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SOUTH AFRICA

Guide to the Competency Standards for Registration in Professional Categories

R-08-CS-GUIDE-PE/PT/PN

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DEFINITIONS

Competency indicator: The typifying guide to evidence indicating competence that is not normative.

Commitment and Undertaking (C&U) is an agreement entered into between an employer and 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.

Continuing Professional Development (CPD): CPD is 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 an engineering practitioner's career.

Competency Standard is a statement of competency required for a defined purpose and in a specific category, expressed in the form of generic baseline competencies that all professionals in the category must demonstrate to be deemed eligible for registered status, irrespective of their discipline.

Dublin Accord: An International Agreement establishing the required educational base for Engineering Technicians. It specifically focuses on the mutual recognition of academic programmes / qualifications that underpin the educational base for Engineering Technicians.

Engineering Practitioner: Engineers before or after professional registration in general are referred to as practitioners of engineering who invent, design, analyse, build and test the equipment / machines, complex systems, structures, components and material to fulfil the functional objective and requirements while considering the limitations imposed by practicality, regulation, safety and cost.

Engineering Problem: A problematic situation that is amenable to analysis and solution using engineering science and methods.

Engineering Science: A body of knowledge based on the natural sciences and using a 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.

Integrated Performance: The overall satisfactory outcome of an activity that requires several outcomes to be satisfactorily attained. For example, a design requires analysis, synthesis, analysis of impacts, checking of regulatory conformance and judgement in decisions.

Initial Professional Development: The systematic participation in the activities typical of Continuing Professional Development but completed prior to professional registration.

Level Descriptor: A measure of performance demands at which outcomes must be demonstrated in accordance with Degree of Responsibilities (DoR). Level descriptors applicable to the registration category are defined within complex (CEA)/broadly defined (DBEA)/well-defined (WDEA) Engineering work/activities/tasks/projects.

Outcome: A statement of the performance criteria that a person must demonstrate to be judged competent at the professional level.

Practice Area: A generally recognised or distinctive area of knowledge and expertise developed by an engineering practitioner through the path of education, training and experience followed.

Professional Development: The continuing education and career training after a person has entered the workforce to help them develop new skills, stay up to date on current trends and advance their career.

Sydney Accord: An international agreement among the bodies responsible for accrediting engineering technology academic programmes.

Washington Accord: An international accreditation agreement relating to undergraduate academic degrees in professional engineering among the bodies responsible for accreditation in its signatory country and region.

ABBREVIATIONS

AIET	Agreement for International Engineering Technician
BDEA	Broadly Defined Engineering Activities
CEA	Complex Engineering Activities
CPD	Continuing Professional Development
CS	Competency Standard
DA	Dublin Accord
DoR	Degree of Responsibility
ECSA	Engineering Council of South Africa
IETA	International Engineering Technologist Agreement
EIT	Engineer-in-Training
IPD	Initial Professional Development
IPEA	International Professional Engineering Agreement
PC	Professional Categories
PD	Professional Development
PE	Professional Engineer
PN	Professional Engineering Technician
PT	Professional Engineering Technologist
SA	Sydney Accord
WA	Washington Accord
WDEA	Well-defined Engineering Activities
VA	Voluntary Association
VPM	Virtual Panel Members

APPLICABLE DOCUMENTS

R-01-POL-PC	Registration Policy in Professional Categories
R-02-STA-PE/PT/PCE/PN	Competency Standard for Registration in Professional Categories PE/PT/PCE/PN
R-03-PRO-PC	Process of Application for Registration of Candidates and Professionals
R-04-TM-GUIDE-PC	Training and Mentoring Guide for Professional Categories
R-04-TM-GUIDE-SC	Training and Mentoring Guide for Specified Categories
R-05-xxx- PE/PT/PN/PCE	Discipline-specific Training Guideline and Requirements
R-08-CS- PE/PT/ PCE/PN	Guide to competency standards for registration
R-01-POL-PC	Registration Policy in Professional Categories
R-02-STA-PE/PT/PCE/PN	Competency Standard for Registration in Professional Categories PE/PT/PCE/PN
R-02-STA-PCE	Competency Standard for Registration as a Professional Certificated Engineer

BACKGROUND

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

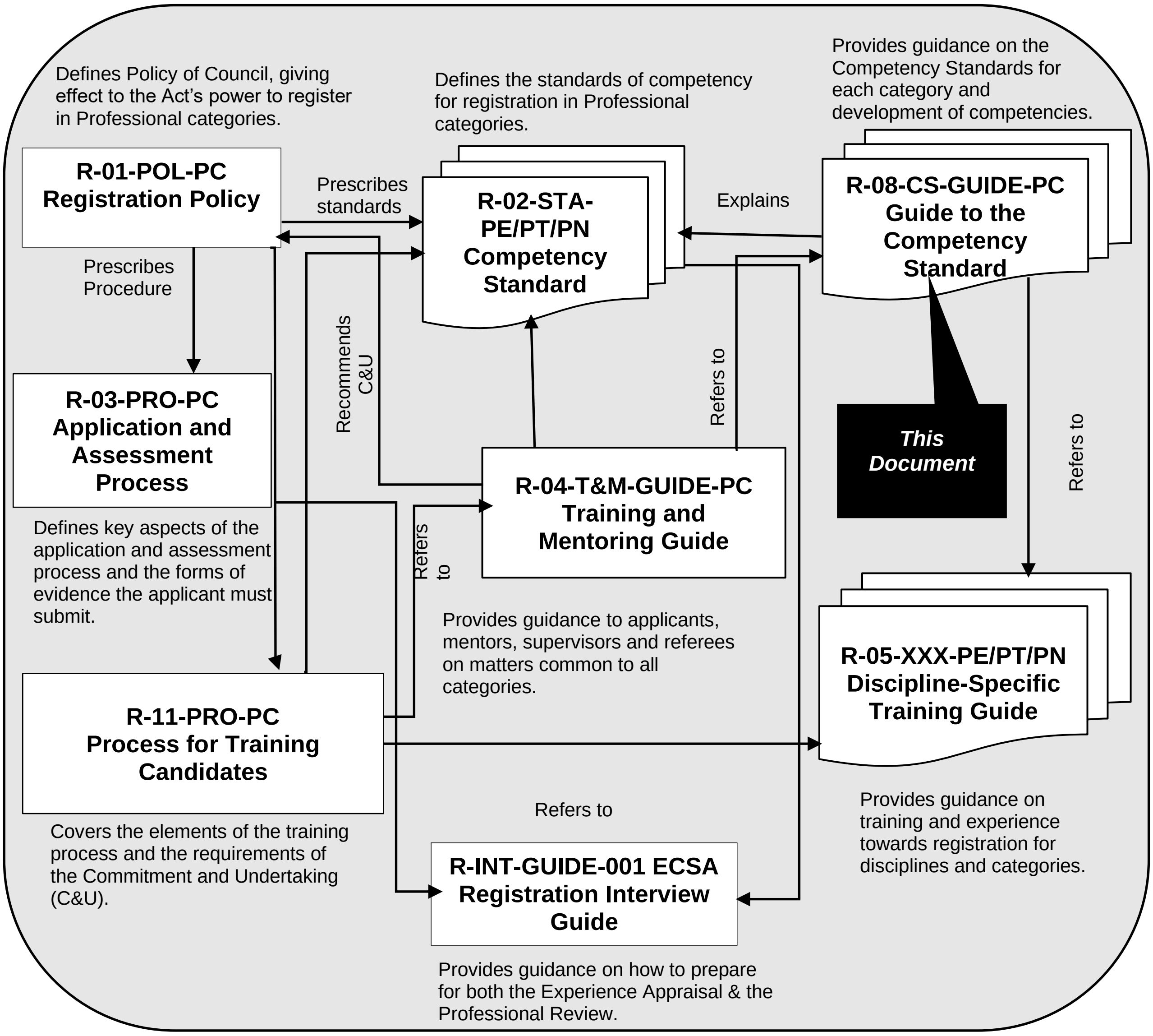

Figure 1: Documents defining the ECSA registration system

1. PURPOSE OF THIS DOCUMENT

This *Guide to Competency Standard for Registration*, **R-08-CS-GUIDE-PE/PT/PN**, amplifies the *General Training and Mentoring Guide* (document **R-04-T&M-GUIDE-PC**), concentrating on an understanding of the competency standards for Professional Engineers, Professional Engineering Technologists and Professional Engineering Technicians that are defined in document **R-02-STA-PE/PT/PN**. This guide indicates ways of developing the requisite competencies and how the competencies can be demonstrated through engineering work/ activities/tasks/projects to determine if an applicant is ready for professional registration. This guide may, in turn, be supplemented by the *Discipline-specific Training Guide*, document **R-05-XXX-PE/PT/PN**, if available, for the applicant's discipline.

The *Processing of Applications for Registration of Candidates/Applicants and Professionals*, document **R-03-PRO-PC**, identifies areas of change from the training-based requirements to output-based competency standards and the accompanying changes in the preparation of applications and assessments of competency.

2. POLICY STATEMENT

The Competency Standards for professional registration are governed by the *Policy on Registration of Professional Categories* (**R-01-POL-PC**).

3. APPLICABLE LEGISLATIVE FRAMEWORK

The Engineering Profession Act, 46 of 2000 stipulates that the Council may, subject to this Act:

(a) consider and decide on any application for registration
(b) prescribe the period of validity of the registration of a registered person
(c) keep a register of registered persons and decide on:

- the form of certificates and the register to be kept
- the maintenance of the register or issuing of certificates
- the reviewing of the register and the manner in which alterations thereto may be effected.

4. NATIONAL AND INTERNATIONAL COMPLIANCE

ECSA is internationally recognised under the auspices of the International Engineering Alliance (IEA) via Educational Accords and Competency Agreements as follows:

Educational Accords:

- Washington Accord (WA)
- Sydney Accord (SA)
- Dublin Accord (DA)

Competency Agreements:

- International Professional Engineers Agreement (IPEA)
- International Engineering Technologist Agreement (IETA)
- Agreement for International Engineering Technicians (AIET)

5. AUDIENCE

The intended audience of this guide is applicants undergoing training towards professional registration and their mentors and supervisors. This document is also an important guideline for persons registered as Professional Engineers/Professional Engineering Technologists/ Professional Engineering Technicians who serves as assessors, moderators and reviewers of candidates or applicants applying for registration.

6. INTRODUCTION TO COMPETENCY, STANDARDS AND PERFORMANCE

Competence is defined as possession of the necessary *knowledge*, *training and experience* to perform the activities within the respective professional category (namely: Professional Engineer / Professional Engineering Technologist / Professional Engineering Technician) to standards expected in independent employment or practice.

Competence is therefore detailed in two categories:

- Knowledge component.
- Training and experience component, which is deeply integrated with Degree of Responsibility (DoR).

The knowledge component of competency consists of attributes from the engineering education process that are subsequently acquired during specialised engineering-related activities both in the work environment and from Continuing Professional Development (CPD). The skills and attitude components are defined by a set of assessable outcomes. Similarly, the training and experience component is defined by a set of assessable outcomes whereby competence must be demonstrated:

- within applicable engineering activities
- by the integrated performance of outcomes
- at the DoR level defined for each outcome.

The *ECSA Competency Standard*, document **R-02-STA-PE/PT/PN**, defines the competencies required for registration across ECSA's categories of professional registrations: Professional Engineer, Professional Engineering Technologist and Professional Engineering Technician. The *Competency Standard* (document **R-02-STA-PE/PT/PN**) applies to all engineering disciplines and specialities. Contexts and functions in which competency may be developed and the outcomes demonstrated may be described in the applicable *Discipline-specific Training Guide* **R-05-XXX-PE/PT/PN**.

In accordance with the *Competency Standard*, document **R-02-STA-PE/PT/PN**, the following competencies must be demonstrated:

- **within complex** engineering activities (CEA) for Professional Engineer
- **within broadly defined** engineering activities (BDEA) for Professional Engineering Technologist
- **within well-defined** engineering activities (WDEA) for Professional Engineering Technician
- **by** the integrated performance of the outcomes
- ***at*** the DoR *level defined* for each outcome.

This guide/document, elaborates on the outcomes, the level of performance and the integrated performance required of an applicant for registration as a Professional Engineer, Professional Engineering Technologist and/or Professional Engineering Technician.

7. OUTCOMES FOR PROFESSIONAL REGISTRATION

Candidates/Applicants must demonstrate competency in all 11 outcomes to be considered for professional registration. Section ***7.1*** should be consulted by candidates/applicants and used as a rubric to determine if they are receiving the necessary exposure. Assessors, moderators and reviewers specifically utilise these outcomes to evaluate candidates'/applicants' applications for professional registration.

7.1 Overview of outcomes

The outcomes required for professional registration as outlined in the *Competency Standard* and are summarised in ***Table 1*** below. In addition to ***Table 1***, applicants need to further refer to the detailed competency indicators for each category as stipulated in the *Competency Standard for Registration*.

The defined outcomes are combined into five groups as follows:

- **Group A:** Engineering problem solving
- **Group B:** Managing engineering activities
- **Group C:** Risk and impact mitigation
- **Group D:** Act ethically, exercise judgment and take responsibility
- **Group E:** Professional development.

Table 1: Overview of outcomes

Group	Outcome	Description – Professional Engineer	Description – Professional Technologist	Description – Professional Technician
Group A Knowledge-based, engineering problem-solving	1	Define, investigate and analyse *complex engineering problems*	Define, investigate and analyse *broadly defined engineering problems*.	Define, investigate, and analyse *well-defined engineering problems.*
	2	Design or develop solutions to *complex engineering problems.*	Design or develop solutions to *broadly defined engineering problems.*	Design or develop solutions to *well-defined engineering problems.*
	3	Comprehend and apply advanced and local knowledge of	Comprehend and apply the knowledge embodied in widely	Comprehend and apply knowledge that is embodied in

Group	Outcome	Description – Professional Engineer	Description – Professional Technologist	Description – Professional Technician
		the widely applied principles underpinning good practice that is specific to the jurisdiction in which the Engineer practices.	accepted and applied engineering procedures, processes, systems and methodologies that is specific to the jurisdiction in which the Engineering Technologist practices.	established engineering practices that is specific to the jurisdiction in which the Engineering Technician practices.
Group B Managing Engineering Activities	4	Manage part or all of one or more *complex engineering activities.*	Manage part or all of one or more *broadly defined engineering activities*.	Manage part or all of one or more *well-defined engineering activities.*
	5	Communicate clearly using multiple media and collaborate inclusively with a broad range of stakeholders in the course of engineering activities.		
Group C Risk and impact mitigation	6	Recognise the reasonably foreseeable economic, social, cultural, and environmental effects of *complex engineering activities* seeking to achieve sustainability.	Recognise the reasonably foreseeable economic, social, cultural, and environmental effects *of broadly defined engineering activities* seeking to achieve sustainability.	Recognise the reasonably foreseeable economic, social, cultural, and environmental effects of *well-defined engineering activities* seeking to achieve sustainability.
	7	Meet all legal and regulatory requirements and protect the health and safety of persons during all *ties*.		
Group D Act ethically, exercising judgement and taking responsibility	8	Conduct engineering activities ethically.		
	9	Exercise sound judgement by evaluating the outcomes, impacts and alternatives in the course of *complex*	Exercise sound judgement by evaluating the outcomes, impacts and alternatives in the course of *broadly defined*	Exercise sound judgement by evaluating the outcomes, impacts and alternatives in the course of *well-defined engineering activities*.

Group	Outcome	Description – Professional Engineer	Description – Professional Technologist	Description – Professional Technician
		engineering activities.	engineering activities.	
	10	Be responsible for making decisions on part or all of *complex engineering activities*	Be responsible for making decisions on part or all of *broadly defined engineering activities*.	Be responsible for making decisions on part or all of *well-defined engineering activities*
Group E Professional Development)	11	Undertake sufficient professional development activities to maintain, extend competence and enhance the ability to adapt to emerging technologies and the ever-changing nature of work.		

As described in the *Competency Standard* and depicted in ***Table 1*** above, the outcomes and performance of the outcomes must be integrated. Competent engineering work/activities/tasks/projects invariably require the simultaneous performance of several actions embodied in the outcomes.

Outcomes 1, 2, 4 and **5** capture the essential functions of Professional Engineers, Professional Engineering Technologists and/or Professional Engineering Technicians, which are all supported by communication and involve analysing and solving engineering problems as well as managing processes, projects and operations to deliver results. To perform these four core functions, Professional Engineers, Professional Engineering Technologists and/or Professional Engineering Technicians rely on fundamental and specialised engineering knowledge and comprehension of the context in which the work takes place.

Outcome 3 deals with the comprehension and application of knowledge by engineering practitioners in specific professional categories embodied in established engineering practices that are specific to the jurisdiction in which the Professional Engineer, Professional Engineering Technologists and/or Professional Engineering Technicians practise.

While solving engineering problems and managing processes, Professional Engineers, Professional Engineering Technologists and/or Professional Engineering Technicians must be able to identify and deal with the impact of the solutions and the applicable regulatory requirements as reflected in **Group C** (i.e., **Outcomes 6 and 7**).

Some attributes are not necessarily taught and do not form part of the education component but are essential on a personal level. Professional Engineers, Professional Engineering Technologists and/or Professional Engineering Technicians must act ethically, exercise judgement and take responsibility as reflected in **Group D** (i.e., **Outcomes 8, 9, 10**).

Outcome 11, which underpins all the other outcomes, emphasises the need for continuous development professionally, that is, to increase knowledge and gain the required competencies for the effective performance of engineering work/activities/tasks/projects.

A visual representation of the set of 11 outcomes is depicted in ***Figure 2*** showing evidence of engineering competence and its interconnectedness. Problem-solving (analysis and synthesis) is seen in the central position, with competencies represented by other outcomes as supporting roles.

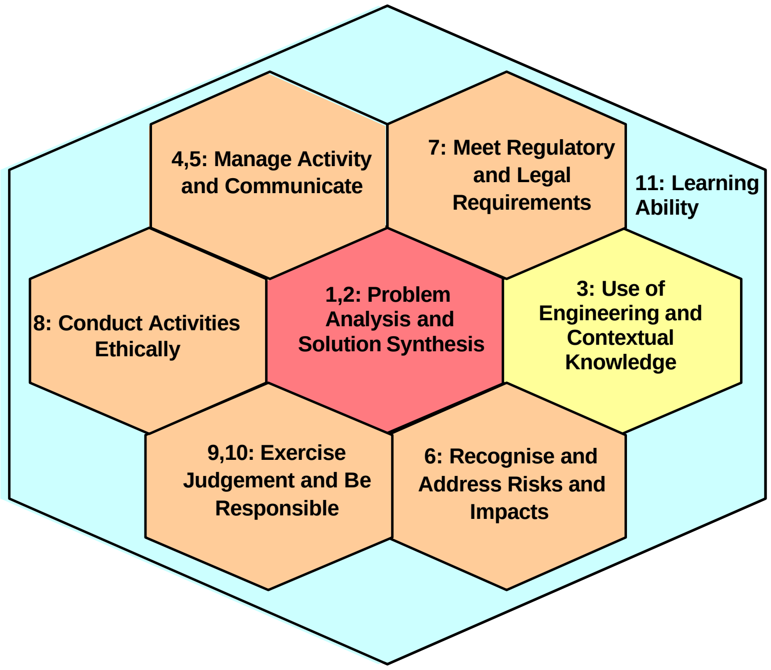

Figure 2: Visualising for the Interconnectedness of the Engineering Outcomes

As indicated in ***Figure 2*** above, the core activity of engineering is problem-solving, i.e., bringing about change from an initial state to a final state and overcoming the barriers involved to achieve a result that is useful to people, enterprises and society. During this process, knowledge that is based on Engineering Science and principles/methods/techniques is applied while accounting for the impacts of engineering activities, legal and regulatory factors and ethics. Responsible, judgement-based, decision-making and management of the process is essential to achieve engineering goals. Competent engineering practitioners underpin their activities by continuous learning, both formally and informally.

Problem-solving also refers to the systematic process of identifying, analysing and finding solutions to technical challenges and issues encountered in the field of engineering. It is a fundamental aspect of engineering practice and is crucial for designing, developing and maintaining various systems, products and processes. Some key elements of problem solving involve problem identification, analysis and understanding of the problem's underlying principles and factors, generation of alternative solutions which vary in terms of feasibility, safety, cost-effectiveness, legal and regulatory requirements, and ethics and performance evaluation. The most suitable option is selected through a process of responsible, judgement-based decision-making and management of the process. Designs are conducted using engineering knowledge and principles to produce engineering drawings, plans, specifications and processes.

Problem solving further involves testing and validation to ensure that the chosen solution meets the desired specifications and performs according to the criteria.

7.2 Demonstration of competency of the 11 outcomes for professional registration

Competency outcomes defined in *Competency Standard* document and summarised in ***Table* 1** of this document may be achieved through undertaking engineering work/activities/ tasks/projects at varying levels of DoR. To be declared competent to register as a Professional Engineer, Engineering Technologist and/or Engineering Technician, an engineering practitioner must demonstrate the defined outcomes at the appropriate level descriptor. The *Competency Standard* document defines the level-descriptor for each category of registration as follows:

Professional Engineer:

- A set of level descriptors for a *complex engineering* problem.
- The level descriptors that allow an engineering activity to be classified within *complex engineering* activities.
- Solving complex engineering problems and performing complex engineering activities.

Professional Engineering Technologist:

- A set of level descriptors for a *broadly defined engineering problem*.
- The level descriptors that allow engineering activity to be classified within *broadly defined engineering activities*.
- Solving broadly defined engineering problems and performing broadly defined engineering activities.

Professional Engineering Technician:

- A set of level descriptors for a *well-defined engineering problem*.
- The level descriptors that allow an engineering activity to be classified within *well-defined engineering activities*.
- Solving well-defined engineering problems and performing well-defined engineering activities.

The DoR has levels of responsibility varying from “Being Exposed” at Level A to “Performing” at Level E, as detailed in the *Training and Mentoring Guide*, document **R-04-T&M-GUIDE-PC**. These are illustrated in ***Table 2*** below and are used to measure the progression of the applicant’s competency. Achievement of “Performing” at Degree of Responsibility “E” is a requirement to demonstrate competency for each category of registration.

Table 2: **The nature of work and summary of DoR defined in document R-04-T&M-GUIDE-PC**

Degree of responsibility (DoR)	Nature of work: the mentee	Responsibility of mentee	Extent of mentor support	Extent of supervisor support
Level A: Being Exposed	Undergoes induction, observes	No responsibility,	Mentor showing genuine interest	Accept mentee’s plan for training and mentoring

Degree of responsibility (DoR)	Nature of work: the mentee	Responsibility of mentee	Extent of mentor support	Extent of supervisor support
	engineering work/ activities/tasks/ projects and processes under close supervision.	except to pay attention.	on mentee work. Mentor explains challenges and forms of solution.	and coaching via the *Training and Mentoring Programme Process Tool/Technique*.
Level B: Assisting	Performs specific engineering activities and processes under close supervision.	Limited responsibility for work output.	Mentor coaches, offers feedback.	Closely supervise mentee's engineering work/activities/ tasks/projects.
Level C: Participating	Performs specific engineering activities and processes as directed with limited supervision.	Mentee articulates own reasoning and compares it with that of supervisor.	Exposes mentee to increasing demands in the range of engineering competencies through shared knowledge.	Supervisor progressively reduces support but monitors outputs.
Level D: Contributing	Performs specific work with detailed approval of work outputs.	Full responsibility for supervised work.	Mentor supports mentee in building strong problem-solving skills via experience sharing.	Full responsibility to supervise the immediate quality of work done by mentee. (e.g., monitor and approve).
Level E: Performing	Works in team without supervision, recommends work outputs, responsible but not accountable.	Level of responsibility to supervisor is appropriate to a registered person; supervisor is accountable for mentee's decisions.	Provide constructive review feedback on industry projects against competency outcome objectives.	Mentee takes on problem-solving without support, or at most, with limited guidance

7.3 Defining engineering activities

The *Competency Standard* takes a broad view of defining engineering activities, listing several possible functions such as design; planning; investigation and problem resolution; improvement of materials, components, systems and processes; implementation, construction, manufacture and engineering operations; maintenance; project management; research; development and commercialisation.

The *Discipline-specific Training Guideline* **R-05-XXX-PE/PT/PN**[1] should be consulted for the types of activities an applicant needs to perform to demonstrate competence.

In summary, evidence of competent performance has two essential requirements:

- Capability to perform a number of defined actions must be demonstrated.
- Performance must be at or exceed a *specified level of demand / DoR*.

The defined actions are the outcomes. The level of performance is defined by the DoR of the engineering work/activities/tasks/projects and the nature of problem-solving. In a professional field, evidence of competent performance is obtained from the competent performance of substantial engineering tasks by the person being assessed. Typical engineering tasks provide evidence of competence for several outcomes, and assessment of activities/knowledge is holistic.

7.3.1 Engineering activities for a Professional Engineer:

Group A: Knowledge-based engineering problem-solving

As described in ***Table 1*** of this document, Group A comprises three outcomes:

- **Outcome 1 –** Define, investigate and analyse complex engineering problems.
- **Outcome 2 –** Design or develop solutions to complex engineering problems.
- **Outcome 3 –** Comprehend and apply advanced and local knowledge of the widely applied principles underpinning good practice that are specific to the jurisdiction in which the Engineer practises.

[1] *XXX in the document name denotes the engineering discipline.*

Outcome 1

What Is engineering problem-solving?

Problem-solving is a process carried out by individuals or teams to bring about a change from a given state to a desired state by means of multi-step or multi-path activities with barriers that must be overcome using knowledge and abilities and taking situational requirements into account. Engineering problem-solving relies on the fundamental engineering sciences and specialised engineering knowledge. Proficiency in solving engineering problems at the level described as *complex* is a characteristic of the competency of a Professional Engineer.

Problem-solving is the common thread that runs through engineering activities and is required in many engineering fields including design, planning, implementing and constructing, operating engineering systems, infrastructure and plants. Competency in problem-solving has two phases – analysis and solution synthesis – as captured in Outcomes 1 and 2 of document **R-02-STA-PE/PT/PN**. Because engineering problem-solving is knowledge-based, Outcome 3 is grouped with Outcomes 1 and 2. However, Outcome 3 also supports other outcomes in line with the notion of integrated performance as described in document **R-02-STA-PE/PT/PN**.

Complex engineering problem-solving is perhaps the best starting point for applicants to determine the level at which they are working. Complex engineering problem-solving must be demonstrated for applicants to be considered for professional registration. Applicants who are unsuccessful in their application are often either not performing at the required level of complexity of problem-solving or have not conveyed it appropriately in the reports and in the review process.

Applicants should refer to the suggested test for a complex engineering problem as recorded in document **R-02-STA-PE/PT/PN**. The test is based on the four logical steps that are illustrated in ***Table 3*** below. If there is one or more affirmative answer at each step, the problem is classified as a complex engineering problem.

Table 3: Test for a *complex engineering problem*

Step	Main question	Criteria
Step 1 Identify the engineering problem.	Is the problem an engineering problem?	a) Does solving the problem require in-depth fundamental and specialised engineering knowledge?
Step 2 Establish the level of complexity of the initial problem state.	What is the nature of the problem? Does it have *one or more* of the characteristics b, c and d?	b) The problem is ill-posed, under or over specified and requires identification and refinement.
		c) The problem is a high-level problem that includes component parts or sub-problems.
		d) The problem is unfamiliar or involves infrequently encountered issues.
Step 3 Determine the complexity of the solution path from the initial state.	What is encountered in the solution process? Do the solutions have *one or more* of the characteristics e, f, g and h?	e) The solutions are not obvious and require originality or analysis based on fundamentals.
		f) The solutions are outside the scope of standards and codes.
		g) The solutions require information from a variety of sources that are complex, abstract or incomplete.
		h) The solutions involve wide-ranging or conflicting issues such as technical and engineering issues and interested or affected parties.
Step 4 Determine the level of decision-making required and potential consequences.	What is involved in the decision-making while solving the problem and evaluating the solution? Does it have *one or more* of the characteristics i and j?	i) Decisions require judgement in decision-making in uncertain contexts.
		j) Decisions have significant consequences in a range of contexts.

Outcome 2

How will I know when I am performing adequately at problem-solving?

At the endpoint of training, applicants must demonstrate these three competencies through their work. The starting point for training is the level of problem-solving ability of the new graduate. Applicants are expected to produce the same level of problem-solving but in a work environment rather than within academia. Applicants must develop problem-solving abilities in an environment in which the consequences of engineering decisions and actions are significant.

After graduation stage, Applicants' knowledge centres on the scientific basis of engineering, engineering technologies, some contextual knowledge and some specialist knowledge. During the training and mentoring programme stage (as stipulated in in document **R-04-T&M-GUIDE-PC)** as part of preparation for registration, knowledge must develop in an applicant's practice area and be relevant to the context in which the applicant practises.

Mentors, supervisors and applicants must plan the progression of tasks and responsibility to ensure the development of these competencies (refer to section for "Progression Levels of Mentee aligned to DoR in document **R-04-T&M-GUIDE-PC**). They are advised to follow suitable planning guidelines, recording and *Training and Mentoring Guide* and feedback sessions (as stipulated in the section for "***Technique for successful Mentor-Mentee Relationship***" in document **R-04-T&M-GUIDE-PC**. Applicants' progress should be evaluated against each outcome using the DoR scale in ***Table 2*** of document **R-04-T&M-GUIDE-PC**. It should be noted that the same body of work may enable development of competencies in other groups.

The strategy for developing problem-solving competence to the level required in the workplace and the DoR is illustrated in ***Table 2*** of this document. The following steps are examples of developing required competencies:

- Initially, candidates/applicants assist experienced engineering personnel in their problem analysis and solution activities, receiving detailed guidance and continuous monitoring.
- Candidates/Applicants then progress to contribute individually and as team members in the solution of engineering problems.

- Finally, candidates/applicants must achieve Level E DoR, performing individually and as team members, to solve problems. In this last phase, candidates/applicants must perform over the entire problem lifecycle.

Applicants should be given the opportunity to experience complex problem-solving in contexts such as design, investigation, planning, and process and product improvement. They should be encouraged to apply first principles to complex problems to develop and apply specialist and contextual knowledge.

Considering the problem of assessing a person's performance against Outcomes 1 and 2, it is necessary to determine if the person performs a creative, systematic analysis of problems at the required level and if the person works systematically to synthesise a solution to the problems.

An example of a schema for systematic analysis is presented below. Applicants:

- identify and formulate the problem, which leads to an agreed definition of the problem to be addressed
- collect, organise and evaluate information
- use conceptualisation, abstraction and modelling
- identify and justify assumptions, limitations, constraints and premises
- use both mathematical and non-mathematical analytical methods
- evaluate the results of the analysis, using judgement
- express understanding of the results emerging from the analysis.

A similar scheme would apply to the synthesis phase. Applicants:

- analyse the requirements for the design/planning/solution and draw up a detailed requirements specification.
- synthesise a range of potential solutions to the problem or a range of approaches to developing a solution that is consistent with assumptions, premises, limitations and constraint;
- evaluate the potential approaches against the requirements and includes cost and impacts outside the requirements

- present reasoned arguments and a proposal for the preferred option
- fully develop the design of the selected option
- evaluate the resulting solution
- produce design documentation for implementation.

What type of problem could be offered to demonstrate problem-solving ability?

Many types of problems would suffice; the problem may be a design requirement, an applied research and development requirement or a problematic situation in an existing component, system or process.

The solution may be the design of a component, system or process or a recommendation of the remedy for the problematic situation.

The level of the problem analysed must be gauged by the test described above to determine its suitability for presentation as evidence of competence. Problem-solving is the core activity of engineering. A wide range of engineering functions are either specific manifestations of problem-solving or are functions that rely on problem-solving at different levels. Some examples are as follows:

- **Design** is the systematic process of conceiving and developing materials, components, systems and processes to serve useful purposes. Design involves the transformation of an initial requirement to produce documented instructions on how to realise the end product. In determining a solution, barriers must be overcome. A design assignment, therefore, is an engineering problem and involves sub-problems that must be addressed.
- **Product** or **Process Improvement** also involves problem-solving. Frequently, an existing piece of infrastructure, plant or process needs improving. The proper process is to analyse the existing state and define the desired final state, and this process must be developed. Again, the investigation is a problem-solving activity, as is the solution synthesis phase.

Problem-solving based on engineering knowledge is at the centre of other engineering activities such as planning, research, development and technology transfer, quality assurance, risk analysis, domain-specific project management, managing engineering processes, safe work practices, environmental protection, sustainability analysis and systems engineering.

Outcome 3

How will I display my application of engineering and contextual knowledge?

All engineering activities, particularly problem-solving, rely on a body of knowledge. The statement of Outcome 3 recognises the three components that comprise a Professional Engineer's knowledge:

- Knowledge is rooted in principles (generally first principles) of general laws of the natural and engineering sciences and the principles of good engineering practice.
- It is recognised that individual Professional Engineers develop specialised knowledge that may be in a generally recognised area or may be a particular combination of topics.
- Knowledge specific to the environment in which the person practises is essential. It includes knowledge about the society, economy, regulatory system and physical environment in which the person practises engineering.

Engineering knowledge is too diverse to allow a detailed specification for every discipline, sub-discipline or practice area. Rather, it is recognised that each engineering practitioner develops a practice area. The *Discipline-specific Training Guideline*, document **R-05-XXX-PE/PT/PN**, may be consulted on this topic. For example, the practice area may be a commonly understood area such as structural engineering or power distribution, or it may be a particular blend emanating from the individual's experience. The engineering knowledge requirements in document **R-02-STA-PE/PT/PN** are therefore stated in generic terms.

For the Professional Engineer, the engineering fundamentals acquired in an accredited undergraduate educational programme form the base for specialist knowledge, and the Professional Engineer must be capable of first-principles analysis. Fundamental knowledge may be used explicitly or tacitly.

Professional Engineers invariably work in teams with specialists, engineering role-players, contractors and other parties from other engineering disciplines and professions. It is, therefore, essential to have a working knowledge of the discipline and the areas in which interaction is required. Applicants need to be aware that certain engineering disciplines may require more diverse cross-discipline interaction and knowledge. However, this depends on the environment and the level at which the engineer is performing the work.

Engineering work/activities/tasks/projects do not occur in isolation and knowledge of the health and safety, environmental, contractual, quality and risk regulatory requirements is essential. The application of engineering knowledge as an outcome is normally demonstrated during design, investigation or operations. Applicants typically:

- display mastery in the understanding of engineering principles, practices and technologies in the practice area
- apply general and underpinning engineering knowledge to support analysis and to provide insight
- use an analytical approach based on fundamentals and first principles in building models as required
- display working knowledge of areas that interact with the practice area
- apply related financial, statutory, safety and management knowledge.

Group B: Managing engineering activities

Groups B, C and D reflect the competencies linked to problem-solving (Group A) and are essential to engineering activities at the professional level. For example, considering impacts is an important stage in solving a problem. Similarly, engineering operations also have impacts that must be assessed and managed.

As described in ***Table 1*** of this document, Group B consists of two outcomes:

- **Outcome 4 –** Manage part or all of one or more complex engineering activities.
- **Outcome 5 –** Communicate clearly using multiple media and collaborate inclusively with a broad range of stakeholders in the course of engineering activities.

Outcome 4

How do I manage engineering competencies?

Competent Professional Engineers must not only perform technical functions but must also manage engineering activities. Two statements of management competency are presented in Group B in document **R-02-STA-PE/PT/PN**. Competency to manage *complex engineering* *activities* must be demonstrated. Linked with management is the ability to communicate with those involved in the engineering activities.

Engineering management can be defined as the application of the generic management functions of planning, organising, leading and controlling together with engineering knowledge in contexts that include the management of projects, construction, operations, maintenance, quality, risk, change and business. The level of experience in engineering management is of necessity limited at the stage of applying for registration as a Professional Engineer. However, applicants must take on the requisite responsibility to demonstrate competency under the guidance of suitably competent persons, as described in document **R-04-T&M-GUIDE-PC**.

Engineering management is more than project management. In most cases, project management is supportive of technical engineering activity but does not demonstrate the acceptable level of performance at the required DoR.

Demonstration of the *Competency Standard* in document **R-02-STA-PE/PT/PN** provides a test of whether a given engineering activity is classed as a complex engineering activity. The test for complex engineering activity is summarised in this document in ***Table 2****.* The test is applied to the activity itself to determine the complexity of its scope and operating environment, resource intensiveness, and severity of constraints, risks and consequences. This test is not independent of the test for complex problem-solving; most of the factors are those that give rise to barriers in the problem-solving process and render the problem complex.

The definition of the required level of activity in document **R-02-STA-PE/PT/PN** does not imply that applicants in every category must work at the stated level all the time. Rather, applicants in each category must demonstrate the ability to practise at the required level. Similarly, at the culmination of training, applicants must be able to demonstrate that they are capable of performing the required actions at the required levels through physically carrying out the actions in the work situation.

The progression of levels of engineering work/activities/tasks/projects and the DoR are detailed in document **R-04-T&M-GUIDE-PC** under section for "***Progression Levels of Mentee aligned to DoR***" and as stipulated under section for "***Technique for successful Mentor-Mentee Relationship***". These DoR, namely *Being exposed (Level A), Assisting (Level B),* *Participating (Level C), Contributing (Level D*) and *Performing (Level E)*, also apply to the management outcome and the communication outcome at the stage of applying for registration as a Professional Engineer.

Applicants' various training and mentoring stages and activities assist in developing the ability to plan, organise, lead and control. Applicants must be able to perform these functions alone and in a team. Conducting engineering work/activities/tasks/projects alone or in a team requires planning and organising to attain the required technical outcomes. Team participation and contribution as a team member and as a leader give the opportunity to demonstrate leadership and the ability to control on a limited scale.

Outcome 5

How do I know when I am managing and communicating at the required level?

Technical communication at a level that supports analysis, synthesis and implementation of solutions is an inherent part of engineering work/activities/tasks/projects. Applicants need the opportunity to communicate orally and in writing not only technical matters but also financial, social, cultural, environmental or political aspects of engineering activity.

In fulfilling Outcome 5, applicants are expected to display personal and work process management abilities:

- Manage self
- Work effectively in a team environment
- Manage people, work priorities, work processes and resources
- Establish and maintain professional and business relationships.

Effective communication can be demonstrated by:

- writing clear, concise, effective reports that are technically, legally and editorially correct using a structure and style that meet communication objectives and user/audience requirements
- reading and evaluating technical and legal matter relevant to the function of the Professional Engineer

- receiving instructions and ensuring correct interpretation
- issuing clear instructions to subordinates using appropriate language and communication aids, ensuring that language and other communication barriers are overcome
- making oral presentations using structure, style, language, visual aids and supporting documents appropriate to the audience and purpose.

This outcome will be evaluated at the following two stages:

- Applicants' written applications for registration
- The review process in which applicants are required to make a presentation and answer questions during the professional review.

Group C: Risk and impact mitigation

As described in ***Table 1*** of this document, Group C consists of two outcomes:

- **Outcome 6** – Recognise the reasonably foreseeable economic, social, cultural, and environmental effects of complex engineering activities seeking to achieve sustainability.
- **Outcome 7** – Meet all legal, regulatory and cultural requirements and protect the health and safety of persons during all engineering activities.

Outcome 6

How do I know when I am able to analyse and manage the impacts, benefits and consequences of engineering activities?

Engineering activities deliver benefits to society and the economy in the form of infrastructure, services and goods. Engineering involves harnessing or controlling natural forces or using and controlling complex information. The actions inherent in engineering activities have accompanying risks that must be mitigated to a level that is acceptable to the affected parties. The management of risk accompanying engineering activity is the very rationale for the regulation of the profession. Some risks are well known and understood and the means of addressing them may be embodied in regulation, for example, pressure vessel design. Other situations may not occur frequently or may occur for the first time with the application of new technology and in consequence may not be regulated. Certain risks may have objective technical measures while others are subject to the judgement of individuals and communities. Some risks may be ethical (Outcome 8 in Group D). The ability to assess and deal with all prevailing risks is integral to the competency of a Professional Engineer: The Professional Engineers are expected to be able to identify and deal with the wide-ranging risks associated with engineering work/activities/tasks/projects.

Applicants should be given the opportunity to study, analyse and recommend measures for:

- social/cultural impacts
- community / political considerations
- environmental impact
- sustainability analysis
- regulatory conditions
- potential ethical dilemmas.

To demonstrate competency in *impact analysis and mitigation*, the following must be accomplished:

- Identify interested and affected parties and their expectations.
- Identify interactions between technical considerations and sociocultural and environmental factors.
- Identify environmental impacts of the engineering activity.
- Identify sustainability issues.
- Propose and evaluate measures to mitigate negative effects of engineering activity.
- Communicate with stakeholders.

Outcome 7

How do I know when I have met all the legal and regulatory requirements in the course of my engineering activities?

Outcome 7 is concerned with explicitly regulated aspects of engineering practice and more general legislation that may apply. Applicants should ascertain the applicable legislation in their work environment. ***APPENDIX 1*** of this document and the *Discipline-specific Guideline*, document **R-05-XXX-PE/PT/PN**, lists recommended (but not exhaustive) material that should be consulted, including relevant legislation.

Of particular importance is occupational health and safety legislation. Two principal Acts are applicable in the South African context:

- Occupational Health and Safety Act, 85 of 1993, as amended, and associated regulations.
- Mine Health and Safety Act, 29 of 1996, as amended.

All Professional Engineers must be cognisant of the Acts and comply with their provisions.

To demonstrate competency *in regulatory aspects*, Applicants must:

- identify applicable legal, regulatory and health and safety requirements for the engineering activity
- identify risk and apply defined and widely accepted risk-management strategies
- select safe and sustainable materials, components, processes and systems.

Group D: Act ethically, exercising judgement and taking responsibility

As described in ***Table 1*** of this document**,** Group D consists of three outcomes:

- **Outcome 8 –** Conduct engineering activities ethically.
- **Outcome 9 –** Exercise sound judgement in the course of complex engineering activities.
- **Outcome 10 –** Be responsible for making decisions on part or all of complex engineering activities.

Professional Engineers must make technical and managerial decisions regarding the risks that arise from their activity. Three outcomes in Group D are concerned with competencies exercised at a personal level.

Outcome 8

How do I know when I have developed the competency to conduct engineering activities ethically?

Outcome 8 simply states: Conduct engineering activities ethically. The baseline for ethical behaviour is the ECSA Code of Conduct, which covers the need to practise ethically and within one's area of competency, to work with integrity, to respect the public's interest and the environment and to uphold the dignity of the profession, including one's relationship with fellow professionals. The ECSA Code of Conduct also contains a section on administrative matters that relate to ethical practice. Applicants must study the ECSA Code of Conduct and be aware of its implications in situations that arise in engineering work/activities/tasks/projects.

As in other professions and business situations, ethical problems arise in engineering activities. These may relate to business practices, inducements or an unregulated impact, for example, the use of a rare and unsustainable material for a solution that will be required well into the future. Professional Engineers must be capable of detecting, analysing and handling ethical dilemmas and problems that arise in the course of engineering activity. This is a non-negotiable aspect of the Code of Conduct, and Professional Engineers must handle any ethical problems that arise.

Applicants who are capable of handling ethical issues adopt a systematic approach to resolving ethical issues that is typified by:

- identifying the central ethical problem
- identifying affected parties and their interests
- searching for possible solutions to the dilemma
- evaluating each solution using the interests of those involved and according with suitable priority
- selecting and justifying the solution that most appropriately resolves the dilemma.

Outcome 9

How do I know when I have exercised sound judgement in the course of complex activities?

Professional Engineers are expected to make decisions in situations where the information to underpin the decision may be highly complex; that is, it has many parts with a myriad of interactions or it may be incomplete. Such decision-making requires due care by Professional Engineers and may be informed by experience. Professional Engineers, therefore, must have the ability to think of many matters at once and address their interdependence, their relative importance and their consequences. This process is known as exercising *judgement* within *complex engineering activities* or exercising equal judgement in the solution of *complex engineering problems.*

First, applicants considering the *Training and Mentoring Guide*, document **R-04-T&M-GUIDE-PC**, should be given the opportunity and be challenged to make decisions when full information is not available to:

- use engineering judgement
- take due care that the outputs and impacts of an assignment are addressed
- self-assess their competence from time to time.

All the above should be done under the supervision and guidance of a suitably qualified person as described in document **R-04-T&M-GUIDE-PC**.

Second, the indication that applicants exhibit engineering judgement is typically demonstrated by the following:

- Considering several factors, some of which may be ill-defined or unknown.
- Considering the interdependence, interactions and relative importance of factors.
- Foreseeing consequences of actions.
- Evaluating a situation in the absence of full evidence.
- Drawing on experience and knowledge.

Outcome 10

How do I know when I have taken responsibility for complex engineering activities?

Engineers are accorded professional status in society by virtue of their competence, the fact that the profession self-regulates and because professionals are accountable for their actions. The person registering as a Professional Engineer must therefore understand the obligation to be responsible and to have experience in making decisions, which if wrong, could have adverse consequences. Subject to the limitations of taking responsibility as a candidate/ applicant/mentee (discussed in document **R-04-T&M-GUIDE-PC**), applicants for registration as a Professional Engineer must demonstrate the capacity to make recommendations that display responsible behaviour in accordance with the ECSA Code of Conduct.

According to document **R-05-XXX-PE/PT/PN**, demonstrating responsibility at the required level (Level D and Level E) is evidenced by:

- always demonstrating a professional approach
- indicating due regard to technical, social, environmental and sustainable development considerations
- seeking advice from a responsible authority on any matter considered to be outside the area of competence
- making decisions and taking responsibility regarding work output.

Group E: Initial professional development

As indicated in ***Table 1*** of this document, Group E consists of only one outcome:

Outcome 11 – Undertake sufficient professional development activities to maintain, extend competence and enhance the ability to adapt to emerging technologies and the ever-changing nature of work.

Outcome 11

How do I meet initial professional development requirements?

Outcome 11 concerns initial professional development (IPD) that consists of activities identified to meet the requirements before registration. Professional development activities carried out between graduation and applying for professional registration is called IPD. This is an integral part of the professional competence required to practise engineering safely and effectively.

Additionally, through training, experience and IPD, applicants are able to attain the level of competence for registration and through work performance to provide evidence the competence. IPD activities are carried out before registration as a professional and similarly, continuing professional development (CPD) activities, which are undertaken post registration, are required to maintain professional competency. Refer to document **ECPD-01-STA** for CPD.

CPD is defined as the activities that a registered professional is required to maintain and complete at the required level to maintain registration. CPD is 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 a Professional Engineer.

The ability to develop and maintain competency is embodied in Outcome 11, namely the ability to undertake professional development activities sufficient to maintain and extend competence. This involves more than completing courses or other activities. The emphasis is on the individual's ability to self-develop. This capability has several dimensions:

- Taking responsibility for one's own development.
- Reflecting on strengths and weaknesses, recognising needs and planning.
- Executing development activities and overcoming obstacles.

An applicant's training towards registration does not have to satisfy formal professional development requirements. However, at the time of applying for registration as a professional, applicants will be assessed on their ability to manage and complete professional development-type activities. Pre-registration IPD is not subject to the requirement of annual points. It involves the initiation of learning activities by applicants that are distinct from the structured learning activities required by employers.

The essential test is whether the activity appropriate to the specific developmental needs of the individual. Also, involvement of applicants in planning learning activities is important, rather than simply entrusting this to employers. The ability to develop one's skills continually is regarded as sufficiently important in an engineering professional to be enshrined as an outcome that must be demonstrated to attain registration.

For a Professional Engineer, it should be noted that boundaries of practice areas change over time; new engineering principles are formulated; new procedures, standards and codes are developed; and engineering practice is advanced. IPD should therefore be planned with these factors in mind.

Each of the activities listed below or combinations thereof constitute professional development and hence, IPD:

- Attending courses, seminars, congresses and technical meetings organised by engineering institutions/institutes, universities, other professional bodies and course providers.
- Actively participating in conferences, serving on technical or professional committees and engaging in working groups.
- Undertaking structured self-study (i.e., using textbooks with examples).
- Taking correspondence courses and studying other supervised study packages.
- Enrolling for formal postgraduate studies (limited credits).
- Writing technical papers or presenting papers or lectures at an organised event.
- Reading technical papers such as white papers or peer-reviewed articles.
- Conducting research and literature reviews that are part of the engineering design and synthesis process.
- Taking in-house training courses offered by companies.
- Undertaking accredited CPD activities through Voluntary Associations (VAs), industries, academies, further/advanced studies with accredited institutions, etc.
- Taking credit-bearing courses at higher education institutions that directly complement the individual's engineering-related knowledge.

Refer to document **R-04-T&M-GUIDE-PC** for details on managing applicants' IPD as demonstrated by:

- planning their own IPD strategy
- selecting appropriate IPD activities

- keeping thorough records of IPD strategy and activities
- demonstrating independent learning ability
- completing IPD activities.

7.3.2 Engineering activities for a Professional Engineering Technologist:

Group A: Knowledge-based engineering problem-solving

As described in ***Table 1*** of this document, Group A consists of three outcomes:

- **Outcome 1** – Define, investigate and analyse broadly defined engineering problems.
- **Outcome 2** – Design or develop solutions to broadly defined engineering problems.
- **Outcome 3** – Comprehend and apply the knowledge embodied in widely accepted and applied engineering procedures, processes, systems and methodologies that is specific to the jurisdiction in which the Engineering Technologist practises.

Problem-solving is a process carried out by individuals or teams to bring about a change from a given state to a desired state by means of multi-step or multi-path activities that have barriers that must be overcome using knowledge and abilities and taking situational requirements into account. Engineering problem-solving relies on the fundamental engineering sciences and specialised engineering knowledge. Proficiency in solving engineering problems at the level described as *broadly defined* is a characteristic of the competency of a Professional Engineering Technologist.

Problem-solving is the common feature that runs through engineering activities and is required in many engineering activities, including the design, development, research, investigation, planning, implementation, construction and operation of engineering systems and maintenance of plant infrastructure. Competency in problem-solving involves two phases – analysis and solution synthesis – as captured in Outcomes 1 and 2 of document **R--02--STA--PE/PT/PN**. Because engineering problem-solving is knowledge-based, Outcome 3 is grouped with Outcomes 1 and 2. However, Outcome 3 also supports other outcomes in line with the notion of integrated performance as described in document **R-02-STA-PE/PT/PN**.

Broadly defined engineering problem-solving is perhaps the best starting point for applicants to determine the level at which they are working. *Broadly defined engineering problem-solving* must be demonstrated for applicants to be considered for professional registration. Candidates/Applicants who are unsuccessful in their application are often either not performing at the level of complexity of problem-solving required or did not convey it appropriately in the reports and the review process.

Outcome 1

What is engineering problem-solving?

Applicants should refer to the suggested test for a *broadly defined engineering problem* that is presented in the *Competency Standard*, document **R-02-STA-PE/PT/PN**. The test is based on the four logical steps illustrated in ***Table 4***. If there is one or more affirmative answers at each step, the problem is classified as a *broadly defined engineering problem*.

Table 4: Test for a *broadly defined engineering problem*

Step	Main question	Criteria
Step 1 Identification of the engineering problem:	Is the problem an engineering problem?	a) Does solving the problem require coherent and detailed engineering knowledge underpinning the applicable technology area?
Step 2 Establishment of the level of complexity of the initial problem state:	What is the nature of the problem? Does it have one or more of the characteristics indicated in criteria b, c and d?	b) The problem is ill-posed, is under or over specified and requires identification and refinement into the technology area.
		c) The problem encompasses systems within complex engineering systems.
		d) The problem is classified as falling within typical engineering requirements that are solved in well accepted and innovative ways.
Step 3 Complexity of the problem path from the initial state:	What is encountered in the problem investigation and analysis process? Does it have one or more of the characteristics indicated in criteria e, f, g and h?	e) The problem can be solved by structural analysis techniques/tools/methodologies.
		f) Standards, codes, and procedures must be applied to solve the problem, and justification to operate outside these standards and codes must be provided.

Step	Main question	Criteria
		g) Verification is required for the received information from practice area and variety of sources that interfacing within practice area that are complex, abstract or incomplete with justification. h) Problem may be solved by involving a variety of issues that may impose conflicting constraints: technical, engineering together with interested and affected parties with defined needs to be considered, including needs for sustainability. Justification may be required.
Step 4 Level of decision-making required and potential consequences:	What is involved in the decision-making while analysing the problem? Does it have either or both characteristics indicated in criteria i and j?	i) Practical solutions to the problem require knowledge and judgement in decision-making in the practice area and require consideration of the interface with other areas.
		j) Decisions have significant consequences that are important in the practice area but may extend more widely.

Outcome 2

How will I know when I am performing adequately at problem-solving?

At completion of the training period, candidates/applicants must demonstrate competence in Outcomes 1, 2 and 3 through their work. The starting point of training is the level of problem-solving ability of the new graduate. Candidates/Applicants are expected to produce the same level of problem-solving in the work environment as that previously produced in the academic environment. Candidates/Applicants must develop problem-solving abilities in an environment in which the consequences of engineering decisions and actions are significant.

After graduation stage, Applicants' knowledge centres on the scientific basis of engineering, engineering technologies, some contextual knowledge and some specialist knowledge. During the training and mentoring programme stage (as stipulated in in document **R-04-T&M-GUIDE-PC**) as part of preparation for registration, knowledge must develop in the candidate's/applicant's practice area and concentrate on the relevant context in which they practise.

Mentors, supervisors and candidates/applicants must plan the progression of tasks and responsibilities to ensure the development of these competencies (refer to section for *Progression Levels of Mentee aligned to DoR* in document **R-04-T&M-GUIDE-PC**). They are advised to follow suitable planning guidelines; recording via the *Training and Mentoring Programme Process Tool/Technique* and feedback sessions (as stipulated under section for *Technique for successful Mentor–Mentee Relationship* in document **R-04-T&M-GUIDE-PC**). Candidates'/Applicants' progress should be evaluated against each Outcome using the DoR scale in ***Table 2*** of this document. It should be noted that the same body of work may serve to develop competencies in other groups.

The strategy for developing problem-solving competence to the level required in the workplace and the DoR is illustrated in ***Table 2*** of this document. The following steps are examples of developing required competencies:

- Initially, candidates/applicants assist experienced engineering personnel in their problem analysis and solution activities, receiving detailed guidance and continuous monitoring.
- Candidates/Applicants then progress to contribute individually and as a team member in solving engineering problems.
- Finally, candidates/applicants must achieve Level E DoR, performing individually and as a team member, to solve problems. In this last phase, candidates/applicants must perform over the entire problem lifecycle.

Candidates/Applicants should be given the opportunity to experience *broadly defined engineering problem-solving* in contexts such as design, development, research, investigation, planning, implementation, construction and operation of engineering systems and maintenance of plant infrastructure. Applicants should be encouraged to apply first principles to *broadly defined engineering problems* and to develop and apply specialist and contextual knowledge.

Considering the problem of assessing the performance of applicants/candidates against Outcomes 1 and 2, ECSA requires applicants/candidates to perform a creative, systematic analysis of problems at the required level and to work systematically to synthesise solutions to the problems.

Outcome 1: Systematic analysis follows a schema as presented below. Applicants:

- interpret and clarify requirements, leading to an agreed definition of the problem to be addressed
- identify interested and affected parties and their expectations
- gather, structure and evaluate adequate information relating to the problem
- perform a structured analysis
- evaluate the result of the analysis and revise or refine as required
- document, report and convey the outcome to the requesting party.

Outcome 2: A similar schema applies to the synthesis phase. Applicants:

- propose potential approaches or alternatives to the solution
- conduct a preliminary synthesis following selected approaches
- evaluate potential solutions against requirements and wider impacts
- present reasoned, economical and contextual engineering arguments and justification for the selected option or preferred solution
- fully develop the selected option or preferred solution
- evaluate the resulting solution
- document the solution for approval and implementation.

Many types of problems can be offered to demonstrate problem-solving ability. The problem may be a design requirement, an applied research and development requirement or a problematic situation in an existing component, system or process.

The solution may be the design of a component, system or process or a recommendation of the remedy to a problematic situation. Developing solutions to *broadly defined engineering problems* involves more than the actual design. Applicants/Candidates are expected to indicate competence in their choice of the systematic approach to provide the solution, demonstrate how alternative options have been considered and how the preferred option/solution has been selected by developing detailed design specification requirements and other engineering design documentation.

The level of the analysed problem must be gauged by the test described above to determine its suitability for presentation as evidence of competence.

Problem-solving is the core activity of engineering. A wide range of engineering functions are either specific manifestations of problem-solving or rely on problem-solving at different levels.

Some examples follow:

- **Design:** This is the systematic process of conceiving and developing materials, components, systems and processes to serve useful purposes. Design involves a transformation from an initial requirement to produce the documented instructions on how to realise the end product. In determining a preferred solution, barriers must be overcome. A design assignment, therefore, is an engineering problem and involves sub-problems that must be addressed.
- **Product or process improvement:** It frequently happens that an existing piece of infrastructure, plant, equipment or process needs improvement. The proper process is to analyse the existing state and define the desired final state. A process for moving from the initial to the final state must be developed. Again, the investigation is a problem-solving activity as is the solution synthesis phase.
- **Developing the solution for engineering problems:** This part of the design process is iterative because of the related steps that are used until the appropriate solution is found and a decision is made. This decision is based on several alternatives or options that are considered against engineering standards or codes of practice in the technology area to meet set parameters or criteria.

Other engineering activities have problem-solving based on engineering knowledge in their practice area. These include planning; research, development, and technology transfer; quality assurance; risk analysis; domain-specific project management; managing engineering processes, safe work practices; environmental protection; sustainability analysis; and systems engineering.

Outcome 3

How will I display my application of engineering and contextual knowledge?

All engineering activities, problem-solving in particular, rely on applicants comprehending and applying the relevant ECSA benchmarked qualification theory and knowledge that is embodied in widely accepted and applied engineering procedures, processes, systems, tools and methodologies that are specific to the practice area. The statement in Outcome 3 recognises three components comprising the knowledge that must be comprehended by Professional Engineering Technologists:

- Knowledge is rooted in principles (generally first principles) of general laws of the natural and engineering sciences, technologies, methodologies and the applied principles of good engineering practice.
- It is recognised that individual Professional Engineering Technologists develop specialised knowledge regarding either a generally recognised area or a particular combination of topics. This includes understanding *broadly defined* procedures, codes and techniques that are mathematically, scientifically and engineering based and that underpin teamwork.
- Knowledge specific to the practice area in which the Professional Engineering Technologist practises is essential. This includes knowledge of the society, economy, regulatory system and physical environment in which the Professional Engineering Technologist practises engineering.

Engineering knowledge is too diverse to allow a detailed specification of knowledge for every discipline, sub-discipline or practice area. Rather, it is recognised that each engineering practitioner develops a practice area. The *Discipline-specific Training Guide* document, **R-05-XXX-PE/PT/PN** may be consulted on this topic. The practice area, for example, may be a commonly understood area such as structural engineering or power distribution or may be a particular blend flowing from the individual's experience. Therefore, the engineering knowledge requirements in the *Competency Standard*, document **R-02-STA-PE/PT/PN**, are stated in generic terms.

For Professional Engineering Technologists, the engineering knowledge acquired in an accredited engineering programme is the basis for practice area knowledge. Professional Engineering Technologists must be capable of engineering analysis and engineering knowledge may be used explicitly or tacitly.

Professional Engineering Technologists invariably work in teams with specialists from other engineering disciplines, other engineering role-players, other professionals, contractors and other parties. It is therefore essential to have a working knowledge of the discipline and the areas in which interaction is necessary. Applicants need to be aware that certain engineering disciplines require more diverse cross-discipline interaction and knowledge. However, this depends on the environment and the level at which the Professional Engineering Technologist is performing the work.

Engineering work/activities/tasks/projects do not occur in isolation and knowledge of the regulatory requirements regarding health and safety, the environment, the contract, and quality and risk is essential. The application of engineering knowledge as an outcome is normally demonstrated during the design, investigation or operation. Applicants typically undertake the following:

- Display mastery of understanding current and emerging technologies in the practice area.
- Apply general and underpinning engineering knowledge to support analysis and provide insight into technologist activities.
- Use an analytical approach as required.
- Display working knowledge of areas that interact with the practice area.
- Apply related financial, statutory, safety and management knowledge.

Group B: Managing engineering activities

Groups B, C and D reflect competencies that are all linked to problem-solving (Group A) and are essential to engineering activities at the professional level. For example, taking impacts into account is an important stage in the solution of a problem. Similarly, an engineering operation also has impacts that must be assessed and managed.

As described in ***Table 1*** of this document, Group B consists of two outcomes:

- **Outcome 4 –** Manage part or all of one or more *broadly defined engineering activities*.
- **Outcome 5 –** Communicate clearly using multiple media and collaborate inclusively with a broad range of stakeholders in the course of engineering activities.

Outcome 4

How do I manage engineering competencies?

Competent Professional Engineering Technologists not only perform engineering functions but must also manage engineering activities. Two statements of management competency in Group B, described in the *Competency Standard*, document **R-02-STA-PE/PT/PN**, are as follows:

- Competency to manage *broadly defined engineering activities* must be demonstrated.
- Linked with management is the ability to communicate with those involved in the engineering activities.

Engineering management can be defined as the application of the generic management functions of planning, organising, leading and controlling together with engineering knowledge in contexts that include the management of projects, construction, operations, maintenance, quality, risk, change and business. The level of engineering management a person is involved in or is sufficiently experienced to do is of necessity limited at the stage of applying for registration as a Professional Engineering Technologist. However, applicants must take on the responsibility necessary to demonstrate competency under the guidance of suitable competent persons, as described in the *Training and Mentoring Guide*, document **R-04-T&M-GUIDE-PC** (refer to ***Table 2***).

Engineering management is more than project management. Project management is in most cases supportive of engineering activity but does not represent the level of demonstration of performance at the degree of responsibility required.

What level of activities must I be able to manage?

The *Competency Standard*, document **R-02-STA-PE/PT/PN**, provides a test for whether a given engineering activity is classed as a *broadly defined engineering activity*. The test for a *broadly defined engineering activity* is summarised in ***Table 1*** of this document. The test is applied to the activity itself to determine the complexity of its scope and operating environment, its resource intensiveness, the severity of constraints and the risks and consequences. This test is not independent of the test for *broadly defined problem-solving*; most of the factors are those that give rise to barriers in the problem-solving process, and they also render the problem *broadly defined*.

The definition of the required level of activity as described in the *Competency Standard*, document **R-02-STA-PE/PT/PN**, does not imply that applicants in every category work at that level all the time. Rather, candidates/applicants in each category must demonstrate the ability to practise at the required level. Similarly, at the culmination of training, applicants must be able to demonstrate they are capable of performing the required actions at the required level by having in effect done so in the work situation.

The progression of levels of engineering work/activities/tasks/projects and the DoR are detailed in document **R-04-T&M-GUIDE-PC** under section for *Progression Levels of Mentee aligned to DoR* and as stipulated under section for *Technique for successful Mentor–Mentee Relationship*. These DoR, namely *Being exposed (Level A), Assisting (Level B), Participating (Level C), Contributing (Level D*) and *Performing (Level E)*, also apply to the management outcomes and the communication outcome at the stage of applying for registration as a Professional Engineering Technologist.

The strategy for developing problem-solving competence to the level required in the workplace and to the DoR is illustrated in ***Table 2*** of this document**.**

An Applicant's various training and mentoring stages and activities assist in developing the ability to plan, organise, lead and control. Applicants must be able to perform these functions both alone and in a team. Conducting engineering work on one's own or in a team requires planning and organising to attain the required engineering outcomes. Team participation and contribution as a team member and as a leader give the opportunity to demonstrate leadership and the ability to control on a limited scale.

Outcome 5

How do I know when I am managing and communicating at the required level?

Technical communication at a level that supports analysis, synthesis and implementation of solutions is an inherent part of engineering work. Applicants need the opportunity to communicate orally and in writing about not only engineering matters but also the financial, social, cultural, environmental and political aspects of engineering activities.

In fulfilling Outcome 5, applicants are expected to demonstrate personal and work process management abilities:

- Manage self.
- Work effectively in a team environment.
- Manage people, work priorities, work processes and resources.
- Establish and maintain professional and business relationships; effective communication can be demonstrated by the ability to write clear, concise, and effective reports that are technically, legally and editorially correct using a structure and style that meets communication objectives and user/audience requirements.
- Read and evaluate engineering and legal matter relevant to the function of the Professional Engineering Technologist.
- Receive instructions and ensure correct interpretation.
- Issue clear instructions to subordinates using appropriate language and communication aids and ensure that language and other communication barriers are overcome.
- Undertake oral presentations using structure, style, language, visual aids and supporting documents appropriate to the audience and purpose.

This communication competency (Outcome 5) is evaluated in two components via the following:

- Applicants' written applications for registration.
- During the oral professional review/interview process in which applicants are required to make a presentation and answer engineering questions on their experience.

Group C: Risk and impact mitigation

As described in ***Table 1*** of this document, Group C consists of two outcomes:

- **Outcome 6** – Recognise the reasonably foreseeable economic, social, cultural, technical and environmental effects of *broadly defined engineering activities* seeking to achieve sustainability.
- **Outcome 7** – Meet all legal and regulatory requirements and protect the health and safety of persons in the course of *broadly defined engineering activities*.

These outcomes deal respectively with the impacts of engineering activity that are not subject to regulation but rely on the professionalism of the applicant and the impacts that are subject to regulation, both specific and general.

Outcome 6 (impacts of engineering), Outcome 7 (legal and regulatory aspects) and Outcome 8 (ethical behaviour in Group D) reflect the professional behaviour and attitudes expected of Professional Engineering Technologists. These are supported by knowledge of the context in which the individual practises (an aspect of Outcome 3). It is recognised that during the training and mentoring programme stage (as stipulated in in document **R-04-T&M-GUIDE-PC**), exposure to these issues is not as intensive as for an experienced Professional Engineering Technologist. Candidates/Applicants are therefore expected to supplement experience by reading and reflecting on these issues before applying for registration.

APPENDIX 1 of this document and the *Discipline-specific Training Guide* **R-05-XXXPE/PT/PN** list materials that should be consulted and relevant legislation. Both candidates and applicants should also make use of suitable IPD courses in these areas.

Outcome 6

How do I know when I am able to analyse and manage the impacts, benefits and consequences of engineering activities?

Engineering activities deliver benefits to society and the economy in the form of infrastructure, services and goods. Engineering involves the harnessing and control of natural forces or the use and control of complex information. The actions inherent in engineering activities have accompanying risks. These risks must be mitigated to a level that is acceptable to the affected parties. The management of risk accompanying engineering activity is the very rationale for regulation of the profession. Some risks are well known and understood and the means of addressing them may be embodied in regulation, for example, pressure vessel design.

Other situations may not occur frequently or may occur for the first time with the application of new technology and consequently may not be regulated. Certain risks may have objective technical measures, while others are subject to the judgement of individuals and communities. Some risks may be ethical (Outcome 8 in Group D). The ability to assess and deal with all prevailing risks is integral to the competency of a Professional Engineering Technologist. Professional Engineering Technologists are expected to be able to identify and to deal with wide-ranging risks associated with engineering work.

Applicants should be given the opportunity to study, analyse and recommend measures for:

- social/cultural impacts
- community/political considerations
- environmental impact
- sustainability analysis
- regulatory conditions
- potential ethical dilemmas.

To show competency in *impact analysis and mitigation*, the following should be done:

- Identify interested and affected parties and their expectations.
- Identify interactions between engineering considerations and social-cultural and environmental factors.

- Identify environmental impacts of the engineering activity.
- Identify sustainability issues.
- Propose and evaluate measures to mitigate the negative effects of engineering activities.
- Communicate with stakeholders.
- Adopt measures to mitigate the negative effects of engineering activities.

Outcome 7

How do I know when I have met all the legal and regulatory requirements in the course of my engineering activities?

Outcome 7 is concerned with explicitly regulated aspects of engineering practice and more general legislation that may apply. Applicants should ascertain the legislation that applies in their work environment. ***APPENDIX 1*** of this document and the *Discipline-specific Training Guide* **R-05-XXX-PE/PT/PN** list certain recommended materials that should be consulted, including the relevant legislation.

Of particular importance is occupational health and safety legislation. The following are the principal examples of the Acts applicable in the South African context, as depicted in ***APPENDIX*** 1 of this document:

- Occupational Health and Safety Act, 85 of 1993, as amended, and the associated regulations.
- Mine Health and Safety Act, 29 of 1996, as amended.

All Professional Engineers must be cognisant of the Acts and comply with their provisions.

To demonstrate competency *in regulatory aspects*, Applicants should:

- identify the applicable legal, regulatory and health and safety requirements for the engineering activity
- identify the risk and apply defined widely accepted risk management strategies
- select safe and sustainable materials, components, processes and systems
- communicate with parties involved in the legal and regulatory aspects of the work.

Group D: Act ethically, exercising judgement and taking responsibility

As described in ***Table 1*** of this document, Group D consists of three outcomes:

- **Outcome 8 –** Conduct engineering activities ethically.
- **Outcome 9 –** Exercise sound judgement by evaluating the outcomes, impacts and alternatives in the course of *broadly defined engineering activities.*
- **Outcome 10 –** Be responsible for making decisions on part or all of *broadly defined engineering activities.*

Professional Engineering Technologists must make engineering and managerial decisions that are related to risks arising from their activities. Three outcomes in Group D are concerned with competencies exercised at a personal level.

Outcome 8

How do I know when I have developed the competency to conduct engineering activities ethically?

Outcome 8 has the simple statement: Conduct engineering activities ethically. The baseline for ethical behaviour is the ECSA Code of Conduct, which covers the need to practise ethically and within one's area of competency, to work with integrity, to respect the public interest and the environment and to uphold the dignity of the profession and one's relationship with fellow professionals. Included is a section on administrative matters that relate to ethical practice. Applicants must study the ECSA Code of Conduct and be aware of its implications in situations that arise in engineering work.

As in other professions and business situations, ethical problems arise in engineering activity. These may relate to business practices, inducements or an unregulated impact, for example, the use of a rare and unsustainable material for a solution that will be required well into the future. Professional Engineering Technologists must be capable of detecting, analysing and handling ethical dilemmas and problems that arise in the course of engineering activity. This is a non-negotiable aspect of the Code of Conduct, and Professional Engineering Technologists must deal with any ethical problems that arise.

Applicants who are capable of dealing with ethical issues adopt a systematic approach to resolving ethical issues that is typified by:

- identifying the central ethical problem
- identifying affected parties and their interests
- searching for possible solutions to the dilemma
- evaluating each solution using the interests of those involved and according with the suitable priority
- selecting and justifying a solution that most appropriately resolves the dilemma.

Outcome 9

How do I know when I have exercised sound judgement in the course of broadly defined activities?

Professional Engineering Technologists are expected to make decisions in situations where the information to underpin the decision may be complex (i.e., the information has more than one part with interactions between parts or the information is incomplete). Such decision-making requires due care by Professional Engineering Technologists and may be informed by experience. Professional Engineering Technologists must therefore have the ability to think of many matters at once and consider their interdependence, their relative importance and their consequences. This process is known as exercising judgement within *broadly defined engineering activities* or in the solution of *broadly defined engineering problems*.

According to the *Training and Mentoring Guide*, document **R-04-T&M-GUIDE-PC**, applicants should be challenged and given the opportunity to:

- make decisions when full information is not available
- use engineering judgement
- take due care that the outputs and the impacts of an assignment are addressed
- self-assess their competence from time to time.

All the above should be done under the supervision and guidance of a suitably qualified person or registered professional as described in document **R-04-T&M-GUIDE-PC**.

Additionally, the indication that an applicant exhibits engineering judgement is typically demonstrated by:

- considering several factors, some of which may not be well defined or may be unknown
- considering the interdependence, interactions and relative importance of factors
- foreseeing consequences of actions
- evaluating a situation in the absence of full evidence
- drawing on experience and knowledge
- justifying judgements in regard to risks associated with decisions.

Outcome 10

How do I know when I have taken responsibility for broadly defined engineering activities?

Professional Engineering Technologists are accorded professional status in society by their competence and the fact that the profession self-regulates and professionals are accountable for their actions. The person registering as a Professional Engineering Technologist must therefore understand the obligation to be responsible and have experience at making decisions since wrong decisions can have adverse consequences. Subject to the limitations regarding taking responsibility as an applicant, as discussed in document **R-04-T&M-GUIDE-PC**, applicants for registration as a Professional Engineering Technologist must demonstrate the capacity to make recommendations that display responsible behaviour in accordance with the ECSA Code of Conduct.

According to document **R-05-XXX-PE/PT/PN**, being responsible at the required DoR (Levels D–E) is evidenced by:

- demonstrating a professional approach at all times
- exhibiting due regard to engineering, social, environmental, and sustainable development considerations
- seeking advice from a responsible authority (or other professional) on any matter considered to be outside the area of competence
- making decisions and taking responsibility for work output.

Group E: Initial Professional Development

As described in ***Table 1*** of this document, Group E consists of only Outcome 11: Undertake professional development activities sufficient to maintain and extend competence.

Outcome 11

How do I meet IPD requirements?

Outcome 11 concerns IPD that consists of activities identified to meet the requirements before registration. Professional development activities carried out between graduation and applying for professional registration are called IPD. This is an integral part of the professional competence required to practise engineering safely and effectively.

Additionally, through training, experience and IPD, applicants are able to attain the level of competence for registration and through work performance to provide evidence of their competence. IPD activities are carried out before registration as a professional; similarly, CPD activities undertaken post registration are required to maintain professional competency. Refer to document **ECPD-01-STA** for CPD.

CPD is defined as the activities a registered professional is required to maintain and complete at the required level to maintain registration. CPD is 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 a Professional Engineering Technologist.

The ability to develop and maintain competency is embodied in Outcome 11, namely the ability to undertake professional development activities sufficient to maintain and extend competence. This involves more than completing courses or other activities. The emphasis falls on the individual's ability to self-develop.

This capability has several dimensions:

- Take responsibility for one's own development.
- Reflect on strengths and weaknesses and recognise needs and plans.
- Execute development activities and overcome obstacles.

Candidates/Applicants training towards registration do not have to satisfy professional development requirements. However, at the time of applying for registration as a professional, candidates are assessed on their ability to manage and to complete engineering work, tasks and/or activities. Pre-registration IPD is not subject to an annual points requirement. It involves learning activities initiated by the applicant that are distinct from the structured learning activities required by the employer.

The essential test is an activity that is appropriate for the specific developmental needs of the individual. In addition, rather than leaving the planning of learning activities to the employer, the applicant's role in this is important. The ability to develop one's skills continually is seen as sufficiently important in an engineering professional to be enshrined as an outcome that must be demonstrated to attain registration.

For Professional Engineering Technologists, it should be noted that boundaries of practice areas change over time, new engineering principles are formulated, new procedures, standards and codes are developed, and engineering practice is advanced. IPD should therefore be planned with these factors in mind.

Each of the activities listed below or combinations thereof constitute professional development and hence, IPD:

- Attending courses, seminars, congresses and technical/engineering meetings organised by engineering institutions/institutes, universities, other professional bodies and course providers.
- Actively participating in conferences, serving on engineering committees, professional committees and in working groups.
- Undertaking structured self-study (i.e., using textbooks with examples).
- Taking correspondence courses and studying other supervised study packages, including e-learning (i.e., online courses).
- Enrolling for formal postgraduate studies (limited credits).
- Writing technical/engineering papers and presenting papers or lectures at organised events.
- Reading technical/engineering papers such as white papers or peer-reviewed articles.

- Studying engineering literature (i.e., journals and magazines).
- Conducting research and literature reviews that are part of the engineering design and synthesis process.
- Attending in-house training courses offered by companies.
- Participating in accredited CPD training activities through VAs, industries, academies, further / advanced studies with accredited institutions, etc.
- Taking credit-bearing courses in higher education institutions that directly complement an individual's engineering-related knowledge.

Refer to document **R-04-T&M-GUIDE-PC** for details on managing an applicant's IPD, which is demonstrated by:

- planning their own IPD strategy
- selecting appropriate IPD activities
- keeping thorough records of IPD strategies and activities;
- demonstrating independent learning ability
- completing IPD activities.

7.3.3 Engineering activities for a Professional Engineering Technician:

Group A: Knowledge-based engineering problem-solving

Problem-solving is a process carried out by individuals or teams to bring about a change from a given state to a desired state by means of multi-step or multi-path activities that have barriers that must be overcome using knowledge and abilities and taking situational requirements into account. Engineering problem-solving is distinguished by requiring engineering knowledge; that is, it relies on fundamental engineering activities and specialised engineering knowledge. Proficiency in solving engineering problems at the level described as *well-defined* is a characteristic of the competency of a Professional Engineering Technician.

Problem-solving is the common thread that runs through engineering activities including design, planning, implementing and constructing in addition to operating and closing engineering systems, infrastructure and plants. Competent problem-solving has two phases – analysis and solution synthesis – as captured in Outcomes 1 and 2 of document

R-02-STA-PE/PT/PN. Because engineering problem-solving is knowledge-based, Outcome 3 is grouped with Outcomes 1 and 2. However, Outcome 3 also supports other outcomes, as depicted in ***Figure 2***.

The test for a *well-defined* engineering problem, which is presented in document **R-02-STA-PE/PT/PN**, is based on four logical steps:

- **Step 1:** Factor a) establishes if a problem is, in fact, an engineering problem by virtue of requiring engineering knowledge. For example, a person performing only project management functions with no role in the engineering aspects of a project would not be solving an engineering problem.
- **Step 2:** Factors b), c) and d) establish the factors that describe complexity of the initial state and the desired end state of the problematic situation: How many factors are known or specified? What is unknown? Are there multiple goals?
- **Step 3:** Factors e) to h) test the complexity of the solution path or process from the initial state to the goal state.
- **Step 4:** Factors i) and j) test the level of decision-making needed in the process of solving the problem and evaluating the solutions and the possible consequences for which responsibility must be taken.

Table 5: Test for a *well-defined engineering problem*

Step	Main question	Criteria
Step 1 Identify the engineering problem	Is the problem an engineering problem?	a) Be solved mainly by practical engineering knowledge that is underpinned by related theory.
Step 2 Establishment of the level of complexity of the initial problem state	What is the nature of the problem? Does it have one or more of the characteristics, b, c or d?	b) Are largely defined but may require clarification. c) Are discreet, focused tasks within engineering systems. d) Are routine and frequently encountered and may be unfamiliar but in a familiar context.
Step 3	What is encountered in the solution process?	e) Can be solved in standardised or prescribed ways.

Step	Main question	Criteria
Complexity of the problem path from the initial state:	Do the solutions have one or more of the characteristics, e, f, g or h?	f) Are encompassed by standards, codes and documented procedures (require authorisation to work outside limits). g) Require information that is concrete and largely complete but require checking and possible supplementation. h) Involve set of interested and affected parties with defined needs to be taken into account, including needs for sustainability.
Step 4 Level of decision-making required and potential consequences	What is involved in decision-making while solving the problem and in evaluating the solution? Does it have one or more of the characteristics, i or j?	i) Require practical judgement in the practice area of evaluating solutions and considering interfaces with other role-players. j) Rave consequences that are locally important but not far reaching (wider impacts are dealt with by others).

If one or more factors are applicable to each step, the problem is classified as a *well-defined engineering problem.*

Outcome 1

What is engineering problem-solving?

When considering the problem of assessing a person's performance against learning Outcomes 1 and 2, registration requires applicants to demonstrate the ability to perform a creative, systematic analysis of problems (at the required level) and to work systematically to synthesise solutions to the problems.

An example of a schema for the systematic analysis is presented below. Applicants:

- interpret the client's demands, leading to an agreed statement of requirements
- clarify the requirements and draw issues and impacts to the client's attention
- identify standards for design aspects and codes and procedures to be followed
- gather information required for problem analysis

- identify acceptance criteria for work product
- verify that the design problem is amenable to solution by their techniques
- document functional solution requirements and gain client acceptance.

A similar schema applies to the synthesis phase. Applicants:

- identify and analyse alternative approaches for meeting the problem specification
- seek advice on aspects of the proposal or design process that fall outside established practices or standards
- plan tasks and select methods to complete the design process
- carry out design or develop solutions and synthesise tasks
- assemble the complete solution and review to check compliance with the client's requirements
- check solution and impacts of solution on interested and affected parties
- review documented design with the client to obtain formal acceptance.

Which types of problems could be presented to demonstrate problem-solving ability?

Many types of problems would suffice. The problem may be a design requirement, a development requirement or a problematic situation in an existing component, system or process.

The solution may be the design of a component, system or process or the recommendation of the remedy to a problematic situation. The level of the problem analysed must be gauged by the test described above to determine its suitability for presentation as evidence of competence.

Outcome 2

How will I know when I am performing adequately at problem-solving?

Problem-solving is the core activity of engineering. A wide range of engineering functions are either specific manifestations of problem-solving or rely on problem-solving at different levels. Some examples follow:

- **Design:** This is the systematic process of conceiving and developing materials, components, systems and processes to serve useful purposes. Design involves the transformation from an initial requirement to the documented instructions on how to realise the end product. In the process of developing a solution, barriers must be overcome. A design assignment is therefore an engineering problem and involves sub-problems that must be addressed.
- **Product or process improvement:** It frequently happens that an existing piece of infrastructure, plant or process needs improvement. The proper approach is to analyse the existing state and define the desired final state. The process for moving from the initial state to the final state must be determined. Again, the investigation is a problem-solving activity as is the solution synthesis phase.

Problem-solving for other engineering activities is based on engineering knowledge of planning, development and technology transfer, quality assurance, risk analysis, domain-specific project management, managing engineering processes, safe work practices, environmental protection, sustainability analysis and systems engineering.

At the end of training and mentoring programme, candidates/applicants must demonstrate these problem-solving competencies through their work. The starting point of training is the new graduate's level of problem-solving ability. The complexity level of the engineering problems applicants need to solve does not change from tertiary education to the workplace; what changes is that in the workplace, the problem is no longer academic in nature. Applicants must develop problem-solving abilities in an environment in which the consequences of engineering decisions and actions are significant.

After graduation stage, applicants' knowledge centres on the scientific basis of engineering, engineering technologies and some contextual knowledge and specialist knowledge. During the training and mentoring programme stage (as stipulated in document **R-04-T&M-GUIDE-PC**), as part of preparation for registration, knowledge must develop in candidates'/applicants' practice areas and be relevant to the context in which they practise.

Mentors, supervisors and candidates/applicants must plan the progression of tasks and responsibility to ensure development of these competencies. They are advised to follow suitable planning guidelines, recording and *Training and Mentoring Programme Process*

Tool/Technique and feedback sessions (as stipulated under section for *Technique for successful Mentor–Mentee Relationship* in document **R-04-T&M-GUIDE-PC**. Candidates'/ Applicants' progress should be evaluated against each outcome using the DoR scale in ***Table*** 2 of this document **R-04-T&M-GUIDE-PC**. It should be noted that the same body of work may serve to develop competencies in other groups.

The strategy for developing problem-solving competence to the level required in the workplace and the DoR is illustrated in ***Table 2*** of this document. The following steps are example of developing required competencies:

- Initially, candidates/applicants assist experienced engineering personnel in their problem analysis and solution activities, receiving detailed guidance and continuous monitoring.
- Candidates/Applicants then progress to contribute individually and as a team member in the solution of engineering problems.
- Finally, candidates/applicants must achieve Level E DoR, performing individually and as a team member to solve problems. In this last phase, candidates/applicants must perform over the entire problem lifecycle.

Candidates/Applicants should be given the opportunity to experience *well-defined problem-solving* in contexts such as design, investigation, process or product improvement and planning. Candidates/Applicants should be encouraged to apply first principles to *well-defined problems* and to develop and apply specialist and contextual knowledge.

Outcome 3

How will I display my application of engineering and contextual knowledge?

All engineering activities and problem-solving rely in particular on a body of knowledge. The statement in Outcome 3 recognises three components regarding the knowledge of a Professional Engineering Technician:

- Knowledge is rooted in principles; that is, the general laws of the natural and engineering sciences and the principles of good engineering practice.

- It is recognised that individual Professional Engineering Technicians develop specialised knowledge that may be in a generally recognised area or may be a particular combination of topics.
- Knowledge that is specific to the environment in which the person practises is essential. This includes knowledge about the society, economy, regulatory system and physical environment in which the person practises engineering.

Engineering knowledge is too diverse to allow a detailed specification of knowledge for every discipline, sub-discipline or practice area. Rather, it is recognised that each engineering practitioner develops a practice area. This may be a commonly understood area such as structural engineering or power distribution, or it may be a particular blend arising from the individual's experience. The knowledge requirements in document **R-02-STA-PE/PT/PN** are therefore stated in generic terms.

For Professional Engineering Technicians, the technical knowledge acquired in the undergraduate programme is the basis for practice area knowledge and Professional Engineering Technicians must be capable of practical analysis and technical knowledge may be used explicitly or tacitly.

Professional Engineering Technicians invariably work in teams with specialists, engineering role-players, contractors and other parties from other engineering disciplines. It is, therefore, essential to have a working knowledge of the discipline and the areas in which interaction is necessary.

Engineering work does not occur in isolation and knowledge of health and safety, environmental, contractual, quality and risk regulatory requirements is essential.

This outcome is normally demonstrated in the course of design, investigation or operations. Applicants typically:

- display mastery of established methods, procedures and techniques in the practice area
- apply the knowledge that underpins methods, procedures and techniques to support technician activities
- display working knowledge of areas that interact with the practice area

- apply codified knowledge in related areas (i.e., financial, statutory, safety, management)
- use information technology effectively as required in the practice area.

Group B: Management of engineering activities

Groups B, C and D reflect competencies linked to problem-solving and are essential to engineering activities at the professional level. For example, considering impacts is an important stage in the solution of a problem. Similarly, an engineering operation also has impacts that must be assessed and managed.

Outcome 4

How do I manage engineering competencies?

Competent engineering practitioners must not only perform technical functions but must also manage engineering activities. Two statements of management competency are presented in Group B in document **R-02-STA-PE/PT/PN**. Competency to manage *well-defined engineering activities* must be demonstrated as being linked with engineering management, and the ability to communicate with those involved in the engineering activities must be evidenced.

Engineering management can be defined as the application of the generic management functions of planning, organising, leading and controlling together with engineering knowledge in contexts including the management of projects, construction, operations, maintenance, quality, risk, change and business. The level of engineering management in which a candidate is either involved or sufficiently experienced is invariably limited at the stage of applying for registration as a Professional Engineering Technician.

Engineering management is more than project management. Project management is, in most cases, supportive of technical engineering activity. Work that is predominantly project management with minor technical engineering content is unacceptable as a demonstration of performance at the DoR in Group E.

The *Competency Standard*, document **R-02-STA-PE/PT/PN**, provides a test to determine whether a given engineering activity is classed as a *well-defined engineering activity*. The test is applied to the activity itself to determine the complexity of its scope and operating environment, resource intensiveness and the severity of constraints, risks and consequences.

This test is not independent of the test for *well-defined* problem-solving. Most of the factors that give rise to barriers in the problem-solving process also render the problem *well defined*.

The definition of the required level of activity in document **R-02-STA-PE/PT/PN** does not imply that professionals in every category work at the level stipulated all the time. Rather, practitioners in each category must demonstrate the ability to practise at the required level. Similarly, at the culmination of training, applicants must demonstrate the capability of performing the required actions at the required level through actual work done in the work situation.

The progression of levels of engineering work and DoR detailed in document **R-04-T&M-GUIDE-PC**, under section for *Progression Levels of Mentee aligned to DoR* and as stipulated under section for *Technique for successful Mentor–Mentee Relationship*. These DoR, namely *Being exposed (Level A), Assisting (Level B), Participating (Level C), Contributing (Level D*) and *Performing (Level E)*, also apply to the management outcomes and the communication outcome at the stage of applying for registration as a Professional Engineering Technician.

Various training and mentoring stages and activities assist in developing the ability to plan, organise, lead and control. Applicants must be able to perform these functions, both alone and in a team. Conducting engineering work on one's own or in a team requires planning and organising to attain the required technical outcomes. Team participation and contribution as a team member and as a leader give the opportunity to demonstrate leadership and the ability to control on a limited scale.

Outcome 5

How do I know when I am managing and communicating at the required level?

Technical communication at a level that supports analysis, synthesis and the implementation of solutions is an inherent part of engineering work. Applicants need the opportunity to communicate orally and in writing not only about engineering matters but also about the financial, social, cultural, environmental and political aspects of engineering activity.

Applicants are expected to display personal and work-process management abilities:

- Manage self.
- Work effectively in a team environment.
- Manage people, work priorities, work processes and resources.
- Maintain professional and business relationships.

Effective communication can be demonstrated by:

- writing clear, concise and effective reports that are technically, legally and editorially correct using a structure and style that meet communication objectives and user/audience requirements
- reading and evaluating technical and legal matters relevant to the function of the Professional Engineering Technician
- receiving instructions and ensuring correct interpretation
- issuing clear instructions to subordinates using appropriate language and communication aids, thus ensuring that language and other communication barriers are overcome
- making oral presentations using structure, style, language, visual aids and supporting documents appropriate to the audience and purpose.

Group C: Risk and impact mitigation

As described in ***Table 1*** of this document, Group C consists of two outcomes:

- **Outcome 6 –** Recognise the reasonably foreseeable economic, social, cultural, technical and environmental effects of *well-defined engineering activities* seeking to achieve sustainability.
- **Outcome 7 –** Meet all legal, regulatory and cultural requirements and protect the health and safety of persons during all engineering activities.

These outcomes deal respectively with the impacts of engineering activity that are not subject to regulation but rely on the professionalism of the applicant and the impacts that are subject to regulation, both specific and general.

Outcome 6 (impacts of engineering), Outcome 7 (legal and regulatory aspects) and Outcome 8 (ethical behaviour in Group D) reflect the professional behaviour and attitudes expected of Professional Engineering Technicians. These are supported by knowledge of the context in which the individual practises (an aspect of Outcome 3). It is recognised that during the training and mentoring programme stage (as stipulated in document **R-04-T&M-GUIDE-PC**), exposure to these issues is not as intensive as for an experienced Professional Engineering Technician. Applicants are therefore expected to supplement experience by reading and reflecting on these issues before applying for registration.

APPENDIX 1 of this document and the *Discipline-specific Training Guide* **R-05-XXXPE/PT/PN** list materials that should be consulted and relevant legislation. Both candidates and applicants should also make use of suitable IPD courses in these areas.

Outcome 6

How do I know when I am able to analyse and manage the impacts, benefits and consequences of engineering activities?

Engineering activities deliver benefits to society and the economy in the form of infrastructure, services and goods. Engineering involves the harnessing or the mitigation of the effects of natural forces or the use and control of information. The actions inherent in engineering activity have accompanying risks. These risks must be mitigated to a level that is acceptable to the affected parties. The management of risk accompanying engineering activity is the very rationale for the regulation of the profession. Some risks are well known and well understood, and the means of addressing them may be embodied in regulation, for example, pressure vessel design. Other situations may not occur frequently or may occur for the first time with the application of new technology and may not, in consequence, be regulated.

Certain risks may have objective technical measures, while others are subject to the judgement of individuals and communities. Some risks may be ethical (Outcome 8 in Group D). The ability to assess and deal with all prevailing risks is integral to the competency of an engineering practitioner. Professional Engineering Technicians are expected to be able to identify and deal with wide-ranging risks associated with engineering work.

The two outcomes in Group C, Outcomes 6 and 7, as defined in document **R-02-STA-PE/PT/PN**, deal with the impacts of engineering activity that are not subject to regulation but rely on the professionalism of the practitioner and the impacts that are subject to regulation, both specific and general.

Outcome 7

How do I know when I have met all the legal and regulatory requirements in the course of my engineering activities?

Outcome 7 is concerned with explicitly regulated aspects of engineering practice and the more general legislation that may apply. Candidates must ascertain the legislation that applies in their work environments. ***APPENDIX 1*** provides a list of Acts that apply generally and in specific areas. Applicants are reminded that this list is provided for information only and is not exhaustive. The onus rests on each applicant to identify the applicable and current legislation.

Of particular importance is occupational health and safety legislation. The following are the principal examples of the Acts applicable in the South African context, as depicted in ***APPENDIX*** 1 of this document:

- Occupational Health and Safety Act, 85 of 1993, as amended, and the associated regulations.
- Mine Health and Safety Act, 29 of 1996, as amended.

All Professional Engineers must be cognisant of the Acts and comply with their provisions.

Outcomes 6 and 7 in the *Competency Standard* are relevant to the cluster of competencies presented below. Applicants should be given the opportunity to study, analyse and recommend measures for:

- social/cultural impacts
- community/political considerations
- environmental impacts
- sustainability analysis
- regulatory conditions
- potential ethical dilemmas.

To demonstrate competency in impact analysis and mitigation, applicants should:

- identify interested and affected parties and their expectations
- identify environmental impacts of the engineering activity

- identify sustainability issues
- propose measures to mitigate negative effects of engineering activity
- communicate with stakeholders.

To demonstrate competency in regulatory aspects, applicants should:

- identify applicable legal, regulatory and health and safety requirements for the engineering activity
- select safe and sustainable materials, components, processes and systems, seeking advice when necessary
- apply defined, widely accepted methods to identify and manage risk.

Outcome 6 (impacts of engineering), Outcome 7 (legal and regulatory aspects) and Outcome 8 (ethical behaviour in Group D) reflect the professional behaviour and attitudes expected of Professional Engineering Technicians. These are supported by knowledge of the context of the individual practices (aspect of Outcome 3). It is recognised that during the training and mentoring programme stage (as stipulated in document **R-04-T&M-GUIDE-PC**), exposure to these issues may not be as intensive as for an experienced, registered engineering technician. Applicants are, therefore, expected to supplement experience by reading and reflecting on these issues before applying for registration. ***APPENDIX 1*** and the *Discipline-specific Training Guides* list material that should be consulted, including the relevant legislation. Applicants should also make use of suitable CPD courses in these areas.

Group D: Act ethically, exercising judgement and taking responsibility

Engineering practitioners must make technical and managerial decisions related to the risks arising from their activity. Three outcomes in Group D are concerned with competencies exercised at a personal level.

Similar to other professions and business situations, ethical problems arise in engineering activity. These may relate to business practices, inducements or an unregulated impact, for example, the use of a rare, unsustainable material for a solution that will be required well into the future. Professional Engineering Technicians must be capable of detecting, analysing, and dealing with ethical dilemmas and problems that arise in the course of engineering activity.

This is a non-negotiable aspect of the ECSA Code of Conduct and Professional Engineering Technicians must address any ethical problems that arise.

Outcome 8

How do I know when I have developed the competency to conduct engineering activities ethically?

Outcome 8 simply states: Conduct engineering activities ethically. The baseline for ethical behaviour is the ECSA Code of Conduct as published in terms of the Engineering Profession Act, 46 of 2000.

The Code of Conduct covers the need to practise ethically and within one's area of competence, work with integrity, respect public interest and the environment and uphold the dignity of the profession, including one's relationship with fellow professionals. There is also a section on administrative matters that relate to ethical practice. Candidates must study the ECSA Code of Conduct and be aware of its implications in situations that arise in engineering work.

Outcome 9

How do I know when I have exercised sound judgement in the course of broadly defined activities?

Professional Engineering Technicians are expected to make decisions in situations where the information to underpin the decision may be incomplete or may be complex, that is, it has more than one part, with interactions among the parts. Such decision-making requires due care by practitioners and may be informed by experience. Professional Engineering Technicians must therefore have the ability to think of more than one matter at once together with their interdependence, their relative importance and their consequences. This process is known as exercising *judgement* within *well-defined engineering activities* or exercising *judgement* in the solution of *well-defined engineering problems.*

Applicants should be given the opportunity and be challenged to:

- make decisions when full information is not available
- take due care that the outputs and the impacts of the assignment are addressed
- self-assess their competence from time to time.

To demonstrate sensitivity and capability in dealing with ethical issues, applicants should adopt a systematic approach to resolving these issues that is typified by:

- identifying the central ethical problem
- identifying affected parties and their interests
- searching for possible solutions for the dilemma
- evaluating each solution using the interests of those involved and according with suitable priority
- selecting and justifying the solution that is best to resolve the dilemma.

Exhibiting judgement is typically demonstrated by:

- considering a limited number of factors, some of which may not be well defined
- considering the interdependence, interactions and relative importance of factors
- foreseeing consequences of actions
- evaluating a situation in the absence of full evidence
- drawing on experience and knowledge.

Outcome 10

How do I know when I have taken responsibility for broadly defined engineering activities?

Engineering technicians are accorded professional status in society by virtue of their competence, because the profession self-regulates and professionals are accountable for their actions. The person registering as a Professional Engineering Technician must therefore understand the obligation to be responsible and to have experience in making decisions, which if wrong, could have adverse consequences. Subject to the limitations regarding taking responsibility as a candidate/applicant or unregistered person detailed in document

R-04-T&M-GUIDE-PC, applicants for registration as Professional Engineering Technicians must demonstrate the capacity to make recommendations that display responsible behaviour.

Being responsible is evidenced by:

- demonstrating a professional approach at all times
- displaying due regard to technical, social, environmental and sustainable development considerations
- taking advice from a responsible authority on any matter considered to be outside one's area of competence
- evaluating work output, revising as required and taking responsibility for work output.

Group E: Initial Professional development

IPD is the systematic maintenance, improvement and broadening of knowledge and skills and the development of personal qualities necessary for the execution of professional and technical duties throughout an engineering technician's career. A registered Professional Engineering Technician is required to maintain and extend competence and must complete at least the required level of IPD to maintain registration.

Applicants training towards registration do not have to satisfy a formal IPD requirement. However, at the time of applying for registration as a professional, applicants are assessed on their ability to manage and complete professional development-type activities. This is an integral part of the professional competence required to practise safely and effectively in engineering. The professional development-type activity carried out before registration is often termed IPD.

Outcome 11

How do I meet IPD requirements?

Outcome 11 concerns IPD that consists of activities identified to meet the requirements before registration. Professional development activities carried out between graduation and applying for professional registration are called IPD. This is an integral part of the professional competence required to practise engineering safely and effectively.

Additionally, through training, experience and IPD, applicants are able to attain the level of competence for registration and through work performance to provide evidence the competence. IPD activities are carried out before registration as a professional and similarly, CPD activities that are undertaken post registration are required to maintain professional competency. Refer to document **ECPD-01-STA** for CPD.

CPD is defined as the activities that a registered professional is required to maintain and complete at the required level to maintain registration. CPD is 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 a Professional Engineering Technician.

The ability to develop and maintain competency is embodied in Outcome 11, namely the ability to undertake professional development activities sufficient to maintain and extend competence. This involves more than completing courses or other activities. The emphasis falls on the individual's ability to self-develop. This capability has several dimensions:

- Taking responsibility for one's own development.
- Reflecting on strengths and weaknesses and recognising needs and plans.,
- Executing development activities and overcoming obstacles.

The range of methods open to applicants for presentation of IPD is substantial and comprises reading, researching, in-house training, accredited professional development courses, credit-bearing courses in higher education institutions and higher qualification studies that complement the individual's training and work experience. The essential test is to confirm that the activity is appropriate for the specific developmental needs of the individual. Also, involvement of the candidate in the planning of the learning activities rather than simply entrusting this to the employer is important.

The ability to develop one's skills continually is regarded as sufficiently important in an engineering professional to be enshrined as an outcome that must be demonstrated to attain registration.

For Professional Engineering Technicians, it should be noted that boundaries of practice areas change over time, new engineering principles are formulated, new procedures, standards and codes are developed and new engineering practice is advanced. IPD should therefore be planned with these factors in mind.

All the activities listed below, including combinations thereof, constitute professional development and thus, IPD:

- Attending courses, seminars, congresses and technical meetings organised by engineering institutions/institutes, universities, other professional bodies and course providers.
- Actively participating in conferences, serving on technical or professional committees, and engaging in working groups.
- Undertaking structured self-study (i.e., using textbooks with examples).
- Studying technical literature (e.g., journals, magazines).
- Taking correspondence courses and studying other supervised study packages in addition to taking in-house courses provided by employers.
- Enrolling for formal postgraduate studies (limited credits).
- Participating in accredited CPD training activities through VAs, industries, academies, further/advanced studies with accredited institutions, etc.
- Writing technical papers or presenting papers or lectures at organised events.

Pre-registration IPD is not subject to the requirement of annual points. It rather involves learning activities initiated by the applicant that are distinct from the structured learning activities required by the employer.

Refer to document **R-04-T&M-GUIDE-PC** for details on managing an applicant's IPD, as demonstrated by:

- planning own IPD strategy
- selecting appropriate IPD activities
- keeping a record of IPD strategy and activities
- displaying independent learning ability
- completing IPD activities.

8. APPLICANTS IN ACADEMIC, RESEARCH AND MANAGEMENT POSITIONS

Refer to *Training and Mentoring Guide,* document: **R-04-T&M-GUIDE-PC**, for details under *Training and Mentoring Programme Process* Stage 2 on how to *Meet Standards for Professional Competency Requirements for Registration*.

In certain cases, applicants are employed in engineering academia as lecturers, in research and development industry or in highly specialised fields during their development towards registration. While these applicants do not conform to the normal industry employment situation, they nevertheless gain the opportunity for development towards meeting the Competency Standards. These applicants should utilise the opportunities that exist while working with industries and students that apply for research or further studies to investigate real industry problems and participate in *complex/broadly defined/well defined engineering activities* to solve engineering problems. Interaction with industry will bridge the gap of certain outcomes that cannot be met/demonstrated in a purely academic environment. For example, samples or experiments can be undertaken from a real live plant or equipment to verify engineering theories. Most industries have a list of problems to be investigated or benchmark practices awaiting to be resolved.

Applicants working in industries in management positions should ensure that they keep themselves abreast of the engineering activities and problems for the IPD and to maintain their CPD points. There are number of areas this can be achieved through, although not limited to the following:

- Participate in engineering projects committees as a member or chairperson; this will assist in sound engineering judgements and ensure the meeting packages are reviewed and to challenge their integrity.
- Review engineering documents that subordinates compile and be part of the approval team.
- Volunteer to lead the engineering problems that arise in the industry and participate as a team member.

Applicants employed in academic and research positions should be alert to opportunities in their work experience that demonstrate competence against the outcomes. For example, the planning, execution and commissioning of a new and substantial laboratory may provide evidence against a number of outcomes. Applicants should seek opportunities to assist senior colleagues who are registered with the ECSA for consulting work. This engagement, while never full time, should be sustained over a substantial period of time. The senior colleague should fulfil a mentorship role and allow the candidate to take on increasing responsibility, moving up to Level E on the responsibility scale. It is likely that the time needed for the lecturer or researcher to obtain the necessary experience at the required level may be longer than in a conventional industrial situation.

9. APPLICANTS WHO HAVE COMPLETED ADVANCED QUALIFICATIONS

The *Training and Mentoring Guide*, document: **R-04-T&M-GUIDE-PC**, indicates the advanced studies that contribute towards training that are recognised as ECSA Accredited Engineering Programmes/Qualifications. In addition, the ECSA registration policy allows such applicants to present appropriate aspects (i.e., experimental and investigation) of their advanced studies as part of the evidence of competence against particular outcomes. Refer to document: **R-04-T&M-GUIDE-PC,** for details under *Training and Mentoring Programme Process Stage 1: Accredited Programme – Meeting Standards for Engineering Educational Requirements* as well as section for “additional information for experienced applicants”.

9.1 Professional Engineer

Applicants who have completed higher education studies beyond the minimum required qualification for registration as a Professional Engineer should identify opportunities to present evidence at the required level against the outcomes defined in the *Competency Standards*.

9.2 Professional Engineering Technologist

Applicants who have completed advanced education studies beyond the minimum required qualification (e.g., research degree) for registration as a Professional Engineering Technologist should identify opportunities to present evidence at the required level against the outcomes defined in the *Competency Standards*. It should be noted that applicants who have a number of years of industry experience with an educational level below the relevant ECSA benchmarked qualification can apply via this Alternative Route.

The term "Alternative Route" refers to an applicant who aspires to become registered in a Professional Category but does not have the accredited or recognised qualifications and who proposes to meet the educational requirement through further study and assessment. Refer to document **E-17-PRO** for actual years of experience required for a professional to register via the Alternative Route. In conjunction with actual engineering years of experience and DoR, Alternative Route qualifications are required to be at the *broadly defined* level of problem-solving or at the *well-defined* level of problem solving for Technologists and Technicians respectively.

The benchmark qualifications for registration of Technicians and Technologists must demonstrate exit-level problem-solving at NQF level 6 and NQF level 7 respectively.

9.3 Professional Engineering Technician

Applicants who have completed higher education studies beyond the National Diploma or the equivalent educational qualification level required for registration as a Professional Engineering Technician should identify opportunities to present evidence at the required level against the outcomes defined in the Competency Standards.

REVISION HISTORY

Revision number	Revision date	Revision details	Approved by
Rev. 0 Draft A	08 July 2022	Merging R-08-PE, R-08-PT and R-08-PN into one combined document R-08-CS-GUIDE-PE/PT/PN	RDDR Business Unit
Rev. 0 Draft B	5 August 2022	First Draft submitted by Working Group	Working Group
Rev.0 Draft C	14 August 2022	First Draft review	RDDR, Registration BU and Working Group
Rev.0 Draft D	29 September 2022	Second Draft Review	RDDR, Registration BU and Working Group
Rev.0 Draft E	03 October 2022	Review and recommendation by ERPS	Acting RPS Executive
Rev.0	13 October 2022	Approval	RPSC
Rev 0	01 December 2022	Ratification	Council
Rev 1 Draft A	15 Aug 2023	The document has been reviewed and some information have been moved to suitable section and Table 1: *Overview of outcomes* have been separated per categories and to align to R-02-STA-PE/PT/PN. The document also expands on Outcome 3 which deals with the comprehension and application of knowledge by the engineering practitioners in specific professional categories embodied in established engineering practices that are specific to the jurisdiction in which the Professional Engineer /	Reviewed by Working group

Revision number	Revision date	Revision details	Approved by
		Professional Engineering Technologists and/or Professional Engineering Technician. More information has been added to explain the Visualising for the Interconnectedness of the Engineering Outcomes. Initial Professional Development Requirements section has been expanded to include what is expected of applicants and to make reference to the ECPD-01-STA document for CPD.	
Rev 1 Draft B	13 Dec 2023	Document revised with WG	RI BU and WG
Rev 1 Draft C	18 Jan 2023	Document revised with WG and Registration BU	RI BU, Registration BU and WG
Rev 1 Draft D	30 Jan 2024	Reviewed and checked	Executive: RPSC
Rev 1	08 Feb 2024	Approval	RPSC

The Standard for:

Guide to the Competency Standards for Registration in Professional Categories

Revision 1 dated 08 February 2024 and consisting of 79 pages reviewed for adequacy by the Business Unit Assistant Manager and approved by the Acting Executive: Research, Policy and Standards (**RPS**).

.... 09 April 2024 ....

Business Unit Manager Date

.... 2024/04/09 ....

Executive: RPS Date

This definitive version of this policy is available on our website

APPENDIX 1: Examples of legislation applicable generally and in particular areas of engineering

1. Engineering Profession Act, 46 of 2000
2. Occupational Health and Safety Act, 85 of 1993:
    - General Machinery Regulations
    - Construction Regulations, 2014
    - Driven Machinery Regulations
    - Pressurised Equipment Regulations
3. Mine Health and Safety Act No. 29 of 1996:
    - Design of underground dam walls, plugs and barricades
    - Regulations on use of water for mining
4. Environment Conservation Act, 73 of 1989
    - National Environmental Management Act, 107 of 1998
    - National Environmental Management Waste Act, 59 of 2008
    - National Radioactive Waste Disposal Institute Act, 53 of 2008
    - National Nuclear Regulator (NNR) Act, 47 of 1999
    - Mine and Safety Act, 1996
    - SANS 10248, 1023: Waste Classification and Management Regulations from South Africa Constitution Act, 108 of 1996
    - Hazardous Substance Act, 5 of 1973
5. National Building Regulations and Building Standards Act, 103 of 1977:
    - Certification of structural system of a building or home
    - Certification of fire protection system
    - Certification of artificial ventilation systems
    - Geotechnical site investigations, stability of excavations, geotechnical investigations on sites underlain by dolomites
    - Fire Protection Standard SANS Code 10139: 2012 for fire detection and alarm systems for buildings – system design, installation and servicing

6. National Water Act, 36 of 1998:
    - Various measures relating to pollution of a water resource
    - South Africa Bureau of Standards (SABS) Act, 24 of 1945; Act 29 of 2008
    - List of SABS/TC 147 STANDARDS listing SANS codes for chemical use for treatment of water intended for human consumption and other purposes, e.g., SANS 241:2015 Drinking Water Standard
    - SANS codes for food and beverages e.g., SANS 10133, etc. from www.sans.co.za
7. Water Act, 54 of 1956
    - Determination of persons permitted to design dams
8. ISO 9001: 2015
9. South Africa Bureau of Standards (SABS) Act, 24 of 1945; Act 29 of 2008
10. Nuclear Energy Act, 46 of 1999
    - Minerals and Energy Acts, e.g., Mineral and Petroleum Act, 28 of 2002
11. SANS Codes fromwww.sabs.co.za