ECSA
ENGINEERING COUNCIL OF SOUTH AFRICA

An Effective Regulator Assuring Engineering Excellence

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

R-05-MET-PE/PT/PN

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INTRODUCTION

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

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

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

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

DEFINITIONS

Applicant: means a person applying to the ECSA for registration in any of the categories according to Section 18 of the Engineering Profession Act, 2000 (Act No. 46 of 2000).

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

Broadly-defined engineering work: is characterised by the following:

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

Candidate: means a person registered with ECSA in a candidate category of registration.

Complex engineering problems: involve multiple factors, uncertainties, interdependencies and constraints, making them difficult to define, analyse and solve.

Complex engineering work: is characterised by the following:

- Scope of activities may encompass entire complex engineering systems or complex subsystems.
- A context that is complex and varying is multidisciplinary, requires teamwork, is unpredictable and may need to be identified.

- It requires diverse and significant resources including people, money, equipment, materials and technologies.
- Significant interactions exist among wide-ranging or conflicting technical, engineering or other issues.
- It is constrained by time, finance, infrastructure, resources, facilities, standards and codes, and applicable laws.
- It has significant risks and consequences in a range of contexts.

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

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

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

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

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

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

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

Key responsibilities of engineering management may include the following:

- **Planning:** Defining project objectives, scope and deliverables, and creating a detailed plan to achieve them.
- **Resource management:** Determining the required resources, such as personnel, equipment and materials, and allocating them appropriately to ensure smooth execution of engineering work.
- **Team coordination:** Managing and leading a team involved in the activities of performing engineering work and ensuring effective communication, collaboration and coordination among team members.
- **Risk management:** Identifying potential risks and developing strategies to mitigate them.
- **Quality control:** Implementing quality assurance processes to ensure that engineering works meet the required standards and specifications.
- **Budget and cost control:** Monitoring project expenses, tracking costs and ensuring that projects are completed within the allocated budget.

- **Stakeholder management:** Engaging with clients, contractors, suppliers and other stakeholders to address their concerns, manage expectations and maintain positive relationships.
- **Executing engineering work:** Direct and control engineering processes and systems, including commissioning, operating and decommissioning equipment, while maintaining safety at all times, and ensuring timeous completion.

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

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

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

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

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

Specified category: means a category of registration for persons who are licensed through the Engineering Profession Act, 46 of 2000 or a combination of external legislation and the Engineering Profession Act and who have specific engineering competencies at the level of NQF 5 that are associated with an identified need to protect the public safety, health and interest or the environment in relation to an engineering activity.

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

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

ABBREVIATIONS

BEng Tech	Bachelor of Engineering Technology
BEng	Bachelor of Engineering
BTech (Eng)	Bachelor of Technology in Engineering
BScEng	Bachelor of Science in Engineering
BDEA	Broadly-defined engineering activities
C&U	Commitment and Undertaking
CEA	Complex engineering activities
CESA	Consulting Engineers South Africa
CPD	Continuing Professional Development
DMS	Dense Medium Separation
DSTG	Discipline-specific Training Guide
ECSA	Engineering Council of South Africa
EVM	Earn Value Management
FMEA	Failure Mode and Effects Analysis
HAZOP **IDoEW**	Hazard and Operability Analysis Identification of Engineering Work
IPD	Initial Professional Development
N.Dip (Eng)	National Diploma in Engineering
NQF	National Qualifications Framework
OEM	Original equipment manufacturer
OFO	Organising Framework for Occupations
PCE	Professional Certificated Engineer

Pr Tech Eng	Professional Engineering Technologist
PGDip (Eng)	Post-graduate Diploma in Engineering
PMI	Project Management Institute
SACPCMP	The South African Council for the Project and Construction Management Professions
SAIMM	Southern African Institute of Mining and Metallurgy
TES	Training and Experience Summary
TERs	Training and Experience Reports
VIPs	Value Improvement Practices
WDEA	Well-defined engineering activities

BACKGROUND

Figure 1 defines the documents that comprise the Engineering Council of South Africa (ECSA) system for registration in professional categories. The illustration also locates the current document.

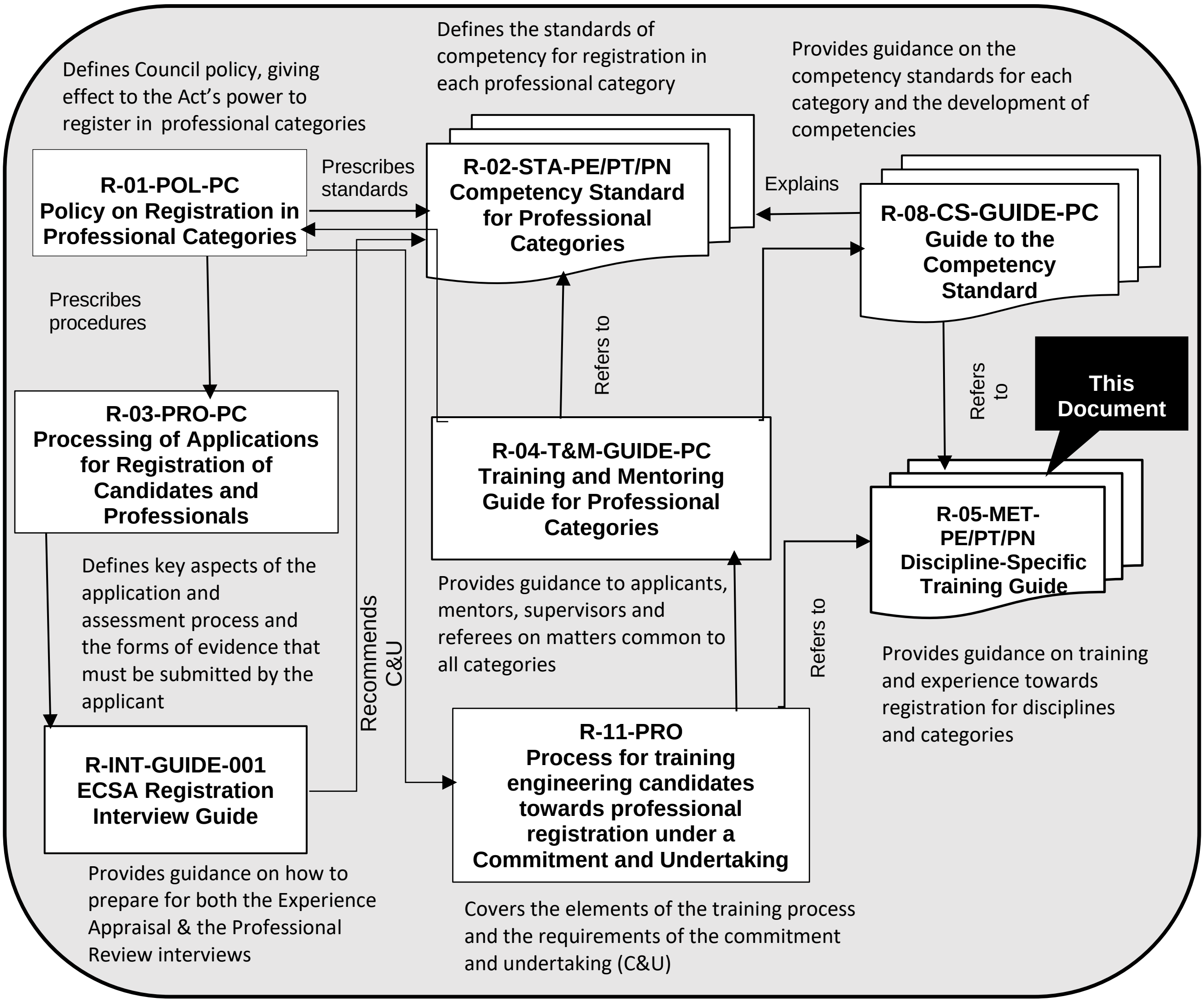

Figure 1: Documents defining the ECSA Registration System

1. PURPOSE OF THIS DOCUMENT

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

This document supplements the generic Training and Mentoring Guide for Professional Categories (document **R-04-T&M-GUIDE-PC**) and the Guide to the Competency Standards for Registration in Professional Categories (document **R-08-CS-GUIDE-PE/PT/PN**) for applicant industrial engineers, technologists and technicians or any other person who intends to register as a professional with ECSA in the respective discipline.

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

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

2. AUDIENCE

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

This guide applies to persons who:

- are registered as a candidate engineer, technologist or technician and/or has embarked on a process of training under a registered mentor guiding the professional development process at each stage

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

2.1 Persons registered with ECSA as a candidate

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

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

2.2 Persons not registered with ECSA as a Candidate

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

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

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

3. TYPE OF ENGINEERING WORK

The engineering professional is responsible for ensuring that the work is carried out competently and in accordance with the relevant engineering standards and regulations. In terms of Section 27(1) of the Engineering Profession Act, 2000 (Act No. 46 of 2000), the Council must draw up a Code of Conduct for Registered Persons and may draw up a Code of Practice in consultation with the Council for the Built Environment (CBE), VAs and registered persons.

3.1 Metallurgical Engineering

Metallurgists normally work within the metal and mineral industry including mining and production in the concentrators and metal recovery operations, in smelters, metal refineries, foundries and research and development laboratories. Metallurgists use their knowledge of chemistry, physics, mineralogy, underlying process fundamentals and process engineering to control and improve processes that separate, concentrate and recover minerals and their valuable metals from natural ores. Three career paths are available to the Metallurgist: Mineral Processing Engineering, Extraction Engineering, Metallurgical and Materials Engineering (Physical Metallurgy).

Applicants may further get knowledge in some or all **practice areas** within their chosen career path which include, research and development, process optimisation, plant and equipment design, risk management and impact mitigation, project management, project development, plant construction, commissioning and hand over, plant decommissioning, product / manufacturing, plant operation and maintenance.

Metallurgical engineers in these practice areas will address complex engineering problems, while Metallurgical engineering technologists address broadly defined engineering problems and Metallurgical engineering technicians address well-defined engineering problems.

3.2 Extractive Metallurgical Engineering

Extractive Metallurgical Engineering is extraction of metals from their natural mineral deposits or intermediate compounds from ores by chemical or physical processes, including wet or hydrometallurgical process stages, high temperatures or pyro metallurgical process stages and electro-metallurgical process stages. The process may contain crude metal products that can be subjected to further processing called metallurgy or physical metallurgy, which includes processes such as alloying, casting in foundry, rolling and extrusion; for example, copper, uranium vanadium and other metals produced by solvent extraction using a hydrometallurgical process.

Typical tasks in Extractive Metallurgical Engineering may include but are not limited to the following:

(a) Conducting research and developing methods of extracting metals from their ores and advising on their application.

(b) Design, development and implementation of complex process projects.

(c) Operation and optimisation of process plants or commercial-scale processes.

Extractive Metallurgical Engineering generally includes one or more of the following fields:

(a) Metallurgy / Mineral Processing Researcher / Lecturer

(b) Extractive Metallurgist

(c) Metallurgy / Mineral Processing Consulting Engineer

(d) Pyro metallurgist

(e) Hydro metallurgist

(f) Electrometallurgist.

3.3 Mineral Processing Engineering

Mineral Processing Engineering is a process by which valuable minerals are separated from worthless material or other valuable minerals by inducing them to gather in and on the surface of a froth layer using processing like flotation, jigging, milling, scrubbing, magnetic separation, Dense Medium Separation (DMS) or Heavy Medium Separation (HMS), etc. The process of froth flotation entails crushing and grinding the ore to a fine size. This fine grinding separates the individual mineral particles from the waste rock and other mineral particles. Valuable minerals such as gold, silver, copper, lead, zinc, molybdenum, iron, potash, phosphate and even sand for glass are often processed by froth flotation.

3.4 Metallurgical and Materials Engineering

Metallurgical and Materials Engineering involves performing research, analysis, design, production, characterisation, failure analysis and application of materials, including metals, for engineering applications based on an understanding of the properties of matter and engineering requirements.

Typical tasks in Metallurgical and Materials Engineering include the following:

(a) Development, control and advice on processes used for casting, alloying, heat treating or welding of metals, alloys and other materials to produce commercial metal products or develop new alloys, materials and processes, evaluate and specify materials for engineering applications, and do quality control and failure analyses.

(b) Investigating properties of metals and alloys, developing new alloys and advice on and supervising technical aspects of metal and alloy manufacture, processing, use and manufacturing.

(c) Doing residual life evaluations, predictions and failure analyses, and prescribing remedial actions to avoid material failures.

Metallurgical and Materials Engineering generally includes one or more of the following areas:

(a) Metallurgy / Mineral Processing Researcher / Lecturer

(b) Physical Metallurgist

(c) Materials Engineer

(d) Welding Engineer

(e) Corrosion Engineer

(f) Quality Assurance Engineer

(g) Metallurgy / Mineral Processing Consulting Engineer: work on a variety of processes, plants and ores – maybe in research and development or project management area.

4. DEVELOPING ENGINEERING COMPETENCIES

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

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

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

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

4.1 Training for registration as a professional engineer

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

To meet Outcome 1 applicants are required to **define, investigate and analyse complex engineering problems**. The applicant should gain experience in at least one or more of the practice areas where they **investigate and evaluate pertinent information and identify systems and sub-systems of complex problems including collecting, organising and evaluating information from all applicable sources including in-situ investigations where appropriate**.

Investigation and problem analysis of **complex** engineering problems involve the following:

- Demonstrating the theoretical and practical knowledge to solve **complex** engineering problems utilising the well-proven analytical techniques and tools. This includes the ability to use trouble-shooting skills.
- Identifying problems / hazards and analysing the causes of process problems in a systematic manner using applicable models, frameworks and tools.
- Using of troubleshooting methodologies, literature surveys, data analysis and root cause analysis tools to identify or analyse problems.
- Demonstrating involvement in investigating properties of metals, ceramics, polymers and other materials, developing and assessing their commercial and engineering applications.

- Preparing reports on metallurgical operations and projects.
- Undertaking fault finding, root cause analysis, trouble shooting, data collection, etc.

The complex engineering problem may be a design requirement, an applied research and development requirement or a problematic situation in an existing component, system or process. Some of the examples of addressing outcome 1 in different practice areas are as follows:

Research and development

To address outcome 1, applicants in the research and development practice area need to demonstrate the following:

- Developing a clear understanding of the **complex** problem/opportunity that is to be investigated by conducting a critical analysis of the literature and other relevant information and thereafter, assembling the documentation on the subject in an organised manner.
- Motivating, planning and designing the broadly defined research project and its associated equipment and/or pilot plant.
- **Investigating complex** theoretical or paper investigations and laboratory-scale investigations.
- **Execute complex** investigations on a laboratory, pilot plant and/or industrial-plant scale.
- **Execute to** interpretation of the results and ensuring that the results are meaningful and have been correctly obtained in accordance with **complex** scientific principles.
- **Execute** data processing and analysis.
- **Execute** studies regarding technical and economic feasibility.

Plant optimisation, plant and equipment design

- Process optimisation involves **defining and investigating complex** problems resulting in the system or metallurgical process not operating as intended; this might achieved be through improving the system/equipment operating parameters by modifying or installing new equipment or systems.
- Outcome 1 may be achieved through undertaking fault finding, root cause analysis, trouble shooting of equipment and process issues, data collection, etc.

- Improvements in process optimisation may be achieved by investigating the operating parameters of the system/equipment, modification or installation of a new system/equipment.
- The applicant can further address outcome 1 by:
  - **investigating** cost and doing an economic analysis for minimising cost and maximising throughput and/or efficiency of the plant operation, process, system or equipment
  - **investigating** mineral processing and extractive metallurgical plants various process systems, unit operations, and process equipment
  - **investigating** process design calculations such as mass/material and water balances, process equipment design, sizing and process technology selection, and development of process diagrams such as process flow diagrams, piping and instrumentation diagrams and plant layout, etc.
  - **executing** HAZOP studies to define and analysis complex hazard and operability problems
  - **executing** trade-off studies.

Risk management and impact mitigation

To address outcome 1, the applicants in the risk management and impact mitigation practice area need to demonstrate the following:

- Investigating and evaluating complex analysis of samples taken from metallurgical process streams to ensure safe and economic operation and they advise operations personnel on process changes required to obtain desired products, processes and quality control.
- Investigating and evaluating complex problems / hazards and analysing the causes of process problems in a systematic manner using applicable models, frameworks and tools.
- Investigating and evaluating complex risk assessments during plant operation and projects.

Project management

- Applicants are required **investigate and evaluate complex** problems in Integrated Project Controls, which includes cost control, estimating resources, capital and operating and/or lifecycle costs, planning and scheduling and project risk management.
- Applicants are required to **investigate and evaluate complex problems** in stakeholder management, including liaising with a wide variety of people on the job such as operators,

maintenance and engineering staff, geologists, mining engineers and supporting specialists in process control, computing, technology provision and research.

- Applicants are required to **investigate and evaluate complex problems** in project resource management and planning.
- Applicants are required to **investigate and evaluate complex problems** in change management and project risk management.

Project development

- Applicants are required to **investigate complex defined problems** during all the project development phases, including ideation, problem analysis, definition need, conceptual design, and basic and detailed engineering. Research and feasibility studies are undertaken to identify, define and investigate broadly defined engineering problems that may arise at any stage of project development.
- Complex defined engineering problems may be defined and investigated following sound financial business concepts, ranging from budgeting to feasibility studies.

Plant construction, commissioning and handover

Applicants are required to investigate **complex defined problems** in the following phases.

- Plant construction: site establishment and site management, provide input during assembling of plant equipment in accordance with drawings and installation designs.
- Preparation: preparation of operating, start-up, shutdown and emergency procedures.
- Plant commissioning: measurement and analysis of actual performance data versus design parameters, responsibility for performance of the plant, optimisation of plant performance, review of all safety standards, operability of the plant and sound labour relations, practices and managerial aspects.
- Plant hand-over: including ‘as-built’ documentation, construction, planning and execution of punch-out items and hand-over.

Plant decommissioning

Applicants are required to **investigate complex defined problems** during plant decommissioning, which involves the dissembling of equipment.

- Applicants are required to **investigate complex defined problems** in the plant decommissioning strategy and safety procedures by understanding the chemical and physical characteristics of the equipment or plant.
- Applicants are required to **investigate complex defined problems** in the procedures for plant decommissioning and consolidation for shutdown or closure.
- Applicants are required to **investigate complex defined problems** in regulatory and statutory application and authorisation processes.

Product manufacturing

- Applicants are required to **investigate complex defined problems** in properties of metals, ceramics, polymers and other materials, developing and assessing their commercial and engineering applications.
- Applicants are required to **investigate complex defined problems** in the development, control and advice on processes used for casting, alloying, heat treating or welding of metals, alloys and other materials to produce commercial metal products or develop new alloys, materials and processes, evaluate and specify materials for engineering applications and do quality control and failure analyses.
- Applicants are required to **investigate complex defined problems** properties of metals and alloys, developing new alloys and advice on and supervising technical aspects of metal and alloy manufacture, processing, use and manufacturing.
- Applicants are required to **investigate complex defined problems** in residual life evaluations, predictions and failure analyses, and prescribe remedial actions to avoid material failures.

Plant operation and maintenance

To address outcome 1 the applicants in the plant operations practice area need to demonstrate the following:

- **Investigate** the measurement and analysis of operational plant or equipment data to define, investigate complex problems.
- **Investigate** and undertake material and energy balances to define, investigate complex problems.

- **Contribute** to the process plant operation, especially with direct and increasing responsibility for unit sections of the plant to define, investigate complex problems.
- **Contribute** to the quality control in respect of measurement and specifications and define and investigate complex problems where quality is not met.
- **Use** plant records and operating costs to define and investigate complex problems.
- **Define and investigate** complex problems that may result in inter-relationships between engineering personnel and management and among members of the engineering team, especially between production and maintenance members.

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

To meet outcome 2, applicants are required to design and develop solutions to complex engineering problems using appropriate theory (See outcome 3) and information technologies, while checking impacts, sustainability and stakeholder views. Some of the examples of addressing outcome 2 in different practice areas are as follows:

Research and development

To address outcome 2, applicants in the research and development practice area need to demonstrate the following:

- Develop solutions to the **complex** problem/opportunity that was investigated by conducting a critical analysis of the literature and other relevant information and thereafter, assembling the documentation on the subject in an organised manner.
- Develop a motivation, plan and design to the broadly defined research project and its associated equipment and/or pilot plant.
- Develop and design the laboratory, pilot plant and/or industrial-plant scale experimental methodology and test/execution procedures.
- Use the data and analysis to validate the develop solutions.
- Use the studies regarding technical and economic feasibility to further select the best solution.

Plant optimisation, plant and equipment design

- Outcome 2 may be achieved through **designing or developing** solutions to **complex** engineering problems that were identified through undertaking fault finding, root cause analysis, trouble shooting of equipment and process issues, data collection, etc.
- Improvements in process optimisation may be achieved by **designing or developing** and implementing operating parameters of the system/equipment, or modification or installation of new system/equipment.
- The applicant can further address outcome 2 by:
  - **executing** and designing mineral processing and extractive metallurgical plants various process systems, unit operations and process equipment
  - **implementing solutions developed** from process design calculations results.

Project management

- Applicants are required to develop Integrated Project Controls, which includes cost control, estimating resources, capital and operating and/or lifecycle costs, planning and scheduling and project risk management.
- Applicants are required to develop stakeholder management, liaising with a wide variety of people on the job such as operators, maintenance and engineering staff, geologists, mining engineers and supporting specialists in process control, computing, technology provision and research.
- Applicants are required to develop project resource management and planning.
- Applicants are required to develop change management and project risk management.

Risk management and impact mitigation

- Applicants are required to develop and design processes and systems to improve and ensure safety, health and environment are complied with in the laboratory, pilot plant or industrial plant.

Project development

- Applicants are required to **design or develop solutions to complex engineering problems** during all the project development phases, including ideation, problem analysis, definition need, conceptual design and basic and detailed engineering. Research and feasibility studies are undertaken to identify, define and investigate broadly defined engineering problems that may arise at any stage of project development.

- Applicants are required to **design or develop solutions to complex engineering problems** following sound financial business concepts, ranging from budgeting to feasibility studies.

Plant construction, commissioning and handover

Applicants are required to **design or develop solutions to complex engineering problems** in the following phases:

- Plant construction: site establishment and site management, providing input during assembling of plant equipment in accordance with drawings and installation designs.
- Preparation: preparation of operating, start-up, shutdown and emergency procedures.
- Plant commissioning: measurement and analysis of actual performance data versus design parameters, responsibility for performance of the plant, optimisation of plant performance, review of all safety standards, operability of the plant and sound labour relations, practices and managerial aspects.
- Plant hand-over: including 'as-built' documentation, construction, planning and execution of punch-out items and hand-over.

Plant decommissioning

Applicants are required to **design or develop solutions to complex engineering problems** during plant decommissioning, which involves the dissembling of equipment.

- Applicants are required to **design or develop solutions to complex engineering problems** in the plant decommissioning strategy and safety procedures by understanding the chemical and physical characteristics of the equipment or plant.
- Applicants are required to **design or develop solutions to complex engineering problems** in the procedures for plant decommissioning and consolidation for shutdown or closure.
- Applicants are required to **design or develop solutions to complex engineering problems** in regulatory and statutory application and authorisation processes.

Product manufacturing

- Applicants are required to **design or develop solutions to complex engineering problems** in properties of metals, ceramics, polymers and other materials, developing and assessing their commercial and engineering applications.
- Applicants are required to **design or develop solutions to complex engineering problems** in the development, control and advice on processes used for casting, alloying, heat treating or welding of metals, alloys and other materials to produce commercial metal products or develop new alloys, materials and processes, evaluate and specify materials for engineering applications and do quality control and failure analyses.
- Applicants are required to **design or develop solutions to complex engineering problems** in properties of metals and alloys, developing new alloys and advice on and supervising technical aspects of metal and alloy manufacture, processing, use and manufacturing.
- Applicants are required to **design or develop solutions to complex engineering problems** in residual life evaluations, predictions and failure analyses, and prescribe remedial actions to avoid material failures.

Plant construction, commissioning and decommissioning

- Applicants are required to commission plants by using the measurement and analysis of actual performance data versus design parameters to improve the performance of the plant and optimise the plant performance.
- Applicants are required to develop safety standards, operability of the plant and sound labour relations, practices and managerial aspects.
- Applicants are required to develop plant decommissioning processes that involve the dissembling of equipment.
- Applicants are required to develop and undertake the design and analysis of the requirements of the new site for optimum performance.
- Applicants are required to develop the decommissioning strategy and safety procedures with the understanding of the chemical and physical characteristics of the equipment or plant.
- Applicants are required to develop and compile procedures for plant decommissioning and consolidation for shutdown or closure.

- Applicants are required to develop/compile regulatory and statutory applications to obtain relevant authorisations.

4.1.3 Outcome 3: Comprehend and apply contextual knowledge (Responsibility level E)

Applicants have technical knowledge, which is knowledge applicable to the practice area, i.e., in hydrometallurgy, pyrometallurgy, physical metallurgy and minerals processing. This is supplemented by legal, regulatory and locally relevant knowledge.

To meet Outcome 3, applicants need to comprehend and apply advanced and local knowledge of the widely applied principles underpinning good practice that are specific to the jurisdiction in which the complex Engineer practises.

Metallurgical Engineers are required to demonstrate knowledge by stating the fundamental engineering principles, practices, sound testable assumptions or previously encountered techniques and demonstrate the application of the NQF 8 theory, engineering standards, codes of practice, legislation, regulations and finance in the practice area

4.1.4 Outcome 4: Manage one or more engineering activities (Responsibility level D)

To meet Outcome 4, applicants need to manage part of all of one or more complex engineering activities.

Management of complex engineering activities is directed at achieving results as a member or leader of a team by planning and harnessing people, resources, processes, systems, money and contracts or agreements. This may require the following:

- Managing self, people, work priorities, processes and resources when performing complex engineering work.
- Management of laboratory or pilot plant project, test work programme, equipment, work priorities, processes, systems and resources.
- Management of and giving support to production / operations teams.
- Management of contractors, commissioning and decommissioning activities.
- Planning, organising, leading and controlling complex engineering activities.

4.1.5 Outcome 5: Professional communication (Responsibility level C)

To meet Outcome 5, applicants are required to **communicate clearly using multiple media and collaborate inclusively with a broad range of stakeholders in the course of complex engineering activities**.

Professional communication may be achieved through compilation of the results into a written report and presentation of verbal reports. Applicants should participate in technology transfer to ensure the maximum benefit is obtained from plant operations and the research and development efforts.

Communication with respect to **complex** engineering problems relates to the technical aspects and the wider impacts of professional work. The audience includes superiors, peers, subordinates, implementing teams, other disciplines, clients and stakeholders. Appropriate modes of communication must be selected.

4.1.6 Outcome 6: Recognise and address social, cultural and environmental effects (Responsibility level B)

Metallurgical engineers need to play a role in shaping the world and, therefore, must be mindful of the social, cultural and environmental impacts of their work. To meet Outcome 6, applicants need to **recognise the reasonably foreseeable economic, social, cultural and environmental effects of complex engineering activities seeking to achieve sustainabili**ty.

The impacts of **complex** engineering activities must be considered over the project life cycle paying due regard to the immediate economic, social and cultural effects, including the protection of the environment and the need for sustainability.

Below are examples of how some of the effects may be identified/recognised. Measures would then need to be taken to address and mitigate any negative effects of engineering activities that may be identified:

- **Ethical and social responsibility** through stakeholder engagements, inclusive design and ethical training.
- **Cultural sensitivity** through cultural research before implementing projects and local collaboration within communities.

- **Environmental considerations** through lifecycle analysis and sustainable design principles and compliance with environmental regulations.
- **Long term and systematic thinking** through impact assessments, adaptive designs and acquire knowledge of global challenges.
- **Advocate for sustainable practices** through promoting green technologies and implementing sustainable practices.

4.1.7 Outcome 7: Statutory and regulatory requirements (Responsibility level E)

To meet Outcome 7, applicants need to **meet all legal, regulatory and cultural requirements and protect the health and safety of persons during all engineering activities**. Applicants should identify applicable legal, regulatory, health and safety requirements and standards and sustainable practices for the **complex** engineering activities.

Applicants should be aware of the requirements for safety appointments in terms of the Occupational Health and Safety Act, 85 of 1993 for plant managers as well other standards as listed below:

- SANS Codes for Specification for Piping Design / Material (ANSI) (see www.sabs.co.za)
- SANS 10248, 1023: Waste Classification and Management Regulations from the Constitution of the Republic of South Africa, 1996
- Minerals and Energy Acts (e.g. Mineral and Petroleum Act, 28 of 2002)
- Mine Health and Safety Act, 29 of 1996 (see www.dmr.gov.za: Design of underground dam walls, plugs and barricades. Regulations on use of water for mining)
- Project and Construction Management Professions Act, 48 of 2000
- National Environmental Management Act, 107 of 1998 (various measures relating to pollution of a water resource; waterworks process controller)
- National Water Act, 54 of 1956 (Determination of persons permitted to design dams)
- National Environmental Management Waste Act, 59 of 2008
- Nuclear Energy Act, 46 of 1999
- National Water Act, 36 of 1998
- Occupational Health and Safety Act, 85 of 1993 (OHS Act) and Regulations: Driven Machinery Regulations; Pressurised Equipment Regulations

- ISO 9001: 2015
- SAMREC (South African Code for Reporting of Exploration Results, Mineral Resources and Mineral Reserves: e.g. 10320:2004)
- SAMVAL (South African Code for Reporting of Mineral Asset Evaluations) (see www.sans.co.za)
- Engineering Profession Act, 46 of 2000, including Rules and specifically the Code of Conduct
- National Building Regulations and Building Standards Act, 103 of 1977: Certification of fire protection systems.

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

Ethical behaviour involves the comprehension and application of professional ethics, responsibilities and norms of engineering practice within one's own limits of competence. To meet outcome 8, applicants are required to have knowledge of and comply with the ECSA Engineering Profession Act, 46 of 2000, its Rules and specifically the Code of Conduct.

Applicants need to identify ethical problems and affected parties and **additionally, identify a systematic approach to resolving the issues**.

4.1.9 Outcome 9: Exercising sound engineering judgement (Responsibility level E)

Metallurgical Engineers need to choose and apply appropriate technical expertise in their fields of practice. To meet outcome 9, applicants need to **exercise sound judgement by evaluating the outcomes, impacts and alternatives in the course of complex engineering activities**.

Sound judgement is expected in considering interactions between technical, engineering, social or other issues and their **far-reaching** impact on affected parties in making recommendations on the following:

- Developing options and final solutions or approaches, which consider impacts, interrelationships with other disciplines, time, cost and other **wider** constraints, **in the light of incomplete knowledge**.
- Taking a **holistic view** of the solution while considering risks, their consequences and the implications for stakeholders and affected parties.

4.1.10 Outcome 10: Responsibility in decision-making (Responsibility level E)

Metallurgical Engineers have the contextual knowledge that allows them to take responsibility for making decisions on part or all **complex engineering activities**.

This is demonstrated through the following:

- Systematic gathering of related information and checking of facts and inputs required for the decision-making process.
- Making the final decision, based on knowledge, past experience and seeking advice on matters falling outside the applicant's education and experience.
- Keeping record of the decision-making process and the reasons for the final decision.
- Taking responsibility and being prepared to be held accountable for immediate consequences of own work and evaluating any shortcomings in the output.

4.1.11 Outcome 11: Professional development (Responsibility level D)

To meet Outcome 11, applicants need to **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 can be achieved through attending relevant technical courses and conferences. Formal safety training is a mandatory requirement and applicants should register with the relevant voluntary associations to access lists of training courses, conferences, seminars and other relevant information (e.g., SAIMM, PMI, PMISA, CESA, SACPCMP).

The following is a list of sample training and courses:

- Problem solving and analysis tools (e.g., brainstorming, gap analysis, FMEA, Pareto Analysis, root cause analysis, problem tree analysis, trade-off tools)
- Risk assessment and analysis techniques
- Project management techniques and tools, including conditions of contract management, finance and economics, quality systems, stakeholder management and project management (planning, scheduling and project controls), tools and software (e.g. MS Project, Primavera, Project Risk Analysis tools, Earn Value Management [EVM] and other SAP Tools)

- Modelling and simulation tools (e.g., for pumps, DMS) from original equipment manufacturers (OEMs) or own development as part of competency gained
- Occupation Health and Safety, including the OHS Act and 'safety in design'
- Formally registered continuing professional development (CPD) courses in Metallurgical Engineering and associated disciplines
- Value engineering and other value improvement practices (VIPs)
- Preparation of engineering design specifications
- Environmental aspects of projects and plant operations
- Waste management and treatment process
- Professional skills such as report writing, presentations, facilitation and negotiation
- Use of specific testing equipment and tools
- Plant operations performance monitoring tools
- Compilation of plant operation procedures
- Plant commissioning, decommissioning and handover
- Maintenance and reliability engineering
- Specific equipment designs for metallurgy or mineral processing.

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

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

To meet Outcome 1, applicants are required to **define, investigate and analyse broadly defined engineering problems**. Applicants should gain experience in at least one or more of the practice areas where they **investigate or contribute to investigating engineering problems, including collecting, organising and evaluating information from all applicable sources.**

Investigation and problem analysis of **broadly defined** engineering problems involve the following:

- Demonstrating theoretical and practical knowledge to solve **broadly defined** engineering problems utilising well-proven analytical techniques and tools. This includes the ability to use trouble-shooting skills.

- Identifying problems or hazards and analysing the causes of process problems in a systematic manner using applicable models, frameworks and tools.
- Using of troubleshooting methodologies, literature surveys, data analysis and root cause analysis tools to identify or analyse problems.
- Demonstrating involvement in investigating properties of metals, ceramics, polymers and other materials, developing and assessing their commercial and engineering applications.
- Preparing reports on metallurgical operations and projects.
- Undertaking fault finding, root cause analysis, trouble shooting, data collection, etc.

The broadly defined engineering problem may be a design requirement, an applied research and development requirement or a problematic situation in an existing component, system or process. Some of the examples of addressing outcome 1 in different practice areas are as follows:

Research and development

To address outcome 1, applicants in the research and development practice area need to demonstrate the following:

- **Performing/Contributing** to developing a clear understanding of the **broadly defined** problem/opportunity that is to be investigated by conducting a critical analysis of the literature and other relevant information and thereafter, assembling the documentation on the subject in an organised manner.
- **Performing/Contributing** to motivating, planning and designing the **broadly defined** research project and its associated equipment and/or pilot plant.
- **Performing/Contributing** to **broadly defined** theoretical or paper investigations and laboratory-scale investigations.
- **Performing/Contributing** to **broadly defined** investigations in a laboratory, pilot plant and/or on an industrial-plant scale.
- **Performing/Contributing** to Interpretation of the results and ensuring that the results are meaningful and have been correctly obtained in accordance with **broadly defined** scientific principles.
- **Performing/Contributing** to data processing and analysis.

- **Performing/Contributing** to conducting studies regarding technical and economic feasibility.
- **Performing/Contributing** to compiling the results into a high-quality written report and presentation involving verbal reporting.

Plant optimisation, plant and equipment design

- Process optimisation involves **performing or contributing to defining and investigating broadly defined** problems resulting in the system or metallurgical process not operating as intended; this might achieved be through improving the system/equipment operating parameters by modifying or installing new equipment or systems.
- Outcome 1 may be achieved through **contributing** to fault finding, root cause analysis, trouble shooting of equipment and process issues, data collection, etc.
- Improvements in process optimisation may be achieved by investigating the operating parameters of the system/equipment, modification or installation of new system/equipment.
- Applicants can further address outcome 1 by:
    - **performing or contributing** to cost and economic analysis for minimising cost and maximising throughput and/or efficiency of the plant operation, process, system or equipment
    - **performing or contributing** to designing mineral processing and extractive metallurgical plants various process systems, unit operations, and process equipment
    - **performing or contributing** to process design calculations such as mass/material and water balances, process equipment design, sizing and process technology selection and well as developing process diagrams such as process flow diagrams, piping and instrumentation diagrams and plant layout etc.
    - **contributing** to HAZOP studies
    - **performing or contributing** to the preparation of process documentation such as process control philosophy and process technical reports
    - **contributing** to trade-off studies.

Risk management and impact mitigation

To address outcome 1, applicants in the risk management and impact mitigation practice area need to demonstrate the following:

- **Investigating or contributing to investigating broadly defined** analysis of samples taken from metallurgical process streams to ensure safe and economic operation, and they advise operations personnel on process changes required to obtain desired products, processes and quality control.
- **Investigating or contributing to investigating broadly defined** problems / hazards and analysing the causes of process problems in a systematic manner using applicable models, frameworks and tools.
- **Investigating or contributing to investigating broadly defined** risk assessments during plant operation and projects.

Project management

- Applicants are required **investigate or contribute to investigating broadly defined** problems in Integrated Project Controls, which includes cost control, estimating resources, capital and operating and/or lifecycle costs, planning and scheduling and project risk management.
- Applicants are required to **investigate or contributing to investigating broadly defined problems** in stakeholder management, which includes liaising with a wide variety of people on the job such as operators, maintenance and engineering staff, geologists, mining engineers and supporting specialists in process control, computing, technology provision and research.
- Applicants are required to **investigate or contribute to investigating broadly defined** in project resource management and planning.
- Applicants are required to **investigate or contribute to investigating broadly defined problems** in change management and project risk management.

Project development

- Applicants are required to **investigate or contribute to investigating broadly defined problems** during all the project development phases, including ideation, problem analysis, definition need, conceptual design and basic and detailed engineering. Research and feasibility studies are undertaken to identify, define and investigate broadly defined engineering problems that may arise at any stage of project development.

- Broadly defined engineering problems may be defined and investigated following sound financial business concepts, ranging from budgeting to feasibility studies.

Plant construction, commissioning and handover

Applicants are required to **investigate or contribute to investigating broadly defined problems** in the following phases.

- Plant construction: site establishment and site management, provide input during assembling of plant equipment in accordance with drawings and installation designs.
- Preparation: preparation of operating, start-up, shutdown and emergency procedures.
- Plant commissioning: measurement and analysis of actual performance data versus design parameters, responsibility for performance of the plant, optimisation of plant performance, review of all safety standards, operability of the plant and sound labour relations, practices and managerial aspects.
- Plant hand-over: including 'as-built' documentation, construction, planning and execution of punch-out items and hand-over.

Plant decommissioning

Applicants are required to **investigate or contribute to investigating broadly defined problems** during plant decommissioning, which involves the dissembling of equipment.

- Applicants are required to **investigate or contribute to investigating broadly defined problems in the plant** decommissioning strategy and safety procedures by understanding the chemical and physical characteristics of the equipment or plant.
- Applicants are required to **investigate or contribute to investigating broadly defined problems** in the procedures for plant decommissioning and consolidation for shutdown or closure.
- Applicants are required to **investigate or contribute to investigating broadly defined problems** in regulatory and statutory application and authorisation processes.

Product manufacturing

- Applicants are required to **investigate or contribute to investigating broadly defined problems** in properties of metals, ceramics, polymers and other materials, developing and assessing their commercial and engineering applications.
- Applicants are required to **investigate or contribute to investigating broadly defined problems** in the development, control and advice on processes used for casting, alloying, heat treating or welding of metals, alloys and other materials to produce commercial metal products or develop new alloys, materials and processes, and to evaluate and specify materials for engineering applications and do quality control and failure analyses.
- Applicants are required to **investigate or contribute to investigating broadly defined problems** relating to properties of metals and alloys, developing new alloys and advice on and supervising technical aspects of metal and alloy manufacture, processing, use and manufacturing.
- Applicants are required to **investigate or contribute to investigating broadly defined problems** in residual life evaluations, predictions and failure analyses, and prescribe remedial actions to avoid material failures.

Plant operation and maintenance

To address outcome 1, applicants in the plant operations practice area need to demonstrate the following:

- **Contribute** to the measurement and analysis of operational plant or equipment data to define, investigate broadly defined problems.
- **Contribute** to the undertaking of material and energy balances to define and investigate broadly defined problems.
- **Contribute** to the process plant operation, especially with direct and increasing responsibility for unit sections of the plant to define and investigate broadly defined problems.
- **Contribute** to the quality control in respect of measurement and specifications and define and investigate broadly defined problems where quality is not met,
- **Use** plant records and operating costs to define and investigate broadly defined problems.

- Define and investigate broadly defined problems that may result in inter-relationships between engineering personnel and management and among members of the engineering team, especially between production and maintenance members.

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

To meet outcome 2, applicants are required to design and develop solutions to broadly defined engineering problems using appropriate theory (See outcome 3) and information technologies while checking impacts, sustainability and stakeholder views. Some of the examples of addressing outcome 2 in different practice areas are as follows:

Research and development

To address outcome 2 the applicants in the research and development practice area will need to demonstrate the following:

- Contribute to developing solutions to the **broadly defined** problem/opportunity that was investigated by conducting a critical analysis of the literature and other relevant information and thereafter, assembling the documentation on the subject in an organised manner.
- Contribute to the development of a motivation, plan and design to the **broadly defined** research project and its associated equipment and/or pilot plant.
- Contribute to the development and design of the laboratory, pilot plant and/or industrial-plant scale experimental methodology and test/execution procedures.
- Contribute to the use of data and analysis to validate the develop solutions.
- Contribute to the use of studies regarding technical and economic feasibility to further select the best solution.

Plant optimisation, plant and equipment design

- Outcome 2 may be achieved through contributing to **designing or developing** solutions to **broadly defined** engineering problems that were identified through undertaking fault finding, root cause analysis, trouble shooting of equipment and process issues, data collection, etc

- Improvements in process optimisation may be achieved by contributing to **designing or developing** and implementing operating parameters of the system/equipment, or modification or installation of new system/equipment.
- Applicants can further address outcome 2 by:
  - **contributing** to designing mineral processing and extractive metallurgical plants various process systems, unit operations and process equipment.
  - **contributing to the implementation of solutions developed from** process design calculations results.

Risk management and impact mitigation

Applicants are required to contribute to the development and design of processes and systems to improve and ensure safety, health and environment are complied with in the laboratory, pilot plant or industrial plant.

Project development

- Applicants are required to **contribute to designing or developing solutions to broadly defined engineering problems** during all the project development phases including ideation, problem analysis, definition need, conceptual design and basic and detailed engineering. Research and feasibility studies are undertaken to identify, define and investigate broadly defined engineering problems that may arise at any stage of project development.
- Applicants are required to **contribute to designing or developing solutions to broadly defined engineering problems** following sound financial business concepts, ranging from budgeting to feasibility studies.

Plant construction, commissioning and handover

Applicants are required to **contribute to designing or developing solutions to broadly defined engineering problems** in the following phases:

- Plant construction: site establishment and site management, provide input during assembling of plant equipment in accordance with drawings and installation designs.
- Preparation: preparation of operating, start-up, shutdown and emergency procedures.

- Plant commissioning: measurement and analysis of actual performance data versus design parameters, responsibility for performance of the plant, optimisation of plant performance, review of all safety standards, operability of the plant and sound labour relations, practices and managerial aspects.
- Plant hand-over: including 'as-built' documentation, construction, planning and execution of punch-out items and hand-over.

Plant decommissioning

Applicants are required to **contribute to designing or developing solutions to broadly defined engineering problems** during plant decommissioning, which involves the dissembling of equipment.

- Applicants are required to **contribute to designing or developing solutions to broadly defined engineering problems** in the plant decommissioning strategy and safety procedures by understanding the chemical and physical characteristics of the equipment or plant.
- Applicants are required to **contribute to designing or developing solutions to broadly defined engineering problems** in the procedures for plant decommissioning and consolidation for shutdown or closure.
- Applicants are required to **contribute to designing or developing solutions to broadly defined engineering problems** in regulatory and statutory application and authorisation processes.

Product manufacturing

- Applicants are required to **contribute to designing or developing solutions to broadly defined engineering problems *in*** properties of metals, ceramics, polymers and other materials, developing and assessing their commercial and engineering applications.
- Applicants are required to **contribute to designing or developing solutions to broadly defined engineering problems** in the development, control and advice on processes used for casting, alloying, heat treating or welding of metals, alloys and other materials to produce commercial metal products or develop new alloys, materials and processes, and to evaluate and specify materials for engineering applications and do quality control and failure analyses.

- Applicants are required to **contribute to designing or developing solutions to broadly defined engineering problems** in properties of metals and alloys, developing new alloys and advice on and supervising technical aspects of metal and alloy manufacture, processing, use and manufacturing.
- Applicants are required to **contribute to designing or developing solutions to broadly defined engineering problems** in residual life evaluations, predictions and failure analyses and prescribing remedial actions to avoid material failures.

Project management

- Applicants are required to contribute to the development of integrated project controls, which includes cost control, estimating resources, capital and operating and/or lifecycle costs, planning and scheduling and project risk management.
- Applicants are required to contribute to stakeholder management, which involves liaising with a wide variety of people on the job such as operators, maintenance and engineering staff, geologists, mining engineers, and supporting specialists in process control, computing, technology provision and research.
- Applicants are required to contribute to developing project resource management and planning.
- Applicants are required to contribute to project change management and project risk management.

Plant operation and maintenance

To address outcome 2, applicants in the plant operations practice area need to demonstrate the following:

- **Contributing developing to solutions** using results from measurement and analysis of operational plant or equipment data.
- **Contributing to developing solutions** using results from material and energy balances.
- **Contributing to developing solutions** to **complex problems** on a process plant operation.
- **Contributing to developing solutions** to the **complex quality control problems** in respect of measurement and specifications.
- **Contributing to developing solutions to complex** operating costs problems.

- **Contributing to developing solutions to improve** inter-relationships between engineering personnel and management and among members of the engineering team, especially between production and maintenance members.

Plant construction, commissioning and decommissioning

- Applicants are required to contribute to plant commissioning by measuring and analysing actual performance data versus design parameters to improve the performance of the plant and optimise the plant performance.
- Applicants are required to contribute to the development of all safety standards, operability of the plant and sound labour relations, practices and managerial aspects.
- Applicants are required to contribute to the development of plant decommissioning processes that involve the dissembling of equipment.
- Applicants are required to contribute and undertake the design and analysis of the requirements of the new site for optimum performance.
- Applicants are required to contribute to the development of the decommissioning strategy and safety procedures with the understanding of the chemical and physical characteristics of the equipment or plant.
- Applicants are required to contribute to the development and compiling procedures for plant decommissioning and consolidation for shutdown or closure.
- Applicants are required to contribute to regulatory and statutory applications to obtain relevant authorisations.

4.2.3 Outcome 3: Comprehend and apply contextual knowledge (Responsibility level E)

Applicants have technical knowledge, which is knowledge applicable to the practice area, i.e., in hydrometallurgy, pyrometallurgy, physical metallurgy and minerals processing. This is supplemented by legal, regulatory and locally relevant knowledge.

To meet Outcome 3, applicants **need to comprehend and apply the knowledge embodied in widely accepted and applied engineering procedures, processes, systems and methodologies that are specific to the jurisdiction in which the broadly defined Engineering Technologist practises**.

Metallurgical Engineering Technologists are required to demonstrate knowledge by stating what engineering principles, practices, procedures, methodologies and technologies and demonstrate the application of the NQF 7 theory, engineering standards, codes of practice, legislation, regulations and finance in the practice area

4.2.4 Outcome 4: Manage one or more engineering activities (Responsibility level D)

To meet Outcome 4, applicants need to **manage part of all of one or more broadly defined engineering activities**.

Management of **broadly defined** engineering activities is directed at achieving results as a member or leader of a team by planning and harnessing people, resources, processes, systems, money and contracts or agreements. This may require the following:

- Managing self, people, work priorities, processes and resources when performing **broadly defined** engineering work.
- Management of laboratory or pilot plant project, test work programme, equipment, work priorities, processes, systems, resources.
- Management and giving support to production / operations teams.
- Management of contractors, commissioning and decommissioning activities.
- Planning, organising, leading and controlling **broadly defined** engineering activities.

4.2.5 Outcome 5: Professional communication (Responsibility level C)

To meet Outcome 5, applicants are required to **communicate clearly using multiple media and collaborate inclusively with a broad range of stakeholders in the course of broadly defined engineering activities**.

Professional communication may be achieved through compilation of the results into a written report and presentation of verbal reports. Applicants should participate in technology transfer to ensure that the maximum benefit is obtained from plant operations and the research and development efforts.

Communication with respect to **broadly defined** engineering problems relates to the technical aspects and the wider impacts of professional work. The audience includes superiors, peers, subordinates, implementing teams, other disciplines, clients and stakeholders. Appropriate modes of communication must be selected.

4.2.6 Outcome 6: Recognise and address social, cultural and environmental effects (Responsibility level B)

Metallurgical technologists need to play a role in shaping the world and, therefore, must be mindful of the social, cultural, and environmental impacts of their work. To meet Outcome 6, applicants need to **recognise the reasonably foreseeable economic, social, cultural and environmental effects of broadly defined engineering activities seeking to achieve sustainabili**ty.

The impacts of **broadly defined** engineering activities must be considered over the project life cycle, paying due regard to the immediate economic, social and cultural effects, including the protection of the environment and the need for sustainability.

Below are examples of how some of the effects may be identified/recognised. Measures would then need to be taken to address and mitigate any negative effects of engineering activities that may be identified:

- **Ethical and social responsibility** through stakeholder engagements, inclusive design and ethical training.
- **Cultural sensitivity** through cultural research before implementing projects and local collaboration within communities.
- **Environmental considerations** through lifecycle analysis and sustainable design principles and compliance with environmental regulations.
- **Long term and systematic thinking** through impact assessments, adaptive designs and acquire knowledge of global challenges.
- **Advocate for sustainable practices** through promoting green technologies and implementing sustainable practices.

4.2.7 Outcome 7: Statutory and regulatory requirements (Responsibility level E)

To meet Outcome 7, applicants need to **meet all legal, regulatory and cultural requirements and protect the health and safety of persons during all engineering activities**. Applicants should identify applicable legal, regulatory, health and safety requirements and standards and sustainable practices for the broadly defined engineering activities.

Applicants should be aware of the requirements for safety appointments in terms of the Occupational Health and Safety Act, 85 of 1993 for plant managers as well as including other standards as listed below:

- SANS Codes for Specification for Piping Design / Material (ANSI) (see www.sabs.co.za)
- SANS 10248, 1023: Waste Classification and Management Regulations from the Constitution of the Republic of South Africa, 1996
- Minerals and Energy Acts (e.g. Mineral and Petroleum Act, 28 of 2002)
- Mine Health and Safety Act, 29 of 1996 (see www.dmr.gov.za: Design of underground dam walls, plugs and barricades. Regulations on use of water for mining)
- Project and Construction Management Professions Act, 48 of 2000
- National Environmental Management Act, 107 of 1998 (various measures relating to pollution of a water resource; waterworks process controller)
- National Water Act, 54 of 1956 (Determination of persons permitted to design dams)
- National Environmental Management Waste Act, 59 of 2008
- Nuclear Energy Act, 46 of 1999
- National Water Act, 36 of 1998
- Occupational Health and Safety Act, 85 of 1993 (OHS Act) and Regulations: Driven Machinery Regulations; Pressurised Equipment Regulations
- ISO 9001: 2015
- SAMREC (South African Code for Reporting of Exploration Results, Mineral Resources and Mineral Reserves: e.g. 10320:2004)
- SAMVAL (South African Code for Reporting of Mineral Asset Evaluations) (see www.sans.co.za)
- Engineering Profession Act, 46 of 2000, including Rules and specifically the Code of Conduct
- National Building Regulations and Building Standards Act, 103 of 1977: Certification of fire protection systems.

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

Ethical behaviour involves the comprehension and application of professional ethics, responsibilities and norms of engineering practice within one's own limits of competence. To meet outcome 8, applicants are required to have knowledge of and comply with the ECSA Engineering Profession Act, 46 of 2000 and its Rules, specifically the Code of Conduct.

Applicants need to identify ethical problems and affected parties. **Additionally, they must identify and select the best solution to resolve the problem.**

4.2.9 Outcome 9: Exercising sound engineering judgement (Responsibility level E)

Metallurgical Engineering Technologists need to choose and apply appropriate technical expertise in their fields of practice. To meet outcome 9, applicants **need to exercise sound judgement by evaluating the outcomes, impacts and alternatives in the course of broadly defined engineering activities**.

Sound judgement is expected in considering interactions among technical, engineering, social or other issues and their **wide-ranging** impact on affected parties in making recommendations on the following:

- Developing options and final solutions or approaches, which consider impacts, interrelationships with other disciplines, time, cost and other constraints, **in the light of limited knowledge**.
- Taking a **wide-ranging view** of the solution while considering risks, their consequences and the implications for stakeholders and affected parties.

4.2.10 Outcome 10: Responsibility in decision-making (Responsibility level E)

Metallurgical Engineering Technologists have the contextual knowledge that allows them to take responsibility for making decisions on part or all of one or more **broadly defined engineering activities**.

This is demonstrated through:

- systematic gathering of related information and checking facts and inputs required for the decision-making process

- making the final decision, based on knowledge, past experience and seeking advice on matters falling outside the applicant's education and experience
- keeping a record of the decision-making process and the reasons for the final decision
- taking responsibility and being prepared to be held accountable for immediate consequences of own work and evaluating any shortcomings in the output.

4.2.11 Outcome 11: Professional development (Responsibility level D)

To meet Outcome 11, applicants need to 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 can be achieved through the attendance of relevant technical courses and conferences. Formal safety training is a mandatory requirement and applicants should register with the relevant voluntary associations to access lists of training courses, conferences, seminars and other relevant information (e.g., SAIMM, PMI, PMISA, CESA, SACPCMP).

The following is a list of sample training and courses:

- Problem solving and analysis tools (e.g., brainstorming, gap analysis, FMEA, Pareto Analysis, root cause analysis, problem tree analysis, trade-off tools)
- Risk assessment and analysis techniques
- Project management techniques and tools, including conditions of contract management, finance and economics, quality systems, stakeholder management and Project Management (planning, scheduling and project controls), tools and software (e.g. MS Project, Primavera, Project Risk Analysis tools, EVM and other SAP Tools)
- Modelling and simulation tools (e.g., for pumps, DMS) from OEM or own development as part of competency gained
- Occupation Health and Safety, including the OHS Act and 'safety in design'
- Formally registered CPD courses in Metallurgical Engineering and associated disciplines
- Value engineering and other VIPs
- Preparation of engineering design specifications
- Environmental aspects of projects and plant operations
- Waste management and treatment process

- Professional skills such as report writing, presentations, facilitation and negotiation
- Use of specific testing equipment and tools
- Plant operations performance monitoring tools
- Compilation of plant operation procedures
- Plant commissioning, decommissioning and handover
- Maintenance and reliability engineering.
- Specific equipment designs for metallurgy or mineral processing

4.3 Training for registration as a professional engineering technician

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

To meet Outcome 1, applicants are required to **define, investigate and analyse well-defined engineering problems**. Applicants should gain experience in at least one or more of the practice areas where they **collect and organise clarifying data from all applicable sources including in-situ investigations where appropriate.**

Investigation and problem analysis of **well-defined** engineering problems involve the following:

- Demonstrating the theoretical and practical knowledge to solve **well-defined** engineering problems utilising well-proven analytical techniques and tools. This includes the ability to use trouble-shooting skills.
- Identifying problems / hazards and analysing the causes of process problems in a systematic manner, using applicable models, frameworks and tools.
- Using troubleshooting methodologies, literature surveys, data analysis and root cause analysis tools to identify or analyse problems.
- Demonstrating involvement in investigating properties of metals, ceramics, polymers and other materials, developing and assessing their commercial and engineering applications.
- Preparing reports on metallurgical operations and projects.
- Undertaking fault finding, root cause analysis, trouble shooting, data collection, etc.

The well-defined engineering problem may be a design requirement, an applied research and development requirement or a problematic situation in an existing component, system or process. Some examples of addressing outcome 1 in different practice areas are as follows:

Research and development

To address outcome 1, applicants in the research and development practice area need to demonstrate the following:

- **Analysing, interpreting and evaluating clarifying information** to develop a clear understanding of the **well-defined** problem/opportunity that is to be investigated by conducting a critical analysis of the literature and other relevant information and thereafter, assembling the documentation on the subject in an organised manner.
- **Analysing, interpreting and evaluating clarifying information** to motivate, plan and design the **well-defined** research project and its associated equipment and/or pilot plant.
- **Investigating or contributing to well-defined** theoretical or paper investigations and laboratory-scale investigations.
- **Contributing to well-defined** investigations in a laboratory, pilot plant and/or on industrial-plant scale.
- **Contributing to** Interpretation of the results and ensuring that the results are meaningful and have been correctly obtained in accordance with **well-defined** scientific principles.
- **Contributing to** data processing and analysis.
- **Contributing to conducting** studies regarding technical and economic feasibility.
- **Contributing to compiling** the results into a high-quality written report and presentation involving verbal reporting

Plant optimisation, plant and equipment design

- Process optimisation involves **analysing, interpreting and evaluating clarifying information to either keep or revise initial instruction to the investigation of well-defined** problems resulting in the system or metallurgical process not operating as intended; this might achieved be through improving the system/equipment operating parameters by modifying or installing new equipment or systems.

- Outcome 1 may be achieved through **analysing, interpreting and evaluating clarifying information to either keep or revise initial instruction** to fault finding, root cause analysis, trouble shooting of equipment and process issues, data collection, etc
- Improvements in process optimisation may be achieved by investigating the operating parameters of the system/equipment, modification or installation of new system/equipment.
- Applicants can further address outcome 1 by:
  - **collecting and organising clarifying data** for a cost and economic analysis for minimising cost and maximising throughput and/or efficiency of the plant operation, process, system or equipment
  - **collecting and organising clarifying data** to design mineral processing and extractive metallurgical plants' various process systems, unit operations, and process equipment
  - **collecting and organising clarifying data** for process design calculations such as mass/material and water balances, process equipment design, sizing and process technology selection, and developing process diagrams such as process flow diagrams, piping and instrumentation diagrams and plant layout etc.
  - **collecting and organising clarifying data** for HAZOP studies
  - **collecting and organising clarifying data** for the preparation of process documentation such as process control philosophy and process technical reports
  - **collecting and organising clarifying data** for trade-off studies.

Risk management and impact mitigation

To address outcome 1, applicants in the risk management and impact mitigation practice area need to demonstrate the following:

- **Collecting and organising clarifying data from all applicable sources to investigate well-defined** analysis of samples taken from metallurgical process streams to ensure safe and economic operation and they advise operations personnel on process changes required to obtain desired products, processes and quality control.
- **Collecting and organising clarifying data from all applicable sources to investigate well-defined** problems or hazards and analysing the causes of process problems in a systematic manner using applicable models, frameworks and tools.

- **Collecting and organising clarifying data from all applicable sources to investigate well-defined** risk assessments during plant operation and projects.

Project management

- Applicants are required **collect and organise clarifying data from all applicable sources to investigate well-defined** problems in integrated project controls, which includes cost control, estimating resources, capital and operating and/or lifecycle costs, planning and scheduling and project risk management.
- Applicants are required to **collect and organise clarifying data from all applicable sources to investigate well-defined** problems in stakeholder management, which includes liaising with a wide variety of people on the job such as operators, maintenance and engineering staff, geologists, mining engineers, and supporting specialists in process control, computing, technology provision and research.
- Applicants are required to **collect and organise clarifying data from all applicable sources to investigate well-defined** problems in project resource management and planning.
- Applicants are required to **collect and organise clarifying data from all applicable sources to investigate well-defined** problems in change management and project risk management.

Project development

- Applicants are required to **collect and organise clarifying data from all applicable sources to investigate well-defined** problems during all project development phases, including ideation, problem analysis, definition need, conceptual design and basic and detailed engineering. Research and feasibility studies are undertaken to identify, define and investigate broadly defined engineering problems that may arise at any stage of project development.
- Well-defined engineering problems may be defined and investigated following sound financial business concepts, ranging from budgeting to feasibility studies.

Plant construction, commissioning and handover

Applicants are required to **collect and organise clarifying data from all applicable sources to investigate well-defined problems** in the following phases.

- Plant construction: site establishment and site management, provide input during assembling of plant equipment in accordance with drawings and installation designs.
- Preparation: preparation of operating, start-up, shutdown and emergency procedures.
- Plant commissioning: measurement and analysis of actual performance data versus design parameters, responsibility for performance of the plant, optimisation of plant performance, review of all safety standards, operability of the plant and sound labour relations, practices and managerial aspects.
- Plant hand-over: including 'as-built' documentation, construction, planning and execution of punch-out items and hand-over.

Plant decommissioning

Applicants are required to **collect and organise clarifying data from all applicable sources to investigate well-defined problems** during plant decommissioning, which involves the dissembling of equipment.

- Applicants are required to **collect and organise clarifying data from all applicable sources to investigate well-defined problems** in the plant decommissioning strategy and safety procedures by understanding the chemical and physical characteristics of the equipment or plant.
- Applicants are required to **collect and organise clarifying data from all applicable sources to investigate well-defined problems** in the procedures for plant decommissioning and consolidation for shutdown or closure.
- Applicants are required to **collect and organise clarifying data from all applicable sources to investigate well-defined problems** in regulatory and statutory application and authorisation processes.

Product manufacturing

- Applicants are required to **collect and organise clarifying data from all applicable sources to investigate well-defined problems** in properties of metals, ceramics, polymers and other materials, developing and assessing their commercial and engineering applications.
- Applicants are required to **collect and organise clarifying data from all applicable sources to investigate well-defined problems** in the development, control and advice on processes used for casting, alloying, heat treating or welding of metals, alloys and other materials to produce commercial metal products or develop new alloys, materials and processes, evaluate and specify materials for engineering applications and do quality control and failure analyses.
- Applicants are required to **collect and organise clarifying data from all applicable sources to investigate well-defined problems** in properties of metals and alloys, developing new alloys and giving advice on and supervising technical aspects of metal and alloy manufacture, processing, use and manufacturing.
- Applicants are required to **collect and organise clarifying data from all applicable sources to investigate well-defined problems** in residual life evaluations, predictions and failure analyses, and prescribe remedial actions to avoid material failures.

Plant operation and maintenance

To address outcome 1, applicants in the plant operations practice area need to demonstrate the following:

- **Collecting and organising clarifying data from all applicable sources to investigate** measurement and analysis of operational plant or equipment data to define and investigate well-defined problems.
- **Collecting and organising clarifying data from all applicable sources** for undertaking of material and energy balances to define and investigate well-defined problems.
- **Collecting and organising clarifying data from all applicable sources** during process plant operation, especially with direct and increasing responsibility for unit sections of the plant to define and investigate well-defined problems.

- **Collecting and organising clarifying data from all applicable sources** for quality control in respect of measurement and specifications to define and investigate well-defined problems where quality is not met.
- **Collecting and organising clarifying data from** plant records and operating costs to define and investigate well-defined problems.
- **Collecting and organising clarifying data from all applicable sources** to define and investigate well-defined problems that may result in inter-relationships between engineering personnel and management and among members of the engineering team, especially between production and maintenance members

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

To meet outcome 2, applicants participate and assist in the design or development of solutions to well-defined engineering problems using appropriate theory (See outcome 3) and information technologies while checking impacts, sustainability and stakeholder views; this may be executed at a desktop level, laboratory-, and/or pilot-, and/or industrial-scale. The solution goes through project development, plant construction and commissioning, and finally handover. Some examples addressing outcome 1 in different practice areas are as follows:

Research and development

To address outcome 2, applicants in the research and development practice area need to demonstrate the following:

- Contribute by **analysing, interpreting and evaluating clarifying information** for the development of solutions to the **well-defined** problem/opportunity that was investigated by conducting a critical analysis of the literature and other relevant information and thereafter, assembling the documentation on the subject in an organised manner.
- Contribute by **analysing, interpreting and evaluating clarifying information** for the development of a motivation, plan and design to the broadly defined research project and its associated equipment and/or pilot plant.

- Contribute by **analysing, interpreting and evaluating clarifying information** for the development and design of the laboratory, pilot plant and/or industrial-plant scale experimental methodology and test/execution procedures.
- Contribute by **analysing, interpreting and evaluating clarifying information** to validate the developed solutions.
- Contribute by **analysing, interpreting and evaluating clarifying information** on studies regarding technical and economic feasibility to further select the best solution.

Plant optimisation, plant and equipment design

- Outcome 2 may be achieved through analysing, interpreting, evaluating and clarifying information for solutions to **well-defined** engineering problems that were identified through undertaking fault finding, root cause analysis, trouble shooting of equipment and process issues, data collection, etc
- Improvements in process optimisation may be achieved by analysing, interpreting, evaluating and clarifying information for solutions required in implementing operating parameters of the system/equipment, modification or installation of new system/equipment.
- Applicants can further address outcome 2 by:
  - **analysing, interpreting and evaluating clarifying information** for designing mineral processing and extractive metallurgical plants various process systems, unit operations and process equipment
  - **analysing, interpreting and evaluating clarifying information for solutions developed from** process design calculations results.

Risk management and impact mitigation

Applicants are required to contribute to the development and design of processes and systems to improve and ensure safety, health and environment are complied with in the laboratory, pilot plant or industrial plant.

Project development

- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information to develop solutions to well-defined engineering problems** during all the project development phases, including ideation, problem analysis, definition need, conceptual design and basic and detailed engineering. Research and feasibility studies are undertaken to identify, define and investigate broadly defined engineering problems that may arise at any stage of project development.

- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information develop solutions to well-defined engineering problems** following sound financial business concepts, ranging from budgeting to feasibility studies.

Plant construction, commissioning and handover

Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information develop solutions to well-defined engineering problems** in the following phases:

- Plant construction: site establishment and site management, provide input during assembling of plant equipment in accordance with drawings and installation designs.
- Preparation: preparation of operating, start-up, shutdown and emergency procedures.
- Plant commissioning: measurement and analysis of actual performance data versus design parameters, responsibility for performance of the plant, optimisation of plant performance, review of all safety standards, operability of the plant and sound labour relations, practices and managerial aspects.
- Plant hand-over: including ‘as-built’ documentation, construction, planning and execution of punch-out items and hand-over.

Plant decommissioning

Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information develop solutions to well-defined engineering problems** during plant decommissioning, which involves the dissembling of equipment.

- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information develop solutions to well-defined engineering problems** in the plant decommissioning strategy and safety procedures by understanding the chemical and physical characteristics of the equipment or plant.

- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information develop solutions to well-defined engineering problems** in the procedures for plant decommissioning and consolidation for shutdown or closure.
- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information develop solutions to well-defined engineering problems** in regulatory and statutory application and authorisation processes.

Product manufacturing

- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information develop solutions to well-defined engineering problems** in properties of metals, ceramics, polymers and other materials, developing and assessing their commercial and engineering applications.
- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information develop solutions to well-defined engineering problems in the** development, control and advice on processes used for casting, alloying, heat treating or welding of metals, alloys and other materials to produce commercial metal products or develop new alloys, materials and processes, evaluate and specify materials for engineering applications and do quality control and failure analyses.
- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information develop solutions to well-defined engineering problems** in properties of metals and alloys, developing new alloys and advice on and supervising technical aspects of metal and alloy manufacture, processing, use and manufacturing.
- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information develop solutions to well-defined engineering problems** in residual life evaluations, predictions and failure analyses, and prescribing remedial actions to avoid material failures.

Project management

- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information** for the development of integrated project controls, which includes cost control, estimating resources, capital and operating and/or lifecycle costs, planning and scheduling and project risk management.

- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information** for stakeholder management, which includes liaising with a wide variety of people on the job such as operators, maintenance and engineering staff, geologists, mining engineers and supporting specialists in process control, computing, technology provision and research.
- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information** for developing project resource management and planning.
- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information** for project change management and project risk management.

Plant operation and maintenance

To address outcome 2, applicants in the plant operations practice area need to demonstrate the following:

- **Analysing, interpreting and evaluating clarifying information** for **developing solutions** using results from measurement and analysis of operational plant or equipment data.
- **Analysing, interpreting and evaluating clarifying information** for **developing solutions** using results from material and energy balances.
- **Analysing, interpreting and evaluating clarifying information** for **developing solutions to well-defined problems** on a process plant operation.
- **Analysing, interpreting and evaluating clarifying information** for **developing solutions** to well-defined quality control problems in respect of measurement and specifications.
- **Analysing, interpreting and evaluating clarifying information** for **developing solutions** to well-defined operating costs problems.
- **Analysing, interpreting and evaluating clarifying information** for **developing solutions to improve** inter-relationships between engineering personnel and management and among members of the engineering team, especially between production and maintenance members.

Plant operation and maintenance

To address outcome 2, applicants in the plant operations practice area need to demonstrate the following:

- **Analysing, interpreting and evaluating clarifying information** for **developing solutions** using results from measurement and analysis of operational plant or equipment data.
- **Analysing, interpreting and evaluating clarifying information** for **developing solutions** using results from material and energy balances.
- **Analysing, interpreting and evaluating clarifying information** for **developing solutions to well-defined problems** on a process plant operation.
- **Analysing, interpreting and evaluating clarifying information** for **developing solutions** to well-defined quality control problems in respect of measurement and specifications.
- **Analysing, interpreting and evaluating clarifying information** for **developing solutions** to well-defined operating costs problems.
- **Analysing, interpreting and evaluating clarifying information** for **developing solutions** to improve inter-relationships between engineering personnel and management and among members of the engineering team, especially between production and maintenance members

Plant construction, commissioning and decommissioning

- Applicants are required to contribute to plant commissioning by **analysing, interpreting and evaluating clarifying information** of actual performance data versus design parameters to improve the performance of the plant and optimise plant performance.
- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information** of all safety standards, operability of the plant and sound labour relations, practices and managerial aspects.
- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information** for developing plant decommissioning processes that involve the dissembling of equipment.

- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information** for undertaking the design and analysis of the requirements of the new site for optimum performance.
- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information** for developing the decommissioning strategy and safety procedures with the understanding of the chemical and physical characteristics of the equipment or plant.
- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information** for developing and compiling procedures for plant decommissioning and consolidation for shutdown or closure.
- Applicants are required to contribute by **analysing, interpreting and evaluating clarifying information** for regulatory and statutory applications to obtain relevant authorisations.

4.3.3 Outcome 3: Comprehend and apply contextual knowledge (Responsibility level E)

Applicants have technical knowledge, which is knowledge applicable to the practice area, i.e., in hydrometallurgy, pyrometallurgy, physical metallurgy and minerals processing. This is supplemented by legal, regulatory and locally relevant knowledge.

To meet outcome 3, applicants need to **comprehend and apply knowledge that is embodied in established engineering practices that are specific to the jurisdiction in which the well-defined Engineering Technician practices**.

Metallurgical Engineering Technicians are required to demonstrate knowledge by stating the established procedures, systems, methodologies and engineering standards and demonstrating the application of the NQF 6 theory, engineering standards, codes of practice, legislation, regulations and finance in the practice area

4.3.4 Outcome 4: Manage one or more engineering activities (Responsibility level D)

To meet outcome 4, applicants need to **manage part of all of one or more well-defined engineering activities**.

Management of **well-defined** engineering activities is directed at achieving results as a member or leader of a team by planning and harnessing people, resources, processes, systems, money and contracts or agreements. This may require the following:

- Managing self, people, work priorities, processes and resources when performing **well-defined** engineering work.
- Management of laboratory or pilot plant project, test work programme, equipment, work priorities, processes, systems, resources.
- Managing and giving support to production / operations teams.
- Managing contractors, commissioning and decommissioning activities
- Planning, organising, leading and controlling **well-defined** engineering activities.

4.3.5 Outcome 5: Professional communication (Responsibility level C)

To meet outcome 5, applicants are required to **communicate clearly using multiple media and collaborate inclusively with a broad range of stakeholders in the course of well-defined engineering activities**.

Professional communication may be achieved through compilation of the results into a written report and presentation of verbal reports. Metallurgical Technicians should participate in technology transfer to ensure that the maximum benefit is obtained from plant operations and the research and development efforts.

Communication with respect to **well-defined** engineering problems relates to the technical aspects and the wider impacts of professional work. The audience includes superiors, peers, subordinates, implementing teams, other disciplines, clients and stakeholders. Appropriate modes of communication must be selected

4.3.6 Outcome 6: Recognise and address social, cultural and environmental effects (Responsibility level B)

Metallurgical technicians need to play a role in shaping the world and therefore must be mindful of the social, cultural and environmental impacts of their work. To meet outcome 6, applicants need to **recognise the reasonably foreseeable economic, social, cultural and environmental effects of well-defined engineering activities seeking to achieve sustainabili**ty.

The impacts of **well-defined** engineering activities must be considered over the project life cycle, paying due regard to the immediate economic, social and cultural effects, including the protection of the environment and the need for sustainability.

Below are examples of how some of the effects may be identified/recognised. Measures would then need to be taken to address and mitigate any negative effects of engineering activities that may be identified:

- **Ethical and social responsibility** through stakeholder engagements, inclusive design and ethical training.
- **Cultural sensitivity** through cultural research before implementing projects and local collaboration within communities.
- **Environmental considerations** through lifecycle analysis and sustainable design principles and compliance with environmental regulations.
- **Long-term and systematic thinking** through impact assessments, adaptive designs and acquired knowledge of global challenges.
- **Advocate for sustainable practices** through promoting green technologies and implementing sustainable practices.

4.3.7 Outcome 7: Statutory and regulatory requirements (Responsibility level E)

To meet outcome 7, applicants, need to **meet all legal, regulatory and cultural requirements and protect the health and safety of persons during all engineering activities**. Applicants should identify applicable legal, regulatory, health and safety requirements and standards and sustainable practices for the **well-defined** engineering activities.

Applicants should be aware of the requirements for safety appointments in terms of the Occupational Health and Safety Act, 85 of 1993 for plant managers as well as including other standards as listed below:

- SANS Codes for Specification for Piping Design / Material (ANSI) (see www.sabs.co.za)
- SANS 10248, 1023: Waste Classification and Management Regulations from the Constitution of the Republic of South Africa, 1996
- Minerals and Energy Acts (e.g., Mineral and Petroleum Act, 28 of 2002)
- Mine Health and Safety Act, 29 of 1996 (see www.dmr.gov.za: Design of underground dam walls, plugs and barricades. Regulations on use of water for mining)
- Project and Construction Management Professions Act, 48 of 2000

- National Environmental Management Act, 107 of 1998 (various measures relating to pollution of a water resource; waterworks process controller)
- National Water Act, 54 of 1956 (Determination of persons permitted to design dams)
- National Environmental Management Waste Act, 59 of 2008
- Nuclear Energy Act, 46 of 1999
- National Water Act, 36 of 1998
- Occupational Health and Safety Act, 85 of 1993 (OHS Act) and Regulations: Driven Machinery Regulations; Pressurised Equipment Regulations
- ISO 9001: 2015
- SAMREC (South African Code for Reporting of Exploration Results, Mineral Resources and Mineral Reserves: e.g., 10320:2004)
- SAMVAL (South African Code for Reporting of Mineral Asset Evaluations) (see www.sans.co.za)
- Engineering Profession Act, 46 of 2000, including Rules and specifically the Code of Conduct
- National Building Regulations and Building Standards Act, 103 of 1977: Certification of fire protection systems.

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

Ethical behaviour involves the comprehension and application of professional ethics, responsibilities and norms of engineering practice within one's own limits of competence. To meet outcome 8, applicants are required to have knowledge of and comply with the ECSA Engineering Profession Act, 46 of 2000 and its Rules, specifically the Code of Conduct.

Applicants need to identify ethical problems and affected parties. **Additionally, applicants need to identify and select the best solution to resolve the problem.**

4.3.9 Outcome 9: Exercising sound engineering judgement (Responsibility level E)

Metallurgical Engineering Technicians need to choose and apply appropriate technical expertise in their fields of practice. To meet outcome 9, applicants **need to exercise sound judgement by evaluating the outcomes, impacts and alternatives in the course of well-defined engineering activities**.

Sound judgement is expected in considering interactions among methods, techniques and procedures and their **immediate** impact on affected parties in making recommendations in the following:

- Developing options and final solutions or approaches that consider impacts, interrelationships with other disciplines, time, cost and other constraints.
- Taking a view of the solution while considering risks, their consequences and the implications for stakeholders and affected parties.

4.3.10 Outcome 10: Responsibility in decision-making (Responsibility level E)

Metallurgical Engineering Technicians have the contextual knowledge that allows them to **take responsibility for making decisions on part or all of one or more well-defined engineering activities**.

This is demonstrated through:

- systematic gathering of related information and checking of facts and inputs required for the decision-making process
- making the final decision, based on knowledge, past experience and seeking advice on matters falling outside the applicant's education and experience
- keeping a record of the decision-making process and the reasons for the final decision
- taking responsibility and being prepared to be held accountable for immediate consequences of own work and evaluating any shortcomings in the output.

4.3.11 Outcome 11: Professional development (Responsibility level D)

To meet outcome 11, applicants need to 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 can be achieved through by attending relevant technical courses and conferences. Formal safety training is a mandatory requirement, and applicants should register with the relevant voluntary associations to access lists of training courses, conferences, seminars and other relevant information (e.g., SAIMM, PMI, CESA, SACPCMP).

The following is a list of sample training / courses:

- Problem solving and analysis tools (e.g. brainstorming, gap analysis, FMEA, Pareto Analysis, root cause analysis, problem tree analysis, trade off tools)
- Risk assessment and analysis techniques
- Project management techniques and tools, including conditions of contract management, finance and economics, quality systems, stakeholder management and Project Management (planning, scheduling and project controls), tools and software (e.g. MS Project, Primavera, Project Risk Analysis tools, EVM and other SAP Tools)
- Modelling and simulation tools (e.g., for pumps, DMS) from OEM or own development as part of competency gained
- Occupation Health and Safety, including the OHS Act and 'safety in design'
- Formally registered CPD courses in Metallurgical Engineering and associated disciplines
- Value Engineering
- Preparation of engineering design specifications
- Environmental aspects of projects and plant operations
- Waste management and treatment process
- Professional skills such as report writing, presentations, facilitation and negotiation
- Use of specific testing equipment / tools
- Plant operations performance monitoring tools
- Compilation of plant operation procedures
- Plant commissioning, decommissioning and handover
- Maintenance and reliability engineering
- Specific equipment designs for metallurgy or mineral processing.

5. FUNCTIONS PERFORMED

5.1 Degrees of responsibility

It is useful to measure the progression of a candidate's competency using the scales regarding Degree of Responsibility, Problem Solving and Engineering Activity as specified in the relevant documentation.

Table 1 contains the Degree of Responsibility Scale. Activities should be selected to ensure that candidates reach the required level of competency and responsibility.

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

The nature of work and the degrees of responsibility defined in document **R-04-P** are presented here in Table 1.

Table 1: Degrees of Responsibility Scale

A: Being Exposed	B: Assisting	C: Participating	D: Contributing	E: Performing
Undergoes induction; observes processes and work of competent practitioners	Performs specific processes under close supervision	Performs specific processes as directed with limited supervision	Performs specific work with detailed approval of work outputs	Works in team without supervision; recommends work outputs; responsible but not accountable
Responsible to supervisor	Limited responsibility for work output	Full responsibility for supervised work	Full responsibility to supervisor for immediate quality of work	Level of responsibility to supervisor is equivalent to that of a registered person; supervisor is accountable for applicant's decisions

5.2 Candidate training programmes

It is necessary to align the DSTG assumptions with the candidate programme, including completion of TES, TER and all other relevant application forms when changing programmes.

6. CONCLUSION

To attain registration in a professional category, applicants should be able to meet the educational requirements for the category and demonstrate competency against the prescribed standards for the registration category. Demonstrating competency is achieved by meeting the requirements for the 11 ECSA outcomes. Applicants and their supervisors and mentors must ensure that the training provided is geared towards achieving the ECSA competency outcomes. Focusing on one training aspect for the entire duration of training will not assist applicants to achieve the necessary skills to demonstrate all the standard competency outcomes.

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

REVISION HISTORY

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

Revision number	Revision date	Revision details	Approved by
		The content under this section is aligned with Outcome 5 *4.1.6 Impact of Engineering Activities & Risk Mitigation* The content under this section is aligned with Outcome 6 *4.1.7 Statutory & Regulatory Requirements* The content under this section is aligned with Outcome 7 *4.1.8 Ethics of Engineering* The content under this section is aligned with Outcome 8 *4.1.9 Exercising sound judgment* The content under this section is aligned with Outcome 9 *4.1.10 Responsibility in Decision-making* The content under this section is aligned with Outcome 10 *4.1.11 Professional Development* The content under this section is aligned with Outcome 11	
Rev 0 Draft C	16 Jan 2025	Document revised with WG and sent to Registration BU for inputs and comments	RI BU, Registration BU and WG
Rev 0 Draft D	29 Jan 2025	Document submitted to the IEA Task Team for alignment to the IEA changes	IEA Review Task Team
Rev 0 Draft E	31 Jan 2025	Reviewed and checked	Executive: RPSC
Rev 0	12 Feb 2025	Approval	RPSC

The Discipline-specific Training Guide for

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

Revision 0 dated 12 February 2025 and consisting of 87 pages reviewed for adequacy by the Business Unit Manager and is approved by the Executive: Regulatory Services & International Relations **(ERSIR)**.

.... 22 April 2025 ....

Business Unit Manager Date

.... 2025/04/22 ....

Executive: RSIR Date

This definitive version of this policy is available on our website

APPENDIX A: TRAINING ELEMENTS

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

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

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

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

Competency Standards for Registration as a Professional Engineering Technologist	Explanation and Responsibility Level
1. Purpose This standard defines the competence required for registration as a **Professional Engineer, Technologist and Technician**. Definitions of terms having particular meaning within this standard is given in text in relevant section.	DSTGs give context to the purpose of the Competency Standards. The **Engineer, Technologist and Technician** operate within the 12 disciplines ECSA recognises. Each discipline can be further divided into sub-disciplines and finally into specific workplaces as given in section 4 of the specific DSTG. <u>DSTGs are used to facilitate experiential development towards ECSA registration and assist in compiling the required portfolio of evidence (specifically the Engineering Report in the application form)</u>. **NOTE:** The training period must be used to develop the trainee's competence towards achieving the standards below at a Responsibility Level E, i.e., Performing. (Refer to the specific DSTG)
2. Demonstration of competence Competence must be demonstrated within *complex, broadly defined and well-defined engineering activities,* defined below, by integrated performance of the outcomes defined at the level defined for each outcome. Required contexts and functions may be specified in the applicable DSTG.	Engineering activities can be divided into (approximately): 5% Complex (Professional Engineers) 5% Broadly defined (Professional Engineering Technologists) 10% Well-defined (Professional Engineering Technicians) 15% Narrowly well-defined (Registered Specified Categories) 20% Skilled Worker (Engineering Artisan) 55% Unskilled Worker (Artisan Assistants) Activities can be in-house or contracted out; evidence of integrated performance can be submitted irrespective of the situation.
Level Descriptor: Complex engineering activities (**CEA**), broadly defined engineering activities (**BDEA**), and well-defined engineering activities (**WDEA**) have several of the following characteristics: a) Scope of practice area is linked to technologies used and changes by adoption of new technology into current practice.	**Level Descriptor: CEA, *BDEA and WDEA*** in the various disciplines are characterised by several or all of the following: a) Scope of practice area does not cover the entire field of the discipline (exposure limited to the sub-discipline and specific workplace). Some technologies used are well established and adoption of new technologies needs investigation and evaluation.

b) Practice area is located within a wider, complex context, requires teamwork, and has interfaces with other parties and disciplines. c) Involves a variety of resources, including people, money, equipment, materials and technologies. d) Requires resolution of occasional problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues. e) Are constrained by available technology, time, finance, infrastructure, resources, facilities, standards and codes and applicable laws. f) Have significant risks and consequences in the practice area and in related areas.	b) Practice area varies substantially with unlimited location possibilities and an additional responsibility to identify the need for advice on **CEA, *BDEA and WDEA*** activities and problems. **CEA, *BDEA and WDEA*** activities in the sub-discipline needs interfacing with professional engineers, professional technicians, artisans, architects, financial staff, etc. as part of the team. c) The bulk of the work involves familiar, defined range of resources, including people, money, equipment, materials, but new technologies are investigated and implemented. d) Most of the impacts in the sub discipline are on wider issues, but some arise from conflicting technical and engineering issues that have to be addressed by the application of broadly defined non-standard engineering principles. e) The work packages and associated parameters are constrained by operational context with variations limited to different locations only. (Cannot be covered by standards and codes.) f) Even locally important minor risks can have far reaching consequences.
Activities include but are not limited to design; planning; investigation and problem resolution; improvement of materials, components, systems or processes; manufacture or construction; engineering operations; maintenance; project management; research; development and commercialisation.	**Activities** include but are not limited to design; planning; investigation and problem resolution; improvement of materials, components, systems or processes; engineering operations; maintenance; project management. For **Engineers, Technologists and Technicians**, research, development and commercialisation happen more frequently in some disciplines but are seldom encountered in others.
3. Outcomes to be satisfied:	**Explanation and Responsibility Level**
Group A: Engineering Problem Solving	
Outcome 1: Define, investigate and analyse *complex, broadly defined and Well-defined,* engineering problems	**Responsibility Level E** Analysis of an engineering problem means the 'separation into parts possibly with comment and judgement'. *complex, broadly, well-defined* means: 'not minute or detailed' and 'not kept within narrow limits'.

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

	j) **The Engineer, Technologist and Technician** must realise that their actions might seem to be of local importance only but may develop into significant consequences extending beyond their own ability and practice area.
Assessment criteria: A structured analysis of broadly defined problems typified by the following performances is expected: 1.1 Performed or contributed to defining engineering problems leading to an agreed definition of the problems to be solved. 1.2 Performed or contributed to investigating engineering problems including collecting, organising and evaluating information. 1.3 Performed or contributed to analysis of engineering problems using conceptualisation, justified assumptions, limitations and evaluation of results.	To perform an engineering task an **Engineer, Technologist and Technician** will typically receive an instruction from a senior person (customer) to do a specific task, and must: 1.1 Ensure the instruction is complete, clear and within his/her capability and that the person who issued the instruction agrees with his/her interpretation. 1.2 Ensure the engineering problem and related information are segregated from the bulk of the information, investigated and evaluated. 1.3 Ensure that the instruction and information to do the work is fully understood and complete, including engineering theory needed to understand the task and acceptance criteria, and to carry out and/or check calculations. If needed supplementary information must be gathered, studied and understood. Concepts and assumptions must be justified by engineering theory and calculations, if applicable.
3. Outcomes to be satisfied:	**Explanation and Responsibility Level**
Range statement: The problem may be a design requirement, an applied research and development requirement or a problematic situation in an existing component, system or process. The problem is one amenable to solution by technologies known to the Candidate. This outcome is concerned with the understanding of a problem: Outcome 2 is concerned with the solution.	Please refer to section 4 of the specific DSTG.
Outcome 2: Design or develop solutions to **complex, broadly defined and well-defined** engineering problems	**Responsibility Levels C and D** Design means ‘drawing or outline from which something can be made’. Develop means ‘come or bring into a state in which it is active or visible’.

Assessment criteria: This outcome is normally demonstrated after a problem analysis as defined in Outcome 1. Working systematically to synthesise a solution to a broadly defined problem, typified by the following performances is expected: 2.1 Designed or developed solutions to **complex, broadly defined and well-defined** engineering problems. 2.2 Systematically synthesised solutions and alternative solutions or approaches to the problem by analysing designs against requirements, including costs and impacts on outside parameters. (requirements). 2.3 Drawing up of detailed specification requirements and design documentation for implementation to the satisfaction of the client.	After the task received is fully understood and interpreted, a solution to the problem posed can be developed (designed). To synthesise a solution is 'the combination of separate parts, elements, substances, etc. into a whole or into a system' by the following: 2.1 The development (design) of more than one way to solve an engineering task or problem should always be done, including the costing and impact assessment for each alternative. All the alternatives must meet the requirements set out by the instruction received, and the theoretical calculations to support each alternative must be done and submitted as an attachment. 2.2 The **Engineer, Technologist and Technician** will in some cases be unable to support proposals with the complete theoretical calculation to substantiate every aspect and must in these cases refer his / her alternatives to an engineer for scrutiny and support. The alternatives and alternative recommended must be convincingly detailed to win customer support for the alternative recommended. Selection of alternatives might be based on tenders submitted with alternatives deviating from those specified. 2.3 The best complete and final solution selected must be followed up with a detailed technical specification, supporting drawings, bill of quantities, etc. for the execution of work to meet customer requirements.
Range Statement: Solutions are those enabled by the technologies in the Candidate's practice area.	Applying theory to do ***complex, broadly defined and well-defined*** *engineering* work is mostly done in a way that has been used before, probably developed by engineers in the past, and documented in written procedures, specifications, drawings, models, examples, etc. **The Engineer, Technologist and Technician** must seek approval for any deviation from these established methods but must also initiate and/or participate in the development and revision of these norms.
Outcome 3: Comprehend and apply the knowledge embodied in widely accepted and applied engineering procedures, processes, systems or methodologies and those specific to the jurisdiction in which he/she practices.	**Responsibility Level E** Comprehend means 'to understand fully'. The jurisdiction in which an **Engineer, Technologist and Technician** practices is given in section 4 of the specific DSTG.

Assessment criteria: This outcome is normally demonstrated in the course of design, investigation or operations. 3.1 Apply engineering principles, practices, technologies, including the application of, B Eng, BTech or B Eng (Tech) and N Dip, theory in the practice area. 3.2 Indicate working knowledge of areas of practice that interact with practice area to underpin teamwork. 3.3 Apply related knowledge of finance, statutory, safety and management.	Design work for **Engineer, Technologist and Technician** is based on B Eng, BTech, N Dip, theory and is mostly the utilisation and configuration of manufactured components and selected materials and associated novel engineering. **Engineers, Technologists and Technicians** develop and apply codes and procedures in their design work. Investigation would be on broadly defined incidents and condition monitoring, and operations mostly on developing and improving engineering systems and operations. 3.1 Calculations at B Eng, BTech or B Eng (Tech) and/or NDip, theoretical level confirming the correct application and utilisation of equipment, materials and systems listed in section 4 of the specific DSTG must be done on broadly defined activities. 3.2 The understanding of **complex, broadly defined, well defined,** procedures and techniques must be based on fundamental mathematical, scientific and engineering knowledge, as part of personal contribution within the engineering team. 3.3 The ability to manage the resources within legal and financial constraints must be evident.
Range Statement: Applicable knowledge includes: a) Technological knowledge that is well-established and applicable to the practice area irrespective of location, supplemented by locally relevant knowledge, for example, established properties of local materials. Emerging technologies are adopted from formulations of others. b) A working knowledge of interacting disciplines (engineering and other) to underpin teamwork. c) Jurisdictional knowledge includes legal and regulatory requirements as well as locally relevant codes of practice. As required for practice area, a selection of law of contract, health and safety, environmental, intellectual property, contract administration, quality management, risk management,	a) The specific location of a task to be executed is the most important determining factor in the layout design and utilisation of equipment. A combination of educational knowledge and practical experience must be used to substantiate decisions taken including a comprehensive study of systems, materials, components and projected customer requirements and expectations. New ideas, materials, components and systems must be investigated, evaluated and applied accompanied by complex theoretical motivation. b) In spite of having a working knowledge of interacting disciplines, **Engineer, Technologist and Technician** take responsibility for the multidisciplinary team of specialists like Civil Engineers on structures and roads, Mechanical Engineers on fire protection equipment, architects on buildings, Electrical Engineers on communication equipment, etc. c) Jurisdictional in this instance means 'having the authority', and **Engineer, Technologist and Technician** must be aware of and decide on the relevant requirements applicable to each specific project that he/she is responsible for. They are usually appointed as the 'responsible person' for specific projects in terms of the OHS Act.

maintenance management, regulation, project and construction management.	
Group B: Managing Engineering Activities	**Explanation and Responsibility Level**
Outcome 4: Manage part or all of one or more ***complex, broadly defined and well-defined*** engineering activities.	**Responsibility Level D** Manage means 'control'.
Assessment criteria: The Candidate is expected to display personal and work process management abilities: 4.1 Managed self, people, work priorities, processes and resources in broadly defined engineering work. 4.2 Role in planning, organising, leading and controlling broadly defined engineering activities evident. 4.3 Knowledge of conditions and operation of contractors and the ability.	In Engineering operations **Engineer, Technologist and Technician** are typically given the responsibility to carry out projects. 4.1 Resources are usually subdivided based on availability and controlled by a work breakdown structure and scheduling to meet deadlines. Quality, safety and environment management are important aspects. 4.2 The basic elements of managements must be applied to broadly defined engineering work. 4.3 Depending on the project, **Engineer, Technologist and Technician** can be the team leader, a team member, or can supervise appointed contractors. To achieve this, maintenance of relationships is important and must be demonstrated.
Outcome 5: Communicate clearly with others in the course of his/her broadly defined engineering activities.	**Responsibility Level C**
Assessment criteria: Demonstrates effective communication by: 5.1 Ability to write clear, concise, effective technical, legal and editorially correct reports shown. 5.2 Ability to issue clear instructions to stakeholders using appropriate language and communication skills evident. 5.3 Oral presentations made using structure, style, language, visual aids	Refer to Range Statement for Outcome 4 and 5 below. Presentation of point of view mostly occurs in meetings and discussions with immediate supervisor.

Range Statement for Outcomes 4 and 5: Management and communication in ***Complex, Broadly defined and Well-defined*** *engineering* involves: a) Planning ***complex, broadly defined and well-defined*** activities b) Organising ***complex, broadly defined and well-defined*** activities c) Leading ***complex, broadly defined and well-defined*** activities d) Controlling ***complex, broadly defined and well-defined*** activities.	a) Planning means 'the arrangement for doing or using something, considered in advance' b) Organising means 'put into working order, arrange in a system, make preparations for' c) Leading means to 'guide the actions and opinions of, influence, persuade' d) Controlling means the 'means of regulating, restraining, keeping in order, check' **The Engineer, Technologist and Technician** write specifications for the purchase of materials and/or work to be done, recommendations on tenders received, place orders and variation orders, write work instructions, report on work done, draw, correct and revise drawings, compile test reports, use operation and maintenance manuals to write work procedures, write inspection and audit reports, write commissioning reports, prepare and present motivations for new projects, compile budget reports, report on studies done and calculations carried out, report on customer requirements, report on safety incidents and risk analysis, report on equipment failure, report on proposed system improvement and new techniques, report on cost control, etc.
Group C: Impacts of Engineering Activity	**Explanation and Responsibility Level**
Outcome 6: Recognise the foreseeable social, cultural and environmental effects of ***complex, broadly defined and well-defined*** engineering activities generally	**Responsibility level B** Social means 'people living in communities; of relations between persons and communities'. Cultural means 'all the arts, beliefs, social institutions, etc. characteristic of a community'. Environmental means 'surroundings, circumstances, influences'.
Assessment criteria: This outcome is normally displayed in the course of analysis and solution of problems. The candidate typically shows:	

6.1 Ability to identify interested and affected parties and their expectations regarding interactions between technical, social, cultural and environmental considerations shown. 6.2 Measures taken to mitigate the negative effects of engineering activities evident.	6.1 Engineering impacts heavily on the environment, e.g., servitudes, expropriation of land, excavation of trenches with associated inconvenience, borrow pits, dust and obstruction, street and other crossings, power dips and interruptions, visual and noise pollution, malfunctions, oil and other leaks, electrocution of human beings, detrimental effect on animals and wildlife, dangerous rotating and other machines, demolishing of structures, etc. 6.2 Mitigating measures taken may include environmental impact studies, environmental impact management, community involvement and communication, barricading and warning signs, temporary crossings, alternative supplies (ring feeders and bypass roads), press releases, compensation paid, etc.
Outcome 7: Meet all legal and regulatory requirements and protect the health and safety of persons in the course of his/her broadly defined engineering activities.	**Responsibility level E**
Assessment criteria: 7.1 Identified applicable legal and regulatory requirements including health and safety requirements for the engineering activity. 7.2 Circumstances stated where applicant assisted in or demonstrated awareness of the selection of safe and sustainable materials, components and systems and have identified risk and applied risk management strategies.	7.1 The OHS Act is supplemented by a variety of parliamentary acts, regulations, local authority by-laws, standards and codes of practice. Places of work might have standard procedures, instructions, drawings and operation and maintenance manuals available. These documents, depending on the situation (emergency, breakdown, etc.) are consulted before work is commenced and during the activity. 7.2 It is essential to attend a Risk Management (Assessment) course, and to investigate and study the materials, components and systems used in the workplace. The **Engineer, Technologist and Technician** seeks advice from knowledgeable and experienced specialists if the slightest doubt exist that safety and sustainability cannot be guaranteed.
Range Statement for Outcomes 6 and 7: Impacts and regulatory requirements include the following: a) Requirements include both explicit regulated factors and those that arise in the course of particular work. b) Impacts considered extend over the lifecycle of the project and include the consequences of the technologies applied.	a) The impacts will vary substantially with the location of the task, e.g., the impact of laying a cable or pipe in the main street of town will be entirely different to construction in a rural area. The methods, techniques or procedures will differ accordingly and may be complex. It is identified and studied by the **Engineer, Technologist and Technician** before starting the work. b) The Safety Officer and/or the Responsible Person appointed in accordance with the OHS Act usually confirms or checks that the instructions are in line with regulations. The **Engineer, Technologist and**

	Technician is responsible to see that this is done, and if not, establish which regulations apply, and ensure that they are adhered to. Usually, the people working on site are strictly controlled.W.r.t. health and safety, but the **Engineer, Technologist and Technician** checks that this is done, but may authorise unavoidable deviation after setting conditions for such deviations. Projects are mostly carried out where contact with the public cannot be avoided, and safety measures like barricading and warning signs must be used and maintained.
c) Effects to be considered include direct and indirect, immediate and long-term related to the technology used.	c) Effects associated with risk management are mostly well known if not obvious, and methods used to address, clearly defined. Risks are mostly associated with elevated structures, subsidence of soil, electrocution of human beings and moving parts on machinery. The **Engineer, Technologist and Technician** needs to identify, analyse and manage any long-term risks and develop strategies to solve these by using alternative technologies.
d) Safe and sustainable materials, components and systems.	d) The safe and sustainable materials, components and systems must be selected and prescribed by the **Engineer, Technologist and Technician** or other professional specialists must be consulted. It is the responsibility of the **Engineer, Technologist and Technician** to use his/her knowledge and experience to confirm that prescriptions by others are correct and safe.
e) Regulatory requirements are explicit for the context in general.	e) Application of regulations associated with the particular aspects of the project must be carefully identified and controlled by the **Engineer, Technologist and Technician**.
Group D: Exercise judgment, take responsibility, and act ethically	**Explanation and Responsibility Level**
Outcome 8: Conduct engineering activities ethically.	**Responsibility level E** Ethically means ‘science of morals; moral soundness’. Moral means ‘moral habits; standards of behaviour; principles of right and wrong’.
Assessment Criteria: Sensitivity to ethical issues and the adoption of a systematic approach to resolving these issues is expected, typified by:	Systematic means ‘methodical; based on a system’.

8.1 Conversance and operation in compliance with ECSA's Rules of Conduct for registered persons confirmed 8.2 How ethical problems and affected parties were identified, and the best solution to resolve the problem selected.	8.1 ECSA's Code of Conduct, as per ECSA's website, is known and adhered to. 8.2 Ethical problems that can occur include tender fraud, payment bribery, alcohol abuse, sexual harassment, absenteeism, favouritism, defamation, fraudulent overtime claims, fraudulent expenses claimed, fraudulent qualifications, misrepresentation of facts, etc.
Outcome 9: Exercise sound judgement in the course of ***complex, broadly defined and well-defined*** engineering activities	**Responsibility level E** Judgement means 'good sense: ability to judge'.
Assessment criteria: Judgement is displayed by the following performance: 9.1 Judgement exercised in arriving at a conclusion within the application of technologies and their interrelationship to other disciplines and technologies. 9.2 Factors taken into consideration given, bearing in mind, risk, consequences in technology application and affected parties.	9.1 The extent of a project given to a junior **Engineer, Technologist and Technician** is characterised by the several broadly defined and a few well-defined factors and their resulting interdependence. He/she will seek advice if educational and/or experiential limitations are exceeded. 9.2 Taking risky decisions will lead to equipment failure, excessive installation and maintenance cost, damage to persons and property, etc. Evaluation includes engineering calculations to substantiate decisions taken and assumptions made.
Range Statement for Outcomes 8 and 9*:* *Judgement* in decision-making involves: a) taking several risk factors into account; **or** b) significant consequences in technology application and related contexts; **or** c) ranges of interested and affected parties with widely varying needs.	In Engineering, about 5% of engineering activities can be classified as broadly defined where the **Engineer, Technologist and Technician** uses standard procedures, codes of practice, specifications, etc, but develops variations and completely unique standards when needed. Judgement must be displayed to identify any activity falling inside the broadly defined range, as defined above: a) Getting the work done in spite of numerous risk factors needs good judgement and substantiated decision-making. b) Consequences are part of the project e.g., extra cost due to unforeseen conditions, incompetent contractors, long-term environmental damage, etc. c) Interested and affected parties with defined needs that may be in conflict, e.g., need for a service irrespective of environmental damage, local traditions and preferences, etc. needs sound management and judgement.

Outcome 10: Be responsible for making decisions on part or all of all of one or more ***complex, broadly defined and well-defined*** engineering activities	**Responsibility level E** Responsible means 'legally or morally liable for carrying out a duty; for the care of something or somebody in a position where one may be blamed for loss, failure, etc.'.
Assessment criteria: Responsibility is displayed by the following performance: 10.1 Engineering, social, environment and sustainable development taken into consideration in discharging responsibilities for significant parts of one or more activities. 10.2 Advice sought from a responsible authority on matters outside your area of competence. 10.3 Academic knowledge of at least B Eng, BTech N Dip, level combined with past experience used in formulating decisions.	10.1 All interrelated factors taken considered are indicative of professional responsibility accepted working on broadly defined activities. 10.2 The **Engineer, Technologist and Technician** does not operate on tasks at a higher level than, complex, broadly defined, well defined and consults professionals at engineer level if elements of the project to be done are beyond his/her education and experience, e.g., power system stability. 10.3 This is in the first instance continuous self-evaluation to ascertain that the task given is done correctly, on time and within budget. Continuous feedback to the originator of the task instruction and corrective action, if necessary, forms an important element. The calculations, for example fault levels, load calculations, losses, etc. are done to ensure that the correct material and components are utilised.
Range Statement: Responsibility must be discharged for significant parts of one or more ***complex, broadly defined and well-defined*** engineering activity.	The responsibility is mostly allocated within a team environment with an increasing designation as experience is gathered.
Note 1: Demonstrating responsibility is under supervision of a competent engineering practitioner but is expected to perform as if he/she is in a responsible position.	
Group E: Initial Professional Development (IPD)	**Explanation and Responsibility Level**
Outcome 11: Undertake independent learning activities sufficient to maintain and extend his or her competence.	**Responsibility level D**

Assessment criteria: Self-development managed typically: 11.1 Strategy independently adopted to enhance professional development evident. 11.2 Awareness of philosophy of employer regarding professional development evident.	11.1 If possible, a specific field of the sub-discipline is chosen, available developmental alternatives established, a programme drawn up (in consultation with employer if costs are involved), and options open to expand knowledge into additional fields investigated. 11.2 Record keeping must not be left to the employer or anybody else. The trainee must manage his/her own training independently, taking initiative and being in charge of experiential development towards **Engineer, Technologist and Technician** engineering**.**
Range Statement: Professional development involves: a) planning own professional development strategy b) selecting appropriate professional development activities c) recording professional development strategy and activities, while displaying independent learning ability.	a) In most places of work training is seldom organised by a training department. It is up to the **Engineer, Technologist and Technician** to manage his/her own experiential development. **Engineer, Technologist and Technician** frequently end up in a 'dead-end street' being left behind doing repetitive work. If self-development is not driven by him/herself, success is unlikely. b) Preference must be given to engineering development rather than developing soft skills. c) Developing a learning culture in the workplace environment of the **Engineer, Technologist and Technician** is vital to his/her success

APPENDIX B: TRAINING ELEMENTS

1	**Introduction**
1.1	*Induction programme* (typically 1–5 days)
1.1.1	Company structure
1.1.2	Company policies
1.1.3	Company Code of Conduct
1.1.4	Company safety regulations
1.1.5	Company staff code
1.1.6	Company regulations
1.2	*Exposure to Practical Aspects of Engineering* (typically 6–12 months) *and covers how things are:* (Responsibility Levels A–B)
Experience in one or more of these sectors but not all:	
1.2.1.	Manufacturing
1.2.2	Construction
1.2.3	Erection
1.2.4	Field installation
1.2.5	Testing
1.2.6	Commissioning
1.2.7	Operation
1.2.8	Maintenance
1.2.9	Fault location
1.2.10	Problem investigation
2	**Design or develop solution**
2.1	*Experience in design and application of design knowledge (Typically 12–18 months) Focus is on planning, design and application* (Responsibility Levels C–D)
In one or more of the above sectors:	
2.1.1	Analysis of data and systems
2.1.2	Planning of networks and systems
2.1.3	System modelling and integration
2.1.4	System design

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

3.5	*Maintenance and repair of 3.1* (Responsibility Level E)
3.5.1	Planning and scheduling maintenance
3.5.2	Monitor quality
3.5.3	Oversee maintenance and repair
4	**Risk and impact mitigation**
4.1	*Impact and risk assessments* (Responsibility Level E)
4.1.1	Risk assessments
4.2	*Regulatory compliance* (Responsibility Level E)
4.2.1	Health and safety
4.2.2	Codes and standards
4.2.3	Legal and regulatory
5	**Managing engineering activities**
5.1	*Self-management* (Responsibility Levels C–D)
5.1.1	Manages own activities
5.1.2	Communicates effectively
5.2	*Team environment* (Responsibility Levels C–D)
5.2.1	Participates in and contributes to team planning activities
5.2.2	Manages people
5.3	*Professional communication and relationships (networking)* (Responsibility Levels C–D)
5.3.1	Establishes and maintains professional and business relationships
5.3.2	Communicates effectively
5.4	*Exercising judgement and taking responsibility* (Responsibility Level E)
5.4.1	Ethical practices
5.4.2	Code of Conduct
5.4.3	Exercises sound judgement in the course of complex engineering activities
5.4.4	Is responsible for decision-making in some or all engineering activities
5.5	*Competency development* (Responsibility Level D)
5.5.1	Plans own development programme
5.5.2	Constructs initial professional development record