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SOUTH AFRICA

Discipline-Specific Training Guideline for Engineering Technologists in Chemical Engineering

R-05-CHE-PT

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ECSA

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1. BACKGROUND: ECSA REGISTRATION SYSTEM DOCUMENTS

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.

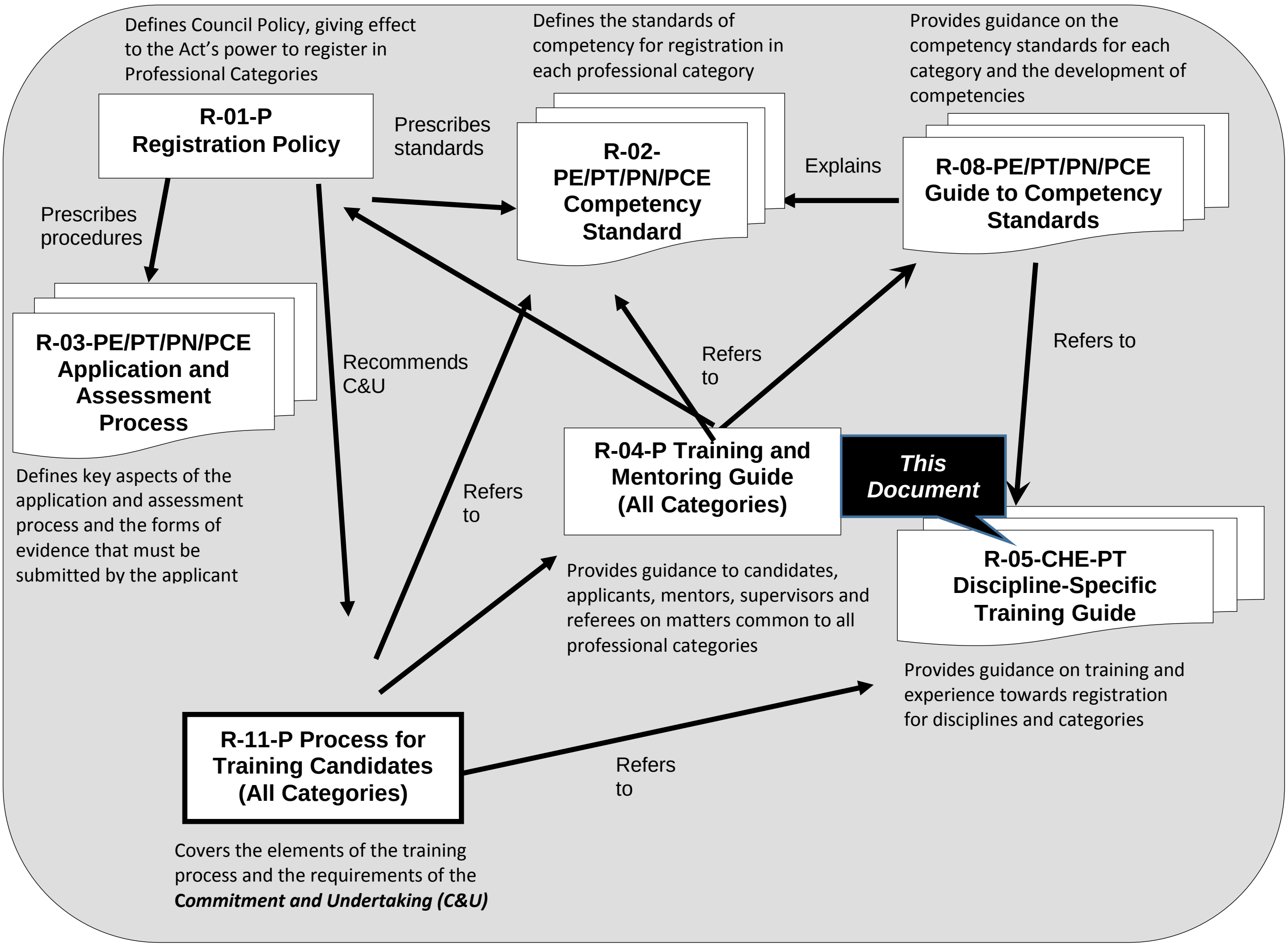

Figure 1: Documents defining the ECSA Registration System

2. PURPOSE

All persons applying for registration as a Professional Engineering Technologist are expected to demonstrate the competencies specified in document R-02-PT through 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

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

This guide applies to persons who have

- completed the education requirements
  - by obtaining an accredited B.Tech. (Engineering) or B.Eng.Tech.-type qualification,
  - by obtaining a Sydney Accord recognised qualification, and
  - 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

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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 and without training under 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 Association for the discipline should be consulted for assistance in locating an external mentor. A mentor should keep abreast of all stages of the development process.

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

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 DSTG 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 (see **section 7.4** below).

An applicant who does not hold a B.Tech. degree may apply under an alternative route. Completion of an additional form is required, which considers 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

Chemical Engineering (Organising Framework for Occupations (OFO) 214501)

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Chemical Engineering Technologists are involved in the planning, design, development, construction, operation and maintenance of industrial-scale machines and plant processes to convert raw and recycled materials to products. This conversion occurs through chemical and physical processes using engineering science such as thermodynamics, fluid mechanics, separation technology, chemical reaction kinetics, process control and design, reactor designs, mass- and heat-transfer processes and other engineering topics. Chemical Engineering is very broad both scientifically and technically, and similar to all engineering disciplines, it requires the application of mathematics, physics and economics to solve technical problems through design and the invention of new processes.

Typical tasks that a Chemical Engineering Technologist may undertake include

- conducting research, advising on and developing broadly defined, commercial-scale processes to produce substances and items such as petroleum derivatives, chemicals, food and drink products, pulp and paper, pharmaceuticals and synthetic materials such as polymers, plastics and cement in addition to incorporating energy and mineral processing and water treatment;
- specifying broadly defined chemical production methods, equipment, materials and quality standards and ensuring that all conform to specifications and accepted industry practices and standards;
- establishing broadly defined control standards and procedures to ensure the safety of production operations and the safety of workers operating equipment or working in close proximity to on-going chemical reactions or processes;
- designing broadly defined chemical plants and equipment and devising broadly defined processes for manufacturing chemicals and other products while meeting targeted efficiencies;
- performing broadly defined tests throughout stages of production to determine degree of control over process variables, which include composition, temperature, density, specific gravity and pressure;
- developing operating procedures to be employed during design and operating phases, including start-up, shutdown and emergency procedures;
- preparing estimates of production costs (CAPEX, OPEX and lifecycle) and production progress reports for management;

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- performing laboratory studies of steps in the manufacturing of new products and testing proposed process(es) by employing small-scale operations such as a pilot plant;
- overseeing plant operation and/or management;
- optimising processes and products for improvement of prescribed performance indices such as profitability, sustainability, energy consumption, environmental sustainability and carbon efficiency;
- developing broadly defined process control philosophies and/or advanced process control (APC) systems;
- evaluating social, environmental, statutory and legal considerations; and
- participating in and leading risk assessment studies such as hazard and operability (HAZOP) studies during the phases of design or operation of equipment, systems and plants.

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 in solving problems by utilising proven analytical techniques and tools;
- the ability to use troubleshooting skills;
- the identification of problems/hazards and the analysis of the cause(s) of process problems in a systematic manner using applicable models and frameworks/tools;
- the identification of opportunities for improving current operations/plant performance, for extending the product range/yield, for changing the feed source, for developing new methods for processing, for developing new applications for products and for developing new methods/technologies that address shortfalls in the currently available methods/technologies and the evaluation of processing alternatives;
- the planning and carrying out of broadly defined experimental investigations in a scientific manner on a laboratory, pilot plant or industrial plant scale;
- the evaluation of broadly defined experimental or theoretical results;
- the evaluation of a proposed project (techno-economic evaluation), deriving conclusions in a logical way and formulating recommendations based on these conclusions;

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- research motivation and development or plant modification projects based on technical, economic, safety and environmental considerations; and
- the use of troubleshooting methodologies, literature surveys, data analyses and root cause analysis tools to identify or analyse problems.

6.2 Location of training in overall engineering lifecycle and functions performed

The areas within which Chemical Engineering Technologists work follow the conventional stages of the project lifecycle.

6.2.1 *Engineering lifecycle considerations*

Chemical Engineering professionals will generally work in one of three broadly defined working environments, and their activities include

- projects and design;
- operations and maintenance;
- manufacturing and construction;
- research and development, including planning, market analysis, feasibility studies, product research, engineering design and specifications, software testing and evaluation of engineering models;
- implementation of Research Engineering by undertaking laboratory experiments and pilot plants, by analysing processes during the development of new services or products or by improving existing services, products or plant equipment;
- utilisation of appropriate tools to simulate design performances;
- process design to solve a process-related problem, to achieve a particular desired result or to select equipment for a particular purpose, including conceptualisation, examination of alternatives, trade-off studies and basic and detailed design;
- plant operation to manufacture the product and make process improvements.

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6.3 Process optimisation and plant and equipment design

Process optimisation involves providing a solution to the identified problem through

- improving system/equipment operating parameters by modification or installation of new equipment or a new system;
- ensuring that the process optimisation or design is according to design specification or plant design basis requirements (cases of beyond design basis may emerge and must be supported with scientific knowledge and appropriate methods of analysis);
- preparing a broadly defined design basis, process flow sheets and mass and energy balances (can involve simulation and/or computational fluid dynamics);
- optimising broadly defined plant system design and using models (normally computerised) to determine configuration options;
- selecting, designing and specifying equipment and service requirements with reference to the applicable codes and consideration of the suitability of materials used, lifecycle requirements and costs;
- checking the reliability of data on the properties of materials to be processed or produced while considering economics, instrumentation, quality control, logistics, safety, spillage/containment management and the effect on the environment;
- defining and developing broadly defined process control and operating philosophies;
- checking of working drawings for suitability with respect to the process, space, accessibility, maintenance, etc.
- designing plants or equipment by considering the aspects of reliability, maintainability, usability, supportability, reducibility, disposability and affordability; and
- performing cost and economic analysis for minimising cost and maximising throughput and/or the efficiency of the plant operation or process.

6.4 Risk Management and impact mitigation

The risk management process is implemented during project management or plant operation. The Chemical Engineering Technologist is involved in risk management and its identification and analysis within the plant, system or project lifecycle through

- performing engineering tasks by considering the social, cultural, environmental, legal and regulatory requirements;
- undertaking risk assessments prior to conducting plant test work, installations or

operations;

- compiling risk assessment plans, a risks register and risk mitigation plans;
- using the risk analysis tools to undertake risk impact analysis and to develop impact mitigation strategies;
- considering risk attributes or factors during risk assessments such as cost, programme, quality, labour, profitability, logistics, legislation, technology and political, social, cultural and environmental aspects;
- considering the inherent safety risk in regard to Chemical Engineering during risk response and control processes; and
- compiling a risk management stakeholder communication plan.

6.5 Process safety

The Chemical Engineering Technologist is involved in process safety through

- applying process safety management principles, which include inherent safety design principles and process safety analysis during plant operation and throughout the project lifecycle phases to ensure safe operation and contingency measures;
- considering plant/equipment design bases and beyond design basis specification and operating parameters;
- assessing design and condition of safety devices that are used to manage and control the process effluent for a controlled release during accidental undesirable events;
- considering the limitation of effect of different types of system or equipment failures;
- considering the process safety aspects of plants and projects that arise from the use of hazardous materials;
- considering process safety when selecting the materials for construction;
- understanding hazardous material conditions;
- assessing the environmental impact of process industry activities and their compliance with legal requirements, including requirements for final decommissioning, shutdown and/or facility closure;
- using risk assessment (e.g. quantitative risk analysis) and HAZOP techniques to improve plant design safety; and
- using applicable techniques/tools for process hazard analysis at the specific project

lifecycle phase.

6.6 Project management

Project management has a number of phases and stages that must be followed to solve industrial problems. Companies use different project lifecycles, which include project development, 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 include

- Integrated Project Controls, including cost control, estimation of resources, capital and operating and/or lifecycle costs, planning and scheduling and project risk management;
- Stakeholder Management (i.e. liaison and responsibility for communication, overall control of the engineering team and interfacing with the client and legal entities);
- Project Resource Management; and
- Project Change and Project Risk Management.

6.7 Project development

Project development involves

- undertaking project management tasks during all the project development phases, including idea/problem analysis, need definition, conceptual design and basic and detailed engineering;
- undertaking research studies and feasibility studies to identify the preferred solution and to develop the solution; and
- undertaking Responsibilities of Procurement and contracts management while considering National Treasury rules. There are number of examples that the technologist and the company may follow for specific projects (e.g. Engineering procurement, Construction Management (EPCM) and commissioning/hand-over).

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6.8 Plant construction, commissioning and hand-over

- *Plant commissioning:* Includes measurement and analysis of plant performance versus design data, responsibility for acceptable plant performance, elimination of operability problems, unacceptable bottlenecks and other problems, checks for compliance with safety standards;
- *Plant hand-over:* Includes as-built documentation, construction punch-out, planning and execution of punch-out and hand-over;
- *Reviews after commissioning and hand-over:* Includes determination of effective reliability, maintainability, usability, supportability, reducibility, disposability and affordability regarding the design; and
- Preparation of operating, start-up, shutdown and emergency procedures.

6.9 Plant decommissioning

Plant decommissioning involves:

- ensuring that decommissioning strategy and safety procedures are followed through understanding the chemical characteristics of the equipment or plant;
- undertaking and compiling procedures for plant decommissioning and consolidating for shutdown or closure;
- undertaking decommissioning phases to ensure that the safety of equipment is maintained; this includes surveillance, inspection, testing and maintenance; and
- ensuring that processes for regulatory and statutory application and authorisation are implemented.

6.10 Production/Manufacturing

Production/Manufacturing involves

- manufacture or production of equipment for plant systems (e.g. heaters, economisers, pumps, scrubbers, distillation columns, reactors, piping, material handling equipment); this includes plant and process design;
- manufacture or production of equipment that may be part of the plant/equipment design

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process. Some technologists may work in industries that either manufacture machinery or produce machinery for process plants or systems;

- manufacture or production of machinery for transportation, storage of fluids (pumps, tanks), waste management systems, evaporation, drying, ion exchange, solid handling, etc.
- consideration of new or existing plant or system specifications and operating parameters detailed by the client; and
- application of manufacturing and market measures.

6.11 Plant operations and maintenance

Plant operation and maintenance involves

- management of production resources (raw materials, manpower, energy) and maintenance;
- quality control and assurance (monitoring quality and meeting equipment and plant design specifications according to design bases);
- assistance in measurement analysis and evaluation of performance data (on-going plant monitoring and plant optimisation, performance and operating costs);
- involvement in budgets, cost control, planning and production scheduling;
- plant performance analysis that comprises problem identification, measurements, modelling and validation of data (processes involved are material balance, energy balance, flow measurements and indications, etc.);
- assurance of availability, reliability and operability of the plant or equipment during operation by monitoring and undertaking necessary calculations;
- an understanding of the different types of maintenance and repair strategies or practices that must be undertaken according to specification for equipment type by identifying physical equipment variables and considering the reliability of the equipment;
- compilation of operating procedures, maintenance bases, lifecycle plans and procedures;
- utilisation of broadly defined tools to perform required plant performance analysis and monitoring;
- process modification and plant modification (may be suggested) as part of plant operations; and

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- implementation of maintenance strategy during the plant or equipment decommissioning process.

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 engineering profession and the Voluntary Associations that are applicable to the Chemical Engineering Technologist.

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

7.2 Functions performed

The functions in which all Chemical Engineering Technologists need to be proficient are listed below. These functions are required to a greater or lesser extent in all engineering areas of employment. The parallels with the broadly defined generic competence elements required by the Competency Standard (document R-02-PT) should be clear. Candidates need to gain experience in these functions even if the functions are not part of their core job roles.

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

- A: Knowledge based problem solving (this should be a strong focus)
- B: Management and Communication
- C: Identifying and mitigating the impacts of engineering activity
- D: Judgement and responsibility
- E: Independent learning

It is very useful to measure the progression of the candidate's competency by making use of the

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scales for Degree of Responsibility, Problem Solving and Engineering Activity as specified in the relevant documentation.

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

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

The nature of work and degrees of responsibility defined in Table 4 of document R-04-P are presented here and in Appendix A below.

A: Being Exposed	B: Assisting	C: Participating	D: Contributing	E: Performing
Undergoes induction, observes processes, works with 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	Fully responsible to supervisor for immediate quality of work	Level of responsibility is appropriate to that of a registered person but supervisor is accountable for candidate's decisions

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7.3 Statutory and regulatory requirements

The Candidate Engineering Technologist should be familiar with the legal requirements of the process industries, including the Acts that are applicable such as the Occupational Health and Safety Act (OHS Act) and the Engineering Profession Act. The Candidate Engineering Technologist is expected to have knowledge and understanding of the statutory requirements pertaining to the work and projects that are included in the experience report submitted for registration.

Candidate must familiarise themselves with the instructions and the construction regulations of the South African National Treasury when implementing projects.

Chemical Engineers must ensure that they understand and follow the relevant statutory codes and rules when designing equipment such as reactor vessels (e.g. ASME), nuclear equipment, systems, plants and processes.

Examples of the relevant Acts and regulations are presented below:

- ASME Boiler and Pressure Vessel Code (First edition in 1914)
- SANS codes of specification for piping design / material (ANSI) (see www.sabs.co.za)
- Plastic Identification Code (see www.cansa.org.za)
- SANS 10248, 1023: Waste classification and management regulations from the Constitution of the Republic of South Africa, 1996
- Hazardous Substance Act, No. 5 of 1973
- Minerals and energy Acts, (e.g. Mineral and Petroleum Act, No. 28 of 2002)
- Mine Health and Safety Act, No. 29 of 1996 (see www.dmr.gov.za)
- Project and Construction Management Professions Act, No. 48 of 2000
- National Environmental Management Act, No. 107 of 1998
- National Environmental Management Waste Act, No. 59 of 2008
- National Radioactive Waste Disposal Institute Act, No. 53 of 2008
- National Nuclear Regulator Act, No. 47 of 1999 (NNR)
- Nuclear Energy Act, No. 46 of 1999
- National Water Act, No. 36 of 1998
- Occupational Health and Safety Act, No. 85 of 1993 and regulations
- ISO 9001: 2015
- Standards Act, No. 24 of 1945

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- Standards Act, No. 29 of 2008
- List of SABS/TC 147 standards
- SANS codes for use of chemicals in treatment of water intended for human consumption and other purposes (e.g. SANS 241: 2015 Drinking Water Standard)
- SANS codes for food and beverages (e.g. SANS 10133) (see www.sans.co.za)
- SANS Code 10139: 2012 for regulating fire protection requirements that include fire detection and alarm systems for buildings with system design, installation and servicing
- Engineering Profession Act, No. 46 of 2000 and its rules, specifically the Code of Conduct

7.4 Desirable formal learning

Candidate Chemical Engineering Technologists should register with the relevant Volunteer Association to access lists of training, conferences and seminars and other relevant information (e.g. SAIChe-IChemE, PMI, PMISA, CESA, SACPCMP). The following list of formal learning activities is by no means extensive and is only a sample of some useful courses:

- Risk assessment and analysis techniques (including HAZOP)
- Problem-solving and analysis tools (e.g. brain storming, gap analysis, FMEA, Pareto Analysis, root cause analysis, problem tree analysis, trade-off tools)
- Project Management techniques and tools, including conditions of contract, finance and economics, quality systems, stakeholder management and Project Management (planning, scheduling and project controls), tools and software (e.g. MS Project, Primavera, Project Risk Analysis, Earn Value Management) and other SAP tools
- Simulation tools (e.g. Aspen, SimSci, ChemCAD, AFT, Metsim)
- Occupational health and safety, including the OHS Act and ‘safety in design’
- Formally registered Continuing Professional Development (CPD) courses in Chemical/Process Engineering and associated disciplines
- Value Engineering and other Value Improvement Practices (VIPs)
- Preparation of engineering design specifications
- Environmental aspects of projects and plant operations
- Regulatory and statutory requirements of equipment operating codes and regimes
- Professional skills such as report writing, presentations and facilitation and negotiation skills

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- Monitoring tools for performance of plant operations
- Compilation of plant operation procedures
- Operate, monitor, optimise and maintain plant or process
- Project lifecycle phases and systems or equipment lifecycle (until the decommissioning process)
- Process Safety Management

8. PROGRAMME STRUCTURE AND SEQUENCING

8.1 Best practice

Best practice is a developmental process that assists candidates in becoming registered Professional Engineering Technologists. Best practice comprises the process for continuous development of the candidate. A number of courses (technical and management) must be attended in order to gain the Initial Professional Development (IPD) points required for registration. This is in addition to on-the-job learning at the organisation in which the candidate is employed. Refer to the South African Institution of Chemical Engineers (SAICHE) and the Institution of Chemical Engineers (IChemE) for some best practice ideas. Candidates may register with these bodies to gain access to courses, articles and relevant information for their development. This may also extend the opportunity to meet with experts during seminars.

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

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 at the time that are assigned to the candidate by the employer. This means that each candidate effectively undertakes a unique programme in which the various activities carried out at the discipline-specific level are linked to the generic competency requirements of document R-08-PT.

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8.2 Realities

Candidate Engineering Technologists are advised that although three years is the minimum required period of experience following graduation, in practice, it is seldom found that Chemical Engineering Technologists meet the experience requirements within this time, and then only if they have followed a structured training programme. Candidates are advised to gain at least five years of experience before applying in a broadly defined engineering responsible level. Furthermore, since the application procedure only allows deferral for one year (plus a possible extension of one additional year in specific circumstances), applicants will lose their application fee if they cannot achieve the necessary competency within this deferral time period.

Candidates are advised to undertake project management courses for IDP because chemical engineering work involves project management activities during design, construction and commission, hand-over and decommissioning. Other courses may include software training for design and simulation processes. It is not mandatory for Chemical Engineer Technologists to be involved in equipment or process design if the organisation in which they are employed does not provide such services. In such cases, Chemical Engineer Technologists must undertake the broadly defined engineering activities of solving engineering problems and developing solutions or be part of reviewing engineering design or provide a statement of work to develop solutions or compile technical requirement specification.

Candidates are not expected to change jobs in order to work in all four areas although this is often followed by many Candidate Engineering Technologists in order to ensure obtaining the broadest possible experience. However, ECSA registration requires that in whichever areas candidates are employed, candidates must ensure that they undertake broadly defined tasks that provide experience in the three generic engineering competence elements, namely problem investigation and analysis, problem solution and execution/implementation. To a greater or lesser extent, all three competence elements are required in each of the areas above. By judicious selection of broadly defined work-task opportunities with the same employer, it should be possible to gain experience in all three elements, as expanded in the functions described in section 6.2 above.

It is also important that applicants demonstrate that they have gained experience at increasing levels of responsibility and ultimately, have operated at the level expected of a Professional Engineering Technologist within the areas of problem investigation and analysis, problem solution and execution/implementation. To this end, it is important for Candidate Engineering Technologists to work

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closely with their mentors and employers and plan broadly defined workplace opportunities in order to gain the necessary experience and expertise.

8.3 Generalists, specialists, researchers and academics

Chemical Engineering Technologists often work in areas such as academia, research and development, lecturing and highly specialised fields in which it is often difficult to gain the breadth of experience required for registration. These candidates must still obtain the necessary experience to enable them to demonstrate that they have met the competencies specified in document R-02-PT at the level expected of a Professional Engineering Technologist. It is expected that this will take longer than it would for candidates working in more general areas.

Chemical Engineering Technologists who wish to specialise in designing fire protection systems may wish to follow the route specified in document R-05-FPSP-SC.

Chemical Engineering Technologists may find themselves gaining experience from 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 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
  - Obtainment of higher qualifications

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

- **Laboratory experiments:**
  - Experimentation
  - Design and building of laboratories
  - Experimental equipment design and construction
  - Experiment design
  - Development of new manufacturing techniques

- **Conferences/Symposia/Seminars:**
  - Publishing papers (peer-reviewed journals and international conferences)
  - Public speaking.

- **Consulting:**
  - Consulting to industry in solving real problems encountered in engineering practice
  - Design of products, structure, systems and components

8.4 Multi-disciplinary 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

- 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

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8.6 Moving into or changing candidacy programmes

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

- The candidate must complete the Training and Experience Summary (TES) and the Training and Experience Reports (TERs) for the previous programme or unstructured experience. In the latter case, it is important to reconstruct the experience as accurately as possible. The TERs must be signed off in the appropriate manner.
- 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.

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REVISION HISTORY

Revision Number	Revision Date	Revision Details	Approved By
Rev 1	17 July 2014		Registration Committee for Professional Engineers
Rev 2	22 Sept 2017	Reviewed in accordance with approved DSTG Framework	
Rev 2	23 Oct 2017	Reviewed and checked	B Collier-Reed; TP Maphumulo: J Cato
Rev 2	30 Jan 2018	Approval	PDSGC

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

Revision 2 dated 30 January 2018 and consisting of 37 pages has been reviewed for adequacy by the Business Unit Manager and is approved by the Executive: Policy Development and Standards Generation (PDSG).

....
Business Unit Manager

30/05/2018
Date

....
Executive: **PDSG**

30/5/2018
Date

The 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, accepting more and more responsibility at the same time as experience is gained. The outcomes achieved and established during the candidacy phase should form the template for all engineering work performed at any stage of an engineering career after professional registration, regardless of the level of responsibility:

1. Confirm understanding of instructions received and clarify if necessary
2. Use theoretical training to develop possible solutions, select the best solution and present to the recipient
3. Apply theoretical knowledge to justify decisions taken and processes used
4. Understand your 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 the legislation applicable to the task and the associated risk identification and management
8. Adhere strictly to high ethical behavioural standards and the Code of Conduct of the ECSA
9. Display sound judgement by considering all factors, including their interrelationship, consequences and their evaluation when all evidence is not available
10. Accept responsibility for own work by using theory to support decisions and by 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. This deviation must be 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 Appendix D.	The 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 divided into specific workplaces as given in Clause 4 of the specific DSTG. Discipline-Specific Training Guides are used to facilitate experiential development towards ECSA registration and assist in compiling the required portfolio of evidence (specifically, the Engineering Report in the application form). NOTE: The training period must be utilised to develop the competence of the trainee towards achieving the standards defined below at Responsibility Level E (i.e. Performing). (Refer to section 7.1 in the specific DSTG)

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2. Demonstration of Competence Competence must be demonstrated within the **broadly defined engineering activities** presented below by integrated performance of the outcomes defined in section 3 at the level defined for each outcome. Required contexts and functions are specified in the applicable DSTG.	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 Artisans) 55% Unskilled Workman (Artisans; 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 have 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) The use of a variety of *resources,* including people, money, equipment, materials and technologies is involved. d) Resolution of occasional problems arising from *interactions* between wide-ranging or conflicting technical, engineering or other issues is required. e) Broadly defined engineering activities are *constrained* by available technology, time, finance, infrastructure, resources, facilities, standards and codes and applicable laws. f) Broadly defined engineering activities have significant *risks* and *consequences* in the practice area and other 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; development; and commercialisation.	**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 the adoption of new technologies needs investigation and evaluation. b) Practice area varies substantially with unlimited location possibilities, resulting in 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 and 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 must 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 or processes; engineering operations; maintenance; and project management. For Engineering Technologists, research, development and commercialisation occur more frequently in certain disciplines and are seldom encountered in others.

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3. Outcomes to be satisfied	Explanation and Responsibility Level
Group A: Engineering Problem-Solving	
Outcome 1: Define, investigate and analyse 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 and require identification and interpretation in 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 (justification to operate outside must be provided); (g) require information from practice area and sources interfacing with practice area that is complex and incomplete; (h) involves 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 and consideration of interfaces with other areas; and (j) have significant consequences that are important in the practice area, and this may extend more widely.	(a) Coherent and detailed engineering knowledge for Engineering Technologists means the problem encountered cannot be solved without combination of all the relevant details, 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) The problem is classified as falling within a typical solution that requires 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 the extent to which they are applicable in order to solve 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) The problem addressed by the Engineering Technologist may be solved by alternatives that are unaffordable, detrimental to the environment, socially unacceptable, not maintainable, not sustainable, etc. Technologists must 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 own work in the interactive environment. (j) Engineering Technologists must realise that their actions may seem to be only of local importance but may develop into significant consequences that extend beyond their 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 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; and 1.3 performed or contributed in analysis of engineering problems, using conceptualisation, justified assumptions, limitations and evaluation of results.	The Engineering Technologist will initially receive instruction from a senior person (customer) to perform a specific task. Thereafter, the technologist must 1.1 make very sure that the instruction is complete, clear and within his/her capability and that the person who issued the instruction agrees with the interpretation; 1.2 segregate the engineering problem and the related information from the bulk of the investigated and evaluated information; and 1.3 ensure that the information and the instruction to do the work is fully understood and complete. The technologist must procure the engineering theory needed to understand the task and the acceptance criteria and to carry out and/or to check calculations. If needed, supplementary information must be gathered, studied and understood. If applicable, concepts and assumptions must be justified by engineering theory and calculations.

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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 Clause 4 of the specific DSTG.**

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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'. 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 defined in Outcome 1. Working systematically to synthesise a solution to a broadly defined problem that is 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 Prepared detailed specification requirements and design documentation for implementation to the satisfaction of the client	After the received task is fully understood and interpreted, a solution to the problem posed can be developed (designed). Synthesis of a solution means 'the combination of separate parts, elements, substances, etc. into a whole or into a system'. 2.1 The development (design) of more than one approach to solve the engineering task or problem should always be done and should include the costing and impact assessment for each alternative. All the alternatives must meet the requirements set out by the instruction received, and <u>the theoretical calculations to support each alternative must be done and submitted as an attachment</u>. 2.2 In certain cases, the Engineering Technologist will not be able to support proposals with a complete theoretical calculation that substantiates 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. Selection of alternatives may 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 enabled by the technologies in the candidate's practice area.	Applying theory to carry out broadly defined engineering work is mainly done using established methods that were probably developed by engineers in the past and are documented in written procedures, specifications, drawings, models, examples, etc. Engineering Technologists must seek approval of any deviation from these established methods and must also initiate and/or participate in the development and revision of these norms.

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Outcome 3: Comprehend and apply the knowledge embodied in widely accepted and applied engineering procedures, processes, systems and methodologies specific to the jurisdiction in which the technologist practises.	**Responsibility Level E** 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 operations. The applicant 3.1 applied engineering principles, practices and technologies, including the application of B.Tech. theory in the practice area; 3.2 Indicated working knowledge of areas of practice that interact with the practice area to underpin team work; and 3.3 applied related knowledge of finance, statutory requirements, safety and management.	Design work for Engineering Technologists is based on B.Tech. theory and mainly involves the utilisation and configuration of manufactured components and selected materials and the associated novel technology. Engineering Technologists develop and apply codes and procedures in their design work. Investigation is predominantly on broadly defined incidents and condition monitoring, and operations mainly involve developing and improving engineering systems and operations. 3.1 Calculations at B.Tech. theoretical level confirming the correct application and utilisation of equipment, materials and systems listed in Clause 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 the 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, and is 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 others) to underpin teamwork (c) Jurisdictional knowledge that encompasses the legal and regulatory requirements plus relevant local codes of practice required for the practice area (a selection of law of contract, health and safety, environmental, intellectual property, contract administration, quality management, risk management, maintenance management, regulation management, 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 the 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 and must be accompanied by complex theoretical motivation. (b) Due to having a working knowledge of interacting disciplines, Engineering Technologists take responsibility for the multi-disciplinary team that comprises specialists such as Civil Engineers on structures and roads, Mechanical Engineers on fire protection equipment, Architects on buildings and 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 is their responsibility. Engineering Technologists are usually appointed as the 'responsible person' for specific projects in terms of the OHS Act.

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Group B: Managing Engineering Activities	Explanation and Responsibility Level
Outcome 4: Manage part or all of one or more 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 to establish and maintain professional and business relationships evident	In engineering operations, Engineering Technologists are typically 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 may be team leaders, team members or may 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 the broadly defined engineering activities	**Responsibility Level C**
Assessment Criteria: Demonstrates effective communication by 5.1 ability to write clear, concise and 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 ability to make oral presentations using structure, style, language, visual aids and supporting documents appropriate to the audience and purpose.	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 the immediate supervisor.
Range Statement for Outcome 4 and Outcome 5: Management and communication in *well-defined* engineering involves the following: (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, considering 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 work to be done, make recommendations on tenders received, place orders and variation orders, write work instructions, report back on work done, draw, correct and revise drawings, compile test reports, use operation and maintenance manuals to write work procedures, write inspection and audit reports, write commissioning reports, prepare and present motivations for new projects, compile budget reports, report on studies done and calculations carried out, report on customer requirements, report on safety incidents and risk analysis, report on equipment failure, report on proposed system improvement and new techniques, report back on cost control, etc.

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Group C: Impacts of Engineering Activity	Explanation and Responsibility Level
Outcome 6: Recognise the foreseeable social, cultural and environmental effects of broadly defined engineering activities	**Responsibility Level B** Social means pertaining to 'people living in communities; relations between persons and communities'. Cultural means pertaining to 'all the arts, beliefs, social institutions, etc. that are characteristic of a community'. Environmental means pertaining to 'the surroundings; circumstances; influences'.
Assessment Criteria: This outcome is normally displayed in the course of the analysis and solution of problems. The candidate demonstrates 6.1 ability to identify interested and affected parties and their expectations in regard to interactions between technical, social, cultural and environmental considerations; 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 effects on animals and wildlife, dangerous rotating machines and other hazardous machines, demolishing of structures). 6.2 Mitigating measures taken may include environmental impact studies, environmental impact management, community involvement and communication, barricades and warning signs, temporary crossings, alternative supplies (ring feeders and bypass roads), press releases and compensation paid.

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Outcome 7: Meet all legal and regulatory requirements and protect the health and safety of persons in the course of broadly defined engineering activities	**Responsibility Level E**
Assessment Criteria: The candidate demonstrates: 7.1 Identification of applicable legal and regulatory requirements, including health and safety requirements for the engineering activity 7.2 Circumstances in which applicant assisted in or demonstrated awareness of the selection of safe and sustainable materials, components and systems plus identified risk and applied risk management strategies	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 may have standard procedures, instructions, drawings and operation and maintenance manuals available. Depending on the situation (emergency, breakdown, etc.), these documents are consulted before commencement of work and thereafter 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. The Engineering Technologist must seek advice from knowledgeable and experienced specialists if there is the slightest doubt that safety and sustainability will be guaranteed.
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. (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 effects and immediate and long-term effects that relate to the technology used. (d) Requirements include safe and sustainable materials, components and systems. (e) Regulatory requirements are explicit for the context in general.	(a) Impacts vary substantially with the location of the task (e.g. the impact of laying a cable or pipe in the main street of a town will be entirely different from the impact of construction in a rural area). The methods, techniques or procedures may be complex and will differ accordingly and thus are 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 for confirming that this is done, and if not done, the technologist 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 also checks that this is done and may authorise unavoidable deviation after setting the conditions for such deviations. Projects are mainly carried out where contact with the public cannot be avoided, and safety measures such as barricades and warning signs must be used and maintained. (c) Effects associated with risk management are generally well known if not obvious, and methods used to address these effects 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 mitigate these risks by using alternative technologies. (d) Safe and sustainable materials, components and systems must be selected and prescribed by Engineering Technologists, or other professional specialists must be consulted. It is the responsibility of Engineering Technologists to use their knowledge and experience to confirm that prescriptions by others are correct and safe. **(e)** Regulations associated with the particular aspects of the project must be carefully identified by the Engineering Technologist and application of these regulations must be carefully controlled.

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Group D: Exercise judgement, 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 are expected – 8.1 Confirmation of conversance and operation in compliance with the ECSA's Rules of Conduct for registered persons 8.2 Demonstration of how ethical problems and affected parties were identified and how the best solution to resolve the problem was selected	Systematic means 'methodical; based on a system'. 8.1 The Code of Conduct of the ECSA (see 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 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 with other disciplines and technologies 9.2 Factors taken into consideration while bearing in mind risk, consequences in technology application and 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. Junior technologists must seek advice if their educational and/or experiential limitations are exceeded. 9.2 Taking risky decisions leads 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; (b) significant consequences in technology application and related contexts; or (c) ranges of interested and affected parties with needs that vary widely.	In Engineering, approximately 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 completely unique standards when needed. Judgement must be displayed to identify any activity falling inside the broadly defined range (defined above). (a) Accomplishing work 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 may be in conflict (e.g. need for a service irrespective of environmental damage, local traditions and preferences), and this needs sound management and judgement.

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Outcome 10: Be responsible for making decisions on 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; 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 performances: 10.1 Engineering, 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 technologist's area of competence; and 10.3 Academic knowledge used in formulating decisions at minimum level of B.Tech. combined with past experience.[1]	10.1 All interrelated factors taken into consideration is indicative of accepting professional responsibility in working on broadly defined activities. 10.2 Engineering Technologists do not operate on tasks at a higher level than broadly defined, and they consult professionals at engineer level if elements of the project to be done are beyond their education and experience (e.g. power system stability). 10.3 This is the first instance of continuous self-evaluation to ascertain that the given task is done correctly, on time and within budget. Continuous feedback to the originator of the task instruction and the taking of corrective action if necessary form important elements. The calculations (e.g. fault levels, load calculations, 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 mainly allocated within a team environment, with an increasing designation as experience is gathered.

[1] Demonstrating responsibility would be under the supervision of a competent engineering practitioner, but technologists are expected to perform as if they are in a responsible position.

Group E: Initial Professional Development (IPD)	Explanation and Responsibility Level
Outcome 11: Undertake independent learning activities that are sufficient to maintain and extend competence	**Responsibility Level D**
Assessment Criteria: Self-development managed – 11.1 Strategy independently adopted to enhance professional development is evident. 11.2 Awareness of philosophy of employer in regard to professional development is evident.	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 are presented to expand knowledge into additional fields that can be investigated. 11.2 Record-keeping must not be left to the employer or to another person. Trainees must manage their own training independently, take initiative and be in charge of experiential development towards Professional Engineering.
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 Engineering Technologists to manage their own experiential development. The progress of Engineering Technologists frequently comes to a halt, and they are left doing repetitive work. If self-development is not driven by the technologists themselves, 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 is vital to the success of Engineering Technologists. Information is readily available, and most senior personnel in the workplace are willing to mentor if approached.

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APPENDIX B: DEFINITIONS

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

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

Ill-posed problem means a problem in which the requirements are not fully defined or may be defined erroneously by the requesting party.

Integrated performance means that the overall satisfactory outcome of an activity requires several outcomes to be satisfactorily attained (e.g. a design requires 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 required coordination of activities:

(i) to direct and control everything that is constructed or results from construction or manufacturing operations;
(ii) to operate engineering works safely and in the manner intended;
(iii) to return engineering works, plant and equipment in an acceptable condition through the renewal, replacement or repair of worn, damaged or decayed parts;
(iv) to direct and control engineering processes and systems, including commissioning and operation and decommissioning of equipment; and
(v) to maintain engineering works and equipment in a state in which they can perform their required function.

Over-determined problem means a problem whose requirements are defined in excessive detail, making the required solution impossible to attain in all of its aspects.

Outcome at the professional level means a statement regarding 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 following the path of education, training and experience.

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 external legislation and the Engineering Profession Act and who have specific engineering competencies at the level of NQF 5 that are associated with an identified need to protect the public safety, health and interest or the environment in relation to an engineering activity.

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