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 Mechanical Engineering

R-05-MEC-PE/PT/PN

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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 Candidate's discipline.

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

- 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 in order 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, No. 46 of 2000

Broadly defined engineering problems: Composed of many inter-related conditions and requiring underpinning methods, procedures, and technical judgement to create a solution within a set of originally broadly defined circumstances

Commitment and Undertaking (C&U): An agreement entered into between an employer and the ECSA under which the employer commits to the training of candidates to the standard required for registration in an identified Professional Category. A C&U may be entered into for one or more of the Professional Categories.

Competency Assessment: A summative assessment of an applicant's competence against the prescribed standard based on evidence from the applicant's work and other assessments that include a Professional Review.

Competency Standard: Statement of competency required for a defined purpose.

Continuing professional development: The systematic maintenance, improvement, and broadening of knowledge and skills and the development of personal qualities necessary for the execution of professional and engineering duties throughout the career of an engineering practitioner

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

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

Ill-posed problem: A problem whose requirements are not fully defined or may be defined erroneously by the requesting party

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

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

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

Outcome: At the *professional* level, outcome means a statement of the performance that a person must demonstrate to be judged competent.

Practise area: A generally recognised or distinctive area of knowledge and expertise developed by an engineering practitioner by virtue of the path of education, training, and experience followed

Range statement: The required extent of or limitations on expected performance stated in terms of situations and circumstances in which outcomes are to be demonstrated.

Supervisor: A person who oversees and controls engineering work performed by an applicant

Well-defined engineering problems: 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

BDEA	Broadly Defined Engineering Activities
BEng	Bachelor of Engineering
BEng (Tech)	Bachelor of Engineering in Technology
BSc (Eng)	Bachelor of Science in Engineering
BTech (Eng)	Bachelor of Technology in Engineering
CPD	Continuing Professional Development
C&U	Commitment and Undertaking
DSTG	Discipline-Specific Training Guide
IDoEW	Identification of Engineering Work
IPD	Initial Professional Development
NDip	National Diploma
PE	Professional Engineer
PGDip	Postgraduate Diploma
PN	Professional Engineering Technician
PT	Professional Engineering Technologist
TER	Training and Experience Report
TES	Training and Experience Summary

BACKGROUND

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

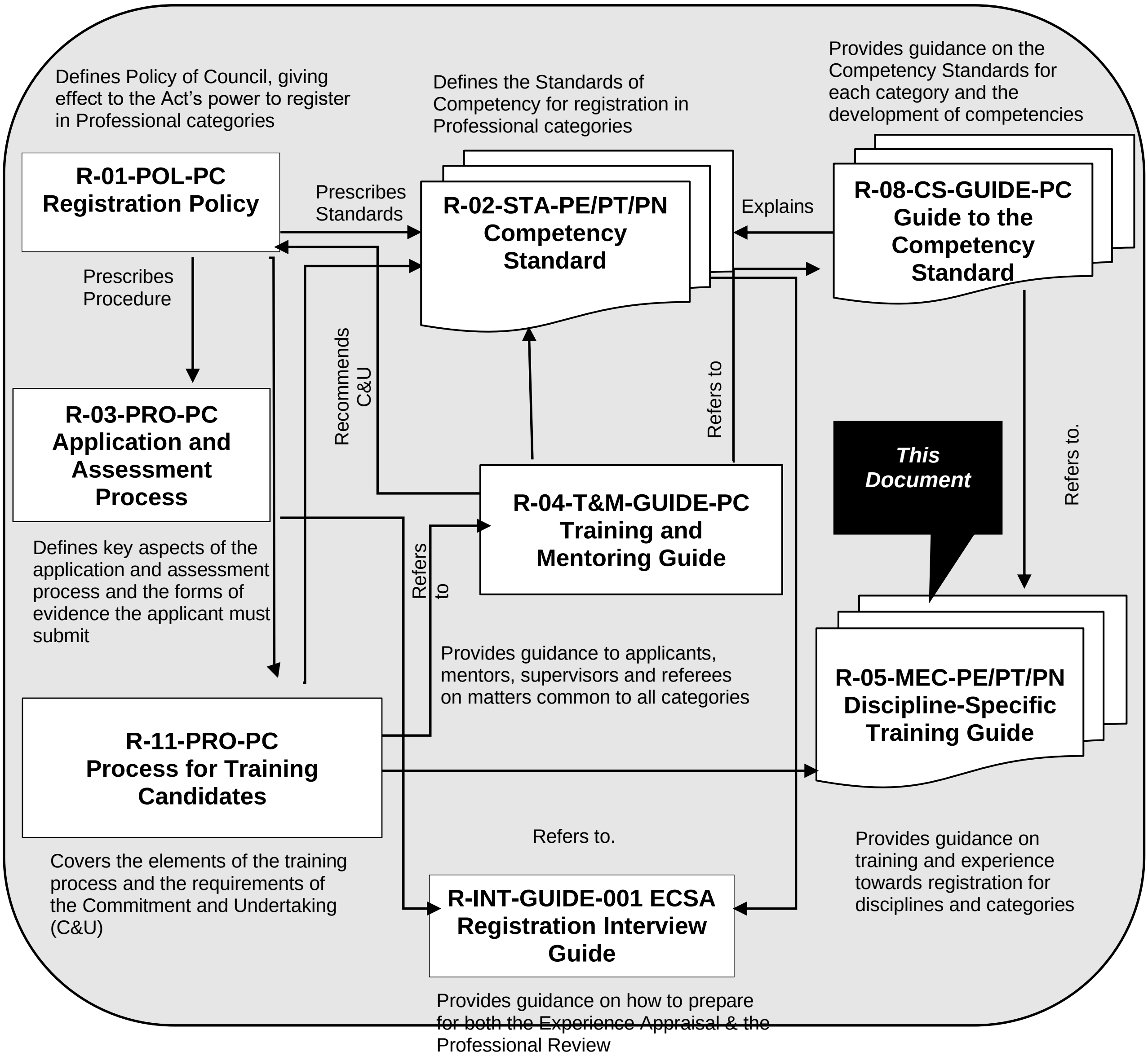

Figure 1: Documents defining the ECSA registration system

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** through work performed by the applicant at the prescribed level of responsibility, irrespective of the trainee's discipline.

This document supplements the generic Training and Mentoring Guide (document **R-04-T&M-GUIDE-PC**) and the Guide to the Competency Standards for Registration in Professional Categories (document **R-08-CS-GUIDE-PE/PT/PN**) for Applicant Mechanical 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 Professional Categories (document **R-01-POL-PC**)
- Processing of Applications for Registration of Applicants and Professionals (document **R-03-PRO-PC**)
- Training and Mentoring Guide for Professional Categories (document **R-04-TM-GUIDE-PC**)

2. AUDIENCE

This Discipline-Specific Training Guide (DSTG) is directed towards applicants and their Supervisors and Mentors in the discipline of Mechanical Engineering. This guide is intended to support a programme of training and experience incorporating elements of good practice.

The guide applies to persons who

- have registered with the ECSA as a Candidate Engineer, Technologist, or Technician;
- 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 benefit of the Candidate. 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

Regardless of the training development path followed by any individual, all persons wishing to register with the ECSA must present the same evidence of having met the ECSA-prescribed competency standard when assessed. Application for registration as a professional in a specific category is accepted without being registered as a Candidate Engineer, Technologist, or Technician, or without training through a C&U candidacy programme or a training academy. However, mentorship and adequate supervision are critical in ensuring effective development towards achieving the competencies required for professional registration.

If the trainee's employer does not offer C&U, the trainee should establish the level of mentorship and supervision that the employer is able to provide. In the absence of an internal Mentor, the services of an external Mentor should be secured. The Voluntary Association for the discipline may be consulted for assistance in locating an external Mentor. The Mentor must keep abreast of all stages of the development process and the ECSA registration requirements.

This DSTG is written for the Candidate/applicant who is training and gaining experience towards registration. Applicants who have not enjoyed mentorship are advised to request an experienced Mentor (internal or external) to act as an application adviser while they prepare their applications for registration.

Document **R-08-CS-GUIDE-PE/PT/PN** adequately describes what is expected of individuals whose formative developments have not followed conventional paths, for example, academics, researchers, and specialists.

3. TYPE OF ENGINEERING WORK

In terms of Section 27(1) of the Engineering Profession Act, 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, Voluntary Associations, and registered persons.

3.1 Mechanical Engineering Professionals Organising Framework for Occupations

Mechanical Engineering is concerned with the design, development, installation, operation, and maintenance of almost anything that has movable parts. It involves the production, transmission, and use of mechanical power. Mechanical Engineering Professionals work in different industries, and job opportunities within these industries include the following:

- Design: Turning plans into new products or revising existing ones

- Production: Planning and designing new production processes or maintaining equipment
- Research and development: Continually trying to find solutions to engineering problems using new technologies when they become available

Mechanical Engineering practitioners must have a strong understanding of mathematics, physics, and engineering science in addition to excellent problem-solving skills and attention to detail. Mechanical Engineering Professionals undertake the planning, design, construction, operation, and maintenance of materials, components, machinery, plants, and systems for lifting, hoisting, and handling materials; turbines, pumps, and fluid power; heating, cooling, ventilating, and air-conditioning units; fuels, combustion engines, steam plants, petrochemical plants, and turbines; automobiles, trucks, aircraft, ships, and special vehicles; fire protection equipment; nuclear energy generation; and lifts and escalators. In addition, Mechanical Engineering Professionals advise on mechanical aspects of particular material products or processes through the application of engineering sciences, namely mechanics, solid mechanics, thermodynamics, fluid mechanics, physics, chemistry, applied mathematics, and computational techniques.

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

- Professional Engineer: Solves complex engineering problems and performs complex engineering activities
- Professional Engineering Technologist: Solves broadly defined engineering problems and performs broadly defined engineering activities
- Professional Engineering Technician: Solves well-defined engineering problems and performs well-defined 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 Tasks a Mechanical Engineering Professional may Undertake

Typical tasks a Mechanical Engineering Professional may undertake include

- advising on and designing machinery and tools for manufacturing, mining, construction, agricultural, and other industrial purposes;
- advising on and designing steam, internal combustion, and other non-electric motors and engines used for propulsion of railway locomotives, road vehicles, or aircraft or for driving industrial or other machinery;
- advising on and designing hulls, superstructures, and propulsion systems of ships; mechanical plants and equipment for the release, control, and use of energy, heating, ventilation, and refrigeration systems, steering gear, pumps, pipe work, valves, and other associated mechanical equipment;
- advising on and designing airframes, undercarriages, and other equipment for aircraft in addition to suspension systems, brakes, vehicle bodies, and other components of road vehicles;
- advising on and designing non-electrical parts of apparatus or products such as computers, precision instruments, and consumer appliances;
- establishing control standards and procedures to ensure efficient functioning and safety of machines, machinery, tools, motors, engines, and industrial plant equipment or systems; and
- ensuring that equipment operation and maintenance comply with design specifications and safety standards.

3.3 Areas of Mechanical Engineering

Practising Mechanical Engineering Professionals generally concentrate on one or more of the following areas:

- Air-conditioning heating and ventilation, including fire protection and detection engineering
- Automotive engineering
- Diesel engineering
- Fluid mechanics engineering
- Forensic engineering
- Machine design and development

- Engineering maintenance management
- Mechatronics engineering
- Piping reticulation engineering
- Power generation engineering
- Pressurised vessels engineering
- Rotational plant engineering
- Structural steel engineering
- Thermodynamics engineering
- Transportation systems engineering

3.4 Research and Development

This type of work may be performed in research and product- development centres of business organisations or at academic institutions. Applicants must undertake research and development work that is predominantly Mechanical Engineering in nature, and this work should include an in-depth application of the various aspects of Mechanical Engineering, including product or system testing under controlled experimental conditions.

4. DEVELOPING ENGINEERING COMPETENCIES: DOCUMENT (R-08-PE/PT/PN)

Mechanical Engineering Professionals may be employed in the private or the public sector. In the private sector, they would typically be involved in consulting and contracting or employed in supplier or manufacturing organisations. Engineering consultants are responsible for planning, designing, documenting, and supervising the construction of projects on behalf of their clients. Engineering contractors are responsible for project implementation, and their activities include planning, construction, and labour and resource management. Those working in supply or manufacturing companies would be involved in production, supply, and quality control and could be involved in research and development.

The public sector is responsible for service delivery and is usually the client, although in some departments, design and construction is also carried out. Mechanical Engineering Professionals are required at all levels of the public sector, including national, provincial, and local government level, state-owned enterprises (SOEs), and public utilities. The public sector mainly handles planning, specifying, and overseeing implementation in addition to operations and maintenance of infrastructure.

An extension of the public sector would include tertiary academic institutions and research organisations.

Depending on where the applicant is employed, there may be situations where the in-house opportunities are not sufficiently diverse to develop all the competencies required in all the groups noted in document **R-02-STA-PE/PT/PN**. For example, the opportunity to develop problem-solving competence (including designing or developing solutions) and to manage engineering activities (including constructing or implementing solutions) may not both be available to the applicant. In such cases, secondment to another employer or enlisting the services of an external Mentor should be considered.

It is fairly common that where an organisation is unable to provide training in certain areas, secondments are arranged with other organisations so that the applicant is able to develop all the competencies required for registration. These secondments are usually reciprocal in nature so both employers and their employees mutually benefit. Secondments between consultants and contractors and between the public and private sectors should be possible.

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

If applicants or Mentors are unsure whether the engineering work they are considering is complex, broadly defined, or well defined, they 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.

4.1 Training for Registration as a Professional Engineer

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

According to the ECSA outcomes, engineers are expected to be able to define, investigate, and analyse complex engineering problems by identifying systems and sub-systems in resolving complex problems and using data and information technologies where applicable. 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 analysis of complex engineering problems requires in-depth fundamental and specialised engineering knowledge, including the collection, organisation, and evaluation of the information from all applicable sources, including investigation where appropriate. The work typically includes the research, planning, design, manufacturing, commissioning, and installation of plant and machinery.

As an example, engineers conduct research, advise on the design, and direct the construction and the operation of a plant and its machinery. They advise on and direct the functioning, maintenance, and repair of equipment in addition to studying and advising on the technological aspects of Mechanical Engineering materials, products, and processes.

Analysis of an engineering problem means the "separation into parts possibly with comment and judgement".

Complex means "engineering systems of context that is complex and varying, is multidisciplinary, requires teamwork, is unpredictable, and may need to be identified. It may also require diverse and significant resources".

The typical tasks may include the following:

- Coherent and detailed engineering knowledge for Engineers means the encountered problem cannot be solved without the combination of all the relevant detail, including the engineering principles applicable to the situation.
- The nature of the problem is not immediately obvious, is unfamiliar, or involves infrequently encountered issues.
- 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.

- The problem is not obvious and requires abstract thinking or originality in analysis to formulate suitable models.
- Solving the problem needs a step-by-step approach.
- The problem falls outside the scope of usual standards and codes.
- The responsibility lies with the Engineer to verify that some information from a variety of sources is complex, abstract, or incomplete, and solutions to problems may need justified assumptions.
- The problem handled by an Engineer may be solved by alternatives that are unaffordable, detrimental to the environment, socially unacceptable, not maintainable, not sustainable, etc., and the Engineer 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 own work on the interactive environment.

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

The engineering design of the solution to a complex engineering problem includes having a detailed requirements specification that aligns with the required design and having potential solutions or methods that can be used to approach and 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.

After the received task is fully understood and interpreted, a solution to the problem that is posed 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 and should include the costing and impact assessment for each alternative. All the alternatives must meet the requirements set out by the instructions that are received, and theoretical calculations to support each alternative must be done and submitted as an attachment.
- In some cases, the Engineer will not be able to support proposals with the complete theoretical calculation to substantiate every aspect. 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 deviating from those specified.

- The complete and final solution that is 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.

4.1.3 Contextual knowledge (Responsibility Level E)

Applicant Engineers should be able to provide evidence that they have comprehended and have mastered the engineering principles and technologies for their practise areas and that they apply first-principle analytical thinking in demonstrating this competency for the associated complex programme. This includes the application of fundamental principles, practices, sound testable assumptions, or previously encountered techniques that the applicant has 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 Engineering project management (Responsibility Level D)

In engineering operations, Engineers will typically be given the responsibility to carry out projects.

- 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 project, Engineers can be team leaders or team members or they can supervise appointed contractors. To achieve this, maintenance of relationships is important and must be demonstrated.

The area in which Mechanical Engineers work generally follows the conventional stages of the life cycle of the project or product as follows:

- Research and development of new products or systems, advancement of solutions to system problems, or system obsolescence
- System or product design to establish a new system or product, to solve system or product problems, to achieve a particular desired result, or to select equipment for a particular purpose
- Operation, maintenance, and support of the system or product
- Project Engineering to install, test, and commission the necessary equipment or system to achieve the desired result
- Decommissioning the system

The training elements of a training scheme (see appendix A) indicate the functions in which an applicant should be competent when carrying out the various phases of a project. The functions include

- solving problems based on engineering and contextual knowledge;
- implementing and operating engineering projects, systems, products, and processes;
- mitigating risk and impact; and
- managing engineering activities.

These functions are aligned with the overall competency of the outcomes expected from the applicants. In addition, applicants must state the requirement of the project in terms of delivery, refer to the initial production requirements for the project and state whether they obtained results, and if not, why they were unsuccessful.

4.1.5 Professional communication (Responsibility Level C)

Other than technical skills, engineers are expected to work on their communication skills in order to communicate clearly with others in the course of their engineering activities. This entails demonstrating the ability to write clear, concise, effective, and technically, legally, and editorially correct reports using a structure and a style that meet communication objectives and user/audience requirements:

- Applicants are expected to issue clear instructions to subordinates using appropriate language and communication aids, ensuring that language and other communication barriers are overcome.
- Applicants are required to make oral presentations using structure, style, language, visual aids, and supporting documents that are appropriate to the audience and purpose.

4.1.6 Impact of engineering activities and risk mitigation (Responsibility Level B)

Complex engineering problems may have an impact on the social, environmental, and cultural components. Applicants should be able to recognise and address the impact of their complex engineering activities on these components 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 wellbeing, and their personal and property rights.
- Environmental effects include the effects on people's environment (i.e. air and water quality, dust and exposure to noise, 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, for example, the ceremonies and customs of a particular group or society.

Mechanical Engineering has a heavy impact on the environment (e.g. emissions, waste, energy consumption, depletion of natural resources, noise and vibration, heat and friction, wear and tear, corrosion and erosion, accidents and injuries, harmful effects on humans and animals, complex and hazardous machinery, maintenance and disposal, etc.).

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 Statutory and regulatory requirements (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. Applicants wishing to register with the ECSA as Professional Engineers 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). The most commonly used engineering regulating standards and Acts that applicants meet in the course of executing the engineering work are as follows:

- Engineering Profession Act, No. 46 of 2000
- Occupational Health and Safety Act, No. 85 of 1993
- National Building Regulations and Building Standards Act, No. 103 of 1977
- National Environmental Management Act, No. 107 of 1998
- Employment Equity Act, No. 55 of 1998
- Environment Conservation Act, No. 52 of 1994 and Environment Conservation Amendment Act, No. 50 of 2003
- Mine Health and Safety Act, No. 29 of 1996
- 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.

Depending on the working environment, the provisions of the Occupational Health and Safety Act, No. 85 of 1993 (OHS Act) and/or the Mine Health and Safety Act, No. 29 of 1996 (MHS Act) must be followed by employers and employees. Applicants should obtain a functional understanding of these provisions in their specific workplaces.

Industry-specific regulations and requirements may or may not be applicable in all fields of Mechanical 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.

4.1.8 Conduct engineering activities ethically (Responsibility Level E)

Applicant Mechanical Engineers are involved in tender evaluations and adjudications and contract management. Ethical problems such as tender fraud and corruption, bribery payment, favouritism, defamation, alcohol abuse, sexual harassment, absenteeism, fraudulent overtime claims, fraudulent expenses claimed, fraudulent qualifications, misrepresentation of facts, and overstating of compensation events may occur. Applicant Engineers are expected to identify ethical problems, affected parties, and the best solution to resolve the problem at Responsibility Level E (i.e. performing).

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. 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 Exercising engineering sound judgement (Responsibility Level E)

Engineers are expected to exercise sound judgement during the course of engineering activities by considering several factors based on consequences they foresee and the regulatory requirements such as policies and standards.

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.

In engineering activities that are classified as complex, Applicant Mechanical Engineers apply their minds diligently through a logical thinking process in order to bring solutions to technically complex problems. This process involves the analysis of systems or the assembly of mechanical components and the integration of various elements of Mechanical Engineering through the application of basic and engineering sciences. The extent of a project given to an Applicant Mechanical Engineer is characterised by complex engineering system factors or complex sub-system factors and their resulting interdependence.

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 the decisions taken and the assumptions made.

Judgement must be displayed to identify any activity falling inside the broadly defined range (defined above) by the following:

- Engineers must apply professional engineering judgement to all work done. This includes the ability to assess design work against the set criteria.
- Getting the work done in spite of 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).

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) need sound management and judgement.

4.1.10 Responsibility in decision-making (Responsibility Level E)

Having the contextual knowledge and operating on Level E of the Degree of Responsibility 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 will assist applicants in making informed decisions and assuming responsibility for those decisions.

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." In the field of Mechanical Engineering,

- All considered inter-related factors are indicative of professional responsibility accepted working on complex engineering activities.
- The Engineer operates on tasks at all levels of engineering complexity within his/her education and experience (e.g. power system stability).
- Responsibility is the continuous self-evaluation to ascertain that the task given is done correctly, on time, and within budget. Continuous feedback to the originator of the task instruction and corrective action, if necessary, form important elements. The calculations, for example, fault levels, load calculations, and losses are done to ensure that the correct material and components are used.

4.1.11 Professional development (Responsibility Level D)

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. The trainee must manage his/her own training independently by taking initiative and being in charge of experiential development towards the level of Professional Engineer.

The following list of formal learning activities is by no means extensive or comprehensive; it is simply a sample of useful courses:

- Project management
- Conditions of Contract / Value Engineering – New Engineering Contract (NEC), Joint Building Contract Committee (JBCC), etc.
- Standards
- Specifications
- Preparation of specifications
- Negotiation skills

- Engineering finance
- Risk analysis
- Quality systems
- Occupational health and safety
- Engineering ethics
- Discipline-specific courses
- Energy efficiency
- Maintenance engineering
- Environmental impacts
- Management
- Report writing
- Planning methods
- System Engineering
- Industrial relations
- Public speaking

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

4.2 Training for Registration as a Professional Engineering Technologist

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

Applicant Mechanical Engineering Technologists are involved with broadly defined engineering activities and solve broadly defined engineering problems. It is critical to understand the problem and its extent properly before attempting to solve such a problem. It is, therefore, critical to define, investigate, and analyse broadly defined engineering problems before deciding on solutions.

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 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, as 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.

4.2.2 Design or develop solutions to broadly defined engineering problems (Responsibility levels C and D)

Engineering design and development of a solution are critical steps, as these result in a plant/system or components that must operate within acceptable engineering and safety parameters. 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.

- The complete and final solution that is selected must be followed up with a detailed technical specification, supporting drawings, and bill of quantities, etc. for the execution of work to meet customer requirements**.**

4.2.3 Contextual knowledge (Responsibility Level E)

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.

Design work for Engineering Technologists is based on BTech or BEngTech theory and mainly involves the use and configuration of manufactured components and selected materials together with the associated novel technology. Engineering Technologists develop and apply codes and procedures in their design work. Investigations are on broadly defined incidents, condition monitoring, and operations, mainly regarding the development and improvement of engineering systems and operations:

- Calculations at theoretical level confirming the correct application and use of equipment, materials, and systems must be done on *broadly defined* activities.
- The understanding of broadly defined procedures and techniques must be based on fundamental mathematical, scientific, and engineering knowledge as part of the personal contribution within the engineering team.
- The ability to manage the resources within legal and financial constraints must be evident.

The specific location of the task to be executed is the most important determining factor in the layout design and the use of equipment. A combination of educational knowledge and practical experience must be used to substantiate the decisions that are taken and a comprehensive study of systems, materials, components and projected customer requirements and expectations must be included. New ideas, materials, components, and systems must be investigated, evaluated, and applied, accompanied by complex theoretical motivation.

Despite having a working knowledge of interacting disciplines, Engineering Technologists take responsibility for the multidisciplinary team of specialists such as Civil Engineers on structures and roads, Mechanical Engineers on fire protection equipment, and Architects on buildings.

Jurisdictional in this instance means, “having the authority”, and Engineering Technologists must be aware of and decide on the relevant requirements that are applicable to each specific project for which they are responsible. Engineering Technologists are usually appointed as the “responsible person” for specific projects in terms of the OHS Act.

4.2.4 Engineering project management (Responsibility Level D)

The practise areas under which Applicant Mechanical Engineering Technologists work generally follow a conventional project or product development life cycle model, which could be as follows:

- Research and development to develop new products or systems to solve a system problem or a problem due to obsolescence
- System or product design to develop a new system or product, to solve a system or product problem, to achieve a particular desired result, or to select equipment for a particular purpose
- Project engineering to install, test, and commission the necessary equipment or system for the desired result
- Operation and maintenance of the system or support of the product
- Decommissioning of the system

In relation to the above engineering activities, applicants are expected to display personal and work-process management abilities for the following:

- Managing self, people, work priorities, processes, and resources in broadly defined engineering work
- Evident role in planning, organising, leading, and controlling broadly defined engineering activities

- Knowledge of conditions and operation of contractors and their ability

4.2.5 Professional communication (Responsibility Level C)

Engineering Technologists write specifications for the purchase of materials and/or work to be done, make recommendations on tenders that are received, place orders and variation orders, write work instructions, and report on work done. In addition, they 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, and prepare and present motivations for new projects. Furthermore, Engineering Technologists compile budget reports and report on various issues such as studies done and calculations carried out, customer requirements, safety incidents and risk analysis, equipment failure, proposed system improvement, new techniques, and cost control.

Professional communication is a vital skill for Applicant Mechanical Engineering Technologists to possess since all their decisions will be communicated to different parties. Applicant Technologists communicate the engineering activities to relevant stakeholders, managers, and supervisors on the work deliverables.

Effective communication plays a vital role in ensuring that the expectations are clearly understood. It is expected that Applicant Mechanical Engineering Technologists demonstrate the ability to

- write clear, concise, and effective technical, legal, and editorially correct reports;
- issue clear instructions to stakeholders using appropriate language and communication skills; and
- conduct oral presentations using structured style, language, and visual aids.

4.2.6 Impact of engineering activities and risk mitigation (Responsibility Level B)

Broadly defined engineering problems may have an impact on social, environmental, and cultural components. Applicants should be able to recognise and address the impact of their broadly defined engineering activities on these components, 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 wellbeing, and their personal and property rights.
- Environmental effects include the effects on people's environment (i.e. air and water quality, dust and exposure to noise, and adequacy of sanitation) and the effects on large ecosystems. This might include disruption of ecosystems and fauna and flora in addition to increased land temperatures and damage to historical buildings.
- Cultural effects include people's customary beliefs, religion, language, and norms, for example, the ceremonies and customs of a particular group or society.

Mechanical Engineering has a heavy impact on the environment (e.g. emissions, waste, energy consumption, depletion of natural resources, noise and vibration, heat and friction, wear and tear, corrosion and erosion, accidents and injuries, harmful effects on humans and animals, complex and hazardous machinery, and maintenance and disposal).

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

4.2.7 Statutory and regulatory requirements (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. Applicants wishing to register with the ECSA as Professional Engineering Technologists are expected to have a working knowledge of the related regulations and Acts and to be able to demonstrate how this legislation affects their broadly defined engineering activities at Responsibility Level E (performing). The most commonly used engineering regulating standards and Acts that applicants meet in the course of executing the engineering work are the following:

- Engineering Profession Act, No. 46 of 2000

- Occupational Health and Safety Act, No. 85 of 1993
- National Building Regulations and Building Standards Act, No. 103 of 1977
- National Environmental Management Act, No. 107 of 1998
- Employment Equity Act, No. 55 of 1998
- Environment Conservation Act, No. 52 of 1994 and Environment Conservation Amendment Act, No. 50 of 2003
- Mine Health and Safety Act, No. 29 of 1996
- 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.

Depending on the working environment, the provisions of the OHS Act and/or the MHS Act must be followed by employers and employees. Applicants should obtain a functional understanding of these provisions in their specific workplaces.

Industry-specific regulations and requirements may or may not be applicable in all fields of Mechanical 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 Conduct engineering activities ethically (Responsibility Level E)

Applicant Mechanical Engineering Technologists are involved in tender evaluations and adjudications, and contract management. Ethical problems such as tender fraud and corruption, bribery payment, favouritism, defamation, alcohol abuse, sexual harassment, absenteeism, fraudulent overtime claims, fraudulent expenses claimed, fraudulent qualifications, misrepresentation of facts, and overstating of compensation events may occur. Applicant Engineering Technologists are expected to identify ethical problems, affected parties, and the best solution to resolve the problem at Responsibility Level E (i.e. performing).

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. It is imperative that Applicant Mechanical Engineering Technologists familiarise themselves with ECSA's Rules of Conduct, a listing of ethics regarding integrity and competency.

4.2.9 Exercising engineering sound judgement (Responsibility Level E)

Taking risky decisions may lead to equipment failure, excessive installation and maintenance costs, 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.

The design of a new product or equipment has technical risk that needs to be considered in the acquisition of any new technologies. While the application of developmental technology potentially offers significantly enhanced capability over existing systems, it can also lead to excessive delays and cost 'blow-outs'. Furthermore, technical risk can have negative impacts on the project, system, or the entire infrastructure if the implementation is not as successful as anticipated.

In developing engineering solutions, applicants should be able to demonstrate the factors that were considered, bearing in mind the risk, the consequences in technology application, and the affected parties. Failure to identify or manage this risk properly may result in performance degradation, security breaches, system failures, increased maintenance time, and a significant amount of technical debt for the organisation. It is essential to have a reliable analysis solution for technical-risk management to ensure early detection of problems.

Therefore, applicants must familiarise themselves with the organisational risk policies and standards. These risks may be identified or demonstrated under practise areas such as research and development, engineering systems design, advisory, planning and directing the construction and operation of components, rotating machines, and projects related to equipment and building services.

The extent of the projects given to Applicant Engineering Technologists is characterised by several broadly defined factors and a few well-defined factors and their resulting interdependence. If the task surpasses their educational or experiential capabilities, they will need to seek guidance. Taking risky decisions will lead to equipment failure, excessive installation and maintenance costs, damage to persons and property, etc. Evaluation includes engineering calculations to substantiate the decisions taken and the assumptions made.

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 in spite of 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 Responsibility in decision-making (Responsibility Level E)

Responsible decision-making includes applying engineering knowledge acquired from accredited engineering programmes. It includes considerations from engineering, social, environmental, and sustainable development factors in solving a broadly defined engineering problem. Applicants should be able to demonstrate recognition of social and environmental issues and application of relevant academic-level knowledge in formulating decisions. The responsibility is mostly allocated within a team environment, with an increasing designation as experience is gathered.

Applicant Mechanical 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 had 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. The trainee must manage his/her own training independently by taking initiative and being in charge of experiential development towards the level of Professional Mechanical Engineering Technologist.

4.2.11 Professional development (Responsibility Level D)

Applicants intending to register as Professional Engineering Technologists are expected to undertake sufficient independent learning activities to maintain and extend their competence. The following list of formal learning activities is by no means exhaustive; it is simply a sample of useful courses to assist applicants:

- Project management
- Conditions of Contract\Value Engineering – NEC, JBCC, etc.
- Standard specifications
- Preparation of specifications
- Negotiation skills
- Engineering finance
- Risk analysis and quality systems
- Occupational health and safety
- Discipline-specific courses
- Energy efficiency
- Electrical tariffs
- Maintenance engineering
- Environmental impact management
- Technical and business report writing
- Planning methods
- Systems Engineering
- Industrial relations
- Business presentation skills / public speaking

- Artificial intelligence
- Internet of things
- Cyber security
- Systems resilience

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. The trainee must manage his/her 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 Define, investigate and analyse well-defined engineering problems (Responsibility Level E)

During training, the Applicant Engineering Technician should be exposed to the technical investigation of equipment, plant, and product failure. The intent is for applicants to be able to define the engineering problem clearly and to investigate and analyse well-defined engineering problems. 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. Defining an engineering problem 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. Investigation of the engineering problem could be in the form of equipment failure in the system, development of new products, and provision of services.

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. Sufficient technical and business information about a plant or system should be collected, evaluated, and analysed for accuracy and reliability. Analysis of the information assists applicants to review the instruction that has been given in the initial engineering problem and assess if the work instruction was well understood. Engineering analysis involves applying scientific, analytic principles and processes to reveal the properties and state of the system, device, or mechanism under study. Applicant Mechanical Engineering Technicians or persons willing to register as Professional Engineering Technicians should be able to demonstrate how the well-defined engineering problem/s were defined and investigated.

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 the Engineering Technician 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 the Engineering Technician 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.

The actions of Engineering Technicians can have broader implications. For example, a small error in a localised task could potentially escalate into a larger problem that affects the entire system or project. When such situations arise, it may be necessary to involve Professional Engineers and Professional Engineering Technologists. These professionals typically have a broader scope of knowledge and are equipped to handle more complex problems. They can provide guidance, support, and solutions to address these larger issues.

4.3.2 Design or develop solutions to well-defined engineering problems (Responsibility Level C and D)

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. Engineering Technicians encounter various engineering problems and should provide solutions to return the plant or system to its normal functioning state. Designing or developing solutions for a well-defined engineering problem normally follows the steps presented below:

- List possible solutions
- Evaluate and rank the possible solutions
- Develop a detailed plan for the most attractive solutions
- Re-evaluate the plan to check desirability
- Check the result through calculations
- Implement the plan
- Communicate the results

Applicant Mechanical Engineering Technicians should be able to demonstrate the application of calculations and engineering concepts in designing or developing solutions to a well-defined engineering problem. Engineering norms and standards should be applied in the process of developing well-defined engineering solutions.

Once 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:

- Design work for Applicant Mechanical Engineering Technicians mainly involves the use and configuration of manufactured components and repetitive design work using an existing design as an example. Engineering Technicians apply existing codes and procedures in their design work. Investigation would be on well-defined incidents, and condition monitoring and operations would be mainly on controlling, maintaining, and improving engineering systems and operations.

- 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 that was received, and the theoretical calculations to support each alternative must be done and submitted as an attachment.
- The Applicant Mechanical Engineering Technician 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 a supervisor or mentor 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 deviating from those specified.

4.3.3 Contextual knowledge (Responsibility Level E)

Applicant Mechanical Engineering Technicians are required to apply engineering knowledge acquired during the accredited undergraduate programmes in order to resolve the 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 that are 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.

Engineering problem-solving of well-defined activities involves justifying the reason why National Diploma (NDip) theory is applied and, in most cases, requires the Engineering Technician to perform calculations to justify certain engineering decisions and assumptions.

Applicant Engineering Technicians are expected to work within prescribed engineering standards and codes in solving engineering problems or to justify operating outside these standards and codes. Engineering Technicians may also rely on knowledge from the National Standards (SANS) and

Rationalised Specifications (NRS) of the South African Bureau of Standards (SABS) and other technical standards and specifications to develop solutions to well-defined engineering activities.

The understanding of well-defined procedures and techniques must be based on fundamental mathematical, scientific, and engineering knowledge. The specific procedures and techniques that are applied to do the work, accompanied by the underpinning theory, must be given. 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 was derived from NDip theory.

- The specific location of the task to be executed is the most important determining factor in the layout design and the use of equipment. A combination of educational knowledge and practical experience must be used to substantiate the decisions taken, including a comprehensive study of materials, components, and projected customer requirements and expectations.
- Despite having a working knowledge of interacting disciplines, Engineering Technicians must appreciate the importance of working with specialists, for example, Civil Engineers on structures and roads, Mechanical Engineers on fire protection equipment, Architects on buildings, and Electrical Engineers on communication equipment. The codified knowledge in the related areas means working to and understanding the requirements set out by specialists in these areas.
- Jurisdictional in this instance means, “having the authority”, and Engineering Technicians must adhere to the terms and conditions associated with each task that is undertaken. They may even be appointed as the ‘responsible person’ or the ‘competent person’ for specific duties in terms of the OHS Act.

4.3.4 Engineering project management (Responsibility Level D)

The areas in which Applicant Mechanical Engineering Technicians work generally follow a conventional-project or product-development life cycle model.

Applicant Mechanical Engineering Technicians may contribute to or participate in a project by managing one or more activities in the project life cycle. The key activities of project management 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. Sometimes work priorities need to be tracked using project management software tools to manage the critical path of a project's activities.

Applicant Mechanical Engineering Technicians must expose themselves to the tools/software that is used to manage well-defined engineering activities and understand their role within the team. Applicant Engineering Technicians or persons wishing to register with the ECSA as a Professional Engineering Technician 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 in order to acquire all the skills in the project life cycle that are listed above.

In engineering operations and projects, Engineering Technicians will typically be given the responsibility to carry out specific tasks and/or to complete projects:

- Resources are usually subdivided based on availability and are controlled by a work breakdown structure and scheduling to meet deadlines. Quality, safety, and environment management are important aspects.
- Depending on the task, Engineering Technicians can be the team leader or a team member, or they can supervise appointed contractors.

4.3.5 Professional communication (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 in order 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 in order to be registered as Professional Engineering Technicians.

4.3.6 Impact of engineering activities and risk mitigation (Responsibility Level B)

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

- Social effects encompass all issues that directly or indirectly affect people and their livelihoods. Engineering activities may affect people's way of life, their political system, their health and wellbeing, and their personal and property rights.
- Environmental effects include the effects on people's environment (i.e. air and water quality, dust and exposure to noise, adequacy of sanitation) and the effects on large ecosystems. This might include disruption of ecosystems and fauna and flora in addition to increased land temperatures and damage to historical buildings.
- Cultural effects include people's customary beliefs, religion, language, and norms, for example, the ceremonies and customs of a particular group or society.

Mechanical Engineering has a heavy impact on the environment (e.g. emissions, waste, energy consumption, depletion of natural resources, noise and vibration, heat and friction, wear and tear, corrosion and erosion, accidents and injuries, harmful effects on humans and animals, complex and hazardous machinery, and maintenance and disposal).

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

4.3.7 Statutory and regulatory requirements (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. Applicants wishing to register with the 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). The most commonly used engineering regulating standards and Acts that applicants meet in the course of executing the engineering work are as follows:

- Engineering Profession Act, No. 46 of 2000
- Occupational Health and Safety Act, No. 85 of 1993
- National Building Regulations and Building Standards Act, No. 103 of 1977
- National Environmental Management Act, No. 107 of 1998
- Employment Equity Act, No. 55 of 1998
- Environment Conservation Act, No. 52 of 1994 and Environment Conservation Amendment Act, No. 50 of 2003
- Mine Health and Safety Act, No. 29 of 1996
- Specific work instructions, standards, and/or specifications of the enterprise

Other Acts not listed here may also be pertinent to an applicant'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.

Depending on the working environment, the provisions of the OHS Act and/or the MHS Act must be followed by employers and employees. Applicants should obtain a functional understanding of these provisions in their specific workplaces.

Industry-specific regulations and requirements may or may not be applicable in all fields of Mechanical 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.

4.3.8 Conduct engineering activities ethically (Responsibility Level E)

Ethical problems arise during engineering activities, for example, using unsustainable material for a solution or contravening other regulations in the process of developing solutions. Other general ethical problems may also arise while performing engineering activities. 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 Mechanical 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 Mechanical Engineering Technician, he/she should seek guidance from relevant parties. Conflict of interest while conducting engineering activities should be avoided or declared so that decisions are made transparently.

4.3.9 Exercising engineering sound judgement (Responsibility Level E)

Sound judgement and decision-making can be defined as one's ability to assess situations or circumstances objectively, using all the relevant information and applying past experience to come to a conclusion. Applicant Mechanical 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.

It is essential to have a reliable analysis solution for technical risk management in order to ensure early detection of problems. This prevents issues from occurring without warning and drastically decreases the effort required to alleviate sudden infrastructure or system problems. Applicant Mechanical Engineering Technicians must familiarise themselves with organisational risk policies and standards. These risks may be identified or demonstrated in building services, product development, or projects relating to research and development. Applicant Mechanical Engineering Technicians should strive to acquire experience in all generic engineering competencies of problem-solving implementation, operation, risk and impact mitigation, and management of engineering activities.

The extent of a project or task given to an Applicant Engineering Technician is characterised by the limited number of factors and their resulting interdependence. If the task surpasses their educational or experiential capabilities, they will need to seek guidance. Taking risky decisions will lead to equipment failure, excessive installation and maintenance cost, and damage to persons and property.

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

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

4.3.10 Responsibility in decision-making (Responsibility Level E)

For engineering activities classified as well defined in which the Engineering Technician uses standard procedures, codes of practice, specifications, etc., judgement must be displayed to identify any activity falling outside the well-defined range.

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. Where an Applicant Mechanical Engineering Technicians does not have the required knowledge, it is responsible to ask for advice from a relevant authority or from those who possess the information. Any decisions taken should be evaluated for shortcomings to ensure there are no surprises at the end of the project/ activity.

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, form important elements.

4.3.11 Professional development (Responsibility Level D)

Professional development refers to continuing education and career training after a person has entered the workforce. Professional development assists in developing new skills, broadening of knowledge, staying up to date on current trends and technologies, and advancing one's career. A registered Professional Engineering Technician is required to maintain and extend the level of competency through CPD activities in order to retain registration.

When applying for registration, applicants should provide evidence of initial professional development (IPD) that has been attained during the training period. These activities could include engineering courses, management courses, and computer courses. Enrolling for a postgraduate engineering programme is considered part of the development activities. Applicants must be able to demonstrate professional development by

- adopting a strategy for own professional development;
- selecting appropriate professional development activities;
- keeping thorough records of professional development activities; and
- demonstrating independent learning ability through completing developmental activities.

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. The trainee must manage his/her own training independently by taking initiative and being in charge of experiential development towards the level of Professional Engineering Technician. Knowledge of the employer's policy and procedures on training is essential.

5. FUNCTIONS PERFORMED

Mechanical Engineering forms an integral part of the broader engineering systems and infrastructure in technologically complex manufacturing, processing, mining, construction, product development, and research environments.

5.1 Degrees of responsibilities

Progression throughout the candidacy period presented in document **R-04-T&M-Guide-PC** and below in **Table 1** refers to the gradual increase in the Degree of Responsibility that Applicant Engineers are exposed to during professional training. Considering the nature of the work, specific examples and outcomes appropriate to training in Mechanical Engineering are presented in Table 1 below:

Table 1: Progression throughout the candidacy period of applicants

Degree of Responsibility	Nature of work	Activities/duties to be undertaken during training
A: Being exposed	The Candidate undergoes induction and observes processes and work of competent practitioners.	• Understand the business environment and the dynamics that shape the businesses and the industries in which they operate. • Understand the business model, its key conversion processes, and the critical outcomes. • Understand the value added by Mechanical Engineering Practitioners and other professionals in the business.
B: Assisting	The Candidate performs specific processes under close supervision.	• Develop insight and understanding of the different processes and systems in transforming inputs into goods and services. • Develop an appreciation of the numerous resources at the disposal of Mechanical Engineering practitioners. • Obtain experience in the day-to-day operations of the business 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.

Degree of Responsibility	Nature of work	Activities/duties to be undertaken during training
C: Participating	The Candidate performs specific processes as directed, with limited supervision.	• Gain first-hand experience of a broad range of Mechanical Engineering activities (e.g. process design and re-engineering, planning and control, work study, value engineering, materials and information management, people management skills, logistics, specialists' inputs, tools and equipment, and quality assurance). • Note the problems and limitations of particular philosophies, methods, and techniques, with emphasis on cost/effort and relative benefit.
D: Contributing	The Candidate performs specific work with detailed approval of work outputs.	• Be involved in activities such as the planning of production, the control of quality and costs of process study and work study, good material handling and workplace layout, activity-based costing, benchmarking, business cases, process re-engineering, maintenance practice and procedures, and project management and system specification. Of particular importance is the collective working of such activities in the economical use of people, materials, and machines. • Give specific attention to human aspects concerning communication, interpersonal relationships and teamwork, training, cost analysis, budget control, and profit accountability. These should proceed in parallel, applying Mechanical Engineering techniques and employing computers in problem-solving.
E: Performing	The Candidate works in a team without supervision, recommends work outputs, and is responsible but not accountable.	• Assume escalating technical responsibility and increasingly co-ordinate the work of others. • Gain exposure to and develop skills in management areas such as labour relations, management accounting, business law, and general business management. This is important for developing well-rounded Engineering Practitioners. • Seek assignments that require judgement, even if full information is unavailable. This leads to a position of professional responsibility, which is of great value and should be pursued.

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

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

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

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

Training Elements have been developed against the Degree of Responsibility Scale (see Appendix A). Activities should be selected to ensure applicants reach the required level of competency and responsibility.

It should be noted that applicants working at **Responsibility Level E** carry responsibility equivalent to that of a registered person except that the applicant's supervisor is accountable for the applicant's recommendations and decisions.

5.2 Candidates training programMEs

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 Mechanical Engineering knowledge in optimising the efficiency of operations or the constructability of projects.

It is suggested that applicants work with their Mentors to determine appropriate projects to gain exposure to elements of the asset life cycle. In addition, applicants need to ensure that their designs are constructible and operable and are designed considering life cycle costing and long-term sustainability. A regular reporting structure with suitable recording of evidence of achievement against the competency outcomes and responsibility needs to be in place.

The training programme should be such that 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 a mechanical workshop environment and have participated in the execution of practical work such that they have learnt sufficient details of basic mechanical procedures to be able to exercise judgement in the workplace.

Applicants must show evidence of adequate training in this function through project work carried out in the analysis of problems and the synthesis of solutions. Evidence is required in the form of a separate comprehensive design report that should accompany the application. This report should describe a synthesised solution to engineering problems to demonstrate that applicants have had an opportunity to apply their technical knowledge and engineering expertise gained through education and practical work experience. In applying technical and scientific knowledge gained through academic training, the applicant must also demonstrate the financial and economic benefits of engineered solutions synthesised from scientific and engineering principles at a sufficiently advanced level.

Applicants are required to undertake Mechanical Engineering projects that significantly enhance the operability and constructability of integrated engineering systems and infrastructure. Such project work must not be a stand-alone type of assignment but should be part of a solution to integrated engineering systems that require a broader application of various theoretical aspects of Mechanical Engineering, ranging from fluid systems and energy systems to structures and machines.

The design or development is a logical process that requires Engineering Professionals to apply their minds carefully in bringing solutions to the various defined levels of engineering problems (see Appendix B). This process involves the analysis of systems or the assembly of mechanical components together with the integration of various elements in Mechanical Engineering through the application of engineering sciences.

As part of demonstrating the advanced application of theoretical knowledge with respect to these systems, applicants must incorporate calculations with clearly defined inputs regarding the formulae that were used and a detailed interpretation of the results that were obtained. Applicants must demonstrate how the calculated results have been used to provide the solution to the problem at hand and indicate the economic benefit to the project or the operating work environment.

Applicant Engineering Professionals must obtain experience in solving a variety of problems in their work environments, and the solutions to these problems should involve the use of fundamental and advanced Mechanical Engineering knowledge obtained from an accredited academic engineering programme. The problems that require a scientific and engineering approach to solve may be encountered in any engineering work environment that consists of integrated engineering systems, equipment, machinery, and infrastructure. 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.

A suitable period of time and degree of practical participation should also be sought in the workshop environment, learning the basic practices that are the essence of the mechanical discipline so that the applicant can judge the efficacies of such practices in the general workplace thereafter.

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.

The ECSA Professional Registration process comprises assessment, moderation of the applicant's portfolio of evidence, and peer review.

6. CONCLUSION

To attain registration as professionals, applicants should be able to meet the educational requirements for the category and demonstrate competency against the prescribed standards for the registration category. Demonstrating competency is achieved by meeting the requirements for the 11 ECSA outcomes. Applicants or persons willing to be registered as professionals together with their Mentors must ensure that the training provided is geared towards achieving the ECSA competency outcomes. Focusing on one training aspect for the entire duration of training will not assist applicants in achieving the necessary skills to demonstrate all the standard competency outcomes.

The development of training remains the responsibility of the applicant, and the applicant must ensure that the training plan being provided covers all aspects of the outcomes. It has been common practice that in situations in which a department or organisation is unable to provide training in certain areas, secondments are arranged with other departments or organisations so that the applicant is able to develop all the competencies required for registration. These secondments are usually reciprocal in nature and benefit the employee and the employer. Secondments between consultants and contractors and between the public and private sectors should be possible to allow applicants to acquire the necessary competencies.

REVISION HISTORY

Revision number	Revision date	Revision details	Approved by
Rev 0 Draft A	12 Dec 2023	The DSTG have been merged into one Discipline Specific Training Guide for Registration as a Professional Engineer, Technologist and Technician in Mechanical Engineering and to ensure that the DSTG clearly detail how each outcome can be achieved.	RDDR BU
Rev 0 Draft B	13 Dec 2023	The review has included and introduction section the document further indicate 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* 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	Working group

Revision number	Revision date	Revision details	Approved by
		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	20 Jan 2024	Document revised with WG and Registration BU	RI BU, Registration BU and WG
Rev 0 Draft D	25 Mar 2024	Document submitted to the IEA Task Team for alignment to the IEA changes	IEA Review Task Team
Rev 0 Draft E	04 Apr 2024	Reviewed and checked	Executive: RPSC
Rev 0	17 Apr 2024	Approval	RPSC

The Discipline-Specific Training Guide for:

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

Revision 0 dated 17 April 2024 and consisting of 55 pages reviewed for adequacy by the Business Unit Manager and is approved by the Executive: Research, Policy and Standards (RPS).

....	21 May 2024 ....
Business Unit Manager	Date
....	22 May 2024 ....
Executive: RPS	Date

This definitive version of this policy is available on our website

APPENDIX A: TRAINING ELEMENTS

1	**Introduction**
1.1	*Induction programme* (typically 1–5 days)
1.1.1	Company structure
1.1.2	Company policies
1.1.3	Company Code of Conduct
1.1.4	Company safety regulations
1.1.5	Company staff code
1.1.6	Company regulations
1.2	*Exposure to Practical Aspects of Engineering (typically 6–12 months) and covers how things are:* (Responsibility Levels A–B)
Experience in one or more of these sectors but not all:	
1.2.1	Manufacturing
1.2.2	Construction
1.2.3	Erection
1.2.4	Field installation
1.2.5	Testing
1.2.6	Commissioning
1.2.7	Operation
1.2.8	Maintenance
1.2.9	Fault location
1.2.10	Problem investigation
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)
In one or more of the above sectors:	
2.1.1	Analysis of data and systems
2.1.2	Planning of networks and systems
2.1.3	System modelling and integration
2.1.4	System design

2.1.5	Network/circuit design
2.1.6	Component/product design
2.1.7	Software design
2.1.8	Research and investigation
2.1.9	Preparation of specifications and associated documentation
2.1.10	Preparation of contract documents and associated documentation
2.1.11	Development of standards
2.1.12	Application of quality systems
2.1.13	Configuration Management
3	**Engineering tasks**
3.1	*Experience in the execution of engineering tasks* (remainder of training period)*. Focus should be on projects and project management* (Responsibility Level E)
	Working in one or more of these sectors but not all
3.1.1.	Design or development of solution
3.1.2	Manufacture
3.1.3	Construction
3.1.4	Erection
3.1.5	Installation
3.1.6	Commissioning
3.1.7	Maintenance
3.1.8	Modifications
3.2	*Organising for implementation of 3.1* (Responsibility Level E)
3.2.1	Manage resources
3.2.2	Optimisation of resources and processes
3.3	*Controlling for implementation or operation of 3.1* (Responsibility Level E)
3.3.1	Monitor progress and delivery
3.3.2	Monitor quality
3.4	*Completion of 3.1* (Responsibility Level E)
3.4.1	Commissioning completion
3.4.2	Documentation completion

3.4.3	Documentation handover
3.5	*Maintenance and repair of 3.1* (Responsibility Level E)
3.5.1	Plan and schedule maintenance
3.5.2	Monitor quality
3.5.3	Oversee maintenance and repair
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)
4.2.1	Health and safety
4.2.2	Codes and standards
4.2.3	Legal and regulatory
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