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SOUTH AFRICA

Discipline-Specific Training Guide for Registration as a Professional Technologist in Metallurgical Engineering

R-05-MET-PT

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ECSA

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DEFINITIONS

Alternative Route: An applicant who aspires to become registered in a Candidate or Professional Category but does not have the accredited or recognised qualifications and who proposes to meet the educational requirement through further study and assessment.

Broadly defined engineering problems: A class of problems with characteristics as defined in document **E-02-PT**.

Benchmark Route: The normal process required to attain registration that consists of the completion of an accredited, recognised or evaluated equivalent qualification and a well-structured and effectively executed programme of training and experience for the category of registration.

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

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

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

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

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

Management of engineering works or activities: The co-ordinated activities that are required are as follows:

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

(b) Operate engineering works safely and as intended.

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

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

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

Mentor: A professionally registered person who guides the competency development of a candidate in an appropriate category.

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

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

Practice area – in the educational context: Synonymous with a generally recognised engineering speciality.

Practice area – at the professional level: A generally recognised or distinctive area of knowledge and expertise developed by an engineering practitioner through the path of education, training and experience.

Range statement: A context in which assessment may take place against an outcome and is expressed in terms of situations, activities, tasks, methods and forms of evidence.

Supervisor: A person who oversees and controls engineering work performed by a Candidate.

ABBREVIATIONS

BDEA	Broadly defined engineering problem
C&U	Commitment and Undertaking
CET	Candidate Engineering Technologist
CPD	Continuing Professional Development
DSTG	Discipline-specific Training Guide
ECSA	Engineering Council of South Africa
IPD	Initial Professional Development
OHS Act	Occupational Health and Safety Amendment Act, 181 of 1993
TER	Training and Experience Report
TES	Training and Experience Summary
VA	Voluntary Association
VIPs	Value Improvement Practices

BACKGROUND

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

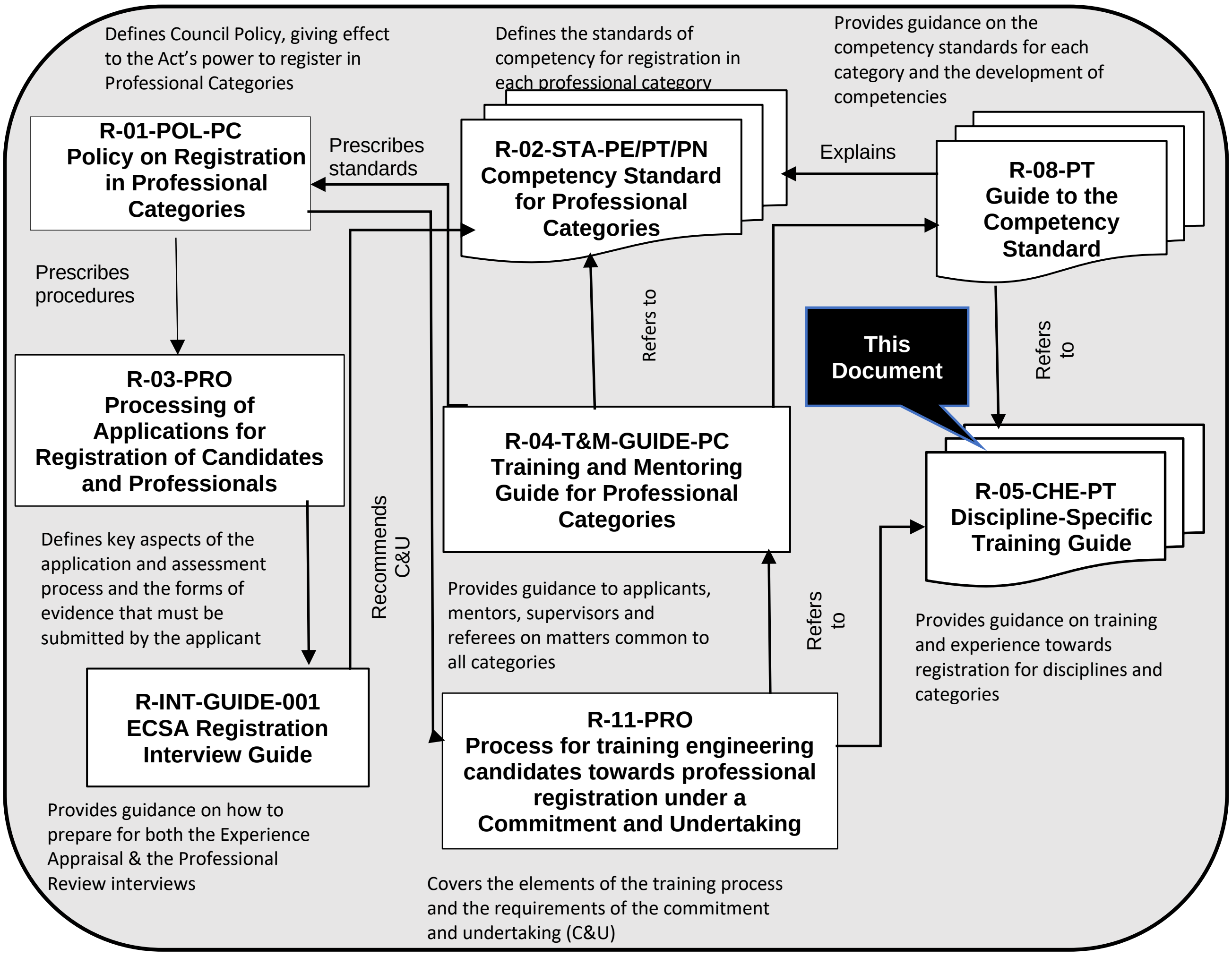

Figure 1: Documents defining the ECSA Registration System

1. PURPOSE OF THIS DOCUMENT

This document presents the critical training components towards registration as a Professional Engineering Technologist in the discipline of Metallurgical Engineering. All persons applying for registration as Professional Engineering Technologists are expected to demonstrate the competencies specified in document **R-02-STA-PE/PT/PN** though work performed at the prescribed level of responsibility, irrespective of the trainee's discipline.

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

In document **R-04-T&M-GUIDE-PC**, the development of an engineering professional is divided into three stages:

- **Stage 1:** Meet standard for engineering education.
- **Stage 2:** Meet the professional competency requirements for registration.
- **Stage 3:** Maintain competency through Continuing Professional Development (CPD) and observe the code of conduct.

In the above document, attention is specifically drawn to the following sections:

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

The second document (document **R-08-PT**) provides a high-level, outcome-by-outcome understanding of the competency standards that form an essential basis for this Discipline-specific Training Guide (DSTG). This guide and documents **R-04-T&M-GUIDE-PC** and **R-08-PT** are subordinate to the *Policy on Registration* (document **R-01-POL-PC**), the *Competency Standard* (document **R-02-STA-PE/PT/PN**) and the application process definition (document **R-03-PRO-PC**).

2. AUDIENCE

The DSTG is directed towards Candidates and their supervisors and mentors in the discipline of Metallurgical Engineering. The guide is intended to support a programme of training and experience through incorporating good practice elements.

The guide applies to persons who:

- have completed the following stage 1 education requirements:
  - Accredited Bachelor of Engineering Technology (BEng Tech) in Metallurgical Engineering qualification that has replaced the previous BTech (Engineering) Degree or a BTech (Eng) qualification and Advanced Diploma in Metallurgical Engineering. The benchmark qualification is pegged at NQF level 7, in South Africa
  - A qualification recognised under the International Engineering Alliance Sydney Accord, or
  - Through a qualification evaluation/assessment for substantial equivalence to a South African accredited BEng Tech in Metallurgical Engineering
- are registered as a Candidate Engineering Technologist; and/or
- are 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
- have completed recognised equivalent educational requirements for registration as either a Professional Engineering Technologist, Professional Engineering Technician but are not registered with ECSA (Alternative Route Applicants)

The guide may also 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 in document **R-04-T&M-GUIDE-PC**.

3. PERSONS NOT REGISTERED AS A CANDIDATE AND/OR NOT TRAINED UNDER C&U

Irrespective of the development path followed, all applicants for registration must present the same evidence of competence and be assessed against the same standards. Application for registration as a Professional Engineering Technologist is permitted without being registered as a Candidate Engineering Technologist (CET) 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 does not offer C&U, the trainee should establish the level of mentorship and supervision that the employer is able to provide. In the absence of an internal mentor, the services of an external mentor should be secured. The Voluntary Associations (VA) for the discipline could be consulted for assistance in locating an external mentor. A mentor must keep abreast of all stages of the development process.

The DSTG is written for recent graduates who are training and gaining experience towards registration. Mature applicants for registration may apply the guide retrospectively to identify possible gaps in their development. In addition, 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 6.8).

Applicants who have not been through a mentorship programme are advised to request an experienced mentor (internal or external) to act as an application adviser while they prepare their application for registration. The training programme's goal is to allow Candidates to develop their competencies until they are able to demonstrate the outcomes at the required level on a sustained basis and to take responsibility for the work performed.

Three key players in the training of Candidates are supervisors, mentors and referees. **Table 1** of document **R-04-T&M-GUIDE-PC** summarises the roles of these players and they are described in terms of roles because an individual may perform more than one function. Applicants who do not hold an NQF level 7 engineering qualification in Metallurgical Engineering may apply under an alternative route provided for in the ECSA policy **E-17-PRO**. This involves completing an additional form and providing information regarding the number of years of experience, the broadly defined engineering activities undertaken during this period and experience at the responsible level.

4. ORGANISING FRAMEWORK FOR OCCUPATIONS

Metallurgical Engineering (Organising Framework for Occupations

Metallurgists normally work within the metal and mineral industry, which includes mining, production and metal recovery operations in concentrators, smelters, metal refineries, foundries and research and development laboratories. Metallurgists use their knowledge of chemistry, physics and mineralogy, underlying process fundamentals and process engineering to control and improve processes that separate, concentrate and recover minerals and their valuable metals from natural ores. Metallurgical Engineering Technologists may choose one of three streams: Mineral Processing, Extraction Metallurgy and Physical Metallurgy.

4.1 Extractive Metallurgical Engineering Technologist

Extractive Metallurgical Engineering is the extraction of metals from their natural mineral deposits or the extraction of intermediate compounds from ores by chemical or physical processes such as wet or hydrometallurgical process stages, high-temperature or pyrometallurgical process stages, and electrometallurgical process stages. The extracts may contain crude metal products that can be subjected to further processing known as metallurgy or physical metallurgy which includes processes such as alloying, casting in foundry, rolling and extrusion. An example is the hydrometallurgical process used in the production of copper, uranium, vanadium and other metals by solvent extraction.

Typical tasks that an Extractive Metallurgical Engineering Technologist may undertake include:

- presentation of research and development of methods for extracting metals from their ores and thereafter, advising on their application
- design, development and implementation of broadly defined process projects
- operation and optimisation of process plants or commercial-scale processes.

Practising Extractive Metallurgical Engineering Technologists generally concentrate on one or more of the following fields:

- Metallurgy / Mineral Processing Research / Lecturing
- Extractive Metallurgy
- Metallurgy / Mineral Processing Consulting Engineering Technologist

- Pyrometallurgy
- Hydrometallurgy
- Electrometallurgy.

4.2 Mineral Processing Engineering Technologist

Mineral Processing Engineering is the process by which valuable minerals are separated from either worthless material (gangue). Processes such as flotation, jigging, scrubbing, magnetic separation, dense medium separation (DMS) or heavy medium separation (HMS), magnetic or electrostatic separation are used. Froth flotation is a very popular mineral concentration process that entails crushing and grinding the ore to a fine size. The minerals in the pulp are separated depending on their affinity for water or the air. This fine grinding separates the individual mineral particles from the waste rock and other mineral particles. Examples of valuable minerals processed by froth flotation are gold, silver, copper, lead, zinc, molybdenum, iron, potash and phosphates.

Typical tasks that a Mineral Processing Engineering Technologist may undertake include:

- ore storage
- communition
- classification
- concentration
- small scale mining.

4.3 Physical Metallurgy and Engineering Technologist

Physical Metallurgical Engineering Technologists are involved in research, analysis, design, production, characterisation, failure analysis and application of metallic materials for engineering applications based on their understanding of the properties of matter and engineering requirements.

Typical tasks that a Metallurgical and Materials Engineering Technologist may undertake include:

- developing, controlling and advising on processes used for casting, alloying, heat treating or welding of metals, alloys and other materials to produce commercial metal products
- developing new alloys, materials and processes
- evaluating and specifying materials for engineering applications
- carrying out quality control and failure analyses
- investigating properties of metals and alloys and developing new alloys
- advising and supervising technical aspects of metal and alloy manufacture, processing and use
- addressing residual life evaluations and predictions, conducting failure analyses and prescribing remedial actions to avoid material failures.

Practising Physical Metallurgical Engineering Technologists generally concentrate on one or more of the following areas:

- Metallurgy / Mineral Processing Research / Lecturing
- Physical Metallurgy
- Materials Engineering
- Welding Engineering
- Corrosion Engineering
- Quality Assurance Engineering
- Metallurgy / Mineral Processing Engineering – Mineral Processing Consulting Engineering Technologists work on a variety of processes, plants and ores in the area of research and development or project management
- Mineral Process Engineering – Technologists work in all stages of ore processing.

5. TRAINING IMPLICATIONS OF THE NATURE AND ORGANISATION OF THE INDUSTRY

5.1 Investigation and problem analysis

Investigation and problem analysis involves demonstrating theoretical and practical knowledge to solve problems utilising proven analytical techniques and tools. This includes the ability to use troubleshooting skills:

- Identification of problems/hazards and analysis of the cause(s) of process problems in a systematic manner using applicable models, frameworks/tools.
- Use of troubleshooting methodologies, literature surveys, data analyses and root cause analyses.
- Use of tools to identify or analyse problems.

Metallic Materials Engineering Technologists must:

- demonstrate involvement in the investigation of properties of metals, ceramics, polymers, and other materials and develop and assess their commercial and engineering applications
- prepare reports on metallurgical operations and projects
- undertake fault finding, root cause analysis, troubleshooting, data collection, etc.

Metallurgical and Mineral Process Engineering Technologists are involved in:

- metallurgical problem-solving regarding addition or application of modified unit processes
- management of processes regarding data collection and analysis.

5.2 Process design

The applicant proposes potential approaches to the solution, conducts a preliminary synthesis following selected approaches, evaluates potential solutions against requirements and wider impacts, presents reasoned, economical and contextual engineering arguments for the selected option, fully develops the chosen option, evaluates the resulting solution and documents the solution for approval and implementation.

This is the systematic process of conceiving and developing materials, procedure, components, systems and processes to serve useful purposes. Design involves a transformation from an initial requirement to produce the documented instructions on how to realise the end product. In determining a solution, barriers must be overcome. A design assignment is therefore an engineering problem which involves sub-problems that must be addressed utilising first principles and adhering to the norms, where applicable justification is required to work outside the norms.

5.3 Location of training in overall engineering lifecycle and functions performed

The areas in which Metallurgical Engineering Technologists work follow the conventional stages of the project lifecycle. Since the Metallurgical Engineering industry encompasses a wide field of activities that range from extractive metallurgy to physical metallurgy, it is unrealistic to expect that all training programmes cover the same fields. However, it is recognised that a Metallurgical Engineering Technologist is usually employed in an organisation that operates in one or more of the following fields:

- Research and development: to develop new production from extraction metallurgy or to solve existing problems using laboratory- or industry-scale pilot plants.
- The undertaking or management of research and development studies to improve existing processes or to apply existing or potential processes to new ores or concentrates.
- The study and application of the fundamentals of metallurgical processes to aid control and to improve the physical and economic operation of the processes.
- Metallurgical plant operation and optimisation.
- Project Management: specification, design and commissioning of metallurgical plants/components.
- Metallurgy and Mineral Processing Consulting (Project Management).

The CET should have sound training in at least one of these fields and have acquired insight preferably into three fields. The levels of experience to which the CET must be exposed to gain broadly defined engineering experience are Research, Development, Technology Transfer and Consulting, which include any of the following sub-disciplines:

- Mineral processing
- Hydrometallurgy
- Pyrometallurgy
- Materials Engineering and other physical metallurgy sub-disciplines.

Graduate Metallurgical Engineering Technologists employed in research and development should gain experience in as many of the following facets as possible:

- Developing a clear understanding of the broadly defined problem/opportunity that is to be investigated by conducting a critical analysis of the literature and other relevant information and thereafter, assembling the documentation on the subject in an organised manner.

- Motivating, planning and designing the broadly defined research project and its associated equipment and/or plant.
- Undertaking broadly defined theoretical or paper investigations and laboratory-scale investigations.
- Conducting broadly defined investigations on a pilot plant and/or industrial-plant scale.
- Interpreting the results and ensuring that the results are meaningful and have been correctly obtained in accordance with broadly defined scientific principles.
- Carrying out data processing and analysis.
- Conducting studies in regard to technical and economic feasibility.
- Compiling the results into a written report and presentation involving verbal reporting.
- Transferring technology to ensure maximum benefit is obtained from the research and development effort.

Functions of Metallurgical Technologists are presented below:

- Metallurgy and Mineral Process Engineering Technologists investigate why and how metals and minerals behave the way they do or are the way they are. These technologists address the economic issues of how to extract metals and minerals from ore.
- Materials Engineering Technologists study the structure and properties of metals and other materials, investigate methods for shaping and fabricating materials and examine methods for joining materials, improving existing materials and evaluating new materials.
- Hydro Metallurgists study the nature and properties of different metals and materials and remove insoluble and toxic materials from metal using water-based solutions to find a more purified form of ore.
- Extractive Metallurgical Engineering Technologists undertake research and develop, control and provide advice on processes used in extracting metals from their ores, including washing, crushing and grading ore or refining metals.
- Minerals Process Engineering Technologists are involved in all stages of the processing of raw materials. These technologists transform low-value impure minerals, recycled materials and by-products of other processing operations into commercially valuable products.

5.4 Process optimisation, plant and equipment design

Practising Mineral Processing Technologists may concentrate on one or more of the following:

- The principles of broadly defined metallurgical engineering practice, including the critical study of broadly defined work methods and the development of more effective techniques for recognising real, significant problems and their solutions.
- Process optimisation involving the provision of solutions to the identified problem – this may be achieved by improving the operating parameters of the system/equipment through modification or installation of new system/equipment.
- Equipment sizing, selection and application of instrumentation.
- Designing plants or equipment by considering the aspects of reliability, maintainability, usability, supportability, reducibility, disposability and affordability.
- Improving performance through optimisation and control of the broadly defined process.
- Cost and economic analysis for minimising cost and maximising throughput and/or efficiency of the plant operation or process.
- Designing mineral processing and extractive metallurgical plants.
- Process design and development.
- Equipment and process optimisation by improving operating parameters, sizing and selection of appropriate equipment.
- Improvement/development of new processes and material; improvement of methods and equipment for extraction, filtration and distillation; design of plants and specification of equipment/processes and layouts; and testing the quality of the process and product.

5.5 Risk management and impact mitigation

Engineering activities deliver benefits to society and the economy in the form of infrastructure, services and goods. Engineering involves the harnessing and control of natural forces or the use and control of complex information. The actions inherent in engineering activity have accompanying risks. These risks must be mitigated to a level that is acceptable to the affected parties. The management of risk accompanying engineering activity is the very rationale for regulation of the profession.

The applicant should be given the opportunity to study, analyse and recommend measures for:

- social/cultural impacts
- community/political considerations
- environmental impact
- sustainability analysis
- regulatory conditions
- potential ethical dilemmas.

To show competency in impact analysis and mitigation, the following should be done:

- Identify interested and affected parties and their expectations.
- Identify interactions among engineering considerations and social-cultural and environmental factors.
- Identify environmental impacts of the engineering activity.
- Identify sustainability issues.
- Propose and evaluate measures to mitigate the negative effects of engineering activity.
- Communicate with stakeholders.
- Adopt measures to mitigate the negative effects of engineering activities.

In addition, Metallurgists:

- coordinate the analysis of samples taken from metallurgical process streams to ensure safe and economic operation
- advise operations personnel on the process changes required to obtain desired products, processes and quality control
- improve environmental performance of metallurgical operations and ensure all environmental standards are met
- undertake risk assessments during plant operation and projects.

5.6 Project management

Project management has a number of phases and stages that must be followed to solve industrial problems. Companies adopt different project lifecycles. A project lifecycle includes project development (design specifications, concept design, basic design and detailed design), procurement management, contract management, plant construction, commissioning and hand-over, and decommissioning.

Application of the supporting project-management process to solve the scientific problem may involve the following:

- *Integrated Project Controls*: including cost control, estimating resources, capital and operating and/or lifecycle costs, planning and scheduling and project risk management.
- *Stakeholder Management:* liaising with a wide variety of people on the job such as operators, maintenance and engineering staff, geologists, mining engineers, and supporting specialists in process control, computing, technology provision and research.
- *Metallurgy:* involving the design, development, construction, commissioning and hand-over and the operation of metal and mineral processing pilot and industry equipment and plants.
- *Project Resource Management*.
- *Management of Project Change and Project Risk.*

5.7 Project development

- Integrated project controls: including cost control, estimating resources, capital and operating and/or lifecycle costs, planning and scheduling, and project risk management.
- Stakeholder management: liaising and assuming responsibility for communication and for overall control of the engineering team in addition to interfacing with client/legal entities.
- Project resource management.
- Management of project change and project risk.
- Undertaking of project management tasks: During all project development phases, including idea/problem analysis/definition need, conceptual design and basic and detailed engineering.
- Undertaking of research and feasibility studies: to identify, select and develop preferred solution.
- Laboratory, pilot or full-scale plant work: primarily aimed at obtaining engineering data for the specification and design of broadly defined new metallurgical plants or for the improvement of existing plants.

- Involvement in sound financial business concepts: ranging from budgeting to feasibility studies.
- Plant design: preparation of broadly 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 regarding the particular broadly defined metallurgical operation and the specification, design and selection of equipment and service requirements.
- Consideration of the design: in regard to materials used, economics, instrumentation, quality control, logistics, safety, acceptable operation conditions, spillage management and effect on the environment.
- Pyrometallurgy: design and the development of high-temperature, heat-based processes and equipment to concentrate, extract and obtain pure metals and ore through various extractive processes such as refining, fusing and smelting metals.
- Consideration of National Treasury rules: in procurement and management of contracts.

5.8 Plant construction, commissioning and hand-over

- Plant construction: site establishment and site management, assembling of plant equipment in accordance with drawings and installation designs.
- Preparation: preparation of operating, start-up, shutdown and emergency procedures.
- Plant commissioning: measurement and analysis of actual performance data versus design parameters, responsibility for performance of the plant, optimisation of plant performance, review of all safety standards, operability of the plant and sound labour relations, practices and managerial aspects.
- Plant hand-over: including ‘as-built’ documentation, construction, planning and execution of punch-out and hand-over.

5.9 Plant decommissioning

Decommissioning involves the dissembling of equipment. This can be a process undertaken from one pilot plant to another depending on the exploration period and the requirements of the mineral processing or mining plant:

- A metallurgist to evaluate and undertake the design and analysis of the requirements of the new site for optimum performance.
- Assurance that the decommissioning strategy and safety procedures are followed by understanding the chemical and physical characteristics of the equipment or plant.
- Undertaking and compiling procedures for plant decommissioning and consolidation for shutdown or closure.
- Assurance that regulatory and statutory application and authorisation processes have been acquired.

5.10 Product/Manufacturing

- Application of physical and chemical methods to concentrate valuable minerals from their ores: processes can involve methods such as magnetic, electrostatic, gravity and flotation processes.
- Application of a combination of processes involving hydrometallurgy, electrometallurgy and pyrometallurgy to produce crude or refined product metal for market.
- Application of physical and mechanical metallurgy fundamentals to develop new alloys and manufacture metallic components by casting, mechanical deformation and additive manufacturing.
- Applications of electrochemistry to protect metallic component from corrosion.

5.11 Plant operation and maintenance

One of the most useful ways a CET can gain experience is to be a member of a team responsible for commissioning a new or modified plant. Routine operation of existing plants is considered sufficient training, providing that as many of the following facets are covered as possible and emphasis is placed on those that are particularly relevant to the operation:

- Measurement and analysis of performance plant or equipment data
- Undertaking of material and energy balances
- Process plant operation, especially with direct and increasing responsibility for certain sections of the plant
- Quality control in respect of measurement and specifications
- Plant records and operating costs

- Process control and management
- Safety and acceptance of the principle that an Engineering Technologist may not endanger the life and physical health of people through negligence
- Inter-relationships between engineering personnel and management and among members of the engineering team, especially between production and maintenance members
- Determination of the impact the operation may have on the environment
- Application of economic analysis of production processes to effect optimal performance
- Management of the technical aspects of metallurgical operations, using tools such as on-line process monitoring, sampling, chemical analysis, data analysis and process modelling
- Management and supervision of production staff in metallurgical operations
- Application of chemical, metallurgical and process engineering fundamentals to production processes
- Undertaking fault findings in plant equipment and taking corrective action to ensure safe operation
- Assurance that appropriate safety, health and environment systems and practices are implemented within the department/organisation
- Assurance that plant availability, utilisation, operability throughput and recovery targets are being met
- Assurance that all plant operations are running efficiently against industry best practices and appropriate standards by updating, recording, archiving and analysing all plant-related data
- Assurance that appropriate metallurgical input has been provided for business plans and forecasts (e.g., monthly, quarterly and annual forecasts)
- Assurance that cost and cash-flow targets have been met
- Compilation or updating of appropriate policies, procedures or work instructions to align with design bases (policies and procedures applicable to main processing plant, final recovery, slimes dam and tailings dump, return water dam, plant water supply and maintenance bases / system / equipment lifecycle plans).

6. DEVELOPING COMPETENCY: DOCUMENT R-08-PT

6.1 Contextual knowledge

Candidates are expected to be aware of the requirements of the engineering profession. For example, the VAs applicable to Metallurgical Engineering Technologists and their functions and services to members provide a broad range of contextual knowledge for CETs throughout their career path to registered Engineering Technologists.

The profession identifies specific contextual activities that are considered essential to developing competence in Metallurgical Engineering Technologists. These activities 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 is identified in each programme within the employer environment. ECSA's Professional Engineering Technologist Registration Committee reviews the Candidate's portfolio of evidence at the completion of the training period.

Chemical Engineering Technologists may find themselves gaining experience in diverse industries such as mining and metallurgy. Chemical metallurgy uses chemical processing at high temperatures or in solution to convert minerals from inorganic compounds to useful metals and other materials.

The ECSA Registration Committee reviews the Candidate's portfolio of evidence at the completion of the training period, against the 11 outcomes as outlined in **Appendix A**.

6.2 Functions performed

The functions in which all Metallurgical Engineering Technologists need to be proficient are listed below.

- Metallurgy and Mineral Process Engineering Technologists investigate why and how metals and minerals behave the way they do or are the way they are. These technologists address the economic issues of how to extract metals and minerals from ore.

- Materials Engineering Technologists study the structure and properties of metals and other materials, investigate methods for shaping and fabricating materials and examine methods for joining materials, improving existing materials and evaluating new materials.
- Hydro Metallurgists study the nature and properties of different metals and materials and remove insoluble and toxic materials from metal using water-based solutions in order to find a more purified form of ore.
- Extractive Metallurgical Engineering Technologists undertake research and develop, control and provide advice on processes used in extracting metals from their ores, including the washing, crushing and grading of ore or refining metals.
- Minerals Process Engineering Technologists are involved in all stages of the processing of raw materials. These technologists transform low-value impure minerals, recycled materials and by-products of other processing operations into commercially valuable products.

These functions are required to a greater or lesser extent in all the areas of employment. Parallels with the broadly defined generic competence elements required by the Competency Standard (document **R-02-STA-PE/PT/PN**) should be clear.

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

- Knowledge-based problem-solving (this should be a strong focus)
- Management and communication
- Identifying and mitigating the impacts of engineering activity
- Judgement and responsibility
- Independent learning.

It is useful to measure progression of Candidates' competency by using the Degree of Responsibility, Problem-Solving and Engineering Activity scales, as specified in document **R-04-T&M-GUIDE-PC**. **Appendix A** below has been developed against the Degree of Responsibility Scale. Activities should be selected to ensure Candidates reach the required level of competency and responsibility.

It should be noted that Candidates working at Responsibility Level E carries the responsibility appropriate to that of a registered person, except that the Candidate's supervisor is accountable for the Candidate's recommendations and decisions. The nature of work and degrees of responsibility defined in document **R-04-T&M-GUIDE-PC** are demonstrated in the table below and in **Appendix A**:

Table 1: Degrees of Responsibility

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 equivalent to a registered person but supervisor is accountable for applicant's decisions

6.3 Statutory and regulatory requirements

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

- SANS Codes for Specification for Piping Design / Material (ANSI). See www.sabs.co.za.
- SANS 10248, 1023: Waste Classification and Management Regulations (e.g., tailings and waste spillage) from the Constitution of the Republic of South Africa, Hazardous Substances Act, 15 of 1973.
- Minerals and Energy Acts (e.g., Mineral and Petroleum Resources Development Act, 28 of 2002)

6.4 Recommended formal learning

Attendance at relevant technical courses and conferences is recommended. Formal safety training should be mandatory. It is advisable to register with relevant VAs to access lists of training courses / conferences / seminars and other relevant information (e.g. SAIMM, PMI, PMISA, CESA, SACPCMP). The following is a sample list of training courses and applicable Acts:

- Problem-solving and analysis tools (e.g., brain storming, gap analysis, FMEA, Pareto Analysis, root cause analysis, problem tree analysis, TradeOff Tools)
- Risk assessment and analysis techniques
- Project management techniques and tools, including conditions of contract management, finance and economics, quality systems, stakeholder management, project management (planning, scheduling, project controls), tools and software (e.g., Ms Project, Primavera, Project Risk Analysis tools, Earn Value Management (EVM) and other SAP tools)
- Modelling and simulation tools (e.g., for pumps, DMS from OEM) (or develop your own as part of competency gained)
- Occupational Health and Safety, including the Occupational Health and Safety Amendment Act, 181 of 1993 (OHS Act) and ‘safety in design
- Formally registered CPD courses in Metallurgical Engineering and associated disciplines
- Value Engineering and other Value Improvement Practices
- Mine and Safety Act, 29 of 1996. See www.dmr.gov.za
- Project and Construction Regulations: Management Professions Act, 48 of 2000
- National Environmental Management Act, 107 of 1998
- National Environmental Management Waste Act, 59 of 2008
- Nuclear Energy Act, 46 of 1999
- National Water Act, 36 of 1998
- Occupational Health and Safety Act, 85 of 1993
- ISO 9001: 2015
- SAMREC (South African Code for Reporting of Exploration Results, Mineral Resources and Mineral Reserves) (e.g., 10320:2004)
- SAMVAL (South African Code for Reporting of Mineral Asset Evaluations); see www.sans.co.za
- Engineering Profession Act, 46 of 2000 (Rules – specifically the Code of Conduct)

- Preparation of engineering design specifications
- Environmental aspects of projects and plant operations
- Professional skills such as report writing, presentations, facilitation and negotiation skills
- Use of specific testing equipment / tools
- Monitoring tools for performance of plant operations
- Compilation of plant operation procedures.

6.5 Best practice

Regardless of the discipline, it is generally unlikely that the period of training will be only 3 years, which is the minimum time ECSA requires. Typically, the period of training will be longer and determined by the availability of functions in the actual work situation and other criteria.

No ideal training programme structure or unique sequencing constitutes best practice. Best practice is a development process that assists applicants to become registered Professional Engineering Technologists. Best practice comprises the process of continuous development of the Candidate. A number of courses (technical and management) must be attended to gain the required Initial Professional Development (IPD) points for registration together with on-the-job learning through the organisation in which the Candidate is employed (refer to the Southern African Institute of Mining and Metallurgy (SAIMM) for some best practice ideas). Applicants may register with these bodies to gain access to courses, articles and relevant information for their development. Registration may also provide opportunities to meet with experts during seminars.

Each Candidate's training programme depends on the available work opportunities at the time that the employer assigns to the Candidate. Best practice programmes are those that address the development of the competencies needed for Candidates to be able to register successfully as Professional Engineering Technologists. The training programme should be such that the candidate progresses through the levels of work capability described in document **R-04-TM-GUIDE-PC** so that by the end of the training period, the Candidate exhibits a Level E Degree of Responsibility and is able to perform individually and as a team member at the level of problem solving and engineering activity required for registration.

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

6.6 Realities

No ideal training programme structure or unique sequencing constitutes best practice. The training programme for each Candidate depends on the available work opportunities the employer assigns to the Candidate. Irrespective of employment area, for ECSA registration, applicants must ensure that they undertake tasks that provide experience in the three generic engineering competence elements: problem investigation and analysis; problem solution; and execution/implementation. By judicious selection of work-task opportunities with the same employer, it should be possible to gain experience in all three elements. Candidate Engineering Technologists are advised that although 3 years is the minimum period of experience following graduation, in practice, Metallurgical Engineering Technologists seldom meet the experience requirements in 3 years and then, only if they have followed a structured training programme.

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

6.7 Generalists, specialists, researchers, and academics

To become a Professional Engineering Technologist, a lecturer/researcher must become involved in the application of engineering knowledge by way of applied research and consulting work under the supervision of a Professional Engineering Technologist.

For generalists and specialists, providing the applicant's specialist knowledge is at least at the level of an M.Tech degree and providing the applicant has demonstrated ability at a professional level to identify engineering problems and produce broadly defined solutions that can be satisfactorily implemented, a degree of trade-off may be acceptable in assessing the experience. Situations in which an applicant's experience is judged to be in a narrow, specialist field, a minimum of 5 years' experience after obtaining the B.Tech in Engineering will be required, but each application is considered on merit.

Applicants who studied Chemical Engineering may find themselves in a metallurgical environment and can undertake mineral processing duties.

Candidates working towards being a Professional Engineering Technologist while in the academic environment need to acquire the following broadly defined engineering activities:

Teaching/Lecturing /Facilitation:

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

Research or further studying:

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

Laboratory experiment activities:

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

- Development of non-destructive testing techniques
- Vibration testing
- Materials/structural testing

Conferences/symposia/seminars:

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

Consulting:

- Consulting for industry in solving real problems encountered in engineering practice
- Design of products/structures/systems/components

6.8 Moving into candidacy programmes

This guide assumes that Candidates enter a programme after graduation and continue with the programme until ready to submit an application for registration. It also assumes that Candidates are supervised and mentored by persons who meet the requirements in document **R-04-P-TM-GUIDE-PC**. In the case of a person changing from one candidacy programme to another, or moving into a candidacy programme from a less structured environment, it is essential that the following steps are completed:

- The Candidate must complete the Training and Experience Summary (TES) and the Training and Experience Reports (TERs) for the previous programme or unstructured experience. In the latter case, it is important to reconstruct the experience as accurately as possible. The TERs must be signed off.
- On entering the new programme, the mentor and supervisor should review the Candidate's development, mindful of the past experience and the opportunities and requirements of the new programme. At minimum, the mentor and supervisor should plan the next phase of the Candidate's programme.
- During Candidacy, Alternative Route Candidates (refer to second paragraph in Section 2: Audience) must ensure that they are conversant with the practical knowledge set out in form **ER-B18-EDR**, Educational Development Report (part of the Application for Registration form) and submit evidence in the form of an Engineering Report (**ER-B2.3**).

7. GENERAL

7.1 Multidisciplinary exposure

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

7.2 Orientation requirements

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

REVISION HISTORY

Revision number	Revision date	Revision details	Approved by
Rev 1	17 Jul 2014		Registration Committee or Professional Engineers
Rev 2	22 Sep 2017	Review in accordance with approved DSTG Framework	
Rev 2	9 Oct 2017	Approved by PDSGC	PDSGC
Rev 2	23 Oct 2017	Reviewed and checked by Cato	B Collier-Reed; TP Maphumulo, J
Revision 2	30 Jan 2018	Approval by PDSGC	PDSGC
Rev 3 Daft A	17 June 2022	Reviewed as pr the four-year routine review the document have been reviewed include definitions, abbreviations and to update document numbers in cases where the document number of referenced document have changed for consistency and to align with the internal document numbering requirements. The working group further added additional information under the following headings: Audience reworked to add the different type of qualifications and indicate the NQF level Typical tasks that a Mineral Processing Engineering Technologist may undertake also expanded Risk management and impact mitigation Process Design	Working Group
Rev 3 Daft B	22 June 2022	Reviewed submission from working Group	RDD&R BU and Registration BU
Rev 3 Daft C	28 June 2022	Final working group review	Working Group
Rev 3 Draft D	30 June 2022	Review and recommendation for Approval	Acting RPSC Executive
Rev 3	13 July 2022	Approval	RPSC

The Discipline-specific Training Guide for:

Registration as a Professional Engineering Technologist in Metallurgical Engineering

Revision 3 dated 13 July 2022 and consisting of 32 pages was reviewed for adequacy by the Business Unit Manager and is approved by the Acting Executive: Research, Policy and Standards (RPS).

....03 August 2022.....

Business Unit Assistant Manager Date

....03 August 2022.....

Acting Executive: RPS Date

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

APPENDIX A: TRAINING ELEMENTS

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

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

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

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

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
1. Purpose This standard defines the competence required for registration as a Professional Engineering Technologist. Definitions of terms having particular meaning within this standard are given in text in relevant section.	DSTGs give context to the purpose of the Competency Standards. Professional Engineering Technologists operate within the nine disciplines ECSA recognises. Each discipline can be further divided into sub-disciplines and finally into specific workplaces as given in section 4 of the specific DSTG. DSTGs are used to facilitate experiential development towards ECSA registration and assist in compiling the required portfolio of evidence (specifically the Engineering Report in the application form). **NOTE:** The training period must be used to develop the trainee's competence towards achieving the standards below at a Responsibility Level E, i.e., Performing. (Refer to 7.1 in the specific DSTG)
2. Demonstration of competence Competence must be demonstrated within *broadly defined engineering activities,* defined below, by integrated performance of the outcomes defined in section 3 at the level defined for each outcome. Required contexts and functions may be specified in the applicable DSTGs. **Level Descriptor:** *Broadly defined engineering activities (BDEA)* have several of the following characteristics: a) Scope of practice area is linked to technologies used and changes by adoption of new technology into current practice. b) Practice area is located within a wider, complex context, requires teamwork, and has interfaces with other parties and disciplines. c) Involves a variety of resources, including people, money, equipment, materials and technologies. d) Requires resolution of occasional problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues. e) Are constrained by available technology, time, finance, infrastructure, resources, facilities, standards and codes and applicable laws.	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) Activities can be in-house or contracted out; evidence of integrated performance can be submitted irrespective of the situation. **Level Descriptor:** ***BDEA*** in the various disciplines are characterised by several of or all the following: a) Scope of practice area does not cover the entire field of the discipline (exposure limited to the sub-discipline and specific workplace). Some technologies used are well established and adoption of new technologies needs investigation and evaluation. b) Practice area varies substantially with unlimited location possibilities and an additional responsibility to identify the need for advice on complex activities and problems. Broadly defined activities in the sub-discipline needs interfacing with professional engineers, professional technicians, artisans, architects, financial staff, etc. as part of the team. c) The bulk of the work involves familiar, defined range of resources, including people, money, equipment, materials, but new technologies are investigated and implemented.

f) Have significant risks and consequences in the practice area and in related areas.	d) Most of the impacts in the sub discipline are on wider issues, but some arise from conflicting technical and engineering issues that have to be addressed by the application of broadly defined non-standard engineering principles. e) The work packages and associated parameters are constrained by operational context with variations limited to different locations only. (Cannot be covered by standards and codes.) f) Even locally important minor risks can have far reaching consequences.
Activities include but are not limited to design; planning; investigation and problem resolution; improvement of materials, components, systems or processes; manufacture or construction; engineering operations; maintenance; project management; research; development and commercialisation.	**Activities** include but are not limited to design; planning; investigation and problem resolution; improvement of materials, components, systems or processes; engineering operations; maintenance; project management. For Engineering Technologists, research, development and commercialisation happen more frequently in some disciplines but are seldom encountered in others.
3. Outcomes to be satisfied:	**Explanation and Responsibility Level**
Group A: Engineering Problem Solving	
Outcome 1: Define, investigate and analyse *broadly defined* engineering problems	**Responsibility Level E** Analysis of an engineering problem means the 'separation into parts possibly with comment and judgement'. *Broadly* means 'not minute or detailed' and 'not kept within narrow limits'.
Broadly defined engineering problems have the following characteristics. They require coherent and detailed engineering knowledge underpinning the technology area and one or more of the following: a) are ill-posed, under- or over-specified, require identification and interpretation into the technology area b) encompass systems within complex engineering systems; belong to families of problems which are solved in well-accepted but innovative ways; *and one or more of:* c) can be solved by structured analysis techniques d) may be partially outside standards and codes; must provide justification to operate outside	a) Coherent and detailed engineering knowledge for Engineering Technologists means the problem encountered cannot be solved without the combination of all the relevant detail including engineering principles applicable to the situation. b) The nature of the problem is not immediately obvious, and further investigation to identify and interpret the real nature of the problem is necessary. c) The problem is not easily recognised as part of the larger engineering task, project or operation and may be obscured by the complexity of the larger system. d) It is recognised that the problem can be classified as a falling within a typical solution requiring innovative adaptation to meet the specific situation. e) Solving the problem needs a step-by-step approach adhering to proven logic. f) The standards, codes and documented procedures must be analysed to determine to what extent they are applicable to solve the problem and justification must be given to operate outside these.

e) require information from practice area and sources interfacing with practice area that is complex and incomplete f) involve a variety of issues which may impose conflicting constraints: technical, engineering and interested or affected parties; *and one or both of:* g) require judgement in decision-making in practice area, considering interfaces to other areas h) have significant consequences which are important in practice area but may extend more widely.	g) The responsibility lies with the Engineering Technologist to verify that some information received as part of the problem encountered may remain incomplete and solutions to problems may need justified assumptions. h) The problem handled by an Engineering Technologist may be solved by alternatives that are unaffordable, detrimental to the environment, socially unacceptable, not maintainable, not sustainable, etc; Technologists will have to justify their recommendations. i) Practical solutions to problems include knowledge and judgement of the roles displayed by the multi-disciplinary team and impact of own work in the interactive environment. j) Engineering Technologists must realise that their actions might seem to be of local importance only but may develop into significant consequences extending beyond their own ability and practice area.
Assessment criteria: A structured analysis of broadly defined problems typified by the following performances is expected: 1.1 Performed or contributed to defining engineering problems leading to an agreed definition of the problems to be solved. 1.2 Performed or contributed to investigating engineering problems including collecting, organising and evaluating information. 1.3 Performed or contributed to analysis of engineering problems using conceptualisation, justified assumptions, limitations and evaluation of results.	To perform an engineering task an engineering technologist will typically receive an instruction from a senior person (customer) to do a specific task, and must: 1.1 Ensure the instruction is complete, clear and within his/her capability and that the person who issued the instruction agrees with his/her interpretation. 1.2 Ensure the engineering problem and related information are segregated from the bulk of the information, investigated and evaluated. 1.3 Ensure that the instruction and information to do the work is fully understood and complete, including engineering theory needed to understand the task and acceptance criteria, and to carry out and/or check calculations. If needed supplementary information must be gathered, studied and understood. Concepts and assumptions must be justified by engineering theory and calculations, if applicable.
3. Outcomes to be satisfied:	**Explanation and Responsibility Level**
Range statement: The problem may be a design requirement, an applied research and development requirement or a problematic situation in an existing component, system or process. The problem is one amenable to solution by technologies known to the Candidate. This outcome is concerned with the understanding of a problem: Outcome 2 is concerned with the solution.	Please refer to section 4 of the specific DSTG.

Outcome 2: Design or develop solutions to broadly defined engineering problems	**Responsibility Levels C and D** Design means 'drawing or outline from which something can be made'. Develop means 'come or bring into a state in which it is active or visible'.
Assessment criteria: This outcome is normally demonstrated after a problem analysis as defined in Outcome 1. Working systematically to synthesise a solution to a broadly defined problem, typified by the following performances is expected: 2.1 Designed or developed solutions to broadly defined engineering problems. 2.2 Systematically synthesised solutions and alternative solutions or approaches to the problem by analysing designs against requirements, including costs and impacts on outside parameters. (requirements). 2.3 Drawing up of detailed specification requirements and design documentation for implementation to the satisfaction of the client.	After the task received is fully understood and interpreted, a solution to the problem posed can be developed (designed). To synthesise a solution is 'the combination of separate parts, elements, substances, etc. into a whole or into a system' by the following: 2.1 The development (design) of more than one way to solve an engineering task or problem should always be done, including the costing and impact assessment for each alternative. All the alternatives must meet the requirements set out by the instruction received, and the theoretical calculations to support each alternative must be done and submitted as an attachment. 2.2 The Engineering Technologist will in some cases be unable to support proposals with the complete theoretical calculation to substantiate every aspect and must in these cases refer his / her alternatives to an engineer for scrutiny and support. The alternatives and alternative recommended must be convincingly detailed to win customer support for the alternative recommended. Selection of alternatives might be based on tenders submitted with alternatives deviating from those specified. 2.3 The best complete and final solution selected must be followed up with a detailed technical specification, supporting drawings, bill of quantities, etc. for the execution of work to meet customer requirements.
Range Statement: Solutions are those enabled by the technologies in the Candidate's practice area.	Applying theory to do *broadly defined engineering* work is mostly done in a way that has been used before, probably developed by engineers in the past, and documented in written procedures, specifications, drawings, models, examples, etc. Engineering Technologists must seek approval for any deviation from these established methods but must also initiate and/or participate in the development and revision of these norms.
Outcome 3: Comprehend and apply the knowledge embodied in widely accepted and applied engineering procedures, processes, systems or methodologies and those specific to the jurisdiction in which he/she practices.	**Responsibility Level E** Comprehend means 'to understand fully'. The jurisdiction in which an Engineering Technologist practises is given in section 4 of the specific DSTG.

Assessment criteria: This outcome is normally demonstrated in the course of design, investigation or operations. 3.1 Apply engineering principles, practices, technologies, including the application of BTech or BEng (Tech) theory in the practice area. 3.2 Indicate working knowledge of areas of practice that interact with practice area to underpin teamwork. 3.3 Apply related knowledge of finance, statutory, safety and management.	Design work for Engineering Technologists is based on BTech theory and is mostly the utilisation and configuration of manufactured components and selected materials and associated novel technology. Engineering Technologists develop and apply codes and procedures in their design work. Investigation would be on broadly defined incidents and condition monitoring, and operations mostly on developing and improving engineering systems and operations. 3.1 Calculations at BTech or BEng (Tech) theoretical level confirming the correct application and utilisation of equipment, materials and systems listed in section 4 of the specific DSTG must be done on broadly defined activities. 3.2 The understanding of broadly defined procedures and techniques must be based on fundamental mathematical, scientific and engineering knowledge, as part of personal contribution within the engineering team. 3.3 The ability to manage the resources within legal and financial constraints must be evident.
Range Statement: Applicable knowledge includes: a) technological knowledge that is well-established and applicable to the practice area irrespective of location, supplemented by locally relevant knowledge, for example, established properties of local materials. Emerging technologies are adopted from formulations of others. b) A working knowledge of interacting disciplines (engineering and other) to underpin teamwork. c) Jurisdictional knowledge includes legal and regulatory requirements as well as locally relevant codes of practice. As required for practice area, a selection of law of contract, health and safety, environmental, intellectual property, contract administration, quality management, risk management, maintenance management, regulation, project and construction management.	a) The specific location of a task to be executed is the most important determining factor in the layout design and utilisation of equipment. A combination of educational knowledge and practical experience must be used to substantiate decisions taken including a comprehensive study of systems, materials, components and projected customer requirements and expectations. New ideas, materials, components and systems must be investigated, evaluated and applied accompanied by complex theoretical motivation. b) In spite of having a working knowledge of interacting disciplines, Engineering Technologists take responsibility for the multidisciplinary team of specialists like Civil Engineers on structures and roads, Mechanical Engineers on fire protection equipment, architects on buildings, Electrical Engineers on communication equipment, etc. c) Jurisdictional in this instance means ‘having the authority’, and Engineering Technologists must be aware of and decide on the relevant requirements applicable to each specific project that they are responsible for. They are usually appointed as the ‘responsible person’ for specific projects in terms of the OHS Act.

Group B: Managing Engineering Activities	Explanation and Responsibility Level
Outcome 4: Manage part or all of one or more *broadly defined* engineering activities.	**Responsibility Level D** Manage means 'control'.
Assessment criteria: The Candidate is expected to display personal and work process management abilities: 4.1 Managed self, people, work priorities, processes and resources in broadly defined engineering work. 4.2 Role in planning, organising, leading and controlling broadly defined engineering activities evident. 4.3 Knowledge of conditions and operation of contractors and the ability.	In Engineering operations Engineering Technologists are typically given the responsibility to carry out projects. 4.1 Resources are usually subdivided based on availability and controlled by a work breakdown structure and scheduling to meet deadlines. Quality, safety and environment management are important aspects. 4.2 The basic elements of managements must be applied to broadly defined engineering work. 4.3 Depending on the project, Engineering Technologists can be the team leader, a team member, or can supervise appointed contractors. To achieve this, maintenance of relationships is important and must be demonstrated.
Outcome 5: Communicate clearly with others in the course of broadly defined engineering activities.	**Responsibility Level C**
Assessment criteria: Demonstrates effective communication by: 5.1 Ability to write clear, concise, effective technical, legal and editorially correct reports shown. 5.2 Ability to issue clear instructions to stakeholders using appropriate language and communication skills evident. 5.3 Oral presentations made using structure, style, language, visual aids	Refer to Range Statement for Outcome 4 and 5 below. Presentation of point of view mostly occurs in meetings and discussions with immediate supervisor.
Range Statement for Outcomes 4 and 5: Management and communication in *well-defined engineering* involves: a) Planning *broadly defined* activities b) Organising *broadly defined* activities	a) Planning means 'the arrangement for doing or using something, considered in advance' b) Organising means 'put into working order, arrange in a system, make preparations for' c) Leading means to 'guide the actions and opinions of, influence, persuade' d) Controlling means the 'means of regulating, restraining, keeping in order, check'

c) Leading *broadly defined* activities d) Controlling *broadly defined* activities.	Engineering Technologists write specifications for the purchase of materials and/or work to be done, recommendations on tenders received, place orders and variation orders, write work instructions, report on work done, draw, correct and revise drawings, compile test reports, use operation and maintenance manuals to write work procedures, write inspection and audit reports, write commissioning reports, prepare and present motivations for new projects, compile budget reports, report on studies done and calculations carried out, report on customer requirements, report on safety incidents and risk analysis, report on equipment failure, report on proposed system improvement and new techniques, report on cost control, etc.
Group C: Impacts of Engineering Activity	**Explanation and Responsibility Level**
Outcome 6: Recognise the foreseeable social, cultural and environmental effects of *broadly defined* engineering activities generally	**Responsibility level B** Social means 'people living in communities; of relations between persons and communities'. Cultural means 'all the arts, beliefs, social institutions, etc. characteristic of a community'. Environmental means 'surroundings, circumstances, influences'.
Assessment criteria: This outcome is normally displayed in the course of analysis and solution of problems. The candidate typically shows: 6.1 Ability to identify interested and affected parties and their expectations in regard to interactions between technical, social, cultural and environmental considerations shown. 6.2 Measures taken to mitigate the negative effects of engineering activities evident.	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 wildlife, 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.
Outcome 7: Meet all legal and regulatory requirements and protect the health and safety of persons in the course of his/her broadly defined engineering activities.	**Responsibility level E**
Assessment criteria: 7.1 Identified applicable legal and regulatory requirements including health and safety requirements for the engineering activity.	7.1 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 Circumstances stated where applicant assisted in or demonstrated awareness of the selection of safe and sustainable materials, components and systems and have identified risk and applied risk management strategies.	7.2 It is essential to attend a Risk Management (Assessment) course, and to investigate and study the materials, components and systems used in the workplace. The Engineering Technologist seeks advice from knowledgeable and experienced specialists if the slightest doubt exist that safety and sustainability cannot be guaranteed.
Range Statement for Outcomes 6 and 7: Impacts and regulatory requirements include the following: a) Requirements include both explicit regulated factors and those that arise in the course of particular work. b) Impacts considered extend over the lifecycle of the project and include the consequences of the technologies applied. c) Effects to be considered include direct and indirect, immediate and long-term related to the technology used. d) Safe and sustainable materials, components and systems. e) Regulatory requirements are explicit for the context in general.	a) The impacts will vary substantially with the location of the task, e.g., the impact of laying a cable or pipe in the main street of town will be entirely different to construction in a rural area. The methods, techniques or procedures will differ accordingly and may be complex. It is identified and studied by the Engineering Technologist before starting the work. b) The Safety Officer and/or the Responsible Person appointed in accordance with the OHS Act usually confirms or checks that the instructions are in line with regulations. The Engineering Technologist is responsible to see that this is done, and if not, establish which regulations apply, and ensure that they are adhered to. Usually, the people working on site are strictly controlled. c) W.r.t. health and safety, but the Engineering Technologist checks that this is done, but may authorise unavoidable deviation after setting conditions for such deviations. Projects are mostly carried out where contact with the public cannot be avoided, and safety measures like barricading and warning signs must be used and maintained. d) Effects associated with risk management are mostly well known if not obvious, and methods used to address, clearly defined. Risks are mostly associated with elevated structures, subsidence of soil, electrocution of human beings and moving parts on machinery. e) The Engineering Technologist needs to identify, analyse and manage any long-term risks and develop strategies to solve these by using alternative technologies. f) The safe and sustainable materials, components and systems must be selected and prescribed by the Engineering Technologists or other professional specialists must be consulted. It is the responsibility of the Engineering Technologist to use his/her knowledge and experience to confirm that prescriptions by others are correct and safe. g) Application of regulations associated with the particular aspects of the project must be carefully identified and controlled by the Engineering Technologist.

Group D: Exercise judgment, take responsibility, and act ethically	**Explanation and Responsibility Level**
Outcome 8: Conduct engineering activities ethically.	**Responsibility level E** Ethically means 'science of morals; moral soundness'. Moral means 'moral habits; standards of behaviour; principles of right and wrong'.
Assessment Criteria: Sensitivity to ethical issues and the adoption of a systematic approach to resolving these issues is expected, typified by: 8.1 conversance and operation in compliance with ECSA's Rules of Conduct for registered persons confirmed 8.2 how ethical problems and affected parties were identified, and the best solution to resolve the problem selected.	Systematic means 'methodical; based on a system'. 8.1 ECSA's Code of Conduct, as per ECSA's website, is known and adhered to. 8.2 Ethical problems that can occur include tender fraud, payment bribery, alcohol abuse, sexual harassment, absenteeism, favouritism, defamation, fraudulent overtime claims, fraudulent expenses claimed, fraudulent qualifications, misrepresentation of facts, etc.
Outcome 9: Exercise sound judgement in the course of *broadly defined* engineering activities	**Responsibility level E** Judgement means 'good sense: ability to judge'.
Assessment criteria: Judgement is displayed by the following performance: 9.1 Judgement exercised in arriving at a conclusion within the application of technologies and their interrelationship to other disciplines and technologies. 9.2 Factors taken into consideration given, bearing in mind, risk, consequences in technology application and affected parties.	9.1 The extent of a project given to junior Engineering Technologists is characterised by the several broadly defined and a few well-defined factors and their resulting interdependence. They will seek advice if educational and/or experiential limitations are exceeded. 9.2 Taking risky decisions will lead to equipment failure, excessive installation and maintenance cost, damage to persons and property, etc. Evaluation includes engineering calculations to substantiate decisions taken and assumptions made.
Range Statement for Outcomes 8 and 9*:* *Judgement* in decision-making involves: a) taking several risk factors into account	In Engineering, about 5% of engineering activities can be classified as broadly defined where the Engineering Technologist uses standard procedures, codes of practice, specifications, etc, but develops variations and completely unique standards when needed. Judgement must be displayed to identify any activity falling inside the broadly defined range, as defined above:

b) significant consequences in technology application and related contexts; **or** c) ranges of interested and affected parties with widely varying needs.	a) Getting the work done in spite of numerous risk factors needs good judgement and substantiated decision-making. b) Consequences are part of the project e.g., extra cost due to unforeseen conditions, incompetent contractors, long-term environmental damage, etc. c) Interested and affected parties with defined needs that may be in conflict, e.g., need for a service irrespective of environmental damage, local traditions and preferences, etc. needs sound management and judgement.
Outcome 10: Be responsible for making decisions on part or all of all of one or more *broadly defined* engineering activities	**Responsibility level E** Responsible means 'legally or morally liable for carrying out a duty; for the care of something or somebody in a position where one may be blamed for loss, failure, etc.'.
Assessment criteria: Responsibility is displayed by the following performance: 10.1 Engineering, social, environment and sustainable development taken into consideration in discharging responsibilities for significant parts of one or more activities. 10.2 Advice sought from a responsible authority on matters outside your area of competence. 10.3 Academic knowledge of at least BTech level combined with past experience used in formulating decisions.[1]	10.1 All interrelated factors taken considered are indicative of professional responsibility accepted working on broadly defined activities. 10.2 The Engineering Technologist does not operate on tasks at a higher level than broadly defined and consults professionals at engineer level if elements of the project to be done are beyond his/her education and experience, e.g., power system stability. 10.3 This is in the first instance continuous self-evaluation to ascertain that the task given is done correctly, on time and within budget. Continuous feedback to the originator of the task instruction and corrective action, if necessary, forms an important element. The calculations, for example fault levels, load calculations, losses, etc. are done to ensure that the correct material and components are utilised.
Range Statement: Responsibility must be discharged for significant parts of one or more *broadly defined* engineering activity.	The responsibility is mostly allocated within a team environment with an increasing designation as experience is gathered.
Note 1: Demonstrating responsibility would be under supervision of a competent engineering practitioner but is expected to perform as if he/she is in a responsible position.	

Group E: Initial Professional Development (IPD)	Explanation and Responsibility Level
Outcome 11: Undertake independent learning activities sufficient to maintain and extend his or her competence.	**Responsibility level D**
Assessment criteria: Self-development managed typically: 11.1 Strategy independently adopted to enhance professional development evident. 11.2 Awareness of philosophy of employer regarding professional development evident.	11.1 If possible, a specific field of the sub-discipline is chosen, available developmental alternatives established, a programme drawn up (in consultation with employer if costs are involved), and options open to expand knowledge into additional fields investigated. 11.2 Record keeping must not be left to the employer or anybody else. The trainee must manage his/her own training independently, taking initiative and being in charge of experiential development towards Engineering Technologist
Range Statement: Professional development involves: a) planning own professional development strategy b) selecting appropriate professional development activities c) recording professional development strategy and activities, while displaying independent learning ability.	a) In most places of work training is seldom organised by a training department. It is up to Engineering Technologists to manage their own experiential development. Engineering Technologists frequently end up in a 'dead-end street' being left behind doing repetitive work. If self-development is not driven by him/herself, success is unlikely. b) Preference must be given to engineering development rather than developing soft skills. c) Developing a learning culture in the workplace environment of Engineering Technologists is vital to their success.