ENSURING THE
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SOUTH AFRICA

Discipline-specific Training Guideline for Candidate Engineering Technologists in Metallurgical Engineering

R-05-MET-PT

REVISION 2: 30 January 2018

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TABLE OF CONTENTS

1. BACKGROUND: SYSTEM DOCUMENTS FOR ECSA REGISTRATION

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

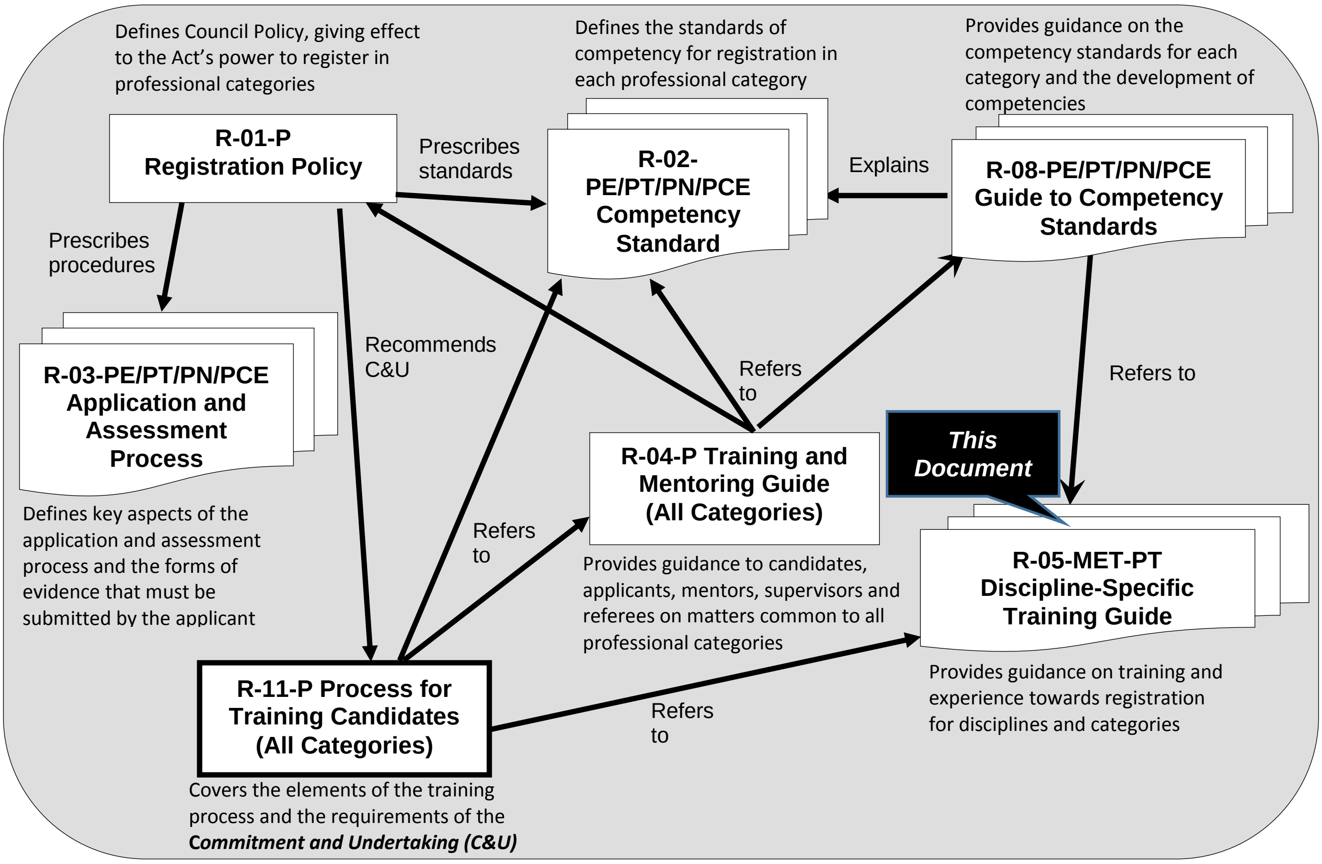

Figure 1: Documents defining the ECSA Registration System

2. PURPOSE

All persons applying for registration as Professional Engineering Technologists are expected to demonstrate the competencies specified in document R-02-PT 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-P) and the *Guide to the Competency Standards for Professional Engineering Technologists* (document R-08-PT).

In document R-04-P, attention is drawn to the following sections:

7.3.2 Duration of training and length of time 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 (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 the documents R-04-P and R-08-PT are subordinate to the Policy on Registration (document R-01-P), the Competency Standard (document R-02-PT) and the application process definition (document R-03-PT).

3. 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 education requirements
  - by obtaining an accredited B.Tech. (Engineering) Degree or a B.Tech. Eng.-type qualification,
  - by obtaining a Sydney Accord recognised qualification, or
  - through evaluation/assessment;
- registered as a Candidate Engineering Technologist; and/or
- 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.

4. PERSONS NOT REGISTERED AS A CANDIDATE AND/OR NOT TRAINED UNDER COMMITMENT AND UNDERTAKING

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 employer of the trainee 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 for the discipline should 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 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. 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 7.4).

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.

Applicants who do not hold a B.Tech. Eng. Degree may apply under an alternative route. 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.

5. ORGANISING FRAMEWORK FOR OCCUPATIONS

Metallurgical Engineering (Organising Framework for Occupations (OFO) 214603)

Metallurgists normally work within the metal and mineral industry that 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. Metallurgists may choose one of three streams: Mineral Processing Engineering, Extraction Engineering or Physical Engineering.

5.1 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 that is known as metallurgy or physical metallurgy and 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; and
- 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

5.2 Mineral Processing Engineering Technologist

Mineral Processing Engineering is the process in which valuable minerals are separated from either worthless material or other valuable minerals by inducing the minerals to gather in and on the surface of a froth layer. Processes such as flotation, jigging, milling, scrubbing, magnetic separation, dense medium separation (DMS) or heavy medium separation (HMS) are used. The process of froth flotation entails crushing and grinding the ore to a fine size. 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. Even sand is processed by this method in the production of glass.

5.3 Metallurgical and Materials Engineering Technologist

Metallurgical and Materials Engineering Technologists are involved in research, analysis, design, production, characterisation, failure analysis and application of materials (including metals) 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; and
- addressing residual life evaluations and predictions, conducting failure analyses and prescribing remedial actions to avoid material failures.

Practising Metallurgical and Materials 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

6. NATURE AND ORGANISATION OF THE INDUSTRY

6.1 Investigation and problem analysis

Investigation and problem analysis involves the demonstration of theoretical and practical knowledge to solve problems through 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

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; and

- undertake fault finding, root cause analysis, troubleshooting, data collection, etc.

Metallurgical and Mineral Process Engineering Technologists are involved in

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

6.2 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.

6.2.1 *Engineering lifecycle considerations*

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 will 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 into preferably three fields.

The levels of experience to which the CET must be exposed in order 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 a presentation involving verbal reporting; and
- transferring technology to ensure that the 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.

- Hydrometallurgists 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.
- The Extractive Metallurgical Engineering Technologist undertakes research, develops, controls and provides advice on processes used in extracting metals from their ores, including the washing, crushing and grading of ore or refining metals.
- The Minerals Process Engineering Technologist is 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.

6.3 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 and selection and application of instrumentation;
- designing of 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 of mineral processing and extractive metallurgical plants;
- Process Design and development;
- equipment and process optimisation by improving operating parameters, sizing and selection of appropriate equipment; and

- 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.

6.4 Risk management and impact mitigation

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; and
- undertake risk assessments during plant operation and projects.

6.5 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

- *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*; and

- *Management of project change and project risk*.

6.6 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

6.7 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

6.8 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;
- the undertaking and compilation of procedures for plant decommissioning and consolidation for shutdown or closure; and
- assurance that regulatory and statutory application and authorisation processes are acquired.

6.9 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

6.10 Plant operation and maintenance

It should be mentioned that one of the most useful ways in which the CET 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 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 that 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 is provided for business plans and forecasts (e.g. monthly, quarterly and annual forecasts);
- assurance that cost and cash-flow targets are met; and
- 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).

7. DEVELOPING COMPETENCY: ELABORATING ON SECTIONS IN THE GUIDE REGARDING COMPETENCY STANDARDS (DOCUMENT R-08-PT)

7.1 Contextual knowledge

Candidates are expected to be aware of the requirements of the engineering profession. For example, the Voluntary Associations 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 the development of 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. The Professional Engineering Technologist Registration Committee of ECSA carries out the review of 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.

7.2 Functions performed

The functions in which all Metallurgical Engineering Technologists need to be proficient are listed below. 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-PT) 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 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 document R-04-PT. Appendix A below 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 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-P 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

7.3 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, No. 15 of 1973
- Minerals and Energy Acts (e.g. Mineral and Petroleum Resources Development Act, No. 28 of 2002)

7.4 Desirable formal learning activities

Attendance at relevant technical courses and conferences is recommended. Formal safety training should be mandatory. It is advisable to register with relevant Voluntary Associations to access lists of training courses / conferences / seminars and other relevant information (e.g. SAIMM, PMI, PMISA, CESA, SACPCMP). The following is a list of sample 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, No. 181 of 1993 (OHS Act) and 'safety in design'

- Formally registered Continuing Professional Development (CPD) courses in Metallurgical Engineering and associated disciplines
- Value Engineering and other Value Improvement Practices (VIPs)
- Mine and Safety Act, No. 29 of 1996. See www.dmr.gov.za
- Project and Construction Regulations: Management Professions Act, No. 48 of 2000
- National Environmental Management Act, No. 107 of 1998
- National Environmental Management Waste Act, No. 59 of 2008
- Nuclear Energy Act, No. 46 of 1999
- National Water Act, No. 36 of 1998
- Occupational Health and Safety Act, No. 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, No. 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.

8. PROGRAMME STRUCTURE AND SEQUENCING

8.1 Best practices

Best practice is a development process that assists applicants in becoming 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 in order 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.

It is suggested that candidates work with their mentors to determine projects that are appropriate for gaining exposure to elements of the asset lifecycle and ensuring that their designs are constructible and operable and are 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.

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

8.2 Realities

There is no ideal training programme structure or unique sequencing that constitutes best practice. The training programme for each candidate depends on the available work opportunities assigned to the candidate by the employer. Irrespective of the 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 three years is the minimum period of experience following graduation, in practice, it is found that Metallurgical Engineering Technologists seldom meet the experience requirements in three years and then, only if they have followed a structured training programme.

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

8.3 Considerations for generalists, specialists, researchers and academics

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

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 to 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 five years' experience after obtaining the B.Tech. in Engineering will be required, but each application will be considered on merit.

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

The candidate working towards being a Professional Engineering Technologist while in the academic environment needs 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

8.4 Multidisciplinary exposure

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

8.5 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

8.6 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 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 while being 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.

REVISION HISTORY

Revision Number	Revision Date	Revision Details	Approved By
Rev 1	17 Jul 2014		Registration Committee for Professional Engineers
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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

The Discipline-Specific Training Guide (DSTG) for:
Candidate Metallurgical Engineering Technologists

Revision 2 dated 30 January 2018 and consisting of 36 pages has been reviewed for adequacy by the Business Unit Manager and is approved by the Executive: Policy Development and Standards Generation (PDSG).

.... 30/05/2018
Business Unit Manager Date

.... 30/5/2018
Executive: **PDSG** Date

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

APPENDIX A: TRAINING ELEMENTS

4.1 Synopsis: Candidate Engineering Technologists should achieve specific competencies at the prescribed level during their development towards professional registration while accepting 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
3. Select the best solution and present to the recipient
4. Apply theoretical knowledge to justify decisions taken and processes used
5. Understand role in the work team and plan and schedule work accordingly
6. Issue complete and clear instructions and report comprehensively on work progress
7. Be sensitive to the impact of the engineering activity and take action to mitigate this impact
8. Consider and adhere to legislation applicable to the task and the associated risk identification and management
9. Adhere strictly to high ethical behavioural standards and the Code of Conduct of the ECSA
10. Display sound judgement by considering all factors together with their interrelationship, consequences and evaluation when all evidence is not available
11. Accept responsibility for own work by using theory to support decisions and by seeking advice when uncertain and evaluating shortcomings
12. 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 and deviates from standard procedures, codes and systems. This deviation is 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 competences required for registration as a Professional Engineering Technologist. Definitions of terms having particular meaning within this standard is given in Appendix B.	Discipline-Specific Training Guides (DSTGs) give context to the purpose of the Competency Standards. Professional Engineering Technologists operate within the nine disciplines recognised by the ECSA. Each discipline can be further divided into sub-disciplines and finally into specific workplaces, as given in Clause 4 of the specific DSTG. The DSTGs are used to facilitate experiential development towards ECSA registration and to 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 at the Responsibility Level E (i.e. Performing) (Refer to section 7.1 in the specific DSTG).
2. Demonstration of Competence Competence must be demonstrated within ***broadly defined engineering activities*** (defined below) by integrated performance of the outcomes defined in section 3 at the level defined for each outcome. Required contexts and functions may be specified in the applicable discipline-specific guidelines. **Level Descriptor: *Broadly defined engineering activities*** demonstrate several of the following characteristics: (a) *Scope* of practice area is linked to technologies used and changes made through adoption of new technology into current practice. (b) Practice area is located within a wider, complex *context,* requires teamwork and interfaces with other parties and disciplines. (c) Activities involve the use of a variety of *resources,* including people, money, equipment, materials and technologies. (d) Activities require resolution of occasional problems arising from *interactions* between wide-ranging or conflicting issues such as technical and engineering issues. (e) Activities are *constrained* by available technology, time, finance, infrastructure, resources, facilities, applicable laws and standards and codes. (f) Activities have significant *risks* and *consequences* in the practice and related areas. ***Activities*** include design; planning; investigation and problem resolution; improvement of materials, components, systems and processes; manufacture and construction; engineering operations; maintenance; project management; research; and development and	Engineering activities can be divided approximately into 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: *Broadly defined engineering activities*** in the various disciplines are characterised by several or all of 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 the additional responsibility of identifying the need for advice on complex activities and problems. *Broadly defined activities* in the sub-discipline need interfacing with professional engineers, professional technicians, artisans, architects, financial staff, etc. as part of the team. (c) The bulk of the work involves a familiar, defined range of *resources,* including people, money, equipment, materials, but new technologies are investigated and implemented. (d) Most of the impacts in the sub-discipline are on wider issues, but some arise from conflicting technical and engineering issues that have to be addressed by the application of *broadly defined*, non-standard engineering principles. (e) The work packages and associated parameters are *constrained* by operational context with variations limited to different locations only (cannot be covered by standards and codes). (f) Even locally important minor risks can have far-reaching consequences. ***Activities*** include design; planning; investigation and problem resolution; improvement of materials, components, systems and processes; engineering operations; maintenance; and project management. For Engineering Technologists, research, development and commercialisation occur more frequently in some disciplines and 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** demonstrate the following characteristics:* (a) require coherent and detailed engineering knowledge underpinning the technology area; *and one or more of:* (b) are ill-posed, are under or over specified, require identification and interpretation into the technology area; (c) encompass systems within complex engineering systems; (d) belong to families of problems that are solved in well-accepted but innovative ways; *and one or more of:* (e) can be solved by structured analysis techniques; (f) may be partially outside standards and codes – must provide justification to operate outside; (g) require information from practice area and sources interfacing with practice area that are complex and incomplete; (h) involve a variety of issues that may impose conflicting constraints: technical, engineering and interested or affected parties; *and one or both of:* (i) require judgement in decision-making in practice area, considering interfaces with other areas; and (j) demonstrate significant consequences that are important in practice area but may extend more widely.	(a) Coherent and detailed engineering knowledge for Engineering Technologists means the problem encountered cannot be solved without combining all the relevant details, including engineering principles that are 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) Recognition that the problem can be classified as falling within a typical solution and requiring innovative adaptation to meet the specific situation. (e) Solving the problem needs a step-by-step approach that adheres to proven logic. (f) The standards, codes and documented procedures must be analysed to determine to what extent they are applicable to solving the problem, and justification must be given to operate outside these. (g) The responsibility lies with the Engineering Technologist to verify that some information received as part of the problem encountered may remain incomplete, and solutions to problems may need justified assumptions. (h) Problems addressed by Engineering Technologists may be solved by alternatives that are unaffordable, detrimental to the environment, socially unacceptable, not maintainable, not sustainable, etc. The 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 the impact of one's own work in the interactive environment. (j) Engineering Technologists must realise that their actions may seem to be of local importance only but may develop into significant consequences extending beyond their own abilities and practice areas.
Assessment criteria: A structured analysis of broadly defined problems typified by the following performances is expected: 1.1 Performed or contributed in defining engineering problems, leading to an agreed definition of the problems to be solved. 1.2 Performed or contributed in investigating engineering problems, including collecting, organising and evaluating information 1.3 Performed or contributed in analysis of engineering problems using conceptualisation, justified assumptions, limitations and evaluation of results	Engineering Technologists will typically receive instructions from senior persons (customers) to perform specific engineering tasks. 1.1 Technologists must ensure that the instructions are complete, clear and within their capabilities and that the persons who issued the instructions agree with their interpretations. 1.2 The engineering problem and related information must be segregated from the bulk of the information and be investigated and evaluated. 1.3 Technologists must ensure that the instruction and information regarding the work is fully understood and complete, including the engineering theory needed to understand the acceptance criteria and to understand and carry out the task and/or check calculations. If needed, supplementary information must be gathered, studied and understood. Concepts and assumptions must be justified by engineering theory and calculations, if applicable.

Range Statement: The problem may be a design requirement, an applied Research and Development requirement or a problematic situation in an existing component, system or process. The problem is one that is 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 Clause 4 of the specific DSTG.**

Outcome 2: Design or develop solutions to broadly defined engineering problems	**Responsibility levels C and D** Design means 'a drawing or outline from which something can be made'. To develop means 'come or bring into a state in which it is active or visible'.
Assessment criteria: This outcome is normally demonstrated after the problem analysis, as defined in Outcome 1. By working systematically to synthesise a solution to a broadly defined problem, the following performances are 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 2.3 Detailed specification requirements and design documentation for implementation according to the wishes of the client	After the task is fully understood and interpreted, a solution to the posed problem can be developed (designed). To synthesise a solution means to combine separate parts, elements, substances, etc. into a whole or into a system'. 2.1 The development (design) of several alternatives 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 in the instructions received. <u>Theoretical calculations to support each alternative must be done and submitted as an attachment</u>. 2.2 In some cases, the Engineering Technologist will not be able to support all proposals with a complete theoretical calculation to substantiate every aspect and must in these cases, refer his/her alternatives to an Engineer for scrutiny and support. The recommended alternative must be convincingly detailed to win customer support for the preferred option. Selection of alternatives might be based on tenders submitted, with alternatives deviating from those specified. 2.3 The final solution selected must be followed up with a detailed technical specification, supporting drawings, bill of quantities, etc. in order for the execution of work to meet customer requirements.
Range Statement: Solutions are enabled by the technologies in the candidate's practice area.	The methods of applying theory to perform *broadly defined engineering work* mainly follow procedures that have been used before. These methods were probably developed by engineers in the past and are documented in written procedures, specifications, drawings, models, examples, etc. Engineering Technologists must seek approval for any deviation from these established methods and 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 that are specific to the jurisdiction in which the technologist practises	**Responsibility Level E** To comprehend means ‘to understand fully’. The jurisdiction in which an Engineering Technologist practises is given in **Clause 4** of the **specific DSTG.**
Assessment criteria: This outcome is normally demonstrated in the course of design, investigation or operation. 3.1 Applied engineering principles, practices and technologies, including the application of B.Tech. Eng. theory in the practice area 3.2 Indicated working knowledge of areas of practice that interact with practice area to underpin team work 3.3 Applied knowledge of finance, statutory requirements, safety and management	Design work for Engineering Technologists is based on B.Tech. Eng. theory and mainly comprises the utilisation and configuration of manufactured components and selected materials together with associated novel technology. Engineering Technologists develop and apply codes and procedures in their design work. Investigation involves broadly defined incidents and condition monitoring. Operations mainly involve developing and improving engineering systems and operations. 3.1 Calculations at B.Tech. Eng. theoretical level confirming the correct application and utilisation of the equipment, materials and systems listed in Clause 4 of the specific DSTG must be done on *broadly defined* activities. 3.2 As part of the personal contribution within the engineering team, the understanding of broadly defined procedures and techniques must be based on fundamental mathematical, scientific and engineering knowledge. 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, and 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 disciplines) to underpin teamwork; and (c) jurisdictional knowledge that includes legal and regulatory requirements and locally relevant codes of practice. As required for practice area, a selection of legislation regarding the law of contract, health and safety, the environment, intellectual property, contract administration, quality management, risk management, maintenance management, regulation and project and construction management.	(a) The specific location of the 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 and must include 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 together with complex theoretical motivation. (b) Despite having a working knowledge of interacting disciplines, Engineering Technologists take responsibility for the multidisciplinary team of specialists such as Civil Engineers on structures and roads, Mechanical Engineers on fire-protection equipment, Architects on buildings and Electrical Engineers on communication equipment. (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 for which they are responsible. Engineering Technologists 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** To manage means 'to control'.
Assessment criteria: The candidate is expected to display personal and work-process management abilities: 4.1 Management of self, people, work priorities, processes and resources in broadly defined engineering work 4.2 Evidence of role in planning, organising, leading and controlling broadly defined engineering activities 4.3 Knowledge of conditions and operation of contractors and evidence of ability to establish and maintain professional and business relationships	In engineering operations, Engineering Technologists typically will be given the responsibility to carry out projects. 4.1 Resources are usually subdivided based on availability and are 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 management must be applied to broadly defined engineering work. 4.3 Depending on the project, Engineering Technologists can be the team leader or 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; 5.2 ability to issue clear instructions to stakeholders, using appropriate language and communication skills; and 5.3 use of structure, style, language, visual aids and supporting documents appropriate to the audience and purpose in oral presentations.	5.1 Refer to Range Statement for Outcome 4 and Outcome 5 below. 5.2 Refer to Range Statement for Outcome 4 and Outcome 5 below. 5.3 Presentation of point of view mainly occurs in meetings and discussions with immediate supervisor.
Range Statement for Outcome 4 and Outcome 5: Management and communication in *well-defined engineering* involves (a) planning *broadly defined* activities (b) organising *broadly defined* activities (c) leading *broadly defined* activities (d) controlling *broadly defined* activities	(a) Planning means 'arranging to do or use something; considered in advance'. (b) Organising means 'putting into working order; arranging in a system; making preparations for'. (c) Leading means 'guiding the actions and opinions of; influencing; persuading'. (d) Controlling means 'regulating; restraining; keeping in order; checking'. Engineering Technologists write specifications for the purchase of materials and/or for the work to be done; provide 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.

Group C: Impacts of Engineering Activity	Explanation and Responsibility Level
Outcome 6: Recognise foreseeable social, cultural and environmental effects of *broadly defined* engineering activities	**Responsibility Level B** Society means 'people living in communities; relationships between persons and communities'. Culture means 'all the arts, beliefs, social institutions and characteristics of a community'. Environment means 'surroundings; circumstances; influences'.
Assessment Criteria: This outcome is normally displayed in the course of analysis and solution of problems. The candidate must typically demonstrate 6.1 ability to identify interested and affected parties and their expectations in regard to interactions between technical, social, cultural and environmental considerations shown; and 6.2 evidence of measures taken to mitigate the negative effects of engineering activities.	6.1 Engineering significantly affects 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 machines and other hazardous equipment and structure demolition). 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 and compensation paid.

Outcome 7: Meet all legal and regulatory requirements and protect the health and safety of persons in the course of the broadly defined engineering activities	**Responsibility Level E**
Assessment Criteria: 7.1 Identified applicable legal and regulatory requirements, including health and safety requirements for the engineering activity 7.2 Circumstances in which applicant assisted are stated, awareness of the selection of save and sustainable materials, components and systems is demonstrated and risk- and applied-risk management strategies are identified.	7.1 The OHS Act is supplemented by a variety of Acts of Parliament, regulations, local authority by-laws and standards and codes of practice. Places of work may have standard procedures, instructions, drawings and operation and maintenance manuals available. Depending on the situation (emergency, breakdown, etc.), these documents are consulted before the work commences and during the activity. 7.2 It is essential to attend a Risk Management (Assessment) course and to investigate and study the materials, components and systems used in the workplace. If the slightest doubt exists that safety and sustainability cannot be guaranteed, the Engineering Technologist must seek advice from knowledgeable and experienced specialists.

Range Statement for Outcome 6 and Outcome 7	
Impacts and regulatory requirements: (a) Requirements include both explicit regulated factors and factors that arise in the course of particular work.	(a) Impacts vary substantially with the location of the task. For example, the impact of laying a cable or pipe in the main street of a town will be entirely different to the impact caused by construction in a rural area. The methods, techniques or procedures will differ accordingly and may be complex. These issues are identified and studied by the Engineering Technologist before starting the work.
(b) Impacts considered extend over the lifecycle of the project and include the consequences of the technologies applied.	(b) The Safety Officer and/or the Responsible Person appointed in accordance with the OHS Act usually confirm/s or check/s that the instructions are in line with regulations. The Engineering Technologist is responsible for ensuring that this is done and if not, must establish which regulations apply and ensure adherence. Usually, the people working on site are strictly controlled with regard to health and safety. The Engineering Technologist checks that this is done but may authorise unavoidable deviations after setting the conditions for such deviations. Since projects are mainly carried out where contact with the public cannot be avoided, safety measures such as barricading and warning signs must be used and maintained.
(c) Effects to be considered include the direct and indirect effects and the immediate and long-term effects related to the technology used.	(c) Effects associated with risk management are well known if not obvious, and methods used to address risk management are clearly defined. Risks are mainly associated with elevated structures, subsidence of soil, electrocution of human beings and moving parts on machinery. The Engineering Technologist needs to identify, analyse and manage any long-term risks and develop strategies to overcome these by using alternative technologies.
(d) Requirements also include safe and sustainable materials, components and systems.	(d) 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 Engineering Technologists to use their knowledge and experience in confirming that prescriptions by others are correct and safe.
(e) Regulatory requirements are explicit for the context in general.	(e) Regulations associated with the particular aspects of the project must be carefully identified and their application must be controlled by the Engineering Technologist.

Group D: Exercise judgement, take responsibility and act ethically	**Explanation and Responsibility Level**
Outcome 8: Conduct engineering activities ethically	**Responsibility Level E** Ethics means ‘science of morals; moral soundness’. Morals mean ‘moral habits; standards of behaviour; principles of right and wrong’.
Assessment Criteria: Sensitivity to ethical issues and adoption of a systematic approach to resolve these issues are expected and typified by 8.1 confirmation of conversance and operation in compliance with the Code of Conduct of the ECSA for registered persons; and 8.2 method for identification of ethical problems and affected parties and selection of best solution to resolve the problems.	Systematic means ‘methodical; based on a system’. 8.1 ECSA’s Code of Conduct (as per the ECSA 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 and misrepresentation of facts.

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 performances: 9.1 judgement exercised in arriving at a conclusion within the application of technologies and their interrelationship to other disciplines and technologies; and 9.2 factors considered, bearing in mind the risk, the consequences of technology application and the affected parties.	9.1 The extent of a project given to a junior Engineering Technologist is characterised by several *broadly defined* and a few *well-defined* factors and their resulting interdependence. The technologist 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 Outcome 8 and Outcome 9*: Judgement* in decision-making involves (a) taking several risk factors into account; **or** (b) significant consequences in technology application and related contexts; **or** (c) ranges of interested and affected parties with widely varying needs.	In Engineering, about 5% of engineering activities can be classified as *broadly defined.* In these activities, the Engineering Technologist uses standard procedures, codes of practice, specifications, etc., but develops variations and unique standards when needed. Judgement must be displayed to identify any activity falling inside the *broadly defined* range (defined above) by: (a) Getting the work done despite 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). (c) Interested and affected parties with defined needs that may be in conflict (e.g. the need for a service irrespective of environmental damage, local traditions and preferences) needs sound management and judgement.

Outcome 10: Be responsible for making decisions regarding part or all of one or more *broadly defined* engineering activities	**Responsibility Level E** Responsible means ‘legally or morally liable for carrying out a duty; accountable for the care of something or somebody in a situation where one may be blamed for loss, failure, etc.’
Assessment criteria: Responsibility is displayed by the following performance: 10.1 engineering and social, environmental 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 the area of competence; and 10.3 academic knowledge to at least B.Tech. Eng. level combined with past experience used in formulating decisions[1].	10.1 All interrelated factors taken into consideration are indicative of professional responsibility in working on broadly defined activities. 10.2 The Engineering Technologist does not operate on tasks at a level higher 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 of 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 form an important element. Calculations, for example, fault levels, load calculations and losses 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 activities.	Responsibility is mostly allocated within a team environment, with an increasing designation as experience is gathered.
Note 1: Demonstrating responsibility under supervision of a competent engineering practitioner but is expected to perform as if in a responsible position	

Group E: Initial Professional Development (IPD)	**Explanation and Responsibility Level**
Outcome 11: Undertake sufficient independent learning activities to maintain and extend competence	**Responsibility Level D**
Assessment Criteria: Self-development managed: 11.1 Evidence of strategy independently adopted to enhance professional development 11.2 Evidence of awareness of philosophy of employer in regard to professional development	11.1 If possible, a specific field of the sub-discipline is chosen, available developmental alternatives are established, a programme is drawn up (in consultation with employer if costs are involved) and options to expand knowledge into additional fields are investigated. 11.2 Record-keeping must not be left to the employer or anybody else. Trainees must manage their own training independently, taking the initiative and being in charge of experiential development towards Professional Engineering Technologist level.
Range Statement: Professional development involves (a) planning own professional development strategy; (b) selecting appropriate professional development activities; and (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 the responsibility of the Engineering Technologists to manage their own experiential development. Engineering Technologists frequently fail to progress and are left with repetitive work. If self-development is not personally driven, success is unlikely. (b) Preference must be given to engineering development rather than the development of soft skills. (c) Developing a learning culture in the workplace environment of Engineering Technologists is vital to their success. Information is readily available, and most senior personnel in the workplace are willing to mentor if approached.

APPENDIX B: DEFINITIONS

Engineering science means a body of knowledge that is based on the natural sciences and uses mathematical formulation where necessary; it 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 means a problematic situation that is amenable to analysis and solution using engineering sciences and methods.

Ill-posed problem means a problem 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 coordinated activities required to:

(i) direct and control everything that is constructed or results from construction or manufacturing operations;
(ii) operate engineering works safely and in the manner intended;
(iii) return engineering works, plant and equipment to an acceptable condition by the renewal, replacement or mending of worn, damaged or decayed parts;
(iv) direct and control engineering processes and systems in addition to the commissioning, operation and decommissioning of equipment; and
(v) maintain 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 the 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 through the path of education, training and experience followed.

Range Statement means the required extent or the limitations of 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 are licensed through the Engineering Profession Act or a combination of the Engineering Profession Act and external legislation and who have 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.