ENSURING THE
EXPERTISE TO GROW
SOUTH AFRICA

Discipline-specific Training Guide for Registration as a Professional Engineering Technologists in Chemical Engineering

R-05-CHE-PT

REVISION 3: 13 July 2022

ENGINEERING COUNCIL OF SOUTH AFRICA
Tel: 011 607 9500 | Fax: 011 622 9295
Email: engineer@ecsa.co.za | Website: www.ecsa.co.za

TABLE OF CONTENTS

DEFINITIONS

Broadly defined engineering work is characterised by the following:

- It is constrained by available technology, time, finance, infrastructure, resources, facilities, applicable laws, standards and codes.
- It involves a variety of resources, including people, money, equipment, materials, and technologies.
- It requires the resolution of occasional problems arising from interactions among wide-ranging or conflicting issues such as technical and engineering issues.
- It has significant risks and consequences in the practice area and related areas.
- The practice area is located within a wider, complex context; it requires teamwork and has interfaces with other parties and disciplines.
- The scope of the practice area is linked to the technologies used and the changes due to the adoption of new technology into current practice.

Candidate means a person who is registered with the ECSA in a candidate category of registration.

Competency standard means a statement of competency required for a defined purpose.

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

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 specialisation.

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 to:

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

Mentor means a professionally registered person who guides the competency development of a Candidate in an appropriate category.

Outcome at the professional level means a statement regarding the performance that a person must demonstrate to be judged competent.

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

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, 46 of 2000 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.

Supervisor means a person who oversees and controls engineering work performed by a candidate.

ABBREVIATIONS

APC	Advanced Process Control
BEng Tech	Bachelor of Engineering Technology
BTech (Eng)	Bachelor of Technology Engineering
CAPEX	Capital Cost
C&U	Commitment and undertaking
CPD	Continuing Professional Development
DSTG	Discipline-Specific Training Guide
ECSA	Engineering Council of South Africa
EPCM	Engineering Procurement Construction Management
EIAs	Environmental Impact Assessments
FIDIC	Fédération Internationale des Ingénieurs-Conseils (The International Federation of Consulting Engineers)
GCC	General Conditions of Contract
HAZOP	Hazard and Operability
FEED	Front End Engineering Design
FMCG	Fast Moving Consumable Goods
ICI	Imperial Chemical Industries
IPD	Initial Professional Development
LOPA	Layer of Protection Analysis
MHS	Mine Health and Safety
NEC	New Engineering Contract
NEMA	National Environmental Management Act
NWA	National Water Act
NQF	National Qualification Framework
OFO	Organising Framework for Occupations
OPEX	Capital expenditure
OHS	Occupational Health and Safety
PCE	Professional Certificated Engineer
PFD	Process Flow Diagram

PID	Piping and instrumentation diagrams
Pr Eng Tech	Professional Engineering Technologist
PROCSA	Professional Consultants Services Agreement Committee
PGDip	Post-graduate Diploma
PE	Professional Engineer
PN	Professional Engineering Technician
PT	Professional Engineering Technologist
RCA	Root Cause Analysis
TES	Training and Experience Summary
TERs	Training and Experience Reports
VIPs	Value Improvement Practices

1. PURPOSE OF THIS DOCUMENT

The illustration in **Error! Reference source not found.** 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.

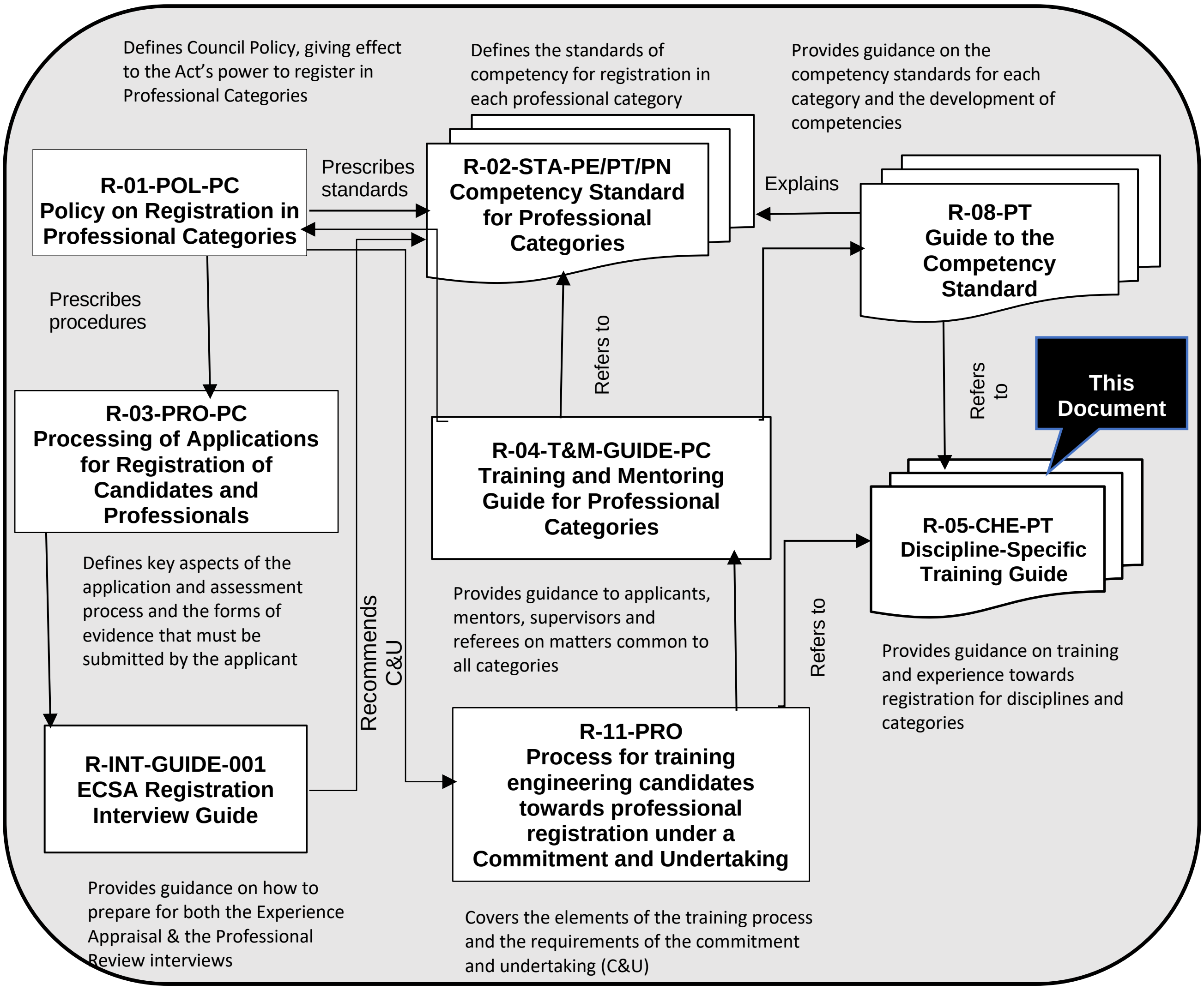

Figure 1: Documents defining the ECSA Registration System

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

This document supplements the generic *Training and Mentoring* Guide for professional categories (document **R-04-T&M-GUIDE-PC**) and the *Guide to the Competency Standards for Registration as a Professional Engineering Technologist* (document **R-08-PT**). In document **R-04-T&M-GUIDE-PC**, attention is drawn to the following sections:

- Duration of the programme
- Planning principles
- Progression of training programme
- Documenting training and experience outline
- Demonstrating sound judgement, responsibility and ethics.

The second document (**R-08-PT**) provides a high-level, outcome-by-outcome understanding of the competency standards that form an essential basis for this Discipline-specific Training Guide (DSTG).

This guide and documents **R-04-T&M-GUIDE-PC** and **R-08-PT** are subordinate to the Policy on *Registration in Professional Categories* (**R-01-POL-PC**), the *Competency Standard* (**R-02-STA-PE/PT/PN**) and the application process definition (**R-03-PRO-PC**).

2. AUDIENCE

This DSTG is directed towards Candidates, supervisors and mentors in the discipline of Chemical Engineering Technology. 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 BTech (Engineering) or BEng Tech type qualification or equivalent qualifications accredited/approved by ECSA
  - by obtaining a Sydney Accord recognised qualification
  - through ECSA educational qualification evaluation/assessment
- registered as a Candidate Engineering Technologist and/or embarked on a process of training under a registered mentor guiding the professional development process at each stage.

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

Irrespective of the development path followed, all applicants for registration must present the same evidence of competence and be assessed against the same standards as prescribed under **R-02-STA-PE/PT/PN**. Application for registration as a Professional Engineering Technologist is permitted without being registered as a Candidate Engineering Technologist and without training under Commitment and Undertaking (C&U). Mentorship and adequate supervision are, however, key factors in effective development to the level required for registration. A C&U indicates that the company is committed to mentorship and supervision.

If the trainee's employer does not offer C&U or ECSA accredited Training Academies, the trainee should establish the level of mentorship and supervision that the employer is able to provide. In the absence of an internal mentor, the services of an external mentor should be secured. The Voluntary Association (VA) for the discipline should be consulted for assistance in locating an external mentor. A mentor should keep abreast of all stages of the development process.

This guide is written for Candidates who are training and gaining experience towards registration.

Applicants who have not been through a mentorship programme through C&U or ECSA Accredited Training Academy are advised to request an experienced mentor (internal or external) to act as an application adviser while they prepare their applications for registration. Applicants who do not hold a BTech / BEng Tech degree may apply under an alternative route as prescribed under **E-17-PRO**.

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.

4. ORGANISING FRAMEWORK FOR OCCUPATIONS

Chemical Engineering (Organising Framework for Occupations

Obtaining a qualification in Chemical Engineering Technology develops skills and specialisation. Chemical Engineering Technology graduates are known for their problem-solving skills and are equipped to deal with problems within and outside the Chemical Engineering field. Many graduates in this field, both in South Africa and internationally, move directly into the finance sector where their analytical skills are used. Other graduates move into medicine, law or academia. This guide assumes that the Candidate is intent on identifying and developing the competencies of a Chemical Engineering Technologist to the level of professional status.

To begin, consider the following definition of Chemical Engineering: The planning, design, development, operation, and maintenance of industrial-scale processes to convert raw and recycled materials to products through chemical and physical processes using engineering science such as thermodynamics, fluid mechanics and transfer processes. Perhaps the most important takeaway from the definition is that fundamental knowledge, which includes learning specialised concepts from first principles, is holistically applied to a real-world problem scenario.

It is also noteworthy that the word ‘processes’ is used in this definition; many industries refer to Chemical Engineering Technologists as ‘Process Engineering Technologists’, which may be more accurate in certain occupational roles.

Nevertheless, it is the development of the Chemical Engineering Technology graduate into a professional Chemical Engineering Technologist that provides the impetus for this guide. Once formal learning has been completed at tertiary level, there is ‘an open road’ for developing the Candidate.

Typical tasks that a Chemical Engineering Technologist may undertake include the following:

- 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 process plants and equipment and devising broadly defined processes for manufacturing 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 of cost estimates such as (CAPEX, OPEX and lifecycle) and production progress reports for management.
- Performing laboratory studies of steps in the manufacturing of new products and testing proposed processes 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 or the modification of existing plants.
- Participating in and leading risk assessment studies such as hazard and operability (HAZOP) studies during phases of design or operation of equipment, systems and plants.

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

The 'industry' refers to the real-world environment in which Chemical Engineering Technologists carry out tasks and duties using their skills. It must be separated from the formalised learning environment. The industry is the setting in which aspiring Professional Engineering Technologists sharpen their skills and develop the requisite competencies.

Historically, the chemical engineering industry and related industries in South Africa have had two major driving forces:

- International sanctions and embargoes imposed on South Africa, leading to the formation of SASOL Limited
- Extensive mineral reserves and involvement in specifically gold and platinum mining and beneficiation since the 1800s.

It thus follows that the major 'traditional' industries in which Chemical Engineering Technologists are found in South Africa are petrochemical and minerals processing. The development of the economy and the maturation of the chemical-processing industry have given rise to several other industries from which Candidate Chemical Engineering Technologists are pooled. Increasing labour and utility costs have also led to the employment of Chemical Engineering Technologists to optimise processes by reducing waste. For reference, typical industry examples are given in Table 1.

Table 1: Typical Industries/ sections in which Chemical Engineering Technologies Practice.

INDUSTRY	SECTOR	APPLICATION
Chemicals	Primary chemicals, fertiliser etc.	Air liquefaction, evaporation, crystallisation
Fast Moving Consumable Goods (FMCG)	Agro processing, sugar, Beverages (Wine, beer, spirits, soft drinks), detergents etc.	Crushing, milling, drying, mixing, anaerobic digestion, fermentation, distillation

INDUSTRY	SECTOR	APPLICATION
Mineral Processing	Extraction of precious metals and base metals	Solid-liquid separation, solvent extraction, electrowinning, leaching, floatation, dense media separation etc.
Mining	Underground or above-ground primary mining industry	Crushing, grinding, sedimentation, cooling, heating, ventilation, effluent treatment, water treatment, energy efficiency, automation etc.
Petrochemical	Refinery, polymer production, solvents etc.	Distillation, refining etc.
Pharmaceutical	Medicinal drugs, radiation products, beauty cosmetic	Synthesis, crystallisation, distillation, filtration, cooling, drying, mixing etc.
Power generation	Industries co-generating power, renewable energy generations, nuclear power etc.	Steam or gas turbine integration
Public Sector Services	National, provincial, national government & state-owned entities	Sector infrastructure planning, policy development
Pulp & Paper	Paper making	Digestions, drying, reaction, filtration, sedimentation
Teaching, Research & Development	Academia, research institutes	Research and development on various aspect of chemical engineering
Waste Management	Municipalities, manufacturing, mining, energy	Waste minimisation, recycling, recovery, re-use, thermal treatment, gasification, pyrolysis, anaerobic digestion, liquefication, combustion, aerobic composting, landfilling, waste-to-energy
Water and Wastewater	Municipalities, industrial, manufacturing, mining, agriculture, acid mine effluent, municipalities, manufacturing.	Pumping, storage, membrane processes, chemical coagulation/flocculation, thermal evaporation, anaerobic/aerobic digestion, floatation, filtration, waste-to-energy, thermal evaporation, anaerobic/aerobic digestion, filtration, waste-to-energy

5.1 Investigation

The ability to undertake investigations and analyse problems critically is a key skill that Engineering Technologists should aim to have and continuously develop. Candidate Chemical Engineering Technologists need to consider many aspects and follow certain steps in the investigation process to interrogate the given scope of work. The analysis must define and investigate the given scope of work to identify the characteristics of a "broadly defined engineering problem" as defined under **R-08-PT**. This should include but not be limited to:

(a) defining the assumptions and limitations for the design basis considered
(b) choosing a combination of applicable fundamental principles of chemical engineering to formulate a technical design basis
(c) defining the most appropriate integrated technical design basis (fundamental principles) and legislative design basis (appropriate legislative requirements)
(d) developing empirical models where specific design conditions/parameters cannot be estimated with theoretical models/defined fundamental models
(e) providing for innovation, safety, cost benefit analysis (opex & capex)
(f) investigating how the solution will improve the lives of affected communities, society, and the surrounding environment.

Apply the principles of integrated evaluation approach, whereby:

- **A**pplicable "Applicability of the proposed **technical solution** within local context/ specific conditions"
- **A**ppropriate "Appropriateness of the proposed solution within the given **institutional** framework"
- **A**chievable "Achievability of the proposed solution within the **legal and regulatory** framework"
- **A**cceptable "Acceptability of the proposed solution within the given **political environment**, communities and society"
- **A**ffordability "Affordability of the proposed solution in terms of capex, opex, **return on investment, financial** risks etc.)"

5.2 Process design

Process design in this guide refers to the synthesis of a solution to an engineering problem. A broadly defined engineering problem has been posed and investigated, and all available tools are utilised to obtain a solution to it. In the Chemical Engineering field, the process design is the hallmark of an experienced Chemical Engineering Technologist. The success of the engineering approach to this step is directly dependent on the preceding investigation and development/research steps. The process synthesis would naturally follow this sequence:

(a) Block Flow Diagram – define fundamental process steps involved including applicable legislative requirements.
(b) Process Flow Diagram (PFD) – select the unit operations and define the inputs and outputs of the process as well as assumptions based on specific conditions.
(c) Mass and energy balance in conjunction with the PFD – reagent consumption, utility requirements, economics of the plant.
(d) Piping and instrumentation diagrams (PID) – the process is defined in detail, and accurate pricing can be obtained in integrated evaluation to test the synthesised design.

The areas within which Chemical Engineering Technologists work follow the conventional stages of the project lifecycle as presented in **Error! Reference source not found.** and **Error! Reference source not found.**. However, not all stages of the project lifecycle can be achieved by a Candidate during the 3-year prescribed training period. It is the responsibility of the mentor /supervisor to ensure that the Candidate is provided with a balanced exposure to meet the requirements of all 11 outcomes within the required degree of responsibility as prescribed under **R-02-STA-PE/PT/PN**.

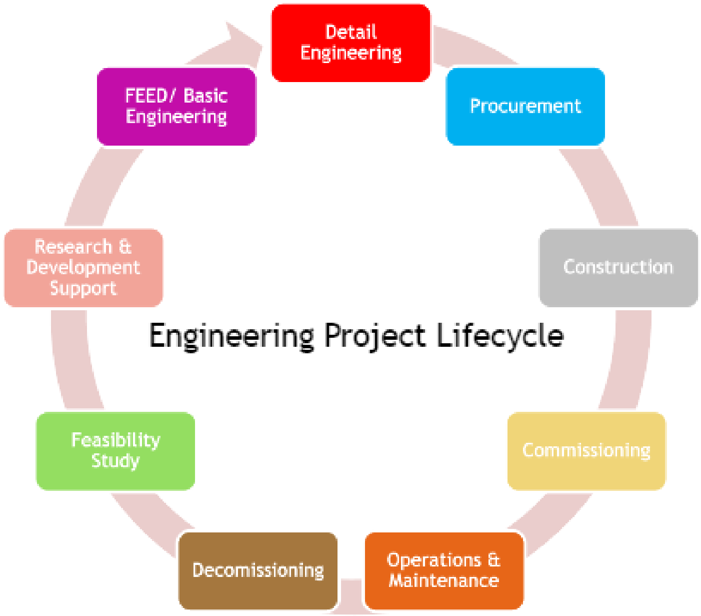

Figure 2: Typical Engineering Project Lifecycle.

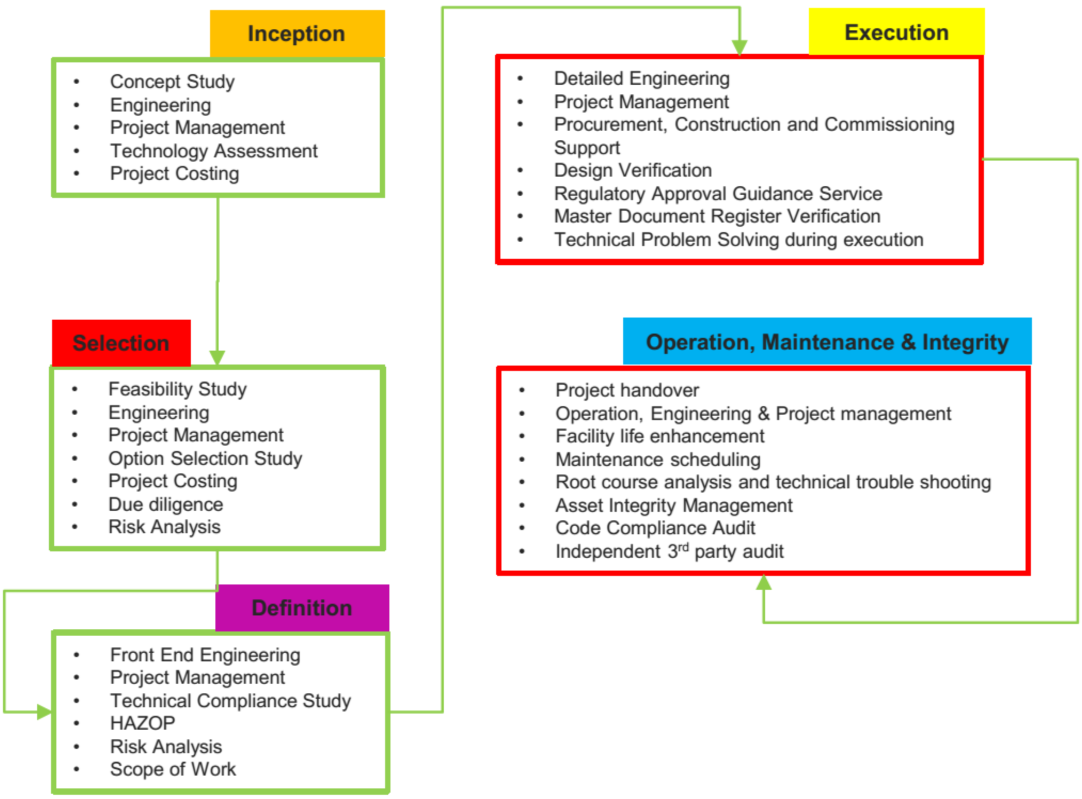

Figure 3: Typical phases of project execution

5.3 Risk management and impact mitigation

The risk management process is implemented during project management or plant operation. Chemical Engineering Technologists are 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 risk 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 regarding Chemical Engineering during risk response and control processes
- compiling a risk management stakeholder communication plan.

Chemical Engineering Technologists are 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.

5.4 Engineering 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
- Project Change and Project Risk Management.

Project development involves the following:

- 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).

5.5 Implementation

- *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.
- *Preparation* of operating, start-up, shutdown and emergency procedures.

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
- ensuring that processes for regulatory and statutory application and authorisation are implemented.

5.6 Production

Production/Manufacturing involves the following:

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

manufacture or produce 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.

5.7 Operations and maintenance

Plant operation and maintenance involves:

- management of production resources (raw materials, workforce, 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 which 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
- understanding 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 implementation of maintenance strategy during the plant or equipment decommissioning process.

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

6.1 Contextual knowledge

Contextual knowledge refers to the specific practice environment in which Candidates work. For example, a Chemical Engineering technologist working in the field of optimising a process plant in a manufacturing environment should become familiar with the fundamental operational philosophy of the unit operations as well as relevant technology advancements and developments. Engineering standards are critical in ensuring that the optimisation outputs do not compromise the design specifications of the individual unit operations, product quality and safety.

Chemical Engineering Technologists need to be familiar with the general provisions of the appropriate codes and standards for the industries under which they practise. Candidates are encouraged to familiarise themselves with the process industries in general by reading journals, joining relevant industry associations and attending training courses and conferences. This includes gaining knowledge of relevant industry standards and specifications.

6.2 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 (**R-02-STA-PE/PT/PN**) 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:

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

- Management and communication
- Identifying and mitigating the impacts of engineering activity
- Judgement and responsibility
- Independent learning.

It is useful to measure the progression of Candidates' competency using the scales for Degree of Responsibility, Problem Solving and Engineering Activity as specified in **R-02-STA-PE/PT/PN**.

Table 2 was developed against the Degree of Responsibility Scale. Activities should be selected to ensure that Candidates reach the required level of competency and responsibility. The nature of work and degrees of responsibility defined in **R-04-T&M-Guide-PC** are presented in Table 2 below and in Appendix A.

Table 2: Nature of work and degrees of responsibility for Engineering Technologists

Degree of responsibility	Nature of work: the Candidate	Responsibility of Candidate to supervisor	Extent of supervisor/mentor support
A: Being Exposed	Undergoes induction, observes processes, work of competent practitioner	No responsibility	Mentor explains challenges and forms solution
B: Assisting	Performs specific processes under close supervision	Limited responsibility for work output	Supervisor/Mentor coaches, offers feedback
C: Participating	Performs specific processes as directed with limited supervision	Full responsibility for supervised work	Supervisor progressively reduces support but monitors outputs
D: Contributing	Performs specific work with detailed approval of work outputs	Full responsibility to supervisor for immediate quality of work	Candidate articulates own reasoning and compares it with that of supervisor
E: Performing	Works in team without supervision, recommends work	Level of responsibility to supervisor is appropriate to a	Candidate takes on problem-solving without support, or at

Degree of responsibility	Nature of work: the Candidate	Responsibility of Candidate to supervisor	Extent of supervisor/mentor support
	outputs, responsible but not accountable	registered person; supervisor is accountable for candidate's decisions	most, with limited guidance

6.3 Statutory and regulatory requirements

Candidate Engineering Technologists who aspire to become professionally registered must be familiar with all the legal requirements of practising as Professional Engineering Technologists in the Republic of South Africa. In executing Engineering Work, Candidates must comply with all relevant overarching legislation and amendments thereto, among others:

- Engineering Profession Act, 46 of 2000
- Occupational Health and Safety Act, 85 of 1993
- National Building Regulations and Building Standards Act, 103 of 1977
- National Environmental Management Act, 107 of 1998
- Employment Equity Act, 55 of 1998
- Hazardous Substance Act, 5 of 1973
- Minerals and energy Acts, (e.g., Mineral and Petroleum Act, 28 of 2002)
- Mine Health and Safety Act, 29 of 1996
- Project and Construction Management Professions Act, 48 of 2000
- National Environmental Management Act, 107 of 1998
- National Radioactive Waste Disposal Institute Act, 53 of 2008
- National Nuclear Regulatory Act, 47 of 1999
- Nuclear Energy Act, 46 of 1999
- National Water Act, 36 of 1998
- Occupational Health and Safety Act, 85 of 1993 and Regulations
- Any other relevant codes and standards.

All Engineering Work must be carried out in accordance with the norms of the profession. Such norms are generally represented by national and international standards, industry standards, codes of practice and best practice guidelines.

ECSA has established a document known as the ECSA Code of Conduct, titled 'Code of Conduct for Registered Persons: Engineering Profession Act, 46 of 2000' and the 'Overarching Code of Practice for the Performance of Engineering Work' (document **R-01- CoP**). The ECSA Code of Conduct sets out the ethical rules of conduct for professionally registered persons in terms of the following categories:

- Competency
- Integrity
- Public interest
- Environment
- Dignity of the profession.

Further administrative considerations and practice requirements are also set out in the Code of Conduct and the Overarching Code of Practice for the Performance of Engineering Work, respectively. The onus is on Candidates and their mentors/supervisors to familiarise themselves with these documents.

Industry-specific regulations and requirements may or may not be applicable in all fields of Chemical Engineering. However, Candidates may find that each industry or aspect of design has developed 'good engineering practices' or has mandated statutory requirements. The onus is, once again, on Candidates and their mentors/supervisors to familiarise themselves with these practices in the South African industry-specific context or country-specific legislation when they undertake projects abroad.

6.4 Recommended formal learning

Formal learning in the context of this guide refers to the continuous development of a Candidate's skills-base using formal programmes, courses, workshops, seminars, webinars, conferences, research and further learning to satisfy the requirement of Initial Professional Development (IPD) for Outcome 11 as per competency standard policy **R-02-STA-PE/PT/PN**.

Since registration of Candidates to professional categories does not require Continuing Professional Development (CPD), it is not necessary for Candidates to attend CPD-accredited courses for registration, although Candidates must be aware that they will be required to maintain their CPD activities once they are registered in the professional category. In order for Candidates to develop a philosophy for IPD, they should adopt an approach of continuous learning after graduating.

The formal learning chosen will depend on the environment in which Candidates work. It is recommended that Candidates engage with their employers or sponsors to select formal learning that is cost-effective and appropriate for their roles in the organisation, including VA membership subscriptions. As a general guide to recommended formal learning for Chemical Engineers, the following options may be considered:

- Microsoft Office tools (MS Excel, MS Word, MS Projects, MS Visio MS PowerPoint, MS Teams, MS Access, MS Outlook, One Note, MS Project, MS Vision, OneDrive etc.)
- HAZOP study methods and techniques
- Layer of Protection Analysis (LOPA)
- Root Cause Analysis (RCA)
- Training in the use of simulation tools such as Mathcad, MATLAB, Aspen, SimSci, ChemCAD, AFT, Metsim, AutoCad, GIS, Earth Google, etc.
- Training in safety-related legislation such as the NEMA, NWA, OHS Act and the MHS Act
- Undertake IPD activities
- Value Engineering and other Value Improvement Practices (VIPs)
- Preparation of specifications
- Environmental aspects of projects
- Professional skills such as report writing and presentations
- Project and operational planning methods
- Project management
- Risk, quality management systems
- Standard Conditions of Contract (NEC, FIDIC, PROCSA, GCC, etc.)
- Negotiation skills in Engineering
- Finance risk analysis
- Quality assurance systems
- Occupational health and safety

- Energy efficiency
- Maintenance engineering
- Environmental impact management.

Some large companies offer significant training opportunities, particularly companies that are specialists in their field. In companies where such opportunities are few, Candidates are advised to consider joining the relevant VA, or other relevant sub-discipline specific VA.

7. PROGRAMME STRUCTURE AND SEQUENCING

7.1 Best practice

No ideal training programme structure or unique sequencing constitutes best practice. The training programme for each Candidate depends on the available work opportunities at the time that the employer assigns to the Candidate. 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**. The onus is on Candidates and their mentors/supervisors to take responsibility for their own development.

7.2 Realities

Candidate Engineering Technologists must bear in mind certain considerations when navigating the path to professional registration. Many companies in South Africa that employ Chemical Engineering Technologists are small, with a relatively flat reporting structure. In such cases, Candidates have the advantage of being exposed to more activities than in a large, more rigid corporate structure. However, such Candidates may eventually experience insufficient responsibility and management opportunities and should make themselves available to lead a team or take on additional responsibilities.

Larger corporate structures often have different approaches compared with smaller companies as every engineering discipline has its role. In a small company, a Candidate may quickly become a specialist in a single area of engineering and fail to gain cross-discipline exposure. Candidates should request exposure opportunities and discuss these with their employers, mentors or supervisors. In addition, the Chemical Engineering industry in South Africa is relatively small, and Candidates should consider this when changing jobs or industries.

Experienced Chemical Engineering Technologists often make good project managers because of their exposure to the entire lifecycle of a project and their interaction with other disciplines. The ‘big picture’ is gained in this way and should be considered by Candidates interested in project management as a future career.

Finally, there is no fixed recommendation for the timeline for registration application. Candidates need to consider the realities of the industry and acknowledge that they are ultimately responsible for their development.

7.3 Generalists, specialists, researchers and academics

Chemical Engineering Technologists often work in various industries/sectors 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-STA-PE/PT/PN** 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 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.

7.4 Multi-disciplinary exposure

Interface management among various disciplines needs to be managed by the Candidate's mentor/supervisor to ensure adequate multi-disciplinary exposure without violating the "Code of Conduct for the Engineering Profession" i.e., Code of Conduct for Registered Persons, under the Engineering Profession Act, 46 of 2000. Due to a common grounding in the mathematical and physical sciences, there are areas of overlap among the various disciplines of engineering as well as overlaps with other professions within the built environment. These overlaps generally occur at a basic level and divergence increases with the degree of specialisation. Mentors must guide Candidates on the practice requirements and ethical requirement as prescribed under **R-01-CoP**.

7.5 Orientation requirements

For the Candidate Engineering technologist starting a career with an employer, the basic introduction to the company's functions is usually performed during the first months of employment. The induction process usually includes the following aspects:

- Company safety regulations
- Company code of conduct
- Company staff code and regulations
- Typical functions and activities in company
- Rotation into other disciplines to gain multi-disciplinary exposure;
- Hands-on experience and orientation in each of the major company divisions.

7.6 Moving into or changing candidacy programmes

This guide assumes that Candidates enter a structured programme or unstructured training experience after graduation and continue with the programme until ready to submit an application for registration. The guide also assumes that Candidates are supervised and mentored by persons who meet the requirements stated in document **R-04-T&M-GUIDE-PC**. In the case of a person changing from one candidacy programme to another or changing jobs, it is essential that the following steps are completed:

- Candidates 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.
- The Candidate should continue with the mentor; should this not be possible, the new 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.

It must be noted that Engineering work by a Candidate or by an Unregistered Person during their training programme or acting on behalf of a Registered Person must be performed under the direction, control and supervision of a person registered in the appropriate category and discipline who must assume full professional responsibility for such work and sign off.

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	PDSG
Rev 3 Daft A	17 June 2022	The document has been revised to include the following sections and sub-section: Definitions, Abbreviations, Process design. The working group further added additional information under the following headings: Organising Framework for Occupations, Training Implications of the Nature and Organisation of the Industry, Contextual knowledge, Statutory and regulatory requirements, Recommended formal learning.	Working Group
Rev 3 Daft B	22 June 2022	Reviewed submission from working Group	RDD&R BU and Registration BU
Rev 3 Daft C	28 June 2022	Final working group review	Working Group
Rev 3 Draft D	30 June 2022	Review and recommendation for Approval	Acting RPSC Executive
Rev 3	13 July 2022	Approval	RPSC

The Discipline-specific Training Guide for

Registration as a Professional Engineering Technologists in Chemical Engineering

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

.... 03 August 2022

Business Unit Assistant Manager — Date

…….. 03 August 2022

Acting Executive: RPS — Date

This definitive version of this policy is available on our website

APPENDIX A: TRAINING ELEMENTS

Synopsis: Candidate Engineering Technologists should achieve specific competencies at the prescribed level during their development towards professional registration, 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 is given in text in Appendix B.	DSTGs give context to the purpose of the Competency Standards. Professional Engineering Technologists operate within the nine disciplines ECSA recognises. Each discipline can be further divided into sub-disciplines and finally into specific workplaces as given in section 4 of the specific DSTG. DSTGs are used to facilitate experiential development towards ECSA registration and assist in compiling the required portfolio of evidence (specifically the Engineering Report in the application form). **NOTE:** The training period must be used to develop the trainee's competence towards achieving the standards below at a Responsibility Level E, i.e., Performing. (Refer to 7.1 in the specific DSTG)
2. Demonstration of competence Competence must be demonstrated within *broadly defined engineering activities,* defined below, by integrated performance of the outcomes defined in section 3 at the level defined for each outcome. Required contexts and functions may be specified in the applicable DSTG. **Level Descriptor:** *Broadly defined engineering activities (BDEA)* have several of the following characteristics: a) Scope of practice area is linked to technologies used and changes by adoption of new technology into current practice. b) Practice area is located within a wider, complex context, requires teamwork, and has interfaces with other parties and disciplines. c) Involves a variety of resources, including people, money, equipment, materials and technologies. d) Requires resolution of occasional problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues.	Engineering activities can be divided into (approximately): 5% Complex (Professional Engineers) 5% Broadly Defined (Professional Engineering Technologists) 10% Well-defined (Professional Engineering Technicians) 15% Narrowly Well-defined (Registered Specified Categories) 20% Skilled Workman (Engineering Artisan) 55% Unskilled Workman (Artisan Assistants) Activities can be in-house or contracted out; evidence of integrated performance can be submitted irrespective of the situation. **Level Descriptor:** ***BDEA*** in the various disciplines are characterised by several 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 an additional responsibility to identify the need for advice on complex activities and problems. Broadly defined activities in the sub-discipline needs interfacing with professional engineers, professional technicians, artisans, architects, financial staff, etc. as part of the team.

e) Are constrained by available technology, time, finance, infrastructure, resources, facilities, standards and codes and applicable laws. f) Have significant risks and consequences in the practice area and in related areas.	c) The bulk of the work involves 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 but are not limited to design; planning; investigation and problem resolution; improvement of materials, components, systems or processes; manufacture or construction; engineering operations; maintenance; project management; research; development and commercialisation.	**Activities** include but are not limited to design; planning; investigation and problem resolution; improvement of materials, components, systems or processes; engineering operations; maintenance; project management. For Engineering Technologists, research, development and commercialisation happen more frequently in some disciplines but are seldom encountered in others.
3. Outcomes to be satisfied:	**Explanation and Responsibility Level**
Group A: Engineering Problem Solving	
Outcome 1: Define, investigate and analyse *broadly defined* engineering problems	**Responsibility Level E** Analysis of an engineering problem means the 'separation into parts possibly with comment and judgement'. *Broadly* means 'not minute or detailed' and 'not kept within narrow limits'.
Broadly defined engineering problems have the following characteristics. They require coherent and detailed engineering knowledge, underpinning the technology area; and one or more of the following: a) Are ill-posed, under- or over-specified, require identification and interpretation into the technology area. b) Encompass systems within complex engineering systems; belong to families of problems which are solved in well-	a) Coherent and detailed engineering knowledge for Engineering Technologists means the problem encountered cannot be solved without the combination of all the relevant detail including engineering principles applicable to the situation. b) The nature of the problem is not immediately obvious, and further investigation to identify and interpret the real nature of the problem is necessary. c) The problem is not easily recognised as part of the larger engineering task, project or operation and may be obscured by the complexity of the larger system.

accepted but innovative ways. *and one or more of:* c) Can be solved by structured analysis techniques d) May be partially outside standards and codes; must provide justification to operate outside. e) Require information from practice area and sources interfacing with practice area that is complex and incomplete. f) Involve a variety of issues which may impose conflicting constraints: technical, engineering and interested or affected parties. *and one or both of:* g) Require judgement in decision-making in practice area, considering interfaces to other areas. h) Have significant consequences which are important in practice area but may extend more widely.	d) It is recognised that the problem can be classified as a falling within a typical solution requiring innovative adaptation to meet the specific situation. e) Solving the problem needs a step-by-step approach adhering to proven logic. f) The standards, codes and documented procedures must be analysed to determine to what extent they are applicable to solve the problem and justification must be given to operate outside these. g) The responsibility lies with the Engineering Technologist to verify that some information received as part of the problem encountered may remain incomplete and solutions to problems may need justified assumptions. h) The problem handled by an Engineering Technologist may be solved by alternatives that are unaffordable, detrimental to the environment, socially unacceptable, not maintainable, not sustainable, etc; the Technologist will have to justify his/her recommendation. i) Practical solutions to problems include knowledge and judgement of the roles displayed by the multi-disciplinary team and impact of own work in the interactive environment. j) Engineering Technologists must realise that their actions might seem to be of local importance only but may develop into significant consequences extending beyond their own ability and practice area.
Assessment criteria: A structured analysis of broadly defined problems typified by the following performances is expected: 1.1 Performed or contributed to defining engineering problems leading to an agreed definition of the problems to be solved. 1.2 Performed or contributed to investigating engineering problems including collecting, organising and evaluating information. 1.3 Performed or contributed to analysis of engineering problems using conceptualisation, justified assumptions, limitations and evaluation of results.	To perform an engineering task an engineering technologist will typically receive an instruction from a senior person (customer) to do a specific task, and must: 1.1 Ensure the instruction is complete, clear and within his/her capability and that the person who issued the instruction agrees with his/her interpretation. 1.2 Ensure the engineering problem and related information are segregated from the bulk of the information, investigated and evaluated. 1.3 Ensure that the instruction and information to do the work is fully understood and complete, including engineering theory needed to understand the task and acceptance criteria, and to carry out and/or check calculations. If needed supplementary information must be gathered, studied and understood. Concepts and assumptions must be justified by engineering theory and calculations, if applicable.

3. Outcomes to be satisfied:	Explanation and Responsibility Level
Range statement: The problem may be a design requirement, an applied research and development requirement or a problematic situation in an existing component, system or process. The problem is one amenable to solution by technologies known to the Candidate. This outcome is concerned with the understanding of a problem: Outcome 2 is concerned with the solution.	Please refer to section 4 of the specific DSTG.
Outcome 2: Design or develop solutions to broadly defined engineering problems	**Responsibility Levels C and D** Design means 'drawing or outline from which something can be made'. Develop means 'come or bring into a state in which it is active or visible'.
Assessment criteria: This outcome is normally demonstrated after a problem analysis as defined in Outcome 1. Working systematically to synthesise a solution to a broadly defined problem, typified by the following performances is expected: 2.1 Designed or developed solutions to broadly defined engineering problems. 2.2 Systematically synthesised solutions and alternative solutions or approaches to the problem by analysing designs against requirements, including costs and impacts on outside parameters. (requirements). 2.3 Drawing up of detailed specification requirements and design documentation for implementation to the satisfaction of the client.	After the task received is fully understood and interpreted, a solution to the problem posed can be developed (designed). To synthesise a solution is 'the combination of separate parts, elements, substances, etc. into a whole or into a system' by the following: 2.1 The development (design) of more than one way to solve an engineering task or problem should always be done, including the costing and impact assessment for each alternative. All the alternatives must meet the requirements set out by the instruction received, and the theoretical calculations to support each alternative must be done and submitted as an attachment. 2.2 The Engineering Technologist will in some cases be unable to support proposals with the complete theoretical calculation to substantiate every aspect and must in these cases refer his / her alternatives to an engineer for scrutiny and support. The alternatives and alternative recommended must be convincingly detailed to win customer support for the alternative recommended. Selection of alternatives might be based on tenders submitted with alternatives deviating from those specified. 2.3 The best complete and final solution selected must be followed up with a detailed technical specification, supporting drawings, bill of quantities, etc. for the execution of work to meet customer requirements.

Range Statement: Solutions are those enabled by the technologies in the Candidate's practice area.	Applying theory to do *broadly defined engineering* work is mostly done in a way that has been used before, probably developed by engineers in the past, and documented in written procedures, specifications, drawings, models, examples, etc. Engineering Technologists must seek approval for any deviation from these established methods but must also initiate and/or participate in the development and revision of these norms.
Outcome 3: Comprehend and apply the knowledge embodied in widely accepted and applied engineering procedures, processes, systems or methodologies and those specific to the jurisdiction in which he/she practices.	**Responsibility Level E** Comprehend means 'to understand fully'. The jurisdiction in which an Engineering Technologist practices is given in section 4 of the specific DSTG.
Assessment criteria: This outcome is normally demonstrated in the course of design, investigation or operations. 3.1 Apply engineering principles, practices, technologies, including the application of BTech or B Eng (Tech) theory in the practice area. 3.2 Indicate working knowledge of areas of practice that interact with practice area to underpin teamwork. 3.3 Apply related knowledge of finance, statutory, safety and management.	Design work for Engineering Technologists is based on BTech theory and is mostly the utilisation and configuration of manufactured components and selected materials and associated novel technology. Engineering Technologists develop and apply codes and procedures in their design work. Investigation would be on broadly defined incidents and condition monitoring, and operations mostly on developing and improving engineering systems and operations. 3.1 Calculations at BTech or B Eng (Tech) theoretical level confirming the correct application and utilisation of equipment, materials and systems listed in section 4 of the specific DSTG must be done on broadly defined activities. 3.2 The understanding of broadly defined procedures and techniques must be based on fundamental mathematical, scientific and engineering knowledge, as part of personal contribution within the engineering team. 3.3 The ability to manage the resources within legal and financial constraints must be evident.
Range Statement: Applicable knowledge includes: a) Technological knowledge that is well-established and applicable to the practice area irrespective of location, supplemented by locally relevant knowledge, for example, established properties of local materials. Emerging technologies are adopted from formulations of others.	a) The specific location of a task to be executed is the most important determining factor in the layout design and utilisation of equipment. A combination of educational knowledge and practical experience must be used to substantiate decisions taken including a comprehensive study of systems, materials, components and projected customer requirements and expectations. New ideas, materials, components

b) A working knowledge of interacting disciplines (engineering and other) to underpin teamwork. c) Jurisdictional knowledge includes legal and regulatory requirements as well as locally relevant codes of practice. As required for practice area, a selection of law of contract, health and safety, environmental, intellectual property, contract administration, quality management, risk management, maintenance management, regulation, project and construction management.	and systems must be investigated, evaluated and applied accompanied by complex theoretical motivation. b) In spite of having a working knowledge of interacting disciplines, Engineering Technologists take responsibility for the multidisciplinary team of specialists like Civil Engineers on structures and roads, Mechanical Engineers on fire protection equipment, architects on buildings, Electrical Engineers on communication equipment, etc. c) Jurisdictional in this instance means 'having the authority', and Engineering Technologists must be aware of and decide on the relevant requirements applicable to each specific project that he/she is responsible for. They are usually appointed as the 'responsible person' for specific projects in terms of the OHS Act.
Group B: Managing Engineering Activities	**Explanation and Responsibility Level**
Outcome 4: Manage part or all of one or more *broadly defined* engineering activities.	**Responsibility Level D** Manage means 'control'.
Assessment criteria: The Candidate is expected to display personal and work process management abilities: 4.1 Managed self, people, work priorities, processes and resources in broadly defined engineering work. 4.2 Role in planning, organising, leading and controlling broadly defined engineering activities evident. 4.3 Knowledge of conditions and operation of contractors and the ability.	In Engineering operations Engineering Technologists are typically given the responsibility to carry out projects. 4.1 Resources are usually subdivided based on availability and controlled by a work breakdown structure and scheduling to meet deadlines. Quality, safety and environment management are important aspects. 4.2 The basic elements of managements must be applied to broadly defined engineering work. 4.3 Depending on the project, Engineering Technologists can be the team leader, a team member, or can supervise appointed contractors. To achieve this, maintenance of relationships is important and must be demonstrated.
Outcome 5: Communicate clearly with others in the course of his/her broadly defined engineering activities.	**Responsibility Level C**

Assessment criteria: Demonstrates effective communication by: 5.1 Ability to write clear, concise, effective technical, legal and editorially correct reports shown. 5.2 Ability to issue clear instructions to stakeholders using appropriate language and communication skills evident. 5.3 Oral presentations made using structure, style, language, visual aids	Refer to Range Statement for Outcome 4 and 5 below. Presentation of point of view mostly occurs in meetings and discussions with immediate supervisor.
Range Statement for Outcomes 4 and 5: Management and communication in *well-defined engineering* involves: a) Planning *broadly defined* activities b) Organising *broadly defined* activities c) Leading *broadly defined* activities d) Controlling *broadly defined* activities.	a) Planning means ‘the arrangement for doing or using something, considered in advance’ b) Organising means ‘put into working order, arrange in a system, make preparations for’ c) Leading means to ‘guide the actions and opinions of, influence, persuade’ d) Controlling means the ‘means of regulating, restraining, keeping in order, check’ Engineering Technologists write specifications for the purchase of materials and/or work to be done, recommendations on tenders received, place orders and variation orders, write work instructions, report on work done, draw, correct and revise drawings, compile test reports, use operation and maintenance manuals to write work procedures, write inspection and audit reports, write commissioning reports, prepare and present motivations for new projects, compile budget reports, report on studies done and calculations carried out, report on customer requirements, report on safety incidents and risk analysis, report on equipment failure, report on proposed system improvement and new techniques, report on cost control, etc.
Group C: Impacts of Engineering Activity	**Explanation and Responsibility Level**
Outcome 6: Recognise the foreseeable social, cultural and environmental effects of *broadly defined* engineering activities generally	**Responsibility level B** Social means ‘people living in communities; of relations between persons and communities’. Cultural means ‘all the arts, beliefs, social institutions, etc. characteristic of a community’. Environmental means ‘surroundings, circumstances, influences’.
Assessment criteria: This outcome is normally displayed in the course of analysis and solution of problems. The candidate typically shows:	6.1 Engineering impacts heavily on the environment, e.g., servitudes, expropriation of land, excavation of trenches with associated inconvenience, borrow pits, dust and obstruction, street and other crossings, power dips and interruptions, visual and noise pollution, malfunctions, oil and other leaks, electrocution of

6.1 Ability to identify interested and affected parties and their expectations in regard to interactions between technical, social, cultural and environmental considerations shown. 6.2 Measures taken to mitigate the negative effects of engineering activities evident.	human beings, detrimental effect on animals and wildlife, dangerous rotating and other machines, demolishing of structures, etc. 6.2 Mitigating measures taken may include environmental impact studies, environmental impact management, community involvement and communication, barricading and warning signs, temporary crossings, alternative supplies (ring feeders and bypass roads), press releases, compensation paid, etc.
Outcome 7: Meet all legal and regulatory requirements and protect the health and safety of persons in the course of his/her broadly defined engineering activities.	**Responsibility level E**
Assessment criteria: 7.1 Identified applicable legal and regulatory requirements including health and safety requirements for the engineering activity. 7.2 Circumstances stated where applicant assisted in or demonstrated awareness of the selection of safe and sustainable materials, components and systems and have identified risk and applied risk management strategies.	7.1 The OHS Act is supplemented by a variety of parliamentary acts, regulations, local authority by-laws, standards and codes of practice. Places of work might have standard procedures, instructions, drawings and operation and maintenance manuals available. These documents, depending on the situation (emergency, breakdown, etc.) are consulted before work is commenced and during the activity. 7.2 It is essential to attend a Risk Management (Assessment) course, and to investigate and study the materials, components and systems used in the workplace. The Engineering Technologist seeks advice from knowledgeable and experienced specialists if the slightest doubt exist that safety and sustainability cannot be guaranteed.
Range Statement for Outcomes 6 and 7: Impacts and regulatory requirements include the following: a) Requirements include both explicit regulated factors and those that arise in the course of particular work. b) Impacts considered extend over the lifecycle of the project and include the consequences of the technologies applied. c) Effects to be considered include direct and indirect, immediate and long-term related to the technology used. d) Safe and sustainable materials, components and systems.	a) The impacts will vary substantially with the location of the task, e.g., the impact of laying a cable or pipe in the main street of town will be entirely different to construction in a rural area. The methods, techniques or procedures will differ accordingly and may be complex. It is identified and studied by the Engineering Technologist before starting the work. b) The Safety Officer and/or the Responsible Person appointed in accordance with the OHS Act usually confirms or checks that the instructions are in line with regulations. The Engineering Technologist is responsible to see that this is done, and if not, establish which regulations apply, and ensure that they are adhered to. Usually, the people working on site are strictly controlled. c) W.r.t. health and safety, but the Engineering Technologist checks that this is done, but may authorise unavoidable deviation after setting conditions for such deviations. Projects are mostly carried out where

e) Regulatory requirements are explicit for the context in general.	contact with the public cannot be avoided, and safety measures like barricading and warning signs must be used and maintained. d) Effects associated with risk management are mostly well known if not obvious, and methods used to address, clearly defined. Risks are mostly associated with elevated structures, subsidence of soil, electrocution of human beings and moving parts on machinery. The Engineering Technologist needs to identify, analyse and manage any long-term risks and develop strategies to solve these by using alternative technologies. e) The safe and sustainable materials, components and systems must be selected and prescribed by the Engineering Technologists or other professional specialists must be consulted. It is the responsibility of the Engineering Technologist to use his/her knowledge and experience to confirm that prescriptions by others are correct and safe. f) Application of regulations associated with the particular aspects of the project must be carefully identified and controlled by the Engineering Technologist.
Group D: Exercise judgment, take responsibility, and act ethically	**Explanation and Responsibility Level**
Outcome 8: Conduct engineering activities ethically.	**Responsibility level E** Ethically means 'science of morals; moral soundness'. Moral means 'moral habits; standards of behaviour; principles of right and wrong'.
Assessment Criteria: Sensitivity to ethical issues and the adoption of a systematic approach to resolving these issues is expected, typified by: 8.1 Conversance and operation in compliance with ECSA's Rules of Conduct for registered persons confirmed 8.2 How ethical problems and affected parties were identified, and the best solution to resolve the problem selected.	Systematic means 'methodical; based on a system'. 8.1 ECSA's Code of Conduct, as per ECSA's website, is known and adhered to. 8.2 Ethical problems that can occur include tender fraud, payment bribery, alcohol abuse, sexual harassment, absenteeism, favouritism, defamation, fraudulent overtime claims, fraudulent expenses claimed, fraudulent qualifications, misrepresentation of facts, etc.

Outcome 9: Exercise sound judgement in the course of *broadly defined* engineering activities	**Responsibility level E** Judgement means 'good sense: ability to judge'.
Assessment criteria: Judgement is displayed by the following performance: 9.1 Judgement exercised in arriving at a conclusion within the application of technologies and their interrelationship to other disciplines and technologies. 9.2 Factors taken into consideration given, bearing in mind, risk, consequences in technology application and affected parties.	9.1 The extent of a project given to a junior Engineering Technologist is characterised by the several broadly defined and a few well-defined factors and their resulting interdependence. He/she will seek advice if educational and/or experiential limitations are exceeded. 9.2 Taking risky decisions will lead to equipment failure, excessive installation and maintenance cost, damage to persons and property, etc. Evaluation includes engineering calculations to substantiate decisions taken and assumptions made.
Range Statement for Outcomes 8 and 9*: Judgement* in decision-making involves: a) taking several risk factors into account 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 where the Engineering Technologist uses standard procedures, codes of practice, specifications, etc, but develops variations and completely unique standards when needed. Judgement must be displayed to identify any activity falling inside the broadly defined range, as defined above: a) Getting the work done in spite of numerous risk factors needs good judgement and substantiated decision-making. b) Consequences are part of the project e.g., extra cost due to unforeseen conditions, incompetent contractors, long-term environmental damage, etc. c) Interested and affected parties with defined needs that may be in conflict, e.g., need for a service irrespective of environmental damage, local traditions and preferences, etc. needs sound management and judgement.
Outcome 10: Be responsible for making decisions on part or all of all of one or more *broadly defined* engineering activities	**Responsibility level E** Responsible means 'legally or morally liable for carrying out a duty; for the care of something or somebody in a position where one may be blamed for loss, failure, etc.'.
Assessment criteria: Responsibility is displayed by the following performance: 10.1 Engineering, social, environment and sustainable development taken into consideration in discharging responsibilities for significant parts of one or more activities.	10.1 All interrelated factors taken considered are indicative of professional responsibility accepted working on broadly defined activities. 10.2 The Engineering Technologist does not operate on tasks at a higher level than broadly defined and consults professionals at engineer level if elements of the project to be done are beyond his/her education and experience, e.g., power system stability.

10.2 Advice sought from a responsible authority on matters outside your area of competence. 10.3 Academic knowledge of at least BTech level combined with past experience used in formulating decisions.[1]	10.3 This is in the first instance continuous self-evaluation to ascertain that the task given is done correctly, on time and within budget. Continuous feedback to the originator of the task instruction and corrective action, if necessary, forms an important element. The calculations, for example fault levels, load calculations, losses, etc. are done to ensure that the correct material and components are utilised.
Range Statement: Responsibility must be discharged for significant parts of one or more *broadly defined* engineering activities.	The responsibility is mostly allocated within a team environment with an increasing designation as experience is gathered.
Note 1: Demonstrating responsibility is under supervision of a competent engineering practitioner but is expected to perform as if he/she is in a responsible position.	
Group E: Initial Professional Development (IPD)	**Explanation and Responsibility Level**
Outcome 11: Undertake independent learning activities sufficient to maintain and extend his or her competence.	**Responsibility level D**
Assessment criteria: Self-development managed typically: 11.1 Strategy independently adopted to enhance professional development evident. 11.2 Awareness of philosophy of employer regarding professional development evident.	11.1 If possible, a specific field of the sub-discipline is chosen, available developmental alternatives established, a programme drawn up (in consultation with employer if costs are involved), and options open to expand knowledge into additional fields investigated. 11.2 Record keeping must not be left to the employer or anybody else. The trainee must manage his/her own training independently, taking initiative and being in charge of experiential development towards Engineering Technologist
Range Statement: Professional development involves: a) planning own professional development strategy b) selecting appropriate professional development activities c) recording professional development strategy and activities, while displaying independent learning ability.	a) In most places of work training is seldom organised by a training department. It is up to the Engineering Technologist to manage his/her own experiential development. Engineering Technologists frequently end up in a 'dead-end street' being left behind doing repetitive work. If self-development is not driven by him/herself, success is unlikely. b) Preference must be given to engineering development rather than developing soft skills. c) Developing a learning culture in the workplace environment of the Engineering Technologist is vital to his/her success