ECSA
ENGINEERING COUNCIL OF SOUTH AFRICA

An Effective Regulator Assuring Engineering Excellence

Discipline-specific Training Guide for Registration as a Professional Engineer, Technologist and Technician in Industrial Engineering

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INTRODUCTION

All persons applying for registration as a professional engineer, technologist or technician 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 applicant's/ candidate's discipline.

The *Training and Mentoring Guide for Professional Categories* (document **R-04-T&M-GUIDE-PC**) provides key aspects of training:

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

It is therefore important to standardise the framework for all engineering disciplines to ensure that all ECSA registration categories are aligned.

DEFINITIONS

Applicant: A person applying to the ECSA for registration in any of the categories according to Section 18 of the Engineering Profession Act, 46 of 2000.

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 registered with ECSA in a candidate category of registration.

Complex engineering work is characterised by the following:

- Scope of activities may encompass entire complex engineering systems or complex subsystems.
- A context that is complex and varying, is multidisciplinary, requires teamwork, is unpredictable and may need to be identified.
- It requires diverse and significant resources including people, money, equipment, materials and technologies.
- Significant interactions exist among wide-ranging or conflicting technical, engineering or other issues.
- It is constrained by time, finance, infrastructure, resources, facilities, standards and codes, and applicable laws.
- It has significant risks and consequences in a range of contexts.

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

Engineering problem means problem that requires the application of engineering theories, principles, knowledge and skills to find a solution. These problems typically arise in various fields of engineering. Engineering problems can range from designing and building structures, developing new technologies or products, optimising processes and/or systems, improving efficiency, solving complex mathematical equations, troubleshooting technical issues and addressing safety concerns, among many others. The goal of solving an engineering problem is to create innovative and practical solutions that meet specific requirements, adhere to applicable regulations and standards and utilise techniques such as cost benefit analysis, risk analysis and technical evaluations to arrive at a cost-effective and sustainable solution.

Engineering science means a branch of science that applies scientific principles and methods to solve engineering problems. It involves the study and application of various scientific disciplines, such as physics, chemistry, mathematics and materials science, to design and develop innovative solutions to address engineering problems. Engineering science focuses on understanding the fundamental principles underlying engineering systems and processes, and uses this knowledge to analyse, predict and optimise the behaviour and performance of engineering systems. It provides the theoretical foundation for various engineering disciplines and plays a crucial role in advancing technology and driving innovation in engineering

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 refers to the evaluation and optimisation of various aspects of a system or product to ensure its overall efficiency, effectiveness, and reliability. It involves considering multiple performance factors, such as functionality, safety, durability, maintainability, cost-effectiveness and environmental impact, and integrating them into a cohesive design. It considers the interactions and trade-offs among different components, subsystems and functions within a system. It aims to achieve a balance between conflicting requirements and constraints to create a well-rounded and high-performing solution. This holistic approach helps ensure that all aspects of the design work together harmoniously, resulting in a successful and optimised engineering solution.

Level descriptor means a measure of performance demands at which outcomes must be demonstrated.

Management of engineering works or activities refers to the process of planning, organising, coordinating and controlling various engineering projects or tasks. It involves overseeing the activities of engineers and other personnel involved in the design, development, construction and maintenance of engineering projects for the successful execution of engineering projects, ensuring that they are completed on time, within budget and to the desired quality standards.

Key responsibilities of engineering management may include the following:

- **Planning**: Defining project objectives, scope and deliverables, and creating a detailed plan to achieve them.
- **Resource management**: Determining the required resources, such as personnel, equipment and materials, and allocating them appropriately to ensure smooth execution of engineering work.
- **Team coordination**: Managing and leading a team involved in the activities of performing engineering work and ensuring effective communication, collaboration and coordination among team members.
- **Risk management**: Identifying potential risks and developing strategies to mitigate them.
- **Quality control**: Implementing quality assurance processes to ensure that engineering works meet the required standards and specifications.
- **Budget and cost control**: Monitoring project expenses, tracking costs and ensuring that projects are completed within the allocated budget.
- **Stakeholder management**: Engaging with clients, contractors, suppliers and other stakeholders to address their concerns, manage expectations and maintain positive relationships.
- **Executing engineering work**: Direct and control engineering processes and systems, including commissioning, operating and decommissioning equipment, while maintaining safety at all times, and ensuring timeous completion.

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 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.

Well-defined engineering problems means problems composed of inter-related conditions and requiring underpinning methods, procedures, and techniques to create a solution within a set of originally well-defined circumstances.

ABBREVIATIONS

BEng Tech	Bachelor of Engineering Technology
BEng	Bachelor of Engineering
BTech (Eng)	Bachelor of Technology Engineering
BScEng	Bachelor of Science in Engineering
BDEA	Broadly defined engineering activities
C&U	Commitment and Undertaking
CPD	Continuing professional development
DSTG	Discipline-specific Training Guide
ECSA	Engineering Council of South Africa
IDoEW	Identification of Engineering Work
IPD	Initial Professional Development
N.Dip	National Diploma
NQF	National Qualification Framework
OFO	Organising Framework for Occupations
PCE	Professional Certificated Engineer
Pr Eng Tech	Professional Engineering Technologist
PGDip	Post-graduate Diploma
PE	Professional Engineer
PN	Professional Engineering Technician
PT	Professional Engineering Technologist
TES	Training and Experience Summary

TERs	Training and Experience Reports

BACKGROUND

Figure 1 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.

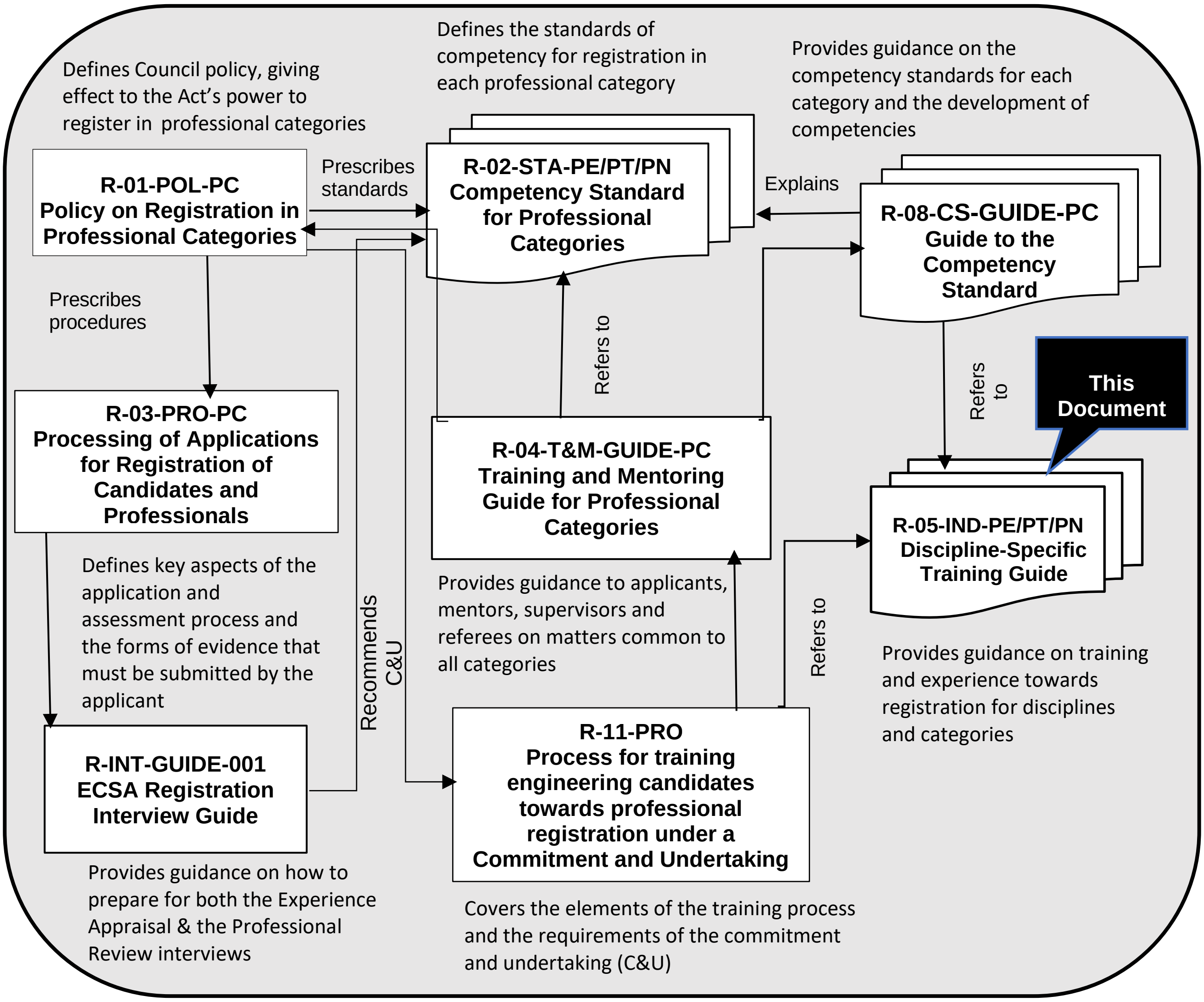

Figure 1: Documents defining the ECSA registration system

1. PURPOSE OF THIS DOCUMENT

All persons applying for registration as engineering professionals are expected to demonstrate the competencies specified in document **R-02-STA-PE/PT/PN**: *Competency Standard for Registration in Professional Categories as Professional Engineer, Technologist and Technician* through work performed at the prescribed level of responsibility, irrespective of the discipline.

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 in Professional Categories* (document **R-08-CS-GUIDE-PE/PT/PN**) for applicant industrial engineers, technologists and technicians or any other person who intends to register as a professional with the ECSA in the respective discipline.

This document must be read in conjunction with the following documents:

- *Policy on Registration in Candidate and Professional Categories* (document **R-01-POL-PC**)
- *Processing of Applications for Registration of Candidates and Professionals* (document **R-03-PRO-PC**)
- *Training and Mentoring Guide for Professional Categories* (document **R-04-T&M-GUIDE-PC**).

2. AUDIENCE

This *Discipline-specific Training Guide* (DSTG) provides guidance and support to those interested in applying for registration to become professionals through ECSA in the field of Industrial Engineering. Additionally, supervisors and mentors of these aspiring applicants can also benefit from this guide, as it offers best practice and elements necessary for a comprehensive training and experience programme.

This guide applies to persons who:

- are registered as a candidate engineer, technologist, or technician and/or has embarked on a process of training under a registered mentor guiding the professional development process at each stage
- are not registered as a candidate, but deem it fit based on experience specified in this document to apply to become a professional
- hold an ECSA accredited qualification or an acceptable combination of accredited qualifications prescribed for the category
- have met the minimum education in a specific category through ECSA educational qualification evaluation or assessment
- have qualifications recognised by the Washington, Sydney and Dublin Accords for which the ECSA is a signatory thereof
- hold a qualification or combination of qualifications recognised under an international academic agreement relevant to the category; or
- hold a qualification or a combination of qualifications that has been determined on a case-by-case evaluation to satisfy criteria for substantial equivalence to an accredited qualification for the category by virtue of:
    - the qualifications being awarded in a jurisdiction or a quality assurance system by the ECSA; or
    - examination of detailed documentation on the qualifications reflecting substantial equivalence.

2.1 Persons registered with ECSA as a candidate

Candidate engineering practitioners refer to persons registered with the ECSA after completing the relevant engineering undergraduate programme as accredited or substantially assessed to be equivalent by the ECSA. Training and development can be done under a Commitment and Undertaking (C&U) candidacy programme according to document **R-11-PRO-PC** or through a training academy's programme as outlined in document **A-01-POL**.

The training under a C&U or through a training academy is structured to align with the ECSA standard competency outcomes for the candidate's benefit. The professional mentor, supervisor, coach and the candidate must ensure that the training covers all developmental aspects aligned with the competency outcomes required for registration as a professional. Mature applicants for registration may apply the guide retrospectively to identify possible gaps in their development.

2.2 Persons not registered with ECSA as a candidate

Individuals who meet the qualifications and competence requirements outlined in **R-02-STA-PE/PT/PN** can apply for professional registration without going through the candidate route. However, it is still essential for these individuals to have mentorship and supervision to ensure effective development towards meeting the competency requirements for professional registration. If the employer does not offer C&U, the aspiring applicant should seek mentorship. If no internal mentor is available, an external mentor can be sought. The individual can consult the Voluntary Association (VA) for the discipline to assist in locating an external mentor. The mentor should stay updated on the development process and the ECSA registration requirements.

This document is intended for applicants/candidates undergoing training and gaining experience in preparation for registration. Applicants who have not had mentorship are advised to seek the guidance of an experienced mentor (internal or external) when preparing their registration applications.

The competencies, as defined by standard **R-08-CS-GUIDE-PE/PT/PN** are independent of the context in which the applicant has training and experience. This document therefore provides guidelines for individuals with development paths that span industry, academia, research and specialist domains.

3. TYPE OF ENGINEERING WORK

Engineering professionals are responsible for ensuring that the work is carried out competently and in accordance with the relevant engineering standards and regulations. In terms of Section 27(1) of the Engineering Profession Act, 46 of 2000, the Council must draw up a Code of

Conduct for Registered Persons and may draw up a Code of Practice in consultation with the Council for the Built Environment, VAs and registered persons

3.1 Industrial Engineering Professionals Organising Framework for Occupations

Industrial engineering is concerned with the design, development, installation, operation and maintenance of processes and systems. It involves the systematic use of processes (both industrial and service) to convert inputs into outputs. It interfaces with many engineering disciplines, including mechanical, electrical, civil, construction and materials engineering, among others. Industrial engineering professionals work in various industries to perform tasks such as the following:

- Design and development of new production and service systems and products or modifying existing ones.
- Research and development: Continuously seeking innovative solutions to engineering problems using new technologies and scientific advancements.

Industrial engineering practitioners have a strong understanding of mathematics, science and engineering principles with excellent problem-solving skills and attention to detail. In addition, industrial engineering professionals provide expertise and advice on the aspects of specific materials, products or processes. They may work in all areas where inputs are transformed into outputs.

The levels of engineering problems for the different categories of registration in industrial engineering are outlined as follows:

- Professional Engineer: Solves complex engineering problems and performs advanced engineering activities.
- Professional Engineering Technologist: Solves broadly defined engineering problems and performs specialised engineering activities.
- Professional Engineering Technician: Solves well-defined engineering problems and performs technical engineering activities.

The characteristics and details of each level descriptor can be found in the *Competency Standard for Registration*, document **R-02-STA-PE/PT/PN**, which defines the competencies required for each category.

3.2 Typical work that industrial engineering professionals undertake

Industrial engineering professionals are employed in a wide range of sectors and industries. Their expertise is in demand due to factors such as globalisation, technological advancements, environmental considerations, government policies and market demands for sustainable products and services.

Engineering professionals can be involved in various types of work. Some common types of engineering work include the following:

- **Research and development:** All areas of systems and processes at the different levels of performance.
- **Process design and development:** Designing processes and systems for manufacturing products while meeting targeted efficiencies.
- **Operations and management:** Developing operating procedures to be employed during design and operating phases, including start-up, shutdown and emergency procedures, management of resources and production reporting.
- **Quality management:** Developing quality assurance and process control systems to manage and optimise processes.
- **Consulting, projects and entrepreneurship:** Managing projects, including management of resources and internal and external service providers to ensure adherence to project timelines and budgets.
- **Supply chain and logistics:** Involvement in design and management of systems to create value for all participants in the supply chain. This includes processes from product design, to sourcing, manufacturing, distribution and customer service, network design, optimisation, information sharing, detailed and long-term planning.

4. DEVELOPING ENGINEERING COMPETENCIES

As the discipline of industrial engineering offers numerous routes, in different sectors and industries, this document underscores the crucial competencies required for individuals aspiring to register as industrial engineering professionals. These competencies, regardless of the work sector, are essential for success in the field. The 11 outcomes specified in document **R-08-CS-GUIDE-PE/PT/PN** are the pillars of these competencies. In some instances, these competencies may not be readily available within an individual's current role, project or position. In such cases, secondment to another department or employer or seeking guidance from an external mentor is recommended.

Progression throughout the candidacy period presented in document **R-04-T&M-GUIDE-PC** and **Table 1** (see Section 5) refers to the gradual increase in the degree of responsibility (DoR) applicants are exposed to during their professional training. The required level of responsibility is included in brackets under each sub-heading for ease of reference.

Applicants or mentors who are unsure whether the engineering work they are considering is complex, broadly defined or well-defined, should refer to document **R-02-STA-PE/PT/PN**, the *Competency Standard for Registration*. Document **R-02-STA-PE/PT/PN** provides detailed information about the characteristics and requirements of each level descriptor, defining the competencies needed for each category.

This balance of this section provides a set of guidelines for each competency (as per the competency standard) for each registration category.

4.1 Training for registration as a professional engineer

4.1.1 Outcome 1: Define, investigate and analyse complex engineering problems (Responsibility Level E)

As per the ECSA outcomes, engineers are expected to be able to define, investigate and analyse complex engineering problems. This includes:

- defining the engineering problems and the procedures for solving the problems

- investigating and evaluating pertinent information and identifying systems and sub-systems of complex problems including collecting, organising and evaluating information from all applicable sources including in-situ investigations where appropriate
- analysing relevant assumptions, inputs and required outputs of complex engineering problems.

The complex engineering problem may be defined as a design requirement, an applied research and development requirement or a problematic situation in an existing component, system or process. The characteristics of a complex problem are included in the competency standard and the definitions section at the start of this document.

In an industrial engineering context, suitable problems could, as examples, include operational problems in a production, manufacturing or service context. They could be problems associated with the individual's own place of work or work that is done for a client as part of a consulting agreement. Problems could also extend to processes and systems in a virtual information technology environment or could involve frameworks and thinking for strategic-level projects.

For this outcome, individuals are advised to present evidence of the definition, investigation and analysis phases of the problem-solving process and to articulate, in detail, how each of these steps was conducted.

4.1.2 Outcome 2: Design or develop solutions to complex engineering problems (Responsibility Levels C and D)

The engineering design or development of solutions to complex engineering problems includes the identification and/or development of clear requirements or needs. Based on these needs, an appropriate approach for the design process will be chosen to resolve the complex problem. The preferred option or way forward is influenced by factors that best fit the solution, taking into consideration cost, practicability, innovation and any impact outside the requirements. The design process, depending on the problem tackled and the chosen approach, could include the following:

- The development (design) of more than one way to solve a complex engineering problem taking into consideration chosen criteria for evaluating the best possible solution for the context.
- Analysis and theoretical calculations to support the proposed and chosen solutions. Where solutions cannot be completely substantiated with theoretical calculations or simulated work, potential limitations or risks of the developed solutions should be presented. A complete and final solution should be presented including sufficient detail to show that the complex problem was solved and/or that the requirements/needs were met.

4.1.3 Outcome 3: Comprehend and apply advanced and local knowledge of the widely applied principles underpinning good practice that is specific to the jurisdiction in which the Engineer practices. (Responsibility Level E)

Evidence should be provided that individuals have comprehended and mastered the engineering principles and technologies for their practice areas and that they apply first-principle analytical thinking in demonstrating this competency for associated complex problems. This includes the application of fundamental principles, practices, sound testable assumptions or previously encountered techniques applicants have used to solve the problem. The theoretical knowledge gained from completing a BEng/BSc degree should also be applied in addition to knowledge of applicable engineering standards, codes of practice, legislation and regulations.

4.1.4 Outcome 4: Manage part or all of one or more complex engineering activities (Responsibility Level D)

In engineering operations, Engineers are typically given the responsibility to carry out management activities. This could involve:

- Planning, coordinating and overseeing engineering projects to ensure they have defined objectives and scope, and are completed on time, within budget and to the required quality standards and agreed objectives.
- Organising resources, scheduling activities, managing risks and impact and communicating with stakeholders for projects and/or operations associated with service

or production activities. When providing evidence to demonstrate competence for this outcome, the following should be noted:

- 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.
- The basic elements of management must be applied to complex engineering work.
- Depending on the context, engineers can be team leaders or team members, or they can supervise appointed contractors. To achieve this, maintenance of all stakeholder relationships is important and must be demonstrated.

- industrial engineers bring technical expertise to projects/activities, interfacing with other disciplines to ensure the project meets the intended design objectives.

Industrial engineering professionals typically work in the following areas that require engineering project management to be demonstrated:

- System, process or product design or re-design/improvement to achieve a particular desired result or outcomes.
- Operation, maintenance and support of systems, infrastructure and processes
- Implementation or installation, testing and commissioning of infrastructure, processes or system to achieve the desired result or outcomes
- Change management associated with system, infrastructure or process changes.

4.1.5 Outcome 5: Communicate clearly using multiple media and collaborate inclusively with a broad range of stakeholders in the course of engineering activities. (Responsibility Level C)

Industrial engineers are expected to communicate professionally by using the effective exchange of information among other engineers/disciplines, stakeholders and teams to ensure clarity and efficiency. This entails demonstrating the ability to write clear, concise, effective and technically, legally and editorially correct reports using a structure and style that meet communication objectives and user/audience requirements.

Engineering professionals must communicate effectively for several reasons:

- **Collaboration:** Engineering professionals work in multidisciplinary teams including other engineering disciplines, experts and other discipline specialists, technologists/technicians and management, so clear communication ensures that everyone understands their roles and responsibilities.
- **Safety:** Engineering professionals are often involved in work that can have an impact on the safety of individuals. Effective communication is critical for conveying safety protocols and emergency procedures to prevent accidents and ensure a safe working environment.
- **Problem solving:** Engineering professionals frequently need to explain complex problems and solutions to colleagues, clients and stakeholders. Effective communication helps in accurately conveying technical information and facilitating collaborative problem-solving.
- **Documentation**: Clear and precise documentation of strategies, systems, processes, procedures and analysis is vital for maintaining records, ensuring reproducibility and complying with regulations and standards.
- **Client relations**: Engineering professionals often interact with clients and non-engineering stakeholders. Effective communication helps to explain technical concepts in an understandable way, building trust and ensuring client satisfaction.
- **Project management:** Successful project management requires clear communication to coordinate tasks, timelines and resources, as well as to provide updates and reports to stakeholders.
- **Innovation and knowledge sharing**: Sharing knowledge and innovative ideas effectively can lead to better collaboration and advancements within the field. Good communication skills facilitate dissemination of new research and best practices.
- **Professional growth**: Effective communication enhances the engineering professional's ability to lead teams, present at conferences and publish research, contributing to their professional development and career advancement.

4.1.6 Outcome 6: Recognise the reasonably foreseeable economic, social, cultural, and environmental effects of complex engineering activities seeking to achieve sustainability. (Responsibility Level B)

Complex engineering problems may have an impact on the social, environmental and cultural elements of the broader context in which the engineering activities are taking place. Applicants should be able to recognise and address the impact of their complex engineering activities on these elements and where there are negative effects, provide mitigating measures.

- **Social effects** encompass all issues that affect people and their livelihoods, directly or indirectly. Engineering activities may affect people's way of life, their political system, their health and well-being, and their personal and property rights.
- **Environmental effects** include the effects on people's environment (i.e., air and water quality, dust and noise exposure and adequacy of sanitation) and the effects on large ecosystems. These may include disruption of ecosystems, disruption of fauna and flora, and increased land temperatures.
- **Cultural effects** include people's customary beliefs, religion, language and norms.

Industrial engineering activities in all industries can have a significant impact on work conditions and practices and labour practices, which can all have social effects and affect individuals' ability to exercise cultural rights. Industrial engineering work in most industries can also have a significant impact on the environment and industrial engineers have a responsibility to reduce and minimise environmental impact wherever possible.

Risk and impact mitigation must include the probability and impact of all the risks connected with the project. Mitigating measures taken may include environmental impact studies, environmental impact management, community involvement and communication, barricading and warning signs, and press releases.

4.1.7 Outcome 7: Meet all legal and regulatory requirements and protect the health and safety of persons during all complex engineering activities. (Responsibility Level E)

The gazetted *Identification of Engineering Work* (IDoEW) promotes safety and the protection of the public and the environment by ensuring that registered professionals in the different categories of registration have demonstrated the required competence and academic qualifications and have performed engineering work or have taken responsibility for engineering work performed per category. Engineering professionals are expected to have a working knowledge of the related regulations and Acts and to be able to demonstrate how this legislation affects their complex engineering activities at Responsibility Level E (performing).

Applicants are expected to have a basic knowledge of the relevant Acts and to investigate whether any Acts are applicable to their particular work environment. 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.

Due to the broad nature of industrial engineering, the applicable legislation varies. The following list includes legislation that is more frequently encountered by industrial engineering professions but it is not meant to be exhaustive:

- Construction Industry Development Board Act, 38 of 2000
- Construction Regulations 2014
- Employment Equity Act, 55 of 1998
- Engineering Profession Act, 46 of 2000
- Hazardous Substance Act, 5 of 1973
- Mine Health and Safety Act, 29 of 1996
- Minerals and Energy Acts, (e.g., Mineral and Petroleum Act, 28 of 2002)
- National Building Regulations and Building Standards Act, 103 of 1977
- National Environmental Management Act, 107 of 1998
- National Water Act, 36 of 1998
- Occupational Health and Safety Act, 85 of 1993
- Project and Construction Management Professions Act, 48 of 2000
- Protection of Personal Information Act, 2013
- Specific work instructions, standards, and/or specifications of the enterprise
- Any other relevant, specialised legislation codes and standards applicable to the relevant industry of practice.

Some of the listed Acts are used in daily operations and failure to comply with these Acts can result in the operations being stopped or the responsible individuals in the company being subject to legal consequences, such as imprisonment or fines.

When providing evidence for competence against this outcome, applicants are advised to include specific details of the regulations and legislation they have used and the context in which it was used.

4.1.8 Outcome 8: Conduct engineering activities ethically (Responsibility Level E)

Applicant engineering professionals are involved in engineering activities that can encompass many ethical problems. These include, as examples, tender fraud and corruption, bribery payments, favouritism, defamation, alcohol abuse, sexual harassment, absenteeism, fraudulent overtime claims, fraudulent expenses claimed, fraudulent qualifications, misrepresentation of facts and overstating of compensation. Applicant engineering professionals are expected to identify ethical problems, affected parties and the best solution to resolve the problem at Responsibility Level E (i.e., performing).

Furthermore, most engineering projects are multidisciplinary in nature, with many role players performing speciality work that could result in individuals conducting engineering activities for which they have no education, training or competency, which creates ethical conflicts.

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.

It is imperative that applicant engineers familiarise themselves with ECSA's *Rules of Conduct*, a listing of ethics regarding integrity and competency. In addition, applicants should have knowledge of the ECSA *Code of Conduct* with an understanding of how it relates to their area of practice. Attention to the health and safety of persons and the areas of competency, truth, integrity and honest behaviour is of paramount importance.

4.1.9 Outcome 9: Exercise sound judgement by evaluating the outcomes, impacts and alternatives in the course of complex engineering activities. (Responsibility Level E)

Exercising engineering sound judgment involves making decisions and taking actions based on a combination of technical expertise, ethical considerations, practical experience and critical thinking skills. Engineers are expected to exercise sound judgement during engineering activities by considering several factors based on consequences they foresee and the regulatory requirements, such as policies and standards.

Sound judgement should be applied in the course of engineering activities, including but not limited to:

- the evaluation of engineering work against criteria
- conducting engineering work amidst numerous risk factors
- development and delivery of engineering solutions where there are several conflicting requirements and/or stakeholder needs.

Applicants are therefore expected to demonstrate this competency by evaluating a situation presented to them in the absence of full evidence. The requirement is that engineers thoroughly investigate, analyse and identify several factors and understand the risks associated with certain decisions.

4.1.10 Outcome 10: Be responsible for making decisions on part or all of complex engineering activities. (Responsibility Level E)

Having the contextual knowledge and operating on Level E of the Degree of Responsibility (DoR) affords applicants an opportunity to demonstrate how they were able to make decisions and take on responsibility for significant parts of one or more complex engineering activities. Seeking advice or guidance from the relevant superiors assists applicants in making informed decisions and assuming responsibility for those decisions.

Responsible means that the engineering professional is legally or morally liable for carrying out their duties where failure to do so can result in loss, failure, errors or unmitigated negative consequences.

4.1.11 Outcome 11: Undertake sufficient professional development activities to maintain, extend competence and enhance the ability to adapt to emerging technologies and the ever-changing nature of work (Responsibility Level D)

Professional development is essential for engineers to continuously improve their skills, advance their careers, contribute to innovation and uphold the highest standards of professionalism and integrity in their practice. Professional development is also important as the context and advancement of technology means that additional knowledge and skills are always required. It is important for applicants to draw up a continuous professional development (CPD) plan – in consultation with the employer. Professional development requires a commitment to lifelong learning and engineering professionals should independently and proactively manage this.

Professional development activities could include:

- completion of higher degrees
- online training courses and webinars
- in-person training courses and workshops
- attendance of relevant conferences.

Professional development could include technical development in the primary discipline or other technical disciplines or development in complementary disciplines such as finance, teaching pedagogies or marketing.

Training and courses that do not carry official CPD points, such as professional development activities offered within the employer organisation or by other organisations or institutions locally or internationally, are also appropriate.

4.2 Error! Reference source not found.**Training for registration as a professional engineering technologist**

4.2.1 Outcome 1: Define, investigate and analyse broadly defined engineering problems (Responsibility Level E)

When individuals seek to register as professional industrial engineering technologists, one of the key competencies they need to demonstrate is the ability to define, investigate and analyse broadly defined engineering problems. This requirement means applicants should be able to effectively identify and understand engineering problems and develop a clear understanding of what needs to be solved.

Defining engineering problems involves identifying the engineering problem to be solved and specifying clear goals or criteria that the final product or system must meet. This process must lead to an agreed definition of the problem to be solved.

Applicants are expected to be exposed to the technical investigation process of broadly defined engineering systems, plant or equipment and product, service or process failure. The nature of the engineering problem is ill-posed and it requires identification and refinement into the technological area under investigation. Investigating a broadly defined engineering problem cannot be a desktop exercise because it requires in-depth knowledge and history of the system, evidence of other attempted or successful solutions, and determination of how far-reaching the solution to the problem may be.

Analysis of a broadly defined engineering problem means the “separation into parts possibly with comment and judgement” and broadly means, “not minute or detailed” and “not kept within narrow limits”.

Coherent and detailed engineering knowledge for Engineering Technologists means the following

- The encountered problem cannot be solved without all the relevant detail, including the engineering principles that are applicable to the situation.
- The nature of the problem is not immediately obvious and further investigation to identify and interpret the real nature of the problem is necessary.
- 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.
- There is recognition that the problem can be classified as falling within a typical solution requiring innovative adaptation to meet the specific situation.
- The solution to the problem requires a step-by-step approach that adheres to proven logic.
- The standards, codes, and documented procedures must be analysed to determine the extent to which they are applicable in solving the problem, and justification must be given to operate outside these.
- The responsibility lies with the Engineering Technologist to verify that some information received as part of the encountered problem may remain incomplete, and solutions to problems may need justified assumptions.
- The problem handled by an Engineering Technologist may be solved by alternatives that are unaffordable, detrimental to the environment, socially unacceptable, not maintainable, and not sustainable, etc., and the Technologist will have to justify his/her recommendation.
- Practical solutions to problems include knowledge and judgement of the roles displayed by the multidisciplinary team and the impact of one’s own work in the interactive environment.

Engineering Technologists must realise that their actions may seem to be of local importance only but may develop into significant consequences that extend beyond their ability and practise area broadly-defined.

To define the problem, Technologists work with engineers, scientists and other stakeholders to understand the objectives, constraints and desired outcomes. Applicants then gather information about the existing manufacturing process, identify potential bottlenecks or inefficiencies, and define the problem statement.

Next, Technologists investigate the problem by collecting and analysing relevant data from various sources. This step could involve conducting experiments, analysing production data, reviewing literature and consulting with other subject matter experts. Applicants then organise and evaluate the information to gain insights into the root causes of the problem and potential areas for improvement.

Finally, Technologists analyse the problem using their theoretical technical knowledge and expertise. Applicants/Candidates conceptualise potential solutions, make justified assumptions, consider any limitations or constraints and evaluate the results of their analysis. This step could involve using mathematical models, simulation software or other engineering tools to assess the feasibility and effectiveness of different approaches.

4.2.2 Outcome 2: Design or develop solutions to broadly-defined engineering problems (Responsibility Levels C and D)

Designing or developing solutions to broadly-defined engineering problems refers to the ability to come up with innovative and practical solutions to solve engineering problems. This step involves using appropriate theories and information technologies, considering the impacts and sustainability of the solution and considering stakeholders' views. Engineering problems are solved by applying standards, codes, and procedures, and justification for operating outside these standards and codes must be provided. Applicants are expected to be able to demonstrate different options for developing a solution. The solution should be supported by engineering principles and concepts. Applicants should strive to solve engineering problems by demonstrating a step-by-step approach that adheres to proven logic. Before a solution is selected, applicants should indicate alternatives or approaches towards solving the problem that have been tested against factors that encompass but are not limited to costs, engineering parameters, and sustainability and environmental considerations. There is always more than one solution to solving a broadly-defined engineering problem.

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”. After the received task is fully understood and interpreted, a solution to the posed problem can be developed (designed). To synthesise a solution means “the combination of separate parts, elements, substances, etc. into a whole or into a system” by the following:

- 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 instructions received, and the theoretical calculations to support each alternative must be done and submitted as an attachment.
- The Engineering Technologist will, in some cases, not be able to support proposals with the complete theoretical calculation to substantiate every aspect and must, in these cases, refer his/her alternatives to an Engineer for scrutiny and support. The alternatives and particularly the recommended alternative must be convincingly detailed to win customer support. The selection of alternatives might be based on tenders submitted with alternatives that deviate from those specified. Technologists should be able to systematically analyse designs, correlate them with requirements and consider the wide-ranging impacts and costs. Applicants/Candidates should also be able to create detailed specification requirements and design documentation that meets a client's satisfaction. The solutions should be based on accepted methods, techniques or procedures based on the theory of practice, and they should consider sustainability.

4.2.3 Outcome 3: Comprehend and apply knowledge that is embodied in established engineering practices that is specific to the jurisdiction in which the Engineering Technician practices. (Responsibility Level E)

Contextual knowledge refers to applying engineering procedures, processes, systems and methodologies specific to Industrial Engineering. For all successful solutions and interventions, the applicant needs to consider the context in which they exist. The integrative nature of Industrial and Systems Engineering specialised knowledge and variety of skills and the requirement of satisfying multiple objectives simultaneously place added emphasis on the understanding and considerations of context. Contextual knowledge includes, but is not limited to the following:

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

In solving broadly-defined engineering problems, Engineering Technologists must comprehend and apply knowledge and accepted engineering procedures, systems, and methodologies. Applicants should be able to understand and demonstrate that during engineering problem-solving,

- they have applied engineering principles, practices, and technologies, including the application of BTech or BEngTech theory in the practise area;
- they have indicated a working knowledge of areas of practice that interact with the practise area to underpin teamwork; and
- they have applied related knowledge of finance, statutes, safety, and management. having a working knowledge of areas of practice that interact with Industrial Engineering to underpin teamwork is important as Industrial Engineering technologists can often work closely with other professionals, such as mechanical and electrical professionals, to design, operate and optimise processes. Understanding the principles and practices of these related disciplines is essential for effective collaboration.

Demonstrating knowledge and application of engineering standards, codes of practice, legislation, regulations and finance in the Industrial Engineering practice area forms part of contextual knowledge. This activity could entail understanding and adhering to safety regulations, environmental regulations, building codes and industry-specific standards for equipment and processes. It also includes being aware of financial considerations, such as cost estimation, budgeting and project management.

4.2.4 Outcome 4: Manage part or all of one or more complex engineering activities (Responsibility Level D)

Engineering project management involves managing part or all of one or more broadly-defined engineering activities. For this outcome, Industrial Engineering technologists should be responsible for planning, organising, leading and controlling engineering activities to achieve desired results. Applicants/Candidates are required to effectively manage and contribute to the successful completion of engineering activities in their practice area.

Typically, the role of the engineering project manager would involve the following:

- **Managing self, people, work priorities, processes and resources:** Engineering technologists need to effectively manage their own time and prioritise tasks. Additionally, they would be responsible for coordinating and leading a team of engineers and technicians involved in the project. This task would require them to allocate resources efficiently and ensure everyone works towards the project goals.
- **Planning and organising broadly-defined engineering activities:** This entails developing a detailed project plan, including timelines, milestones and deliverables. This plan outlines the engineering activities required to create and optimise the drug production process. Industrial Engineering technologists need to organise resources, such as equipment, materials and personnel, to ensure smooth execution of the plan.
- **Leading and controlling engineering activities:** As project managers, Industrial engineering technologists lead and guide the team members. They monitor progress, identify potential issues or risks and take necessary actions to keep the project on track. This task may involve making decisions, resolving conflicts and adjusting the project plan.
- **Managing contracts and professional relationships:** This task involves managing contracts with suppliers, contractors and other project stakeholders. It includes negotiating terms, ensuring compliance and maintaining positive professional relationships to facilitate smooth project execution.

4.2.5 Outcome 5: Communicate clearly using multiple media and collaborate inclusively with a broad range of stakeholders in the course of engineering activities. (Responsibility Level C)

Industrial Engineering technologists are required to demonstrate professional communication. Professional communication means effectively communicating with a wide range of stakeholders in various media. For a person seeking to register as a Professional Industrial Engineering Technologist, communication involves the following:

- Writing clear, concise, effective and compelling documentation.
- Issuing instructions and guidance.
- Delivering oral and written presentations appropriate for the audience and purpose of the communication.
- Ensuring other communication barriers are overcome.

This communication may be in written form, such as technical reports, legal documents and editorial pieces, or oral, such as presentations.

4.2.6 Outcome 6: Recognise the reasonably foreseeable economic, social, cultural, and environmental effects of complex engineering activities seeking to achieve sustainability (Responsibility Level B)

The impact of engineering activities refers to the effects of engineering projects and processes on various aspects of society, the environment and the economy. It involves understanding and evaluating the potential consequences of these activities and taking measures to mitigate any adverse effects.

On the other hand, risk mitigation refers to identifying potential risks associated with engineering activities and implementing measures to minimise or eliminate those risks. This activity includes assessing the likelihood and severity of possible hazards, developing strategies to prevent or control them and implementing safety measures to protect people, property and the environment. The risk document must be a live document through the life cycle of a project and may include:

- technical risk
- environmental risk
- quality risk
- commercial risk (late or wrong deliveries of equipment)
- schedule risk
- social risk
- cultural risk
- construction risk.

4.2.7 Outcome 7: Meet all legal and regulatory requirements and protect the health and safety of persons during all complex engineering activities (Responsibility Level E)

The gazetted IDoEW promotes safety and protection of the public and the environment by ensuring that registered professionals in the different categories of registration have demonstrated the required competence and academic qualifications and have performed engineering work or have taken responsibility for engineering work performed per category. When seeking to register as a professional Industrial Engineering technologist, one of the requirements is to demonstrate competence in addressing the statutory and regulatory requirements. Those seeking registration as Professional Industrial Engineering Technologists must demonstrate their commitment to meeting legal obligations, protecting the health and safety of individuals, and ensuring compliance with industry standards throughout the project life cycle.

The most commonly used engineering regulating standards and Acts that applicants meet in the course of executing the engineering work are the following:

- Construction Industry Development Board Act, 38 of 2000
- Construction Regulations 2014
- Employment Equity Act, 55 of 1998
- Engineering Profession Act, 46 of 2000
- Hazardous Substance Act, 5 of 1973
- Mine Health and Safety Act, 29 of 1996
- Minerals and Energy Acts, (e.g., Mineral and Petroleum Act, 28 of 2002)

- National Building Regulations and Building Standards Act, 103 of 1977
- National Environmental Management Act, 107 of 1998
- National Water Act, 36 of 1998
- Occupational Health and Safety Act, 85 of 1993
- Project and Construction Management Professions Act, 48 of 2000
- Protection of Personal Information Act, 2013
- Specific work instructions, standards, and/or specifications of the enterprise

Other Acts not listed here may also be pertinent to a Candidate's specific work environment. Applicants are expected to have a basic knowledge of the relevant Acts and to investigate whether any Acts are applicable to their particular work environment. 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.

Industry-specific regulations and requirements may or may not be applicable in all fields of industrial engineering. However, applicants 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 applicants and their mentors/supervisors to familiarise themselves with these practices in the South African industry.

4.2.8 Outcome 8: Conduct engineering activities ethically (Responsibility Level E)

Demonstrating the ethics of engineering means adhering to a set of ethical principles and standards in one's professional practice. Therefore, candidates are expected to conduct themselves in an ethical manner, always demonstrating professionalism during the course of their engineering activities. This includes understanding and complying with the *ECSA Code of Conduct* for registered persons, identifying ethical problems and affected parties, and selecting the best solution to resolve these problems. Attention to the health and safety of persons, area of competency, truth, integrity and honest behaviour is of paramount importance.

4.2.9 Outcome 9: Exercise sound judgement by evaluating the outcomes, impacts and alternatives in the course of complex engineering activities. (Responsibility Level E)

Exercising sound engineering judgment means making informed decisions by carefully evaluating the outcomes, impacts and alternatives related to engineering activities. It involves considering factors such as environmental impacts, interrelationships with other disciplines, time constraints, cost limitations and other relevant constraints, even when faced with limited knowledge.

Taking risky decisions may lead to system, process or equipment failure and damage to persons and property. Evaluation of engineering solutions may include engineering calculations to substantiate decisions taken and assumptions made. Therefore, judgement exercised by the applicant in arriving at a conclusion within the application of technologies and their interrelationship to other disciplines and technologies is crucial.

In engineering activities that are classified as broadly defined and in which the applicant engineering technologist uses standard procedures, codes of practice, specifications, etc., but may develop variations and completely unique standards when needed, judgement must be displayed to identify any activity falling inside the broadly defined range (defined above) by the following:

- Getting the work done despite numerous risk factors needs good judgement and substantiated decision-making.
- Consequences are part of the project (e.g., extra cost due to unforeseen conditions, incompetent contractors, long-term environmental damage, etc.).
- The presence of interested and affected parties with defined needs that may be in conflict (e.g., need for a service irrespective of environmental damage, local traditions, preferences, etc.) requires sound management and judgement

4.2.10 Outcome 10: Be responsible for making decisions on part or all of complex engineering activities. (Responsibility Level E)

Responsibility in decision-making refers to the ability to make informed and ethical decisions that significantly impact the field of industrial engineering. It involves considering various factors, such as safety, environmental impact, cost-effectiveness and regulatory compliance. A professional industrial engineering technologist's responsibility in decision-making also requires a comprehensive understanding of the field, adherence to ethical standards and a commitment to ensuring the safety, efficiency and sustainability of industrial engineering processes.

Applicant industrial engineering technologists should discharge responsibilities for significant parts of one or more considered activities relating to the impact of engineering, social, environmental, and sustainable development at Responsibility Level E. It is important for applicant engineering technologists to demonstrate how they have sought advice from a responsible authority on matters outside their area of competence:

- 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 that are open to expand knowledge into additional fields are investigated.
- Record-keeping must not be left to the employer or anybody else. Trainees must manage their own training independently by taking initiative and being in charge of experiential development towards the level of professional industrial engineering technologist.

4.2.11 Outcome 11: Undertake sufficient professional development activities to maintain, extend competence and enhance the ability to adapt to emerging technologies and the ever-changing nature of work. (Responsibility Level D)

Professional development refers to the ongoing process of acquiring and enhancing the knowledge, skills and competencies necessary to excel in a particular profession. It involves activities and opportunities that help individuals stay up to date with the latest developments in their field, improve their expertise and advance their careers. Applicants intending to register as professional engineering technologists are expected to undertake sufficient independent learning activities to maintain and extend their competence.

Addressing professional development means actively engaging in activities that contribute to growth and development as an industrial engineering technologist. The development could include various forms of learning, such as attending workshops, conferences and seminars, pursuing higher education and participating in training programmes to stay informed about industry trends and advancements.

By actively addressing professional development, individuals seeking to register as professional industrial engineering technologists demonstrate their commitment to staying current with industry advancements, expanding their skill sets and continuously improving their abilities. Professional development enhances their professional credibility and opens opportunities for career growth and advancement within the field.

Training and courses that do not carry official CPD points, such as courses or training offered within the employer organisation or by other organisations, are also appropriate.

- If possible, a specific field of the sub-discipline is chosen, available developmental alternatives are established, a programme is drawn up (in consultation with the employer if costs are involved) and options that are open to expand knowledge into additional fields are investigated.
- Record-keeping must not be left to the employer or anybody else. Trainees must manage their own training independently by taking initiative and being in charge of experiential development towards the level of professional engineering technologist.

4.3 Training for registration as a professional engineering technician

4.3.1 Outcome 1: Define, investigate and analyse well-defined engineering problems (Responsibility Level E)

When individuals seek to register as a professional industrial engineering technicians, one of the key competencies they need to demonstrate is the ability to define, investigate and analyse well-defined engineering problems. This requirement means the applicant should be able to effectively identify and understand engineering problems and develop a clear understanding of what needs to be solved. For engineering technicians to solve well-defined engineering problems, it is imperative to understand the nature of the engineering problem. Inability to understand the engineering problem could lead to incorrect design or incorrect development of solutions. Engineering problems should be thoroughly investigated through site visits, collecting technical information and checking engineering drawings. No investigation can be completed using desktop information only.

A practical problem for applicant engineering technicians means the encountered problem cannot be solved by artisans because theoretical calculations and engineering decisions are necessary to substantiate the proposed solution:

- Further investigation to identify the nature of the problem is seldom necessary.
- The problem is easily recognised as part of the larger engineering task, project or operation.
- It is recognised that the problem occurred in the past or the possibility exists that it may have happened before – definitely not something new.
- Solving the problem does not require the development of a new solution – find out how it was solved before.
- Encompassed means encircled. The standards, codes and documented procedures must be obtained to solve the problem, and authorisation from the supervisor or mentor must be obtained to waive the stipulations.
- The responsibility lies with engineering technicians to check that the information received as part of the encountered problem is correct and added to as necessary to ensure the correct and complete execution of the work.
- The problem handled by engineering technicians must be limited to well-known matters, preferably needing standardised solutions without possible complications.
- Practical solutions to problems include knowledge of the skills displayed by specified category practitioners and engineering artisans without sacrificing theoretical engineering principles and/or cutting corners to satisfy the involved parties.
- Engineering technicians need guidance from technologists or engineers.

4.3.2 Outcome 2: Design or develop solutions to well-defined engineering problems (Responsibility Levels C and D)

Designing or developing solutions to well-defined engineering problems refers to the ability to come up with innovative and practical solutions to solve engineering problems.

Once the analysis of the engineering problem has been established, applicants are expected either to design or to develop engineering solutions to resolve well-defined engineering problems. Well-defined engineering problems can be solved in standardised or prescribed ways. They are encompassed by standards, codes and documented procedures.

The solutions should be based on accepted methods, techniques or procedures based on the theory of practice and should consider sustainability.

In choosing the solution, a design criteria matrix is required to justify the solution/design (e.g., life cycle cost, operability, maintainability etc)

4.3.3 Outcome 3: Comprehend and apply knowledge that is embodied in established engineering practices that is specific to the jurisdiction in which the engineering technician practises. (Responsibility Level E)

Applying engineering procedures, processes, systems and methodologies specific to industrial engineering could involve understanding and utilising various industrial engineering calculations, such as mass and energy balances, process design, equipment sizing and optimisation techniques.

Applicant industrial engineering technicians are required to apply engineering knowledge acquired during the accredited undergraduate programmes to resolve well-defined engineering problems and subsequently to provide solutions to such problems. During training, applicant engineering technicians are expected to be introduced to engineering standards, procedures, and the different systems used in the process of engineering problem-solving. It is imperative that applicant engineering technicians are able to understand and demonstrate the application of acceptable engineering theory, engineering standards, engineering procedures, systems and governing laws in solving well-defined engineering problems.

Applicant engineering technicians must be able to base their decision on theory learnt at school.

Calculations confirming the correct application and use of equipment must be done on practical, well-defined activities. Reference must be made to the standards and procedures that were used and how calculations were derived from NDip theory.

In this scenario, industrial engineering technicians would be responsible for managing various aspects of the project, such as the following:

- **Planning:** Develop a detailed project plan that outlines the scope, objectives, timeline and resources required for the project, as well as identifying key milestones and deliverables.
- **Organising:** Allocating resources, including personnel, equipment and materials to ensure that the project tasks are executed as planned. This task involves coordinating with different teams and departments involved in the project.
- **Leading:** Technicians provide guidance and direction to the project team members, ensuring that they understand their roles and responsibilities. Technicians should motivate and inspire the team to work towards the project's objectives.
- **Controlling:** Monitoring the project's progress, tracking key performance indicators, and taking corrective actions if deviations from the plan occur. This task includes managing risks, resolving issues and ensuring the project stays on track.
- **Managing contracts and relationships:** Technicians should be able to establish and maintain professional and business relationships with contractors, suppliers and other stakeholders involved in the project. This task includes negotiating contracts, managing procurement processes and ensuring compliance with legal and regulatory requirements.

4.3.4 Outcome 4: Manage part or all of one or more well-defined engineering activities. (Responsibility Level D)

The areas in which applicant industrial engineering technicians work generally follow a conventional project or product development life cycle model.

The key project management activities involve time, cost and quality. Applicant engineering technicians should be able to manage their engineering work activities and minimise project delays in operations and maintenance and capital projects.

Engineering project management involves managing part or all of one or more well-defined engineering activities. For this outcome, industrial engineering technicians should be responsible for planning, organising, leading and controlling engineering activities to achieve desired results. Applicants are required to effectively manage and contribute to the successful completion of engineering activities in their practice area.

Applicant engineering technicians or persons wishing to register with ECSA as professional engineering technicians must participate in and contribute to the work activities in a project life cycle. Applicant engineering technicians are not expected to change their places of employment to acquire all the skills in the project life cycle listed above.

4.3.5 Outcome 5: Communicate clearly using multiple mediums and collaborate inclusively with a broad range of stakeholders in the course of engineering activities. (Responsibility Level C)

While conducting engineering works, applicant engineering technicians are expected to communicate with their team members, supervisors, clients and contractors effectively. Professional communication is a vital skill for applicant engineering technicians to possess since all their decisions are communicated to different parties. Professional communication is important in running effective meetings, working with people who are not technical, working with other cultures, issuing and receiving instructions, reporting on engineering works, and sharing ideas.

The main types of professional communication include oral, written and graphical techniques or a combination thereof. During the execution of engineering work activities, engineering technicians hold meetings and develop technical reports, tender document specifications and bills of quantity. These should be clear and concise to convey the message to the recipients. Creating presentations for colleagues, team members, supervisors and clients using visual aids and supporting documents is an important part of engineering problem-solving. Moreover, oral and written communication skills are important for effective professional communication.

Applicants must develop effective communication skills during training and be able to demonstrate such skills to be registered as professional engineering technicians.

4.3.6 Outcome 6: Recognise the reasonably foreseeable economic, social, cultural and environmental effects of well-defined engineering activities seeking to achieve sustainability. (Responsibility Level B)

Well-defined engineering problems may have an impact on the social, environmental and cultural elements of the broader context in which the engineering activities are taking place . Applicants should be able to recognise and address the impact of their well-defined engineering activities. It involves understanding and evaluating the potential consequences of these activities and taking measures to mitigate any adverse effects.

- **Social effects** encompass all issues that affect people and their livelihoods, directly or indirectly. Engineering activities may affect people's way of life, their political system, their health and well-being, and their personal and property rights.
- **Environmental effects** include the effects on people's environment (i.e., air and water quality, dust and noise exposure, and adequacy of sanitation) and the effects on large ecosystems. These may include disruption of ecosystems, disruption of fauna and flora, and increased land temperatures.
- **Cultural effects** include people's customary beliefs, religion, language and norms.

Industrial engineering activities in all industries can have a significant impact on work conditions and practices and labour practices, which can all have social effects and affect individuals' ability to exercise cultural rights. Industrial engineering work in most industries can also have a significant impact on the environment and industrial engineers have a responsibility to reduce and minimise environmental impact wherever possible.

Well-defined engineering problems may have an impact on the social, environmental and cultural aspects of people's lives. Applicants should be able to recognise and address the impact of their engineering activities on these elements and where there are negative effects, provide mitigating measures.

Risk and impact mitigation must include the probability and impact of all the risks connected with the project. Mitigating measures taken may include environmental impact studies, environmental impact management, community involvement and communication, barricading and warning signs, and press releases.

4.3.7 Outcome 7: Meet all legal and regulatory requirements and protect the health and safety of persons during all well-defined engineering activities. (Responsibility Level E)

Applicants wishing to register with ECSA as Professional Engineering Technicians are expected to have a working knowledge of the related regulations and Acts and to be able to demonstrate how this legislation affects their well-defined engineering activities at Responsibility Level E (performing). Technicians, like engineers and technologists, are also required to comply with the regulations applicable to their respective industries in the performance of their duties. The compliance ensures that their engineering work is carried out legally and safely for the protection of the profession and their integrity. Refer to the list at the beginning of section 4 for the most common Acts and regulatory standards.

Other Acts, not listed here, may also be pertinent to an applicant's specific work environment such as, work instructions, standards and/or specifications of the enterprise. Applicants are expected to have a basic knowledge of the relevant Acts and to investigate whether any Acts are applicable to their particular work environment. All engineering work must be carried out in accordance with the norms of the profession.

The onus is, once again, on applicants and their mentors/supervisors to familiarise themselves with these practices in the South African industry.

4.3.8 Outcome 8: Conduct engineering activities ethically (Responsibility Level E)

Applicant engineering technicians should be able to identify ethical issues arising during engineering activities, identify affected parties and determine how such issues may affect them. The solution to an ethical problem must consider all affected parties.

Applicant industrial engineering technicians must perform engineering work and make technical decisions while adhering to the *ECSA Code of Conduct* for registered persons. The following factors should be considered when performing engineering work:

- Make decisions within the limits of the practitioner's education, training and experience.
- Act with integrity and in accordance with the general norms of professional conduct.

- Strive to respect the interests of the public and health and safety and minimise environmental impact.
- If the scope of work falls outside the area of expertise of the applicant industrial engineering technicians, they should seek guidance from relevant parties.

4.3.9 Outcome 9: Exercise sound judgement by evaluating the outcomes, impacts and alternatives in the course of well-defined engineering activities. (Responsibility Level E)

Exercising sound engineering judgment means making informed decisions by carefully evaluating the outcomes, impacts and alternatives related to engineering activities. It involves considering factors such as environmental impacts, interrelationships with other disciplines, time constraints, cost limitations and other relevant constraints, even when faced with limited knowledge.

Applicant industrial engineering technicians should be able to make judgement on a sustainable solution after ensuring that all factors, including consideration of other disciplines, have been taken into consideration.

Applicant industrial engineering technicians must familiarise themselves with organisational risk policies and standards.

Engineering activities classified as well-defined in which engineering technicians use standard procedures, codes of practice, specifications, etc., require judgement to be displayed to identify any activity falling outside the well-defined range (defined above) by:

- seeking advice when risk factors exceed their capability
- determining any consequences outside the immediate work contexts (e.g., long-term, not normally handled)
- accounting for interested and affected parties with defined needs outside the well-defined parameters.

4.3.10 Outcome 10: Be responsible for making decisions on part or all of well-defined engineering activities. (Responsibility Level E)

Responsibility in decision-making refers to the ability to make informed and ethical decisions that significantly impact the field of industrial engineering. It involves considering various factors, such as safety, environmental impact, cost-effectiveness and regulatory compliance. Professional industrial engineering technicians' responsibility in decision-making also requires a comprehensive understanding of the field, adherence to ethical standards and a commitment to ensuring the safety, efficiency and sustainability of industrial engineering processes.

Industrial engineering technicians must also ensure compliance with health and safety regulations and industry standards.

Responsible decision-making includes applying engineering knowledge acquired from accredited engineering programmes. It includes using relevant calculations to justify why certain solutions are chosen to solve well-defined engineering problems.

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 task originator, instruction and corrective action, if necessary, form important elements.

4.3.11 Outcome 11: Undertake sufficient professional development activities to maintain, extend competence and enhance the ability to adapt to emerging technologies and the ever-changing nature of work. (Responsibility Level D)

Professional development is essential for technicians to continuously improve their skills, advance their careers, contribute to innovation and uphold the highest standards of professionalism and integrity in their practice. Professional development is also important as the context and advancement of technology means that additional knowledge and skills are always required. It is important for applicants to draw up a CPD plan in consultation with the employer. Professional development requires a commitment to lifelong learning and engineering professionals should independently and proactively manage this.

Professional development activities could include:

- completion of higher degrees
- online training courses and webinars
- in-person training courses and workshops
- attendance of relevant conferences.

Professional development could include technical development in the primary discipline or other technical disciplines or development in complementary disciplines such as finance, teaching pedagogies or marketing.

Training and courses that do not carry official CPD points, such as professional development activities offered within the employer organisation or by other organisations or institutions locally or internationally, are also appropriate.

5. DEGREES OF RESPONSIBILITY

Progression throughout the various experiences presented in document **R-04-T&M-Guide-PC** and below in **Table 1** refers to the gradual increase in the DoR that applicant engineering professionals are required to undergo during professional training or experience. Considering the nature of the work, specific examples and outcomes appropriate to training in industrial engineering are also presented in Table 1:

Table 1: Progression to gather experience at appropriate levels of responsibility suitable for the registration category desired by prospective applicants

Degree of Responsibility	Nature of work	Activities/duties to gain experience
A: Being exposed	Shadows experienced practitioners, attending meetings, and familiarising themselves with the overall operations of the industry/company/ organisation to understand how their role fits into the larger context and observe the tasks and responsibilities of	• Undergo induction. • Observe processes and work of competent practitioners. • Understand the contextual environment and the dynamics that shape the organisation and the industries/landscape in which they operate. • Understand the organisation's operating model, processes and systems, and the critical outcomes and measures. • Understand the value added by industrial engineering practitioners, other professionals

Degree of Responsibility	Nature of work	Activities/duties to gain experience
	senior or more experienced colleagues.	and stakeholders in the organisational context.
B: Assisting	Work in specific processes under close supervision.	• Develop an appreciation of the numerous resources at the disposal of industrial engineering practitioners. • Obtain experience in the day-to-day operations of the organisation to gain insight and understanding of the different processes and systems involved in transforming inputs into goods and services, with specific emphasis on productivity and quality measurements.
C: Participating	Work under the limited direction, guidance, or supervision of another professional or senior staff member.	• Gain first-hand experience of a broad range of industrial engineering activities (e.g., process and system design, optimisation, improvement and re-engineering, planning and control, work study, value engineering, materials and information management, people management skills, logistics, and quality assurance). • Note the problems and limitations of particular philosophies, methods, and techniques, with emphasis on the impact on environmental, societal and cultural elements, legal and safety requirements, cost/effort and relative benefit.
D: Contributing	Work independently but requires detailed approval of work outputs from a supervisor or senior staff member.	• Be involved in activities such as the planning of operations, the control of quality and costs, system/ process/work analysis and design, flow/material handling and workplace layout, costing, budgeting and profit accountability, benchmarking, business cases, process re-engineering, maintenance practice and procedures, project management and system specification. The collective work of such activities is vital in the economical use of people, materials, time, technology and equipment. • Give specific attention to human aspects concerning communication, interpersonal relationships, teamwork, training, conflict management, labour relations, change management, job design and ergonomics.

Degree of Responsibility	Nature of work	Activities/duties to gain experience
		• These should proceed in parallel, applying industrial engineering techniques and employing computers in problem-solving.
E: Performing	Works in a team without supervision, recommends work outputs, and is responsible but not necessarily accountable.	• Assume escalating technical responsibility and increasingly co-ordinate the work of others. Take a leadership role to develop and apply skills in management areas such as labour relations, management accounting, law and general operations management. • Scope work or projects, as well as corresponding contracts/agreements. • Participate in assignments that require sound judgement, even if full information is unavailable. This leads to the requirement for decision making and adopting a position of professional responsibility.

Appendix A has been developed against the Degree of Responsibility scale. Activities should be selected to ensure the Candidate reaches the required level of competency and responsibility. It is, therefore, expected that the Candidate or the applicant should ensure that each outcome meets the responsibility level as indicated in Appendix A for application as a Professional Engineer, Professional Engineering Technologist, or Professional Engineering Technician.

6. CANDIDATE TRAINING GUIDELINES

There is no ideal training programme structure or unique sequencing that constitutes best practice. The training programme for each applicant depends on the available work opportunities that the employer assigns to the applicant at the time. Applicants must develop the skills required to demonstrate the advanced use of industrial engineering knowledge in optimising the efficiency of operations or the design, analysis and implementation of new systems and processes. It is suggested that applicants work with their mentors to determine appropriate work to gain exposure to elements of work activities that will allow for the development of competence against the 11 outcomes. A regular reporting structure with suitable recording of evidence of achievement against the competency outcomes and responsibility needs to be in place.

The training programme should be such that applicants progress through the levels of work capability (described in document **R-04-T&M-GUIDE-PC**) to ensure that by the end of the training period, applicants exhibit Responsibility Level E and are able to perform individually and as a team member at the level of problem-solving and engineering activity required for registration. Applicants must be able to demonstrate that they have been actively involved in engineering work to develop the ability to exercise judgement in the workplace. Applicants must show evidence of adequate training in this function through work carried out in the analysis of problems and the synthesis of solutions. Evidence is required in the form of a reflective engineering report that forms part of the application. This engineering report should reflect on how the applicant demonstrates competence for all 11 outcomes.

From their early training years, applicants must actively seek opportunities to obtain experience in the area of synthesising solutions to the real-life engineering problems that are encountered in the workplace. The DSTG assumes that applicants enter a programme after graduation and continue with the programme until they are ready to apply for professional registration. The guide also assumes that applicants 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 moving into a candidacy programme from a less structured environment, it is essential that the following steps are completed:

Applicants must complete the *Training and Experience Summary* (TES) and the *Training and Experience Reports* (TERs) for the previous programme or the unstructured experience. Regarding the latter, it is important to reconstruct the experience as accurately as possible. The TERs must be signed off by the relevant supervisor or mentor. On entering the new programme, the mentor and supervisor should review the applicant's development while being mindful of past experience and the opportunities and requirements of the new programme. At minimum, the mentor and the supervisor should plan the next phase of the applicant's programme.

A suggested list of elements that should be included in a candidate's training and experience journey is included in Appendix A.

REVISION HISTORY

Revision number	Revision date	Revision details	Approved by
Rev 0 Draft A	11 May 2024	The DSTG has been merged into one Discipline-specific Training Guide for Registration as a Professional Engineer, Technologist and Technician in Industrial Engineering and to ensure that the DSTG clearly details how each outcome can be achieved.	RDDR BU
Rev 0 Draft B	30 May 2024	The review has included an introduction section. The document further indicates the type of engineering work that the different categories should undertake. Section 4. Developing Competency: Document (**R-08-PE/PT/PN**) Under training for registration as a professional engineer, professional engineering technologist and professional engineering technician has been revised to ensure that each training element is aligned to each outcome, *4.1.1 Investigation & Analysis* The content under this section is aligned with Outcome 1 *4.1.2 Engineering Design & Development of solution* The content under this section is aligned with Outcome 2 *4.1.3 Contextual Knowledge* The content under this section is aligned with Outcome 3 *4.1.4 Engineering Project Management* The content under this section is aligned with Outcome 4 *4.1.5 Professional Communication*	Working group

Revision number	Revision date	Revision details	Approved by
		The content under this section is aligned with Outcome 5 *4.1.6 Impact of Engineering Activities & Risk Mitigation* The content under this section is aligned with Outcome 6 *4.1.7 Statutory & Regulatory Requirements* The content under this section is aligned with Outcome 7 *4.1.8 Ethics of Engineering* The content under this section is aligned with Outcome 8 *4.1.9 Exercising sound judgment* The content under this section is aligned with Outcome 9 *4.1.10 Responsibility in Decision-making* The content under this section is aligned with Outcome 10 *4.1.11 Professional Development* The content under this section is aligned with Outcome 11	
Rev 0 Draft C	16 Oct 2024	Document revised with WG and sent to Registration BU for inputs and comments	RI BU, Registration BU and WG
Rev 0 Draft D	03 Oct 2024	Document submitted to the IEA Task Team for alignment to the IEA changes	IEA Review Task Team
Rev 0 Draft E	11 Oct 2024	Reviewed and checked	Executive: RPSC
Rev 0	23 Oct 2024	Approval	RPSC

The Discipline-specific Training Guide for

Registration as a Professional Engineer, Technologist, and Technician in Industrial Engineering

Revision 0 dated 23 October 2024 and consisting of 54 pages reviewed for adequacy by the Business Unit Manager and is approved by the Executive: Regulatory Services & International Relations **(ERSIR)**.

.... 2 December 2024

Business Unit Manager Date

.... 2024/12/02

Executive: RSIR Date

This definitive version of this policy is available on our website

APPENDIX A: TRAINING ELEMENTS

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

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

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

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

Competency Standards for Registration as a Professional Engineering Technologist	**Explanation and Responsibility Level**
1. Purpose This standard defines the competence required for registration as a **Professional Engineer, Technologist and Technician**. Definitions of terms having particular meaning within this standard is given in text in relevant section.	DSTGs give context to the purpose of the Competency Standards. The **Engineer, Technologist and Technician** operate within the 12 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 the specific DSTG)
2. Demonstration of competence Competence must be demonstrated within Complex, broadly defined and Well-defined *engineering activities,* defined below, by integrated performance of the outcomes defined at the level defined for each outcome. Required contexts and functions may be specified in the applicable DSTG. **Level Descriptor:** Complex engineering activities (**CEA**), Broadly-defined engineering activities (**BDEA**), and Well-defined engineering activities (**WDEA**) 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.	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: CEA, *BDEA and WDEA*** 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 is located within a wider, complex context, requires teamwork, and has interfaces with other parties and disciplines. c) Involves a variety of resources, including people, money, equipment, materials and technologies. d) Requires resolution of occasional problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues. e) Are constrained by available technology, time, finance, infrastructure, resources, facilities, standards and codes and applicable laws. f) Have significant risks and consequences in the practice area and in related areas.	b) Practice area varies substantially with unlimited location possibilities and an additional responsibility to identify the need for advice on **CEA, *BDEA and WDEA*** activities and problems. **CEA, *BDEA and WDEA*** activities in the sub-discipline needs interfacing with professional engineers, professional technicians, artisans, architects, financial staff, etc. as part of the team. c) The bulk of the work involves familiar, defined range of resources, including people, money, equipment, materials, but new technologies are investigated and implemented. 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 **Engineers, Technologists and Technicians**, 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 *Complex, broadly defined and Well-defined,* engineering problems	**Responsibility Level E** Analysis of an engineering problem means the ‘separation into parts possibly with comment and judgement’. Complex, *Broadly, Well-defined* means: ‘not minute or detailed’ and ‘not kept within narrow limits’.

Complex, Broadly-defined and Well-defined engineering problems have the following characteristics.	
a) They require coherent and detailed engineering knowledge, underpinning the technology area;	Coherent and detailed engineering knowledge for **Engineer, Technologist and Technician** means the problem encountered cannot be solved without the combination of all the relevant detail including engineering principles applicable to the situation.
and one or more of the following:	
b) Are ill-posed, under- or over-specified, require identification and interpretation into the technology area.	a) 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) Encompass systems within complex engineering systems;	b) 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) Belong to families of problems which are solved in well-accepted but innovative ways.	c) It is recognised that the problem can be classified as falling within a typical solution requiring innovative adaptation to meet the specific situation.
and one or more of:	
e) Can be solved by structured analysis techniques	d) Solving the problem needs a step-by-step approach adhering to proven logic.
f) May be partially outside standards and codes; must provide justification to operate outside.	e) 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) Require information from practice area and sources interfacing with practice area that is complex and incomplete.	f) The responsibility lies with the **Engineer, Technologist and Technician** to verify that some information received as part of the problem encountered may remain incomplete and solutions to problems may need justified assumptions.
h) Involve a variety of issues which may impose conflicting constraints: technical, engineering and interested or affected parties.	g) The problem handled by **Engineer, Technologist and Technician** may be solved by alternatives that are unaffordable, detrimental to the environment, socially unacceptable, not maintainable, not sustainable, etc; the **Engineer, Technologist and Technician** will have to justify his/her recommendation.
and one or both of:	
i) Require judgement in decision-making in practice area, considering interfaces to other areas.	h) 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) Have significant consequences which are important in practice area but may extend more widely.	

	i) **The Engineer, Technologist and Technician** 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 **Engineer, Technologist and Technician** 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:	**Responsibility Levels C and D**

Design or develop solutions to **Complex, Broadly-defined and Well-defined** engineering problems	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 **Complex, Broadly-defined and Well-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 **Engineer, Technologist and Technician** 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 ***Complex, Broadly-defined and Well-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. **The Engineer, Technologist and Technician** 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,	**Responsibility Level E** Comprehend means 'to understand fully'. The jurisdiction in which an **Engineer, Technologist and Technician** practices is given in section 4 of the specific DSTG.

systems or methodologies and those specific to the jurisdiction in which he/she practices.	
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, B Eng, BTech or B Eng (Tech) and N Dip, 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 **Engineer, Technologist and Technician** is based on B Eng, BTech, N Dip, theory and is mostly the utilisation and configuration of manufactured components and selected materials and associated novel einingeering., **Engineer, Technologist and Technician** 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 B Eng, BTech or B Eng (Tech) and/or NDip, 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 **complex, broadly defined, well defined,** procedures and techniques must be based on fundamental mathematical, scientific and engineering knowledge, as part of personal contribution within the engineering team. 3.3 The ability to manage the resources within legal and financial constraints must be evident.
Range Statement: Applicable knowledge includes: a) Technological knowledge that is well-established and applicable to the practice area irrespective of location, supplemented by locally relevant knowledge, for example, established properties of local materials. Emerging technologies are adopted from formulations of others. b) A working knowledge of interacting disciplines (engineering and other) to underpin teamwork. c) Jurisdictional knowledge includes legal and regulatory requirements as well as locally relevant codes of practice. As required for practice area, a selection of law of contract, health and safety, environmental, intellectual property, contract administration, quality management, risk management,	a) The specific location of a task to be executed is the most important determining factor in the layout design and utilisation of equipment. A combination of educational knowledge and practical experience must be used to substantiate decisions taken including a comprehensive study of systems, materials, components and projected customer requirements and expectations. New ideas, materials, components and systems must be investigated, evaluated and applied accompanied by complex theoretical motivation. b) In spite of having a working knowledge of interacting disciplines, **Engineer, Technologist and Technician** take responsibility for the multidisciplinary team of specialists c) Jurisdictional in this instance means 'having the authority', and **Engineer, Technologist and Technician** 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.

maintenance management, regulation, project and construction management.	
Group B: Managing Engineering Activities	**Explanation and Responsibility Level**
Outcome 4: Manage part or all of one or more ***Complex, Broadly-defined and Well-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 **Engineer, Technologist and Technician** 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, **Engineer, Technologist and Technician** 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 ***Complex, Broadly-defined and Well-defined*** *engineering* involves: a) Planning ***Complex, Broadly-defined and Well-defined*** activities b) Organising ***Complex, Broadly-defined and Well-defined*** activities c) Leading ***Complex, Broadly-defined and Well-defined*** activities d) Controlling ***Complex, Broadly-defined and Well-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' **The Engineer, Technologist and Technician** 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 ***Complex, Broadly-defined and Well-defined*** engineering activities generally	**Responsibility level B** Social means 'people living in communities; of relations between persons and communities'. Cultural means 'all the arts, beliefs, social institutions, etc. characteristic of a community'. Environmental means 'surroundings, circumstances, influences'.
Assessment criteria: This outcome is normally displayed in the course of analysis and solution of problems. The candidate typically shows: 6.1 Ability to identify interested and affected parties and their expectations in regard to interactions between technical, social, cultural and environmental considerations shown. 6.2 Measures taken to mitigate the negative effects of engineering activities evident.	6.1 Engineering impacts heavily on the environment, e.g., servitudes, expropriation of land, excavation of trenches with associated inconvenience, borrow pits, dust and obstruction, street and other crossings, power dips and interruptions, visual and noise pollution, malfunctions, oil and other leaks, electrocution of human beings, detrimental effect on animals and wildlife, dangerous rotating and other machines, demolishing of structures, etc.

	6.2 Mitigating measures taken may include environmental impact studies, environmental impact management, community involvement and communication, barricading and warning signs, temporary crossings, alternative supplies (ring feeders and bypass roads), press releases, compensation paid, etc.
Outcome 7: Meet all legal and regulatory requirements and protect the health and safety of persons in the course of his/her broadly defined engineering activities.	**Responsibility level E**
Assessment criteria: 7.1 Identified applicable legal and regulatory requirements including health and safety requirements for the engineering activity. 7.2 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 **Engineer, Technologist and Technician** seeks advice from knowledgeable and experienced specialists if the slightest doubt exist that safety and sustainability cannot be guaranteed.
Range Statement for Outcomes 6 and 7: Impacts and regulatory requirements include 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 **Engineer, Technologist and Technician** 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 **Engineer, Technologist and Technician** 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.W.r.t. health and safety, but the **Engineer, Technologist and Technician** 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. c) 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 **Engineer, Technologist and Technician** needs to identify, analyse and manage any long-term risks and develop strategies to solve these by using alternative technologies. d) The safe and sustainable materials, components and systems must be selected and prescribed by the **Engineer, Technologist and Technician** or other professional specialists must be consulted. It is the responsibility of the **Engineer, Technologist and Technician** to use his/her knowledge and experience to confirm that prescriptions by others are correct and safe. e) Application of regulations associated with the particular aspects of the project must be carefully identified and controlled by the **Engineer, Technologist and Technician**.
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 ***Complex, Broadly-defined and Well-defined*** engineering activities	**Responsibility level E** Judgement means 'good sense: ability to judge'.
Assessment criteria: Judgement is displayed by the following performance: 9.1 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 **Engineer, Technologist and Technician** 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; **or** b) significant consequences in technology application and related contexts; **or** c) ranges of interested and affected parties with widely varying needs.	In Engineering, about 5% of engineering activities can be classified as broadly defined where the **Engineer, Technologist and Technician** 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 ***Complex, Broadly-defined and Well-defined*** engineering activities	**Responsibility level E** Responsible means 'legally or morally liable for carrying out a duty; for the care of something or somebody in a position where one may be blamed for loss, failure, etc.'.

Assessment criteria: Responsibility is displayed by the following performance: 10.1 Engineering, social, environment and sustainable development taken into consideration in discharging responsibilities for significant parts of one or more activities. 10.2 Advice sought from a responsible authority on matters outside your area of competence. 10.3 Academic knowledge of at least B Eng, BTech N Dip, level combined with past experience used in formulating decisions.[1]	10.1 All interrelated factors taken considered are indicative of professional responsibility accepted working on broadly defined activities. 10.2 The **Engineer, Technologist and Technician** does not operate on tasks at a higher level than, complex, broadly defined, well defined and consults professionals at engineer level if elements of the project to be done are beyond his/her education and experience, e.g., power system stability. 10.3 This is in the first instance continuous self-evaluation to ascertain that the task given is done correctly, on time and within budget. Continuous feedback to the originator of the task instruction and corrective action, if necessary, forms an important element. The calculations, for example fault levels, load calculations, losses, etc. are done to ensure that the correct material and components are utilised.
Range Statement: Responsibility must be discharged for significant parts of one or more ***Complex, Broadly-defined and Well-defined*** engineering activity.	The responsibility is mostly allocated within a team environment with an increasing designation as experience is gathered.
Note 1: Demonstrating responsibility 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.	11.1 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 Awareness of philosophy of employer regarding professional development evident.	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 **Engineer, Technologist and Technician** engineering**.**
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 **Engineer, Technologist and Technician** to manage his/her own experiential development. **Engineer, Technologist and Technician** 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 **Engineer, Technologist and Technician** is vital to his/her success

APPENDIX B: TRAINING ELEMENTS

1	**Introduction**
1.1	*Induction programme* (typically 1–5 days)
1.1.1	Organisation structure
1.1.2	Organisation policies
1.1.3	Organisation Code of Conduct
1.1.4	Organisation legal and safety regulations
1.1.5	Organisation staff code
1.1.6	Organisation regulations
1.2	*Exposure to Practical Aspects of Engineering (typically 6–12 months) and covers how things are:* (Responsibility Levels A–B)
Experience to various aspects of the organisation for example: Process mapping and analysis, problem investigation and root cause analysis, production and operations, maintenance, product design and testing, research and innovation, systems analysis and design, and project management.	
2	**Design or develop solution**
2.1	*Experience in design and application of design knowledge* (typically 12–18 months). *Focus is on planning, design, and application* (Responsibility Levels C–D)
3	**Engineering tasks**
3.1	*Experience in the execution of engineering tasks* (remainder of training period). (Responsibility Level E)
3.2	*Organising, planning and managing engineering activities* (Responsibility Level E)
4	**Risk and impact mitigation**
4.1	*Impact and risk assessments* (Responsibility Level E)
4.1.1	Risk assessments
4.2	*Regulatory compliance* (Responsibility Level E)
5	**Managing engineering activities**
5.1	*Self-management* (Responsibility Levels C–D)
5.1.1	Manages own activities
5.1.2	Communicates effectively
5.2	*Team environment* (Responsibility Levels C–D)

5.2.1	Participates in and contributes to team planning activities
5.2.2	Manages people
5.3	*Professional communication and relationships (networking)* (Responsibility Levels C–D)
5.3.1	Establishes and maintains professional and business relationships
5.3.2	Communicates effectively
5.4	*Exercising judgement and taking responsibility* (Responsibility Level E)
5.4.1	Ethical practices
5.4.2	Code of Conduct
5.4.3	Exercises sound judgement in the course of complex engineering activities
5.4.4	Is responsible for decision-making in some or all engineering activities
5.5	*Competency development* (Responsibility Level D)
5.5.1	Plans own development programme
5.5.2	Constructs initial professional development record