categories)**

***This Document***

Refers to

**R-05-MEC-PN**

**Discipline-specific**

**Training Guide**

**Figure 1: Documents defining the ECSA Registration System**

# 1. Purpose

All persons applying for registration as Professional Engineering Technician are expected to demonstrate the competencies specified in document R-02-PN at the prescribed level, irrespective of the trainee’s discipline, through work performed by the applicant at the prescribed level of responsibility.

This document supplements the generic *Training and Mentoring Guide* R-04-P and *the Guide to the Competency Standards for Professional Engineering Technicians*, document

R-08-PN. In document R-04-P attention is drawn to the following sections:

* + 1. Duration of training and period working at level required for registration
    2. Principles of planning training and experience
    3. Progression of Training programme
    4. Documenting Training and Experience

7.4 Demonstrating responsibility

The second document R-08-PN provides both a high-level and outcome-by-outcome understanding of the competency standards as an essential basis for this discipline specific guide.

This Guide, as well as R-04-P and R-08-PN, are subordinate to the Policy on Registration, document R-01-P, the Competency Standard (R-02-PN) and the application process definition (R-03-PN).

# 2. Audience

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

This guide applies to persons who have:

* 1. Completed the education requirements by obtaining an accredited Dip (Engineering), Dip (Eng Tech), Adv Cert (Engineering) type qualification, or a Dublin-Accord Recognised qualification or through evaluation/assessment;
  2. Registered as Candidate Engineering Technicians;
  3. 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 a Candidate or not Training under a C&U

All applicants for registration must present the same evidence of competence and be assessed against the same standards, irrespective of the development path followed. Application for registration as a Professional Engineering Technician is permitted without being registered as a Candidate Engineering Technician or without training under a C&U. Mentorship and adequate supervision are however 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 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 written for the recent graduate who is training and gaining experience toward registration. Mature applicants for registration may apply the guide retrospectively to identify possible gaps in their development.

Any applicants who have not enjoyed mentorship 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 into a candidacy programme at a later stage that is at a level below that required for registration (see **Section 7.5**).

# 4. Mechanical Engineering

*Mechanical Engineering Technicians* undertake the planning, design, construction, operation and maintenance of materials, components, machines plant and systems for lifting, hoisting and materials handling;

turbines, pumps and fluid power; heating, cooling, ventilating and airconditioning; fuels, combustion, engines, steam plant , petrochemical plant, turbines; automobiles, trucks, aircraft, ships and special vehicles; fire protection; nuclear energy generation, lifts and escalators; advise on mechanical aspects of particular materials products or processes; through the application of engineering sciences: mechanics, solid mechanics, thermodynamics, fluid mechanics.

Typical tasks that a *Mechanical Engineering Technicians* may undertake include:

* Advising on and designing machinery and tools for manufacturing, mining, construction agricultural and other industrial purposes
* Advising on and designing steam, internal combustion and other non-electric motors and engines used for propulsion of railway locomotives, road vehicles or aircraft or for driving industrial or other machinery
* Advising on and designing hulls, superstructures and propulsion systems of ships; mechanical plant and equipment for the release, control and utilization of energy, heating , ventilation and refrigeration systems, steering gear, pumps, pipe work, valves and other associated mechanical equipment
* Advising on and designing airframes, undercarriages and other equipment for aircraft as well as suspension systems, brakes, vehicle bodies and other components of road vehicles.
* Advising on and designing non-electrical parts of apparatus or products such as word processors, computers, precision instruments, cameras and projectors
* Establishing control standards and procedures to ensure efficient functioning and safety of machines, machinery, tools, motors, engines, industrial plant, equipment or systems.
* Ensuring that equipment operation and maintenance comply with design specifications and safety standards

Practising *Mechanical Engineering Technicians* generally concentrate in one or more of the following areas:

Air-conditioning Heating and Ventilation Incl. Fire Protection and Detection Engineering Technician.

Automotive Engineering Technician

Diesel Engineering Technician

Fluid Mechanics Engineering Technician

Forensic Engineering Technician

Heating and Ventilation Engineering Technician

Machine Design and Development

Engineering Technician Maintenance Management

Engineering Technician Mechanical Engineer Mines

Mechatronics Engineering Technician

Piping Engineering Technician

Power Generation Engineering Technician

Pressurised Vessels Engineering Technician

Rotational Plant Engineering Technician

Structural Steel Engineering Technician

Thermodynamics Engineering Technician

Transportation Systems Engineering Technician

# 5. Training Implications of the Nature and Organisation of the Industry

Mechanical engineering technicians may be employed in both the private and public sector.

Typically in the private sector they would be involved in consulting, contracting, or in supplier or manufacturing organisations. Engineering consultants are responsible for planning, designing, documenting, and supervising the construction of projects on behalf of their clients. Engineering contractors are responsible for project implementation and activities include planning, construction, labour and resource management. Those working in supply or manufacturing companies could be involved in research and development, and would be involved in production, supply and quality control.

The public sector is responsible for service delivery and is usually the client, though in some departments design and construction is also carried out. Mechanical engineering technicians are required at all levels of the public sector, including at national, provincial and local government level, state owned enterprises (SOEs), and public utilities. The public sector largely handles planning, specifying, overseeing implementation, operations and maintenance of infrastructure.

An extension of the public sector would include tertiary academic institutions and research organisations.

Depending on where the candidate is employed, there may be situations where the opportunities in- house are not sufficiently diverse to develop all the competencies required in all the groups noted in document R-02-PN. For example the opportunity for developing problem solving competence (including design or developing solutions) and for managing engineering

activities (including implementing or constructing solutions) may not both be available to the candidate. In such cases employers are encouraged to put a secondment system in place.

It has been fairly common practice that where an organisation is not able to provide training in certain areas that secondments are arranged with other organisations, so that the candidate is able develop all the competencies required for registration.

These secondments are usually of a reciprocal nature so both employers and their respective employees get the mutual benefit from the other party. Secondments between consultants and contractors, and between the public and private sector should be possible.

Problem solving in design, operational, construction and research environment is the core of mechanical engineering. It is a logical thinking process that requires engineering technicians to apply their minds diligently in bringing solutions to technically well-defined problems. This process involves the analysis of systems or assembly of mechanical components, and integration of various elements in mechanical engineering through the application of basic and engineering sciences.

The problem solving experience may be obtained in any of the following work categories:

# Design

Examples of acceptable designs would include, but are not limited to the design of:

Well-defined fluid systems, which includes rotating or reciprocating machines.

Well-defined machines/equipment or major parts thereof.

Well-defined energy systems involving heat transfer.

Well-defined pressure systems/HVAC systems.

Well-defined structures.

# Operations

This would mostly deal with investigating failure or underperformance of major equipment or systems and the synthesis of implemented and proven solutions to avoid recurrence of the problem. In addition this category of work will also involve the improvement projects necessary for optimising the operational efficiencies. The engineering technician must, in carrying out the above, apply professional engineering judgment to all work he or she does in the management of operations. This would include, but would not be limited to, the ability to assess design work against the following criteria:

* + - Conformance to design specifications, health and safety regulations.
    - Ease of fabrication and assembly.
    - Constructability.
    - Maintainability.
    - Conformance to environmental requirements.
    - Ergonomic considerations.
    - Life cycle costs.
    - Alternative solutions

# Research and Development

This type of work may be carried out in research and product development centres of business organizations or at the academic institutions. Candidates must undertake research and development work that is predominantly of mechanical engineering nature, and this work must include an in-depth application of the various aspects of mechanical engineering, including product or system testing under controlled experimental conditions.

# 6. Developing competency: Elaborating on sections in the Guide to the Competency

Applicants are required to demonstrate the insight and ability to use and interface various design aspects through verifiable work carried out in providing engineered and innovative solutions to practical well-defined problems experienced in their operating work environment. In addition applicants must develop the skills required to demonstrate the advanced use of mechanical engineering knowledge in optimizing the efficiency of operations or the constructability of projects.

Candidates must be able to demonstrate that they have been actively involved in a mechanical work shop environment participating in the execution of practical work such that they have learnt sufficient details on basic mechanical procedures to be able to exercise judgment in the workplace thereafter.

Applicants must show evidence of adequate training in this function through well-defined project work carried out in the analysis of problems and the synthesis of solutions. Evidence is required in the form of a separate comprehensive design report that should accompany the application. This report should describe a synthesized solution to sufficiently well-defined engineering problems to demonstrate that applicants have had an opportunity to apply their technical knowledge and engineering expertise

gained through university of technology education and practical work experience. In applying technical and scientific knowledge gained through academic training, the applicant must also demonstrate the financial and economic benefits of engineered solutions, synthesized from scientific and engineering principles at a sufficiently advanced level.

**What is a sufficiently well-defined engineering problem?**

We can summarise the definition of *well-defined* in *well-defined engineering problems* as follows:

"Composed of ***inter-related conditions***; requiring ***underpinning methods, procedures and techniques judgment*** to create a solution within a set of ***originally well-defined circumstances*"**

Mechanical engineering forms an integral part of broader engineering systems and infrastructure in technologically complex manufacturing, processing, mining, construction, product development and research environment. Applicants are required to undertake mechanical engineering projects that significantly enhance the operability and constructability of integrated engineering systems and infrastructure. Such project work must not be stand-alone type of assignment, but should be part of a solution to integrated engineering systems that requires a broader application of various theoretical aspects of mechanical engineering, ranging from fluid systems and energy systems, to structures and machines.

The design is a logical thinking process that requires engineering technicians to apply their minds carefully in bringing solutions to technically well-defined problems. This process involves the analysis of systems or assembly of mechanical components, and integration of various elements in mechanical engineering through the application of basic and engineering sciences. Simple, straightforward calculation exercises and graphical representations from computer generated data are not considered as sufficiently well-defined engineering designs. The reason is because anybody with qualifications in basic science and engineering science can be able to perform this kind of work, and the professional registration requires advanced application of engineering **knowledge** in well-defined design problems.

As part of demonstrating advanced application of theoretical knowledge with respect to these systems, applicants must incorporate calculations with clearly defined inputs to the formulae used and detailed interpretation of the results obtained. They have to demonstrate how the calculated results have been used to provide the solution to the problem at hand, and the economic benefit to the project or the operating work environment.

Candidate Engineering Technicians must obtain experience in solving a variety of problems in their work environment, and the solution to these problems should also involve the use of fundamental and advanced mechanical engineering knowledge obtained at a university of technology. The problems that require scientific and engineering approach in solving them may be encountered in any engineering work environment that consists of integrated engineering systems, equipment, machinery and infrastructure. From their early training years, candidates must actively seek opportunities to obtain experience in the area of synthesizing solutions to real life engineering problems encountered at the workplace.

A suitable period of time and degree of practical participation should be sought in the workshop environment learning the basic practices that are the essence of the mechanical discipline so that the Candidate can judge the efficacies of such practices in the general workplace thereafter.

# Contextual Knowledge

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

The profession identifies specific contextual activities that are considered essential to the development of competence of the Mechanical Engineering Technician. These include awareness of basic workshop, manufacturing and fabrication activities and the competencies required of the engineer, technologist, technician and artisan. Exposure to practice in these areas will be identified in each programme within employer environment.

The Professional Technician Registration Committee (Mechanical) of ECSA carries out the review of the Candidate’s portfolio of evidence at the completion of the training period.

# Functions Performed

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

A Knowledge based problem solving (this should be a strong focus)

B Management and Communication

C Identifying and mitigating the impacts of engineering activity

D Judgement and responsibility

E Independent learning

It is very useful to measure the progression of the candidate’s competency by making use of the Degree of Responsibility, Problem Solving and Engineering Activity scales as specified in the relevant documentation.

The **Appendix** has been developed against the Degree of Responsibility Scale

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

# Industry-related statutory requirements

Candidates are expected to have a working knowledge of the following regulations and Acts and how they affect their working environment:

* + ECSA – Engineering Profession Act, 2000, (Act No. 46 of 2000)’ its Rules and the Code of Conduct
* OHSAct – Occupation Health and Safety Act, 1993 (Act No. 85 of 1993), as amended by Act No. 181 of 1993.
* Building Regulations – National Building Regulations and Building Standards Act, 1977 (Act No. 103 of 1977), as amended by Act No. 49 of 1995



Machinery and Works Regulations Labour Relations Act

Environment Conservation Act, 1989 (Act No. 73 of 1989), as amended by Act No. 52 of 1994 and Act No. 50 of 2003.

Mine Health and Safety Act. 1996 (Act No. 29 of 1996)



Industry Specific Work Instructions

Many other Acts not listed here may also be pertinent to a candidates work environment. Candidates will be expected to have a basic knowledge of the applicable Acts and to investigate whether any Acts are applicable in the particular work environment.

# Recommended Formal Learning Activities

The following list of formal learning is a sample of some useful course types: CPD courses on specific disciplines

Project Management

Value Engineering

Standard Conditions of Contract: NEC, FIDIC, GCC etc Preparation of Specifications

Negotiation Skills

Engineering Finance

Risk Analysis

Quality Systems

Occupation Health and Safety

Energy Efficiency

Maintenance Engineering

Environmental Impacts

Management

Report Writing

Planning methods

# 7. Programme Structure and Sequencing

**7.1 Best Practice**

There is no ideal training programme structure or a 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

It is suggested that the candidate works with their mentors to determine appropriate projects to gain exposure to elements of the asset cycle, to ensure that their designs are constructible, operable, and are designed considering life cycle costing and long-term sustainability

The training programme should be such that candidate progresses through levels of work capability, which is described in 7.3.4 of R-04-P, such that by the end of the training period, the candidate must perform individually and as a team member at the level of problem solving and engineering activity required for registration and exhibit degree of responsibility E.

The nature of work and degrees of responsibility defined in document R-04-P, Table 4, are used here (and in Appendix A below)**:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| A: Being Exposed | B: Assisting | C: Participating | D: Contributing | E: Performing |
| Undergoes induction, observes processes, 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 appropriate to a registered person, supervisor is accountable for applicant’s decisions |

The Mentor and Candidate must identify at which level of responsibility an activity provides the compliance with and demonstration of the various Outcomes. The evidence of the candidate’s activities and acceptance by the Mentor will be recorded on the appropriate system such that it meets the requirements of the Training Elements **Appendix A**. ECSA will specify the applicable recording system.

**7.2 Orientation requirements**

Introduction to Company

Company Safety Regulations

Company Code of Conduct

Company Staff Code and Regulations Typical functions and activities

Hands on experience and orientation in each of the major company divisions

# 7.3 Realities

Generally, irrespective of the discipline, it is unlikely that the period of training will be three years, the minimum time required by ECSA. Typically, it will be longer and would be determined amongst others by the availability of functions in the actual work situation.

Each candidate will effectively undertake a unique programme where the various activities carried out at the discipline specific level are then linked to the generic competency requirements of R-08-PN.

# Considerations for generalists, specialists, researchers and academics

Section 10 of document R-08-PN adequately describes what would be expected of persons whose formative development has not followed a conventional path, for example academics, researchers, specialists and those who have not followed a candidate training programme.

The overriding consideration is that, irrespective of the route followed, the applicant must provide evidence of competence against the standard.

# Moving into or Changing Candidacy Programmes

This Guide assumes that the candidate enters a programme after graduation and continues with the programme until ready to submit an application for registration. It also assumes that the candidate is supervised and mentored by persons who meet the requirements in document R-04-P section 7.2. In the case of a person changing from one candidacy programme to another or moving into a candidacy programme from a less structure environment, it is essential that the following steps be completed:

* + - The candidate must complete the Training and Experience Summary (TES) and Training and Experience Reports (TER) 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 in the light of the past experience and opportunities and requirements of the new programme and plan at least the next phase of the candidate’s programme.

|  |  |  |  |
| --- | --- | --- | --- |
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**Application and Assessment Process**

Refers to

**R-04-P Training and Mentoring Guide (All Categories)**

***This Document***

Refers to

**R-05-MET-PN**

**Discipline-specific**

**Training Guide**

**Figure 1: Documents defining the ECSA Registration System**

# 1. Purpose

All persons applying for registration as Professional Engineering Technicians are expected to demonstrate the competencies specified in document R-02-PN at the prescribed level, irrespective of the trainee’s discipline, though work performed by the applicant at the prescribed level of responsibility.

This document supplements the generic *Training and Mentoring Guide* R-04-P and *the Guide to the Competency Standards for Professional Engineering Technicians*, document R-08-PN. In document R-04-P attention is drawn to the following sections:

* + 1. Duration of training and period working at level required for registration
    2. Principles of planning training and experience
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    4. Documenting Training and Experience

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The second document R-08-PN provides both a high-level and outcome-by-outcome understanding of the competency standards as an essential basis for this discipline specific guide.

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# 2. Audience

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

This guide applies to persons who have:

* 1. Completed the education requirements by obtaining an accredited Dip (Engineering), Dip (Eng Tech), Adv Cert (Engineering) type qualification, or a Dublin-Accord Recognised qualification or through evaluation/assessment;
  2. Registered as Candidate Engineering Technicians;
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**3. Persons not Registered as a Candidate or not Training under a C&U**

All applicants for registration must present the same evidence of competence and be assessed against the same standards, irrespective of the development path followed. Application for registration as a Professional Engineering Technician is permitted without being registered as a Candidate Engineering Technician (CEN) or without training under a C&U. Mentorship and adequate supervision are however 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 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 pace at all stages of the development process.

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Any applicants who have not enjoyed mentorship 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 into a candidacy programme at a later stage that is at a level below that required for registration (see **Section 7.3**).

# 4. Metallurgical Engineering

### Extractive Metallurgical Engineering Technician

Extractive Metallurgical Engineering: perform research, plan, design, develop, and operate commercial-scale processes for the extraction of metals or intermediate compounds from ores by chemical or physical processes, including those at high temperatures.

Typical Tasks that an *Extractive Metallurgical Engineering Technician* may undertake include:

* Assist in conducting research, developing methods of extracting metals from their ores and advising on their application
* Design, development and implementation of well-defined process projects
* Operation and optimisation of process plants

Practising *Extractive Metallurgical Engineering Technicians* generally concentrate in one or more of the following fields:

Lecturer / Researcher Technical

Projects / Commercial Operations

and sub-disciplines:

Mineral Processing Pyro metallurgy

Hydrometallurgy

### Metallurgical and Materials Engineering Technician

*Metallurgical and Materials Engineering Technicians* perform research, analysis, design, production, characterisation, failure analysis and application of materials, including metals, for engineering applications based on an understanding of the properties of matter and engineering requirements.

Typical Tasks that a *Metallurgical and Materials Engineering Technician* may undertake include:

* Assist in the development, control and advice on processes used for casting, alloying, heat treating or welding of metals, alloys and other materials to produce commercial metal products or develop new alloys, materials and processes, assist in evaluating and specifying materials for engineering applications, and do quality control and failure analyses.
* Investigate properties of metals and alloys, assist in developing new alloys and advice on and supervising technical aspects of metal and alloy manufacture, processing, use and manufacturing.
* Do residual life evaluations and predictions, failure analyses, and assist in prescribing remedial actions to avoid material failures.

Practising *Metallurgical and Materials Engineering Technicians* generally concentrate in one or more of the following areas:

* Physical Metallurgist
* Materials Engineering Technician
* Welding Engineering Technician
* Corrosion Engineering Technician
* Quality Assurance Engineering Technician

**5. Training Implications of the Nature and Organisation of the Industry**

Since the metallurgical engineering industry encompasses a wide field of activity, ranging from extractive metallurgy to physical metallurgy, it is not realistic to expect that all training programmes should cover the same field. However, it is recognised that a metallurgical engineering technician is usually employed in an organisation operating in one or more of the following fields:

1. Metallurgical Plant Operation / Optimisation

2. Specification, Design, and Commissioning of Metallurgical Plants / Components

3. Research, Development, Technology transfer and Consulting

The CEN should have sound training in at least one of these fields and insight in preferably all three fields. Ideally the CEN should start in field 1. Field 1 generally allows some exposure to fields 2 and 3. Experience in field 1 allows improved progress in fields 2 and 3.

# 6. Developing competency: Elaborating on sections in the Guide to the Competency Standards, document R-08-PN

## 6.1 Contextual Knowledge

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

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

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

## 6.2 Functions Performed

**6.2.1 Metallurgical Plant Operation / Optimisation**

It should be mentioned that one of the most useful ways in which the CEN can gain experience is to be a member of a team responsible for the commissioning of a new or modified plant. Routine operation of existing plants will be considered as sufficient training, provided that as many of the following facets as possible are covered, with emphasis being placed on those that are particularly relevant to the operation:

* 1. Measurement and analysis of performance data;
  2. Material and energy balances;
  3. Process plant operation, especially with direct and increasing responsibility for certain sections of the plant;
  4. Quality control in respect of measurement and specifications;
  5. Plant records and operating costs;
  6. The selection and application of instrumentation;
  7. Optimisation and control of the well-defined process to improve performance;
  8. The principles of well-defined industrial engineering practice, including the critical study of well-defined work methods and the development of more effective techniques for recognising real and significant problems and how to solve them;
  9. Safety, and the acceptance of the principle that an engineering technician may not endanger the life and limb of people through negligence;
  10. Inter-relationships between engineering personnel and management, and between the members of the engineering team; especially between production and maintenance
  11. The impact that the operation may have on the environment;
  12. Involvement in sound financial business concepts ranging from budgeting to feasibility studies;

## 6.2.2 Specification, Design, Erection and Commissioning of Plants and Components

Training in this field should contain elements of each of the following three sub-sections:

* 1. Process Plant Development - laboratory, pilot, or full-scale plant work primarily aimed at obtaining engineering data for the specification and design of well-defined new metallurgical plants or the improvement of existing plants;
  2. Plant Design - preparation of well-defined flow sheets and material and energy balances, appreciation of the operation of a drawing office and an engineering purchasing office, checking of working drawings for suitability with respect to the particular well-defined metallurgical operation, specification, design and selection of equipment, and service requirements, consideration of the design with regard to materials used, economics, instrumentation, quality control, logistics, safety, acceptable operation conditions, spillage management and the effect on the environment;
  3. Commissioning - measurement and analysis of actual performance data versus design parameters, responsibility for performance of the plant, optimization of plant performance, review of all safety standards, operability of the plant, sound labour relations and practices and managerial aspects.

## 6.2.3 Research, Development, Technology Transfer and Consulting

Research, Development, Technology Transfer and Consulting would include any of the following sub-disciplines:

* Mineral Processing
* Hydrometallurgy
* Pyrometallurgy
* Materials engineering and other physical metallurgy sub-disciplines

Graduate metallurgical engineering technicians employed in research, development, technology transfer and consulting should gain experience in as many of the following facets as possible:

* 1. Develop a clear understanding of the well-defined problem/opportunity to be investigated by conducting a critical analysis of the literature and other relevant information, and assembling of the documentation on the subject in an organised manner;
  2. Motivation, planning and design of the well-defined research project and its associated equipment and/or plant;
  3. Well-defined theoretical or paper investigations;
  4. Well-defined laboratory-scale investigation;
  5. Well-defined investigations on a pilot plant and/or industrial plant scale;
  6. Interpretation of results, and ensuring that results are meaningful and have been correctly obtained in accordance with well-defined scientific principles;
  7. Data processing and analysis;
  8. Studies of technical and economic feasibility;
  9. Compilation of the results into a written report and presentation of verbal reports;
  10. Safety aspects with respect to the handling of hazardous materials, and selection of instrumentation and equipment;
  11. Spillage management and the effect on the environment;
  12. Operational staff training and acceptable operating conditions;
  13. Technology transfer to ensure that the maximum benefit is obtained from the research and development effort.

Consulting will generally bring together the majority of the aspects listed under 6.2.1, 6.2.2 and 6.2.3.

## 6.3 Industry-related statutory requirements

The Candidate Engineering Technician should be aware of the requirements for safety appointments in terms of the occupational Health and Safety Act for plant managers.

## 6.4 Recommended Formal Learning Activities

Attendance of relevant technical courses and conferences is recommended. Formal safety training should be mandatory.

# 7. Programme Structure and Sequencing

## 7.1 Realities

There is no ideal training programme structure or a 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. What is expected for ECSA registration is that in whatever area they are employed, applicants ensure that they undertake tasks that provide experience in the 3 generic engineering competence elements: problem investigation and analysis; problem solution; 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 3 years is the minimum period of experience following graduation, in practice it is found that very seldom do metallurgical engineering technicians meet the experience requirements in three years, and then only if they have followed a structured training program.

Applicants are advised to gain at least 5 years of experience before applying.

## 7.2 Considerations for generalists, specialists, researchers and academics

To be able to become a professional engineering technician 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 engineer.

For generalists and specialists, provided that the applicant's specialist knowledge is at least at the level of a BTech degree and provided that the applicant has demonstrated the ability, at a professional level, to identify engineering problems, and to produce well-defined solutions which 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 National Diploma in engineering will be required, but each application will be considered on merit.

## 7.3 Moving into or Changing Candidacy Programmes

This Guide assumes that the candidate enters a programme after graduation and continues with the programme until ready to submit an application for registration. It also assumes that the candidate is supervised and mentored by persons who meet the requirements in document R-04-P section 7.2. In the case of a person changing from one candidacy programme to another or moving into a candidacy programme from a less structure environment, it is essential that the following steps be completed:

* The candidate must complete the Training and Experience Summary (TES) and Training and Experience Reports (TER) 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 in the light of the past experience and opportunities and requirements of the new programme and plan at least the next phase of the candidate’s programme.

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| **ENGINEERING COUNCIL OF SOUTH AFRICA**  ***Standards and Procedures System*** | | |  |
| **Discipline-specific Training Guideline for Candidate Engineering Technicians in Mining Engineering** | | |
| **Status: Approved by Central Registration Committee** | | |
| **Document : R-05-MIN-PN** | **Rev-1** | **17 July 2014** |

# Background: ECSA Registration System Documents

The documents that define the Engineering Council of South Africa (ECSA) system for registration in professional categories are shown in **Figure 1** which also locates the current document.

**R-01-P**

**Registration Policy**

Prescribes

Prescribes Standards

**R-02-PN**

**Competency**

**Standard**

Explains

**R-08-PN Guide to the Competency Standards**

Procedures

**R-03-PN**

**Application and Assessment Process**

Refers to

**R-04-P Training and Mentoring Guide (All Categories)**

***This Document***

Refers to

**R-05-MIN-PN**

**Discipline-specific**

**Training Guide**

**Figure 1: Documents defining the ECSA Registration System**

# 1. Purpose

All persons applying for registration as Professional Engineering Technician are expected to demonstrate the competencies specified in document **R-02-PN** at the prescribed level, irrespective of the trainee’s discipline, through work performed by the applicant at the prescribed level of responsibility.

This document supplements the generic *Training and Mentoring Guide* **R-04-P** and *the Guide to the Competency Standards for Professional Engineering Technicians*, document **R-08-PN**. In document **R-04-P** attention is drawn to the following sections:

* + 1. Duration of training and period working at level required for registration
    2. Principles of planning training and experience
    3. Progression of Training programme
    4. Documenting Training and Experience

7.4 Demonstrating responsibility

The second document **R-08-PN** provides both a high-level and outcome-by-outcome understanding of the competency standards as an essential basis for this discipline specific guide.

This Guide, as well as **R-04-P** and **R-08-PN**, are subordinate to the Policy on Registration, document **R-01-P**, the Competency Standard (**R-02-PN**) and the application process definition (**R-03-PN**).

# 2. Audience

This Guide is directed at Candidates and their Employers, Supervisors and Mentors in the discipline of Mining Engineering. It is also applicable to engineering technicians who study in related sub-disciplines or practice areas but whose engineering work is primarily that of Mining Engineering and who wish to be assessed for professional registration based on their work/experience in the Mining Engineering environment.

This Guide is intended to support a programme of training and experience incorporating good practice elements and applies to persons who have:

* Completed the education requirements by obtaining an accredited Dip (Engineering), Dip (Eng Tech), Adv Cert (Engineering) type qualification, or a Dublin-Accord Recognised qualification or through evaluation/assessment;
* Registered as Candidate Engineering Technicians; 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.

# 3. Persons not Registered as a Candidate or not Training under a C&U

All applicants for registration must present the same evidence of competence and be assessed against the same standards, irrespective of the development path followed. Application for registration as a Professional Engineering Technician is permitted without being registered as a Candidate Engineering Technician or without training under a C&U. Mentorship and adequate supervision are however key factors in effective development to the level required for registration. A C&U indicates that the company is committed to mentorship and supervision and to make available the necessary resources to support the training and development of the Candidate or Engineering Technician-in-Training.

If the trainee’s Employer have not signed a C&U with ECSA, the trainee should establish the level of mentorship and supervision 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 written 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.

Any applicants who have not enjoyed mentorship 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 into a candidacy programme that is at a level below that required for registration (see **Section 7.5**) at a later stage.

# 4. Mining Engineering (OFO 214600)

The Mining Engineering Technician (MEN) designs and prepares specifications for mineral-extraction (Mining) methodology, processes and systems and the management of the operation of Mining engineering processes for different types of mineral depositions and minerals.

## 4.1 Typical tasks performed by MENs

Typical tasks that a MEN may perform, include but are not limited to one or more of the following:

* Conducting well-defined fundamental or operational research and advising on well-defined occupational health and safety and environmentally responsible mineral excavation methodology, processes and systems;
* Designing and specifying well-defined mineral excavation (production) processes, application of mining resources and mining technical support services required, occupational health, safety and environmental considerations and quality assurance;
* Establish well-defined production/operational control standards and procedures to ensure compliance with legislatory and site-specific requirements;
* Manage occupational health, safety and environmentally-related hazards and accompanying risks;
* Performing tests throughout the life-cycle stages and mineral excavation processes to determine the degree of control over variables identified during the well-defined strategic and tactical Mine Design and Planning processes;
* Assist in the development of an appropriate site-specific Risk Management Policy, Procedures and Standards (Codes of Practice);
* Prepare Pre-Feasibility and Feasibility Reports and Life-of-Mine Exploitation Strategies and Plans, Business Plans and Bankable Documents based on site-specific assumptions, premises, constrains and best practice standards e.g. SAMCODES (i.e. SAMREC and SAMVAL);
* Converting mineral resources into mineral reserves; and
* Education and Training of candidate Mining Engineering Technician Practitioners.

## 4.2 Typical Practice Areas for MENs

Practicing MENs generally concentrate on one or more of the following practice areas:

* MEs Conducting Mineral Excavations/Mining Operations;
* Rock Engineers/Strata Control;
* Occupational Environmental Engineering and Hygiene;
* Mineral Asset Valuations (MAV);
* Research and Development;
* Mine Planning and Design;
* Education and Training of MEN Practitioners; and
* Consultancy Work.

## 4.2.1 MENs conducting Mineral Excavations/Mining Operations

Those MENs whose training has been concerned predominantly with the production (mineral excavation) processes should obtain competency/experience in:-

* + - 1. **Production:** Mineral Excavation Processes including Occupational Health and Safety and Environmental Management.
      2. **Production Programming and Scheduling:** To be captured in an appropriate Mining Plan.
      3. **Project Work / Research and Development:** To be covered in a project report.
      4. **Mining Technical Services:** Work Study, Survey and Mineral Evaluation, Ventilation Engineering and Occupational Hygiene, Rock Mechanics, Strata Control, Mineral Beneficiation, Geology, Grade Control and Administration, Integrated Environmental Management.
      5. **Supervisory Experience:** Miner/Rockbreaker, Shift Supervisor, Mine Overseer or equivalent and preferably assisting a Sub-ordinate Manager.
      6. **Training and Development of MENs:** Assisting Lecturers at Tertiary Institutions, Supervisors and Mentors
      7. **Consultancy work:** Assisting in specialist consultancy services in one or more of the MEN practice areas.

## 4.2.2 Rock Engineers/Strata Control

Those MENs whose training has been concerned with Rock Engineering/Strata Control should obtain competency/experience in:-

* + - 1. **Production:** Mineral Excavation Processes including Occupational Health and Safety and Environmental Management.
      2. **Production Programming and Scheduling:** To be recorded in an appropriate Mining Plan.
      3. **Basic Mining processes and procedures:** Mineral Excavation Processes including Occupational Health and Safety, Support Installation and Rock Stability, Stability of Mining Excavations.
      4. **Project Work / Research and Development:** To be covered in a Project Report
      5. **Rock Mechanics Design:** Optimisation of well-defined mining layouts, Computer applications in Rock Mechanics, selection of occupationally safe Mining Methods, addressing OH&S-related Hazards and Risks and Stability of Mining Excavations.
      6. **Supervision of Rock Mechanics:** Support installation in a supervisory capacity, e.g. Miner/Rockbreaker, Shift Supervisor / Mine Overseer equivalent Monitoring and Maintenance of Support Installations.
      7. **Training and Development of RENs and RMs:** Assisting Lecturers at Tertiary Institutions, Supervisors and Mentors
      8. **Consultancy work:** Assisting in specialist consultancy services in one or more of the MEN practice areas.

## 4.2.3 Occupational Environmental Engineering and Hygiene

Those MENs whose training has been concerned with the ventilation of mines and occupational hygiene should demonstrate that they have obtained competency/experience in: -

* + - 1. **Basic Mining:** Mineral excavation Processes including Occupational Health and Safety and Environment Management.
      2. **Project Work/Research and Development:** To be covered in a Project Report
      3. **Mine Environment Design & Specification:** Layouts, Refrigeration, Fan specifications, Airflow; Occupational Environment Control/Hygiene.
      4. **Supervision of Ventilation:** Controlling and Monitoring of Dust, Air Control, Fumes and Gases in a section of a mine, Installation of Fans, Air Conditioners, Hazardous Substances and Pollution, etc.
      5. **Installation:** Fans, Air Controls, Brattices, etc.
      6. **Training and Development of Mine Environment Practitioners:** Assisting Lecturers at Tertiary Institutions, Supervisors and Mentors
      7. **Consultancy work:** Assisting in specialist consultancy services in one or more of the ME practice areas.

## 4.2.4 Mineral Asset Valuations (MAV)

Those MENs whose training has been concerned with the evaluation of mineral deposits should obtain competency experience in: -

* + - 1. **Basic Mining:** Mineral Excavation Processes including Occupational Health and Safety and the Environment Management.
      2. **Tonnage / Grade Estimates:** Sampling, Regression, Geostatistics, Kriging, Geology, Sedimentology on Evaluation process.
      3. **Mine Planning and Design**: Impact of Mine layouts on the Evaluation Process, Rock Mechanics, HIRA.
      4. **Survey:** Appreciation of survey techniques and interpretation of mine plans.
      5. **Project Work /Research and Development:** To be covered in a Project Report
      6. **Economic Evaluation:** Costs, Revenue, Pay Limits, Life of Mine calculations, Cash Flow Estimates, Return on investment, Pre-and Feasibility Studies, Bankable documents and Business Planning,
      7. **Geology:** Appreciation of geological analysis techniques and interpretation of well-defined geological models.
      8. **Training and Development of MAV practitioners:** Assisting Lecturers at Tertiary Institutions, Supervisors and Mentors
      9. **Consultancy work:** Assisting in specialist consultancy services in one or more of the MEN practice areas.

## 4.2.5 Research and Development

Candidates must undertake well-defined research and development work that is predominantly of a mining engineering nature, and this work must include application of the various aspects of mining engineering principles. Candidates must be involved in improvement projects necessary for mining operational efficiencies. In addition applicants must develop the skills required to demonstrate the advanced use of well-defined mining engineering knowledge in mining business optimisation.

* + - 1. Application of mining engineering principles in well-defined mine design problems
      2. Use of applied Operations Research in Mineral Resources Management
      3. Mine-to-mill or resource to market optimisation
      4. Decision analysis techniques

## 4.2.6 Mine Planning and Design

Those MENs whose training has been concerned with the Planning and Design of mines should develop competency/gain experience in:

* + - 1. Well-defined mineral resource to mineral reserve conversion
      2. Well-defined mining value chain
      3. Well-defined mine design criteria
      4. Mining technical risk analysis
      5. Production forecasting
      6. Public reporting requirements, compliance to Codes
      7. Well-defined planning horizons and planning cycles
      8. Multi criteria decision process and trade off studies
      9. Planning integration
      10. Mining business optimisation
      11. Mineral resource management
      12. Value engineering

## 4.2.7 Education and Training of ME Practitioners

Those MENs whose Education and Training enables them to participate in the:

* The education of MENs candidate and/or specialist Candidate MEs;
* Perform the duties of Supervisors as set out in **R-04-P**; and
* Perform the duties of the Mentor as set out in **R-04-P**.

## 4.2.8 Consultancy Work

Those MENs whose Education, Training and/or Experience qualifies them as recognised specialists in a unique competency area to provide specialist consultancy services in one or more of the practice areas set out in **4.2.1** through **4.2.7** hereinbefore.

# 5. Training Implications of the Nature and Organisation of the Industry

MENs may be employed in both the private and public sector.

Typically in the private sector they would be involved in consulting, contracting, or in supplier or manufacturing organisations. MEN consultants are responsible for planning, designing, documenting, and supervising the construction of projects on behalf of their clients. MEN contractors are responsible for project implementation and activities include planning, construction, labour and resource management. Those working in supply or manufacturing companies could be involved in research and development, and would be involved in production, supply and quality control.

An extension of the public sector would include tertiary academic institutions and research organisations.

Depending on where the candidate is employed, there may be situations where the opportunities in-house are not sufficiently diverse to develop all the competencies required in both Groups A and B noted in document **R-02-PN**. For example the opportunity for developing problem solving competence (including design or developing solutions) and for managing engineering activities may not both be available to the candidate. In such cases employers are encouraged to put a secondments system in place.

It has been fairly common practice that where an organisation is not able to provide training in certain areas, that secondments are arranged with other organisations so that the candidate is able develop all the competencies required for registration. Such secondments are usually of a reciprocal nature so both employers and their respective employees get the mutual benefit from the other party. Secondments between consultants and contractors, and between the public and private sector should be possible.

Problem solving in design, operational, construction and research environment is the core of MEN. It is a logical thinking process that requires engineering technicians to apply their minds diligently in bringing solutions to technically well-defined problems. This process involves the analysis of systems or assembly of mechanical components, and integration of various elements in mechanical engineering through the application of basic and engineering sciences.

## 5.1 Diversity of Mining

Owing to the diversity in application of Mining Engineering within the SA Mining Industry, Mining Engineering Technicians can follow a range of routes to registration across multiple minerals/commodities (e.g. precious metals, precious stones, ferrous metals, coal) in differing mining method environments (e.g. surface mining, narrow tabular underground mining, massive underground mining) and underground coal mining.

These routes to registration usually cover, from graduation as a Candidate MEN, a period of operational experience which leads to specialisation in an application of mining engineering in a particular field or sector of the SA Mining Industry. Typically these fields are: mining operations, mine planning and design, rock engineering/strata control, occupational environment engineering (ventilation), refrigeration engineering, techno-economic evaluation, equipment selection, establishment and maintenance of Mining infrastructure, provision of Mining consulting services and education and training of engineering technicians-in-training.

Each field should have been covered but not necessarily all the supplementary elements mentioned after each heading. The objective should be that the MEN has become a well-rounded Engineering Technician.

## 5.2 Engineering Lifecycle Considerations. Mining projects follow the typical Mining Value Chain

The typical engineering industry lifecycle is depicted in **Figure 2** below:

**Develop new brief**

**Projects**

**& Design**

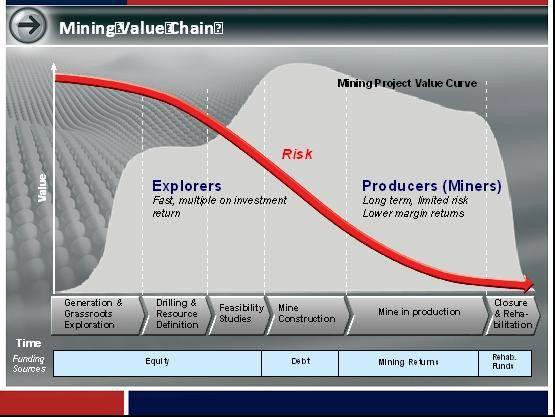
**Operations & Maintenance**

**Management**

**Construction or Manufacturing**

**Figure 2:** Typical Engineering Industry Life Cycle

MENs should demonstrate sufficient and appropriate exposure and experience across the elements of the typical Mining Value Chain set out in **Figure 3**.



**Figure 3:** Typical Mining Value Chain

## Specific appropriate exposure and/or experience should be demonstrated across the following five phases of the typical mining project life cycle.

* Project data collection and investigations;
* Evaluation Planning and Design;
* Construction and Mine Establishment;
* Mining Operations (Mineral excavation/exploitation);
* Mine Decommissioning and Closure.

# 6. Developing competency: Elaborating on sections in the Guide to the Competency Standards, document R-08-PN

### 6.1 Developing competency: Elaborating on sections in the Guide to the Competency

Applicants are required to demonstrate the insight and ability to use and interface various design aspects through verifiable work carried out in providing engineered and innovative solutions to well-defined practical problems experienced in their operating work environment. In addition applicants must develop the skills required to demonstrate the use of MEN knowledge in optimizing the efficiency of operations.

Applicants must show evidence of adequate training in these activities through well-defined project work carried out in the analysis of problems and the synthesis of solutions.

Applicants need to demonstrate that they have had an opportunity to apply their technical knowledge and engineering expertise gained through technical university education and practical work experience. In applying technical and scientific knowledge gained through academic training, the applicant must also demonstrate the financial and economic benefits of engineered solutions, synthesised from scientific and engineering principles at a sufficiently advanced level.

### 6.2 What is a sufficiently well-defined engineering problem?

We can summarise the definition of *well-defined* in *well-defined engineering problems* as follows:

“Composed of ***inter-related conditions***; requiring ***practical judgment*** to create a solution within a set of ***largely defined frequently encountered circumstances*”**

Candidate Engineering Technicians must obtain experience in solving a variety of problems in their work environment, and the solution to these problems should also involve the use of fundamental MEN knowledge obtained at university of technology. The problems that require scientific and engineering approach in solving them may be encountered in any engineering work environment that consists of integrated engineering systems, equipment, machinery and mining infrastructure. From their early training years, candidates must actively seek opportunities to obtain experience in the area of synthesising solutions to real life engineering problems encountered at the workplace.

Candidates are encouraged to familiarise themselves with the Mining and Minerals Sector in general by reading journals, joining relevant professional associations and attending conferences. This includes gaining knowledge of industry standards and specifications.

**6.3 Contextual Knowledge**

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

Across all these routes to registration, MEN in training should demonstrate appropriate exposure and experience in:

* Mineral Excavation processes;
* Mine Planning and design;
* Project execution;
* Research and Development
* Supervision and Management;
* Technical and Financial valuation;
* Occupational Health and Safety and Environmental Management; and

This should be done in one or more of the following sub-sectors/contexts of the SA Mining Industry:

* U/G Narrow Tabular Hard Rock;
* U/G Massive Hard Rock;
* U/G Coal Mining; and
* Surface Mining inclusive of Open Pits, Open Cast and Quarrying operations.

## 6.4 Functions Performed

Special considerations in the discipline, sub-discipline or speciality must be given to the competencies specified in the following learning outcome groupings:

A: Knowledge based problem solving (this should be a strong focus)

B: Management and Communication

C: Identifying and mitigating the impacts of engineering activity

D: Judgement and responsibility

E: Independent learning

It is very useful to measure the progression of the candidate’s competency by making use of the Degree of Responsibility, Problem Solving and Engineering Activity scales as specified in the relevant documentation. The degrees of responsibility defined in document **R-04-P**, Table 4, are used here (and in the Appendix A below):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| A: Being Exposed | B: Assisting | C: Participating | D: Contributing | E: Performing |

Degree of responsibility E means performing at the level required for registration. This corresponds to the range statement in outcome 10 in the Competency Standard **R-02-PN** which requires that the applicant to display responsibility “for the outcomes of significant parts of one or more well-defined engineering activities”.

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 Candidates recommendations and decisions.

**6.5 Industry-related statutory requirements**

Candidates are expected to have a working knowledge of at least the following relevant mining- related legislation and how they affect their working environment:

 ECSA – Engineering Profession Act, 2000, (Act No. 46 of 2000)’ its Rules and the Code of Conduct;

Labour Relations Act;

Environment Conservation Act, 1989 (Act No. 73 of 1989), as amended by Act No. 52 of 1994 and Act No. 50 of 2003;

Water Services Act 1997 (Act No. 108 of 1997);

National Water Act 1998 (Act No. 36 of 1998);

Mine Health and Safety Act. 1996 (Act No. 29 of 1996) and Minerals Act and Regulations 1991 (Act 50/1991);

Mandatory Codes of Practice;

SANS and other relevant Mining-related Standards; Chief Inspector of Mines, Directives/Instructions; and Guidelines issued by the Chief Inspector of Mines.

Candidates are also expected to have in-depth knowledge of at least the following site/mine-specific mining-related standards/requirements:

Hazard Identification and Risk Assessments (HIRA/HAZOP); Occupational health and Safety Risk Management Programme; Managerial Instructions;

Mine/Site-specific Standards Procedures;

List of Recorded significant OH&S-related Risks; Working Guides; and

Relevant Original Equipment Manufacturer’s (OEM’s) Specifications.

## 6.6 Recommended Formal Learning Activities

Candidates may find many of the following recommended formal learning activities, which is by no means extensive, useful in developing the required competencies:

* Formally registered CPD courses;
* Project Management (basic);
* Value Engineering;
* Negotiation Skills;
* Engineering Finance;
* Hazard Identification and Risk Assessment (HIRA, HAZOP);
* Quality Systems;
* Environmental Impacts;
* Management;
* Report Writing;
* Planning methodology and technique;
* Public speaking; and
* Systems Engineering.

# 7. Programme Structure and Sequencing

## 7.1 Best-practice programmes

Since professional development programmes (PDPs) should primarily be outcomes-based, there is no ideal (prescribed) training programme structure or a unique sequencing that constitutes best practice.

The training programme for each candidate will consequently depend on the work opportunities available at the time for the employer to assign to the candidate.

It is suggested that the candidate works with their mentors to determine appropriate projects to gain the necessary exposure and experience needed to comply with the desired Outcomes. A regular reporting structure with suitable recording of evidence of achievement against the competency outcomes and responsibility need to be put in place.

The training programme should be such that the candidate progresses through levels of work capability, which is described in 7.3.4 of **R-04-P**, such that by the end of the training period, the candidate must perform individually and as a team member at the level of problem solving and engineering activity required for registration and exhibit at the degree of responsibility E.

Depending on the nature and extent of the engineering-related work undertaken by an Employer, it should be possible to develop candidate-specific PDPs which will provide opportunities to undertake the necessary exposure/experience in a phased approach described in **APPENDIX 1**. This guidance should be read in conjunction with sections hereinbefore.

**Appendix A** has been developed against the Degree of Responsibility Scale. Activities should be selected to ensure that the candidate reaches the required level of competency and responsibility.

## 7.2 Orientation requirements

Introduction to Company; Company OH&S requirements; Company Code of Conduct;

Company Staff Code and Regulations; Typical functions and activities;

Hands on experience and orientation in each of the major company divisions; and Overall Mining Operations and Mining-related facilities.

## 7.3 Realities

This section should be read in conjunction with 5.1 hereinbefore.

Generally, no matter the discipline, it is unlikely that the period of training and development will be less than three years the minimum period prescribed by ECSA. The length of the candidates’ individual PDP will be determined, amongst others, by Recognition of Prior Learning (RPL) and the availability of opportunities in the actual work situation.

It should also be appreciated that the envisaged individual PDPs’ period of 3 years would most probably only accommodate exposure to experience in one of the following sub-sectors/specialisation practice areas:

U/G Thin Tabular Hard rock operations; U/G Massive Hard Rock operations; U/G Coal mining; and

Surface Mining.

In the case of candidates specialising in practice areas referred to in 4.2.2 through 4.2.8, the recommended period for the candidate-specific PDP is 5 years.

Should the Employer require exposure to/experience in more than the initial sub-sector/specialisation practice area, this would have to be addressed through a supplementary PDP.

## 7.4 Considerations for generalists, specialists, researchers and academics

This section to be read in conjunction with 5.1 hereinbefore.

Section 10 of document **R-08-PN** adequately describes what would be expected of persons whose formative development has not followed a conventional path, for example academics, researchers, and specialists.

The overriding consideration is that, irrespective of the route followed, the applicant must provide evidence of competence against the prescribed standard.

## 7.5 Moving into or changing Candidacy Training Programme

This Guide assumes that the candidate enters a programme after graduation and continues with the programme until ready to submit an application for registration. It also assumes that the candidate is supervised and mentored by persons who meet the requirements in document **R-04-P** section 7.2. 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 be completed:

 The candidate must complete the Training and Experience Summary (TES) and Training and Experience Reports (TER) 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 in the light of the past experience and opportunities and requirements of the new programme and plan at least the next phase of the candidate’s programme.

**Appendix 1: Phased approach for PDPs**

**Entry: Stage 1 Qualification**

NDip (Min. Eng.)

Register as Candidate MEN Stage 2

**Phase 1** Induction Service Depts L3 Rockbreaker Qualification

**Phase 4** Mine Overseer Project Work

**Phase 3** Prod Supervisor L5 Qualification

Project Work

**Phase 2**

Mining Logistics Exposure to Mining Operations L4 Qualification

**Phase 5**

Project Work Acting Certificated Manager

**Phase 6** Summative As- sessment for Registration

Eligible for registration with ECSA as

Pr Techni Eng.

|  |  |  |  |
| --- | --- | --- | --- |
| **ENGINEERING COUNCIL OF SOUTH AFRICA**  ***Standards and Procedures System*** | | |  |
| **Appendix A to Discipline-specific Training Guideline for Candidate Engineering Technicians** | | |
| **Status: Approved by Professional Technicians Registration Committee** | | |
| **Document : R-05-APPENDIX A-PN** | **Rev-1** | **13 May 2014** |

# Appendix A: Training Elements

**Synopsis: A candidate engineering technician should achieve specific competencies at the prescribed level during his/her 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 to 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; and**

**11. Become conversant with your employer’s training and development program and develop your own lifelong**

**development program within this framework.**

**Well-defined engineering work is usually restricted to applying standard procedures, codes and systems, i.e. work**

**that was done before.**

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

|  |  |
| --- | --- |
| **Competency Standards for Registration as a Professional Engineering Technician** | **Explanation and Responsibility Level** |
| **1. Purpose**  This standard defines the competence required for registration as a Professional Engineering Technician. Definitions of terms having particular meaning within this standard is given in text in Appendix D. | Discipline Specific Training Guides (DSTG) gives context to the purpose of the Competency Standards. Professional Engineering Technicians operate within the nine disciplines recognised by ECSA. Each discipline can be further divided into sub-disciplines and finally into specific workplaces as given in Clause 4 of the specific Discipline Specific Training Guideline. DSTG’s 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 utilised to develop the competence of the trainee towards achieving the standards below at a responsibility level E, i.e. Performing. (Refer to 7.1 of the specific DSTG) |
| **2. Demonstration of Competence**  Competence must be demonstrated within ***well-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: *Well-defined engineering activities (WDEA) have*** several of the following characteristics:   1. *Scope* of practice area is defined by techniques applied; change by adopting new techniques into current practice; 2. Practice area is located within a wider, complex *context,* with well-defined working relationships with other parties and disciplines; 3. Work involves familiar, defined range of *resources,* including people, money, equipment, materials, technologies; 4. Require resolution of *interactions* manifested between specific technical factors with limited impact on wider issues; 5. Are *constrained* by operational context, defined work package, time, finance, infrastructure, resources, facilities, standards and codes, applicable laws; 6. Have *risks* and *consequences* that are locally important but are generally not far reaching.   ***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. | Engineering activities can be divided into (approximately):  5% Complex (Professional Engineers)  5% Broadly Defined (Professional Engineering Technologists)  10% Well-defined (Professional Engineering Technicians)  15% Narrowly Well-defined (Registered Specified Categories)  20% Skilled Workman (Engineering Artisan)  55% Unskilled Workman (Artisan Assistants)  The activities can be in-house or contracted out; evidence of integrated performance can be submitted irrespective of the situation.  **Level Descriptor: *WDEA*** in the various disciplines are characterised by several or all of:   1. *Scope* of practice area does not cover the entire field of the discipline (exposure limited to the sub-discipline and specific workplace). Techniques applied are largely well established and change by adopting new techniques into current practice is the exception; 2. Practice area varies substantially with unlimited location possibilities and an additional responsibility to identify the need for complex and/or *broadly defined* advice to be included in the well-defined working relationships with other parties and disciplines; 3. The bulk of the work involves familiar, defined range of *resources,* including people, money, equipment, materials, technologies; 4. Most of the impacts in the sub discipline are on wider issues, and although occurring frequently, are *well-defined* and can be resolved by following established procedures. 5. 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). 6. 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; engineering operations; maintenance; project management. For Engineering Technicians, research, development and commercialisation happen more frequently in some disciplines and are seldom encountered in others. |

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| **3. Outcomes to be satisfied:** | **Explanation and Responsibility Level** |
| **Group A: Engineering Problem Solving.** |  |
| **Outcome 1:**  Define, investigate and analyse well-defined engineering problems | **Responsibility level E**  Analysis of an engineering problem means the “separation into parts possibly with comment and judgement”. |
| ***Well-defined engineering problems*** *have the following characteristics:*  (a) can be solved mainly by practical engineering knowledge, underpinned by related theory;  *and one or more of:*  (b) are largely defined but may require clarification;  (c) are discrete, focused tasks within engineering systems;  (d) are routine, frequently encountered, may be unfamiliar but in familiar context;  *and one or more of:*  (e) can be solved by standardised or prescribed ways;  (f) are encompassed by standards, codes and documented procedures; requires authorisation to work outside limits;  (g) information is concrete and largely complete, but requires checking and possible supplementation;  (h) involve several issues but few of these imposing conflicting constraints and a limited range of interested and affected parties;  *and one or both of:*  (i) requires practical judgment in practice area in evaluating solutions, considering interfaces to other role players;  (j) have consequences which are locally important but not far reaching (wider impact are dealt with by others). | 1. practical problems for Engineering Technicians means the problem encountered cannot be solved by artisans because theoretical calculations and engineering decisions are necessary to substantiate the solution proposed; 2. further investigation to identify the nature of the problem is seldom necessary;   (c) discrete means *individually distinct*: The problem is easily recognised as part of the larger engineering task, project or operation;  (d) recognised that the problem occurred in the past or the possibility exists that it might have happened before – definitely not something new;  (e) solving the problem does not require the development of a new solution – find out how it was solved before;  (f) encompassed means *encircled:* The standards, codes and documented procedures must be obtained to solve the problem and ; authorisation from the Engineer or Technologist in charge must be obtained to wave the stipulations;  (g) the responsibility lies with the Engineering Technician to check the information received as part of the problem encountered is correct, and added to as is necessary to ensure the correct and complete execution of the work;  (h) the problem handled by an Engineering Technician must be limited to well-known matters preferably needing standardised solutions without possible complications;  (i) practical solutions to problems includes knowledge of the skills displayed by Practical Specialists and Engineering Artisans without sacrificing theoretical engineering principles and / or cutting corners to satisfy parties involved;  (j) Engineering Technicians must realise that their actions might seem to be of local importance only, but may develop into further problems where support from Engineers and Technologists might be needed to deal with these consequences. |
| **Assessment Criteria:** A structured analysis of well-defined problems typified by the following performances is expected:  1.1 State how you interpreted the work instruction received, checking with your client or supervisor if your interpretation is correct  1.2 Describe how you analysed, obtained and evaluated further clarifying information, and if the instruction was revised as a result. | To perform an engineering task an Engineering Technician will typically receive an instruction from a senior person (customer) to do this task, and must:   * 1. Make very sure that 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 Ensure that the instruction and information to do the work is fully understood and is complete, including the engineering theory needed to understand the task and to carry out and/or check calculations, and the acceptance criteria. If needed supplementary information must be gathered, studied and understood. |
| **Range Statement:** The problem may be part of a larger engineering activity or may stand alone. The design problem is amenable to solution by established techniques practiced regularly by the candidate. This outcome is concerned with the understanding of a problem: Outcome 2 is concerned with the solution. | **Please refer to clause 4 of the specific DSTG.** |

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| **Outcome 2:**  Design or develop solutions to well-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 well-defined problem, typified by the following performances is expected:  2.1 Describe how you designed or developed and analysed alternative approaches to do the work. Impacts checked. Calculations attached  2.2 State what the final solution to perform the work was, client or your supervisor in agreement | After the task received is fully understood and interpreted, a solution to the problem posed can be developed (designed). To synthesise a solution means “the combination of separate parts, elements, substances, etc. into a whole or into a system” by:  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 Technician 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 or Technologist 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 submitted deviating from those specified. |
| **Range Statement:** The solution is amenable to established methods, techniques or procedures within the candidate’s practice area. | Applying theory to *well-defined engineering* work is done in a way that’s been used before, probably developed by Engineers or Technologists in the past, and documented in written procedures, specifications, drawings, models, examples, etc. Engineering Technicians must seek approval for any deviation from these established methods. |
| **Outcome 3:**  Comprehend and apply knowledge embodied in established engineering practices and knowledge specific to the jurisdiction in which he/she practices. | **Responsibility level E**  Comprehend means “to understand fully”. The jurisdiction in which an Engineering Technician practices is given in **Clause 4 of the specific DSTG.** |
| **Assessment Criteria:** This outcome is normally demonstrated in the course of design, investigation or operations.  3.1 State what NDip level engineering standard procedures and systems you used to execute the work, and how NDip level theory was applied to understand and/or verify these procedures;  3.2 Give your own NDip level theoretical calculations and/or reasoning on why the application of this theory is considered to be correct (Actual examples). | Design work for Engineering Technicians is mostly to utilise and configure manufactured components and repetitive design work using an existing design as an example. Engineering Technicians apply existing codes and procedures in their design work. Investigation would be on well-defined incidents and condition monitoring and operations mostly on controlling, maintaining and improving engineering systems and operations.  3.1 The understanding of well-defined procedures and techniques must be based on fundamental mathematical, scientific and engineering knowledge. Specific procedures and techniques applied to do the work accompanied by the underpinning theory must be given.  3.2 Calculations confirming the correct application and utilisation of equipment listed in Clause 4 of the specific DSTG must be done on practical *well-defined* activities. Reference must be made to standards and procedures used and how it was derived from NDip theory. |
| **Range Statement:** Applicable knowledge includes:   1. Technical knowledge that is applicable to the practice area irrespective of location, supplemented by locally relevant knowledge, for example established properties of local materials. 2. A working knowledge of interacting disciplines. Codified knowledge in related areas: financial, statutory, safety, management. 3. Jurisdictional knowledge includes legal and regulatory requirements as well as prescribed codes of practice. | 1. The specific location of a task to be executed is the most important determining factor in the layout design and utilisation of equipment. A combination of educational knowledge and practical experience must be used to substantiate decisions taken including a comprehensive study of materials, components and projected customer requirements and expectations. 2. In spite of having a working knowledge of interacting disciplines, Engineering Technicians must appreciate the importance of working with specialists like Civil Engineers on structures and roads, Mechanical Engineers on fire protection equipment, Architects on buildings, Electrical Engineers on communication equipment, etc. The codified knowledge in the related areas means working to and understanding the requirements set out by specialists in the areas mentioned. 3. Jurisdictional in this instance means “having the authority”, and Engineering Technicians must adhere to the terms and conditions associated with each task undertaken. They may even be appointed as the “responsible person” for specific duties in terms of the OHS Act. |

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| **Group B: Managing Engineering Activities.** | **Explanation and Responsibility Level** |
| **Outcome 4:**  Manage part or all of one or more *well-defined* engineering activities. | **Responsibility level D**  Manage means “control”. |
| **Assessment Criteria:** The display of personal and work process management abilities is expected:  4.1 State how you managed yourself, priorities, processes and resources in doing the work (e.g. bar chart);  4.2 Describe your role and contribution in the work team. | In engineering operations and projects Engineering Technicians will typically be given the responsibility to carry out specific tasks and/or complete projects.  4.1 Resources are usually subdivided based on availability and controlled by a work breakdown structure and scheduling to meet deadlines. Quality, safety and environment management are important aspects.  4.2 Depending on the task, Engineering Technicians can be the team leader, a team member, or can supervise appointed contractors. |
| **Outcome 5:**  Communicate clearly with others in the course of his or her well-defined engineering activities | **Responsibility level C** |
| **Assessment Criteria:** Demonstrates effective communication by:  5.1 State how you presented your point of view and compiled reports after completion of the work.  5.2 State how you compiled and issued instructions to entities working on the same task | 5.1 Refer to Range State for Outcome 4 and 5 below. Presentation of point of view mostly occurs in meetings and discussions with immediate supervisor.  5.2 Refer to Range State for Outcome 4 and 5 below. |
| **Range Statement for Outcomes 4 and 5:** Management and communication in *well-defined engineering* involves:   1. Planning *well-defined* activities; 2. Organising *well-defined* activities; 3. Leading *well-defined* activities and 4. Controlling *well-defined* activities.   Communication relates to technical aspects and wider impacts of professional work. Audience includes peers, other disciplines, client and stakeholders audiences. Appropriate modes of communication must be selected. The Engineering Technician is expected to perform the communication functions reliably and repeatedly | 1. Planning means “the arrangement for doing or using something, considered in advance”. 2. Organising means “put into working order; arrange in a system; make preparations for”. 3. Leading means to “guide the actions and opinions of; influence; persuade”. 4. Controlling means the “means of regulating, restraining, keeping in order; check”.   Engineering Technicians write or participate in writing specifications for the purchase of materials and/or work to be done, make recommendations on tenders received, place orders and variation orders, write work instructions, report back on work done, draw, correct and revise drawings, compile test reports, use operation and maintenance manuals to write work procedures, write inspection and audit reports, write commissioning reports, prepare and present motivations for new projects, compile budget reports, report on studies done and calculations carried out, report on customer requirements, report on safety incidents and risk analysis, report on equipment failure, report on proposed system improvement and new techniques, report back on cost control, etc. |

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| **Group C: Impacts of Engineering Activity.** | **Explanation and Responsibility Level** |
| **Outcome 6:**  Recognise the foreseeable social, cultural and environmental effects of *well-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, by typically:  6.1 Describe the social, cultural and environmental impact of this engineering activity;  6.2 State how you communicated mitigating measures to affected parties and acquired stakeholder engagement. | 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, compensation paid, etc. |

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| **Outcome 7:**  Meet all legal and regulatory requirements and protect the health and safety of persons in the course of his or her well-defined engineering activities. | **Responsibility level E** |
| **Assessment Criteria:**  7.1 List the major laws and regulations applicable to this particular activity and how health and safety matters were handled;  7.2 State how you obtained advice in doing risk management for the work and elaborate on the risk management system applied. | 7.1 The OHS Act is supplemented by a variety of parliamentary acts, regulations, local authority by-laws, standards and codes of practice. Places of work 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 advisable to attend a Risk Management (Assessment) course, and to investigate and study the materials, components and systems used in the workplace. The Engineering Technician seeks advice from knowledgeable and experienced specialists if the slightest doubt exist that safety and sustainability cannot be guaranteed. |
| **Range Statement for Outcomes 6 and 7:** Impacts and regulatory requirements include:   1. Impacts to be considered are generally those identified within the established methods, techniques or procedures used in the practice area; 2. Regulatory requirements are prescribed; 3. Apply prescribed risk management strategies; 4. Effects to be considered and methods used are defined; 5. Prescribed safe and sustainable materials, components and systems. 6. Persons whose health and safety are to be protected are both inside and outside the workplace. | 1. 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 is identified and studied by the Engineering Technician before starting the work. 2. The Safety Officer and/or the Responsible Person appointed in accordance with the OHS Act usually confirm or check that the instructions are in line with regulations. The Engineering Technician is responsible to see to it that this is done, and if not, establishes 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 Technician checks that this is done. Tasks and 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. 3. Risks are mostly associated with elevated structures, subsidence of soil, electrocution of human beings and moving parts on machinery. Risk management strategies are usually done by more senior staff, but are understood and applied by the Engineering Technician. 4. Effects associated with risk management are mostly well known if not obvious, and methods used to address, clearly defined. 5. Usually the safe and sustainable materials, components and systems are prescribed by Engineers, Technologists or other professional specialists. It is the responsibility of the Engineering Technician to use his/her knowledge and experience to check and interpret what is prescribed and report anything that he/she is not satisfied with. 6. Staff working on the task or project as well as persons affected by the engineering work being carried out. |

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| **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”. |
| **Assessment Criteria:** Sensitivity to ethical issues and the adoption of a systematic approach to resolving these issues is expected, typified by:  8.1 State how you identified ethical issues and affected parties and their interest and what you did about it when a problem arose.  8.2 Confirm that you are con-versant and in compliance with ECSA’s Code of Conduct and why this is important in your work. | Systematic means “methodical; based on a system”.  8.1 Ethical problems that can occur include tender fraud, payment bribery, alcohol abuse, sexual harassment, absenteeism, favouritism, defamation, fraudulent overtime claims, fraudulent expenses claimed, fraudulent qualifications, misrepresentation of facts, etc.  8.2 ECSA’s Code of Conduct, as per ECSA’s website, is known and adhered to. Applicable examples given. |

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| **Outcome 9:**  Exercise sound judgement in the course of *well-defined* engineering activities | **Responsibility level E**  Judgement means “good sense: ability to judge”. |
| **Assessment Criteria:** Judgement is displayed by the following performance:  9.1 State the factors applicable to the work, their interrelationship and how you applied the most important factors.;  9.2 Describe how you foresaw work consequences and evaluated situations in the absence of full evidence. | 9.1 The extent of a project or task given to a junior Engineering Technician is characterised by the limited number of factors and their resulting interdependence. He/she will seek advice if educational and/or experiential limitations are exceeded. Examples of the main engineering factors applied must be given.  9.2 Taking risky decisions will lead to equipment failure, excessive installation and maintenance cost, damage to persons and property, etc. Give examples. |
| **Range Statement for Outcomes 8 and 9:** Judgement in decision making involves:   1. taking limited risk factors into account some of which may be ill-defined; **or** 2. consequences are in the immediate work contexts; **or** 3. identified set of interested and affected parties with defined needs to be taken into account. | In engineering about 10% of the activities can be classified as *well-defined* where the Engineering Technician uses standard procedures, codes of practice, specifications, etc. Judgement must be displayed to identify any activity falling outside the *well-defined* range, as defined above by:   1. Seeking advice when risk factors exceed his/her capability. 2. Consequences outside the immediate work contexts, e.g. long-term, not normally handled. 3. Interested and affected parties with defined needs outside the *well-defined* parameters to be taken into account. |

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| **Outcome 10:**  Be responsible for making decisions on part or all of all of one or more *well-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 Show how you used NDip theoretical calculations to justify decisions taken in doing engineering work. Attach actual calculations;  10.2 State how you took responsible advice on any matter falling outside your own education and experience;  10.3 Describe how you took responsibility for your own work and evaluated any shortcoming in your output | 10.1 The calculations, for example fault levels, load calculations, losses, etc. are done to ensure that the correct material and components are utilized.  10.2 The Engineering Technician does not operate on tasks at a higher level than *well-defined* and consult professionals at engineer and/or technologist level if elements of the tasks to be done are beyond his/her education and experience, e.g. power system stability.  10.3 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 instruction, and corrective action if necessary, forms an important element. |
| **Range Statement:** Responsibility must be discharged for significant parts of a one or more *well-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 is expected to perform as if he/she is in a responsible position. |  |

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| **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 by typically:  11.1 Provide your strategy adopted independently to enhance professional development. (IPD report);  11.2 Be aware of the philosophy of employer in regard to professional development. | 11.1 If possible, a specific field of the sub-discipline is chosen, available developmental alternatives established, a program 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 be in charge of experiential development towards Professional Engineering Technician level. Knowledge of the employer’s policy and procedures on training is essential. |
| **Range Statement:** Professional development involves:   1. Taking ownership of own professional development; 2. Planning own professional development strategy; 3. Selecting appropriate professional development activities; and 4. Recording professional development strategy and activities; while displaying independent learning ability. | 1. This is your professional development, not the organisation you are working for. 2. In most places of work training is seldom organised by some training department. It is up to the Engineering Technician to manage his/her own experiential development. Engineering Technicians 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. 3. Preference must be given to engineering development rather than developing soft skills. 4. Developing a learning culture in the workplace environment of the Engineering Technician is vital to his / her success. Information is readily available, and most senior personnel in the workplace are willing to mentor, if approached. |

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| **Appendix D: Definitions**  ***‘Engineering science’*** means 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, solve problems and provide the knowledge base for engineering specialisations.  ***“Engineering problem”*** means a problematic situation that is amenable to analysis and solution using engineering sciences and methods.  ***‘Ill-posed problem”*** means problems whose requirements are not fully defined or may be defined erroneously by the requesting party.  ***“Integrated performance”*** means that 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”*** means a measure of performance demands at which outcomes must be demonstrated.  ***Management of engineering works or activities”*** means the co-ordinated activities required to:   1. direct and control everything that is constructed or results from construction or manufacturing operations; 2. operate engineering works safely and in the manner intended; 3. return engineering works, plant and equipment to an acceptable condition by the renewal, replacement or mending of worn, damaged or decayed parts; 4. direct and control engineering processes, systems, commissioning, operation and decommissioning of equipment; 5. maintaining engineering works or equipment in a state in which it can perform its required function.   ***“Over-determined problem”*** means a problem whose requirements are defined in excessive detail, making the required solution impossible to attain in all of its aspects.  ***“Outcome”*** at the *professional* level means a statement of the performance that a person must demonstrate in order to be judged competent.  ***“Practice area”*** means 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”*** means 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”** means a category of registration for persons who must be registered through the Engineering Profession Act or a combination of the Engineering Profession Act and external legislation as having specific engineering competencies at NQF 5 related to an identified need to protect the public safety, health and interest or the environment, in relation to an engineering activity. |