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SOUTH AFRICA

Sub Discipline-specific Training Guide for Candidate Certificated Engineers (Mines and Works)

R-05-MW-PCE

REVISION No 0. 09 February 2022

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

ECSA

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DEFINITIONS

Alternative Route refers to an applicant who aspires to become registered in a Candidate or Professional Category but does not have the accredited or recognised qualifications and who proposes to meet the educational requirement through further study and assessment.

Benchmark Route means the normal process required to attain registration that consists of the completion of an accredited, recognised or evaluated equivalent qualification and a well-structured and effectively executed programme of training and experience for the category of registration.

Competency area means the performance area where all the outcomes can be demonstrated at the level prescribed in a specific technology in an integrated manner.

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

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

Ill-posed problem means problems whose requirements are not fully defined or may be defined erroneously by the requesting party.

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

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

Management of engineering works or activities *means* the coordinated activities required to:

(a) direct and control everything that is constructed or results from construction or manufacturing operations

(b) operate engineering works safely and in the manner intended

(c) return engineering works, plant and equipment to an acceptable condition by the renewal, replacement or mending of worn, damaged or decayed parts

(d) direct and control engineering processes, systems, commissioning, operation and decommissioning of equipment

(e) maintaining engineering works or equipment in a state in which it can perform its required function.

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

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

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

Range statement means the required extent of or limitations on 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 must be licensed through the Engineering Profession Act, 46 of 2000, or a combination of the Engineering Profession Act and external legislation as having specific engineering competencies at NQF 5 related to an identified need to protect the public safety, health and interest or the environment, in relation to an engineering activity.

ABBREVIATIONS

C&U	Commitment and Undertaking
CPD	Continuous Professional Development
DMRE	Department of Mineral Resources and Energy
ECSA	Engineering Council of South Africa
GCC	Government Certificate of Competence
HVAC	Heating, ventilating and air-conditioning
IPD	Initial Professional Development
VA	Voluntary Association

BACKGROUND

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

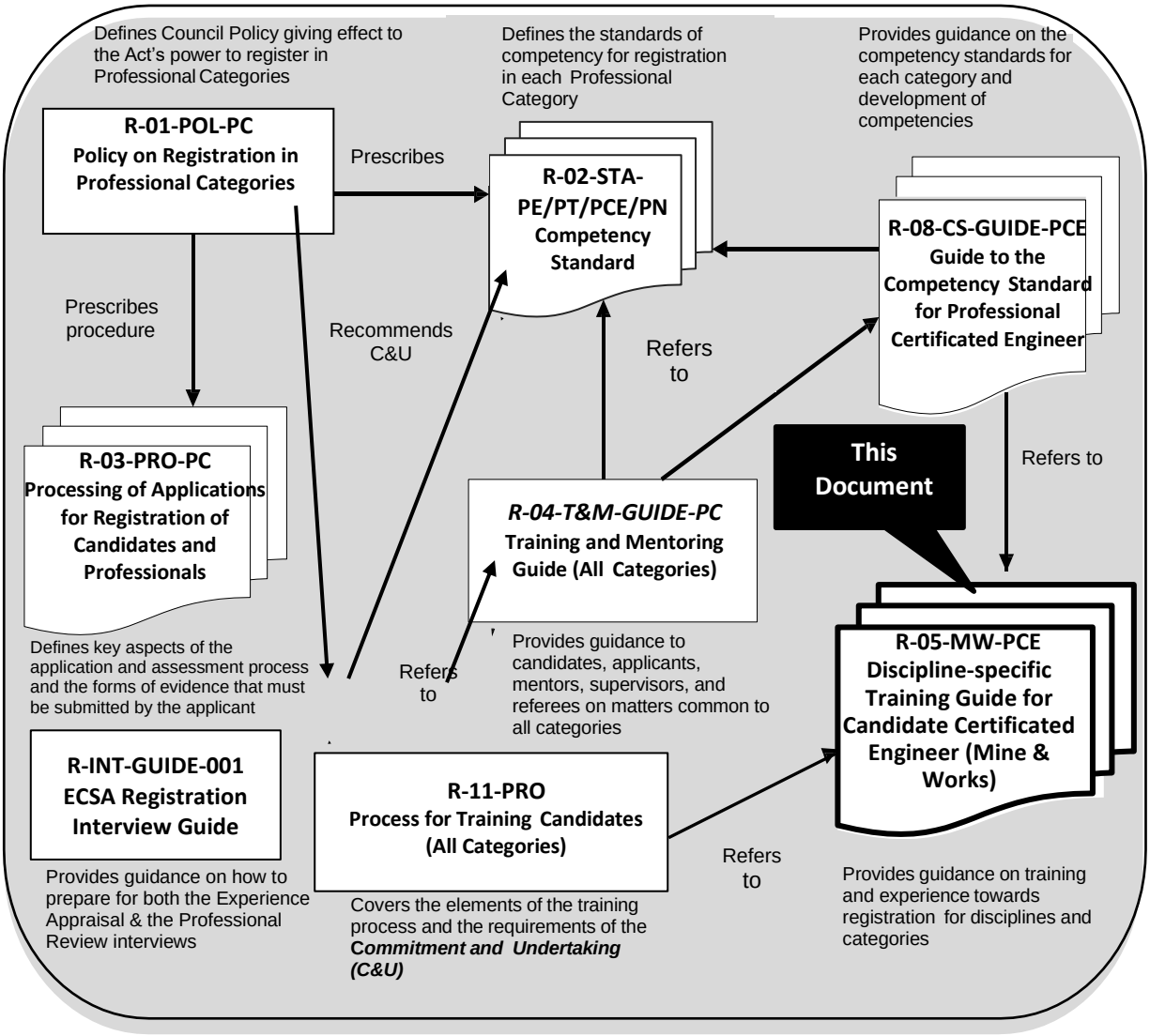

Figure 1: Documents defining the ECSA Registration System

1. PURPOSE OF THIS DOCUMENT

All persons applying for registration as Professional Certificated Engineers are expected to demonstrate the competencies specified in the Competency Standard for Registration in Professional Categories (document **R-02-STA-PE/PT/PCE/PN)** at the prescribed level, irrespective

of the type of certificate applicable, through work performed by the applicant at the prescribed level of responsibility. In addition, the Discipline Specific Requirements set out in 7.4 below must be met.

This document supplements the *Training and Mentoring Guide for Professional Categories* (**R-04-T&M-GUIDE-PC**), G*uide to the Competency Standards for Registration as a Professional Certificated Engineer* **(R-08-CS-GUIDE-PCE)** and *Process for Training Engineering Candidates towards Professional Registration* (**R-11-PRO)**.

In document **R-04-T&M-GUIDE-PC**, attention is drawn to the following sections:

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

Document **R-08-CS-GUIDE-PCE** provides both a high-level and outcome-by-outcome understanding of the competency standards as an essential basis for this discipline-specific training guide (DSTG) and requirements document. Document **R-11-PRO** elaborates on the elements of the training process and the requirements of the Commitment and Undertaking (C&U).

This guide and requirements document, as well as **R-04-T&M-GUIDE-PC**, **R-08-CS-GUIDE-PCE** and **R-11-PRO**, are subordinate to the *Policy on Registration in Professional Categories*, (**R-01-PPOL-PC)**, the **R-02-STA-PE/PT/PCE/PN** and the *Processing of Application for Registration of Candidates and Professionals* (**R-03-PRO-PC)**.

The guide and requirements are intended to support a programme of training and experience incorporating good practice elements.

2. AUDIENCE

This DSTG is directed to candidates and their supervisors and mentors in the discipline of Certificated Engineers (Factories). This guide is intended to support a programme of training and experience incorporating good practice elements.

This guide applies to persons who have:

- completed the education requirements by obtaining an accredited BSc (Engineering), BTech (Engineering), BEng Tech, or NDip type qualification, or through evaluation/assessment
- attained an Electrical or Mechanical Engineer's Certificate of Competency issued by the Department of Labour and Employment
- been appointed as a competent person in terms of regulation 2.1 or 2.7 of General Machinery Regulations promulgated under the Occupational Health and Safety Act, 85 of 1993.
- registered as a Candidate Certificated Engineer and/or
- embarked on a process of acceptable training under a registered C&U with a mentor guiding the professional development process at each stage.

There are seven certificates of competency issued in terms of three sets of legislation and the minimum duration of education, training and experience is laid out in the Table 1 below:

Table 1: Minimum duration of education, training and experience towards registration:

Pathway	Qualification	Post qualification total training and experience in the specific sub-discipline	Post qualification experience (part of total) with legal appointment
Benchmark Route	a) Electrical Engineer's Certificate of Competency issued in terms of the Mines Health and Safety Act b) Electrical Engineer's Certificate of Competency issued in terms of the Occupational Health and Safety Act c) Mechanical Engineer's Certificate of Competency issued in terms of the Mines Health and Safety Act	3 years	1 year

Pathway	Qualification	Post qualification total training and experience in the specific sub-discipline	Post qualification experience (part of total) with legal appointment
	d) Mechanical Engineer's Certificate of Competency issued in terms of the Occupational Health and Safety Act e) Manager's Certificate of Competency (Metalliferous) issued in terms of the Mines Health and Safety Act f) Manager's Certificate of Competency (Coal) issued in terms of the Mines Health and Safety Act g) Chief Marine Engineer Officer Class 1 Certificate of Competency issued in terms of the Merchant Shipping Act		
Notes:	Training and experience must incorporate legal requirements stipulated in laws, regulations and standards applicable. Training and experience must incorporate practical requirements executed to meet any legal requirements applicable to the particular legal appointment. A legal appointment, which requires the possession of a Government Certificate of Competency (GCC), as a **Manager** or as an **Engineer** in terms**, of Regulation 2.6.1, or Regulation 2.13.1, 2.13.3.1 and 2.13.3.2** respectively of the Mines Health and Safety Act, 29 of 1996, or if appointed in terms of **Section 3.1(a), 4.1 or 2(a)** where they are required in terms of their appointment to assume the responsibilities of the **Regulation 2.6.1 appointee requiring a GCC**, or as an **Engineer** in terms of **Regulation GMR 2.1 or 2.7** of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993) or as a **Chief Engineer Officer – Foreign Going** on a vessel with a registered power of no less than 3 000 kW in terms of the Merchant Shipping Act, Act 57 of 1951, or in terms of any Act which preceded or superseded any of the Acts mentioned above, and which demonstrates the applicant's competence to implement and manage the provisions of these Acts, and ensure the safe operation and maintenance of plant and equipment. Experience gained in operations, maintenance, appropriate processes and systems, trouble shooting and problem solving, failure analysis and incident investigations, construction and commissioning, training and project management, provided that at least 2 of the required 3 years of experience are directly concerned with the installation, operation and/or maintenance of machinery which requires sound engineering judgement, ability to work in a team, sound communication skills and management and which demonstrates the applicant's competence at the required level of a certificated engineer over the full 3-year period. In the case of marine engineers, as an alternate to the specified experience above, the following will be considered:		

Pathway	Qualification	Post qualification total training and experience in the specific sub-discipline	Post qualification experience (part of total) with legal appointment
	Experience gained as the appointed Chief Marine Engineer Officer for 5 years, on a variety of vessels with registered power of no less than 2 200 kW plus at least 6 months' experience in an acting capacity as Supervising Marine Engineer, with proven continuing updating of competence during this period, will be considered in lieu of the experience specified above		

This DSTG is specifically applicable to the Electrical Engineer's Certificate of Competency and the Mechanical Engineer's Certificate of Competency issued in terms of the Occupational Health and Safety Act – i.e., Factory Plant Engineers as opposed to Mine Engineers, Mine Managers and Chief Marine Engineer Officer which are dealt with in respective DSTGs.

3. PERSONS NOT REGISTERED AS CANDIDATES OR NOT BEING TRAINED UNDER C&U

Irrespective of the development path followed, all applicants for registration must present the same evidence of competence and be assessed against the same standards. It must be noted that application for registration as a Professional Certificated Engineer is permitted without being registered as a Candidate Certificated Engineer or without C&U training. Mentorship and adequate supervision are, however, key factors in effective development to the level required for registration. A C&U indicates that the company is committed to mentorship and supervision.

If the trainee's employer does not offer C&U, the trainee should establish the level of mentorship and supervision the employer is able to provide. In the absence of an internal mentor, the services of an external mentor should be secured. Alternately, the Voluntary Associations (VA) for the discipline should be consulted for assistance in locating an external mentor. A mentor must be kept abreast of all stages of the development process.

This DSTG is written for the recent graduate who is training and gaining experience toward registration as stipulated by council in of the policy **R-01-POL-PC**. Mature applicants for registration may apply the guide retrospectively to identify possible gaps in their development.

Any applicant who has not been though a mentorship programme is advised to request an experienced mentor (internal or external) to act as an application adviser while they prepare their application for registration.

To achieve ECSA registration the applicant's training programme should achieve the following:

- Expose applicants to experience and training enabling them to apply engineering theory acquired during educational development to practical workplace situations for the prescribed period required.
- Incorporate an increasing level of responsibility to enable the applicant to submit evidence in the training and experience reports (TERs)of achieving the level required.
- Develop the engineering competency of the applicant to cover the 11 outcomes in the five major groups referred to in **Section 6.2** and **Annexure B**, and the discipline specific requirements referred to in **Section 6.3**.

The DSTG may be applied in the case of a person moving into a candidacy programme at a later stage that is at a level below that required for registration (see Section 7.5 of this document).

4. ORGANISING FRAMEWORK FOR OCCUPATIONS (OFO)

Certificated Engineers predominantly operate within the disciplines of mechanical and electrical engineering. Their jurisdiction is regulated by the Mine Health and Safety Act, 29 of 1996.

4.1 Certificated Engineer's legal appointment

Training and experience must incorporate practical requirements executed to meet any legal requirements applicable to the particular legal appointment.

A legal appointment, which requires the possession of a GCC, as a Manager or as an Engineer in terms, Regulation 2.13.1, 2.13.3.1 and 2.13.3.2, respectively of the Mines Health and Safety Act, 1996 Act, 29 of 1996, or in terms of any Act which preceded or superseded the Act mentioned above, and which demonstrates the applicant's competence to implement and manage the provisions of this Act, and ensure the safe operation and maintenance of plant and equipment.

An engineer's legal responsibility as a "competent person" is designated by a letter of appointment by an employer and acknowledged with confirmation by the relevant government department after receipt of one or more of the following GCC – Mines and Works:

- Electrical Engineer's Certificate of Competency issued in terms of the Mine Health and Safety Act (MHSA)
- Mechanical Engineer's Certificate of Competency issued in terms of the MHSA.

Without limiting the general nature of legally appointed Certificated Engineers' responsibilities, all applicants are required, to the extent reasonably practicable, to:

- take all steps to ensure that all persons under their charge are fully conversant with the provisions of the Minerals and Petroleum Resource Development Act, 28 of 2002 (MPRDA), MHSA, MHSA Regulations and the Minerals Act Regulations that remain in force and effect in terms of Schedules of the MHSA as amended or replaced from time to time, and to enforce the provisions of the MPRDA, MHSA and Regulations
- observe and enforce any codes of practice, instructions, procedures, directives, permissions, exemptions, etc. issued by the Mine, the responsible government department or any other person who is authorised to do so
- provide and maintain a working environment that is safe and without risk to the health of employees within their area of responsibility
- identify relevant hazards and assess the related risks within their area of responsibility, to which persons who are not employees may be exposed, and ensure that persons who are directly affected by activities within their area of responsibility are not exposed to any hazards to their health and safety
- consider an employee's training and capabilities in respect of health and safety before assigning tasks to that employee
- provide proper and adequate health and safety training
- provide employees within their area of responsibility with any information, instruction, training or supervision that is necessary to enable them to perform their work safely and without risk to health

- report any contraventions of the provisions of the MPRDA, MHSA, MHSA Regulations and the Minerals Act Regulations that remain in force and effect in terms of Schedules of the MHSA, codes of practice, instructions, permissions, exemptions, etc.

- **Competence:** ensure workforce competence and responsibility at all levels through education, training and awareness in all aspects of safety and sustainable development
- **Risk assessment and change management:** identify, assess and prioritise the hazards and risks associated with all activities in their area of responsibility
- **Prevention and control:** prevent, minimise or control priority risks through planning, design, investment, management and workplace procedures. Prepare and periodically test emergency response plans. Where accidents or incidents do occur, take prompt corrective action, investigate root causes and take remedial action. Actively seek to prevent recurrences and disseminate experiences learned
- **Performance:** set appropriate goals, objectives, targets and performance indicators for all operations in their area of responsibility and meet all applicable laws and regulations as a minimum and where appropriate, apply international best practice
- **Evaluation:** monitor, review and confirm the effectiveness of management and workplace performance against divisional and mine standards, objectives, targets and applicable legal requirements; key to this process is system appropriate audits and progress reports
- **Stakeholder engagement:** promote and maintain open and constructive dialogue and good working relationships with employees, local communities, regulatory agencies, business organisations and other affected and interested parties, to increase knowledge and enhance mutual understanding in matters of common concern
- **Continual improvement:** foster creativity and innovation in the management of challenges facing their area of responsibility; support research and development into safety and sustainable development issues and promote the implementation of international best practices and technologies where appropriate
- **Environmental:** Preserve the environment in which the company operates and as such ensure that each operating organisation where appointed adheres to the commitments made in that operation's Environmental Management Plan (EMP) and hold a relevant ISO accreditation (ISO 14001 or 18001) ensure the responsible engineer and his/her staff have sufficient knowledge of the objectives and standards, inspections, submission of reports on non-conformances,

responding to incidents, reporting of incidents and responding to non-conformance reports generated by others; the engineer and his/her staff will also be expected to take part in audits to verify compliance with mine standards from time-to-time – these audits may be carried out by government departments, accreditation agencies, consultants or peer groups review and sign off proof of competency of all employees, contractors and contractor employees before such persons are allowed to perform any functions/tasks which may cause injury or damage to persons/machinery or equipment review codes of practice, standard procedures, safe working practices and other documents on a regular systematic basis

The Certificated Engineer is responsible for the safe installation and the proper operation, running and maintenance of all machinery. All machinery may include, but not be limited to:

- Trackless mobile machinery (TMM)
- Conveyors
- Winders
- Substations
- Pumps
- Compressors
- Refrigeration plants
- Surface and Underground Infrastructures
- Equipment inside buildings and workshops
- All other equipment other than TMMs.

Safe installation of machinery

Safe installation of all machinery means:

- commissioning of new and overhauled machinery/equipment (all other than TMM) and checking that it complies with all the requirements of the MHSA and Regulations, codes of practice guidelines issued by the Department of Mineral Resources and Energy (DMRE) and relevant SABS/SANS Codes with respect to guarding, safety devices, functionality, labelling, lockouts, lighting, brakes, alarms, etc.
- safe declarations of machinery/equipment by artisans

- safe erection, construction, overhaul, repairs, and commissioning of all equipment on a mine, plant or central workshop facility ensuring that it is safe for use.

Proper operation and running of all machinery

Proper operation and running of all machinery means:

- operators are trained and licensed on the correct ways to operate machinery/equipment
- operational discipline is embedded to ensure machinery/equipment are not misused/abused/ damaged
- formalised pre-use inspections are performed by licensed operators and deviations repaired by competent artisans.

Proper maintenance of machinery

Proper maintenance of all machinery means:

- an up-to-date asset register
- a maintenance schedule covering all machinery/equipment
- maintenance task lists developed in consultation with the OEMs for all machinery/equipment
- all mandatory aspects of machinery/equipment covered during maintenance interventions
- artisans and their assistants are trained on all critical tasks related to maintenance and repairs of machinery/equipment
- job safety assessments, standard operating procedures and planned task observations are developed to cover all critical maintenance and repair tasks of machinery/equipment
- codes of practice are implemented with full compliance
- a work management process is implemented with full compliance
- legal compliance tasks are completed to the required standards.

Safe erection of buildings, structures and tanks

Safe erection of buildings, structures and tanks means:

- proper planning and execution (permanent and temporary) of buildings, structures and tanks (e.g. silos, water reservoirs, bulk fuel storage tanks, etc.)

- contractor management in terms of compliance with legislation, mine codes of practice, standard operating procedures and directives
- rigging studies for lifting work with mobile cranes
- buildings, structures and tanks must be properly designed and approved by appropriate professional registered engineers
- construction and earthmoving equipment to be checked and approved by the engineer prior to it being used.

Proper maintenance of all buildings, structures and tanks

Proper maintenance of all buildings, structures and tanks means:

- an up-to-date asset register
- maintenance schedule covering all buildings, structures and tanks
- maintenance task lists developed in consultation with the OEMs for all buildings, structures and tanks
- all mandatory aspects of buildings, structures and tanks covered during maintenance interventions
- logbooks implemented for all critical equipment (e.g., pressure vessels, boilers, earth leakage testing, lamp room equipment, etc.)
- artisans and their assistants are trained on all critical tasks related to maintenance and repairs of buildings, structures and tanks
- job safety assessments, standard operating procedures and planned task observations are developed to cover all critical maintenance and repair tasks of buildings, structures and tanks
- codes of practice are implemented with full compliance
- a work management process is implemented with full compliance
- legal compliance tasks are completed to the required standards.

4.2 General engineering responsibilities

It is important to note that for GCC holders for Mines and Works, candidates complete similar training requirements to qualify for entry for GCC exams and sit for the same examination even though the issued certificates may be for a mechanical or electrical discipline.

Experience gained in operations, maintenance, appropriate processes and systems, trouble shooting and problem solving, failure analysis and incident investigations, construction and commissioning, training and project management is relevant, provided that at least 2 of the required 3 years of experience are directly concerned with the installation, operation and/or maintenance of machinery which requires sound engineering judgement, ability to work in a team, sound communication skills and management and which demonstrates the applicant's competence at the required level of a certificated engineer over the full 3-year period.

In addition to the legal responsibility stipulated in the above Act and corresponding Regulations applicable to the "workplace", general *engineering responsibilities* applicable to the discipline practised are indicated as follows:

4.2.1 Mechanical Engineering

In *Mechanical Engineering,* Certificated Engineers undertake the planning, design (or development), construction, operation and maintenance of materials, components, machines plant and systems for lifting, hoisting and materials handling; turbines, pumps and fluid power; heating, cooling, ventilating.

They further undertake air-conditioning; fuels, combustion, engines, steam plant, petrochemical plant; automobiles, trucks, aircraft, ships and special vehicles; asset fire detection and protection systems; nuclear energy generation, lifts and escalators; advise on mechanical aspects of particular materials, products or processes through the application of fundamental knowledge in engineering sciences: machine dynamics, material science, thermodynamics and fluid mechanics.

Typical *Mechanical Engineering* tasks that a Certificated Engineer may undertake include the following:

- Planning and development of plant, equipment and machinery for mining processes, and other industrial purposes.
- Maintenance and safe operation of equipment used in the abovementioned mining industry.
- Maintenance and safe operation of mechanical plant and equipment for the release, control and utilisation of energy, heating, ventilation and refrigeration systems, steering gear, pumps, pipe work, valves and other associated mechanical equipment.
- Maintenance and safe operation of suspension systems, brakes, vehicle bodies and other components of on-road as well as off-road vehicles.

- Maintenance and safe operation of non-electrical parts of apparatus or products such as word processors, computers, precision instruments, cameras and projectors.
- Implement measures and controls to ensure efficient functioning and safety of TMMs, machinery, tools, motors, engines, industrial plant, equipment or systems.
- Ensuring that equipment operation and maintenance comply with design specifications and safety standards.

Practising Certificated Engineers who are legally appointed to perform a *Mechanical Engineering* function generally in one or more of the following areas:

- Air-conditioning, heating and ventilation
- Automotive engineering
- Diesel engineering
- Fluid mechanics engineering
- Fire protection and detection
- Incident investigations and failure analysis
- Machine development
- Engineering maintenance management
- Mechanical engineering, mines
- Mechatronics engineering
- Piping engineering
- Power generation engineering
- Pressurised vessels engineering
- Rotational plant engineering
- Structural steel engineering
- Thermodynamics engineering
- Transportation systems engineering.

Certificated Engineers (Mechanical and/or Electrical) should be conversant with operations mostly dealing with investigating failure or underperformance of major equipment or systems and the synthesis of implemented and proven solutions to avoid recurrence of the problem. In addition, this category of work also involves the practical improvement recommended for optimising the operational efficiencies.

Certificated Engineers (Mechanical and/or Electrical) must, in performing the abovementioned work, apply professional engineering judgment to all work they do in the management of operations.

This includes but would not be limited to the ability to assess design work against the following criteria:

- Conformance to design specifications, health and safety regulations
- Ease of installation and assembly
- Constructability
- Maintainability
- Conformance to environmental requirements
- Ergonomic considerations
- Lifecycle costs
- Sustainability.

Certificated Engineers (Mechanical and/or Electrical) should be competent in the operation of the following engineering systems:

- Broadly defined fluid systems, which includes rotating or reciprocating machines
- Broadly defined machines/equipment or major parts thereof
- Broadly defined energy systems involving heat transfer
- Broadly defined pressure systems/HVAC systems
- Broadly defined structures
- Broadly defined civil structures (bridges, silos, surface bunkers, dam walls, etc.)

The problem-solving experience may be obtained in any of the above work categories. Acceptable broadly defined design reviews would include reviews of major machine systems such as turbines/compressors with their auxiliary systems, power station systems and their major components, broadly defined refrigeration systems, petrochemical and other production and manufacturing plant systems and the like.

4.2.2 Electrical Engineering

In *Electrical Engineering*, Certificated Engineers conduct planning, design (or development), and direct the construction and operation of electronic, electrical and telecommunications systems, computer and software systems, components, motors and equipment. They organise and establish control systems to monitor the performance and safety of electrical and electronic components, assemblies and systems.

They perform some of the following broadly-defined functions: planning, design (or development), construction, operation and maintenance of materials, components, plant and systems for generating, transmitting, distributing and utilising electrical energy; electronic devices, apparatus and control systems for industrial systems, robotics and consumer products; computing, communication and software for critical applications, instrumentation and control of processes, through the application of electrical, electromagnetic and information technology.

Within the broad collective field of electrical engineering, certificated engineers are legally appointed to take responsibility in the following areas:

- **Electrical Power Engineering** covers electrical systems, components, transformers, motors and equipment, electrical engineering materials, products and processes.
- **Electrical Engineering** covers electronic systems, electronic engineering materials, products or processes.
- **Telecommunications Engineering** is a broad specialisation of electrical engineering encompassing the design, construction and management of systems that carry out the transmission, processing and storage of information as electrical or optical signals and the control services based on this capability.
- **Computer and Software Engineering** addresses the relationship and interactions between software, hardware and external systems in solving real engineering problems. Computer engineering concentrates its effort on the ways in which computing ideas are mapped into working physical systems.

Certificated Engineers often take dual legal responsibility for the safe operation and maintenance of mechanical and electrical engineering process and systems, for example *Mechatronics Engineering* – involving process control.

Practising Certificated Engineers (electrical and/or mechanical) may concentrate on one or more of the following electrical engineering areas:

- Mining, plant and factories, power generation, power transmission, power distribution, power systems protection, metering, illumination, railway signalling, signalling and communications, control and instrumentation, product development, power electronics, electrical drives, energy management, infrastructure maintenance, construction projects, training, ocean going vessels, etc.
- SCADA, control, instrumentation, fire and safety, rail network control, electronic warfare, optimisation of control systems in process plants, etc.
- Digital signal processing development, communications, fibre optics, radio frequency development, radar, radio, radio and telecommunications, mobile radio, satellite transmission, signal processing systems, communications consulting, communications specialist (ict), telecommunications consulting, telecommunications network planning, telecommunications specialist, microwave, etc.
- Computer hardware, computer systems analysis, computer systems design, computer communication specialisation, computer network development, software systems, etc.

4.2.3 Additional specific engineering responsibilities

Other duties pertaining to the Practising Certificated Engineer's role include but are not limited to the following skillsets:

- People management
- Asset management
- Process/production management
- Engineering management
- Cost/budget management
- Contractor management
- Project management
- Risk management.

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

Certificated Engineers may be employed in both the private and public sector. Typically, in the private sector they would have legal appointments in mining operations, manufacturing, factories, shipping and related industries. They may also be appointed to have legal responsibilities for contracting or project work in these types of industries.

Certificated Engineers may be responsible for project implementation and related activities which may include planning, construction, labour and resource management or outsourcing of such services to engineering contractors. Maintenance and safe operation of systems, processes, plant, equipment and machinery are key functions of Certificated Engineers.

They must ensure that work processes and activities are undertaken in accordance with the requirements of the relevant Acts and Regulations, design specifications, standards and codes. Certificated Engineers may be appointed as Inspectors by the Departments of Mineral Resources and Energy, Public Works and Transport to ensure compliance with the relevant Acts and Regulations, design specifications, standards and codes is being maintained by affected industries.

Owing to the diversity in application of engineering within the South African Mining Industry, Certificated Engineers can follow various registration routes across multiple minerals/commodities (e.g., precious metals, precious stones, ferrous metals, coal, etc.) with different mining methods and environments (e.g., surface mining, narrow tabular underground mining, massive underground mining and underground coal mining).

Depending on where the candidate is employed, there may be situations where the opportunities in-house are not sufficiently diverse to develop all the competencies required in both Groups A and B noted in document **R-02-STA-PE/PT/PCE/PN**. For example, the opportunity to develop problem solving (including design synthesis or developing solutions) and engineering activity (including implementing or constructing solutions) management skills may not be available to the candidate.

It has been common practice that where an organisation is unable to provide training in certain areas that secondments are arranged with other organisations, so that candidates are able to

develop all the competencies required for registration. These secondments are usually reciprocal in nature, so both employers and their respective employees get the mutual benefit from the other party. Secondments between consultants and contractors and between the public and private sector should be possible.

Problem solving in various sectors of engineering is a logical thinking process that requires Certificated Engineers to apply their minds diligently in bringing solutions to broadly defined technical problems. This process involves the analysis of systems or assembly of mechanical, electrical, marine, ventilation or mining engineering components, and integration of various elements in mechanical, electrical, marine, ventilation or mining engineering through the application of fundamental knowledge in engineering sciences.

Location of training in overall engineering lifecycle and functions performed.

The areas where *Certificated Engineers* work generally follow the conventional stages of the project (or product) life cycle in Figure 2:

(a) Analysis of broadly defined problems and design or development of solutions to improve the performance of products or systems within the areas of their legal responsibilities.

(b) Broadly defined system or product design or development to solve a broadly defined system or product problem, or to achieve a desired result, or to select equipment for a particular purpose.

(c) Project engineering to install and test and commission the necessary equipment or system to ensure compliance with operational requirements and design specifications.

(d) Safe operation and maintenance of the system or process in accordance to the legislative requirements.

(e) Decommissioning and disposal of assets.

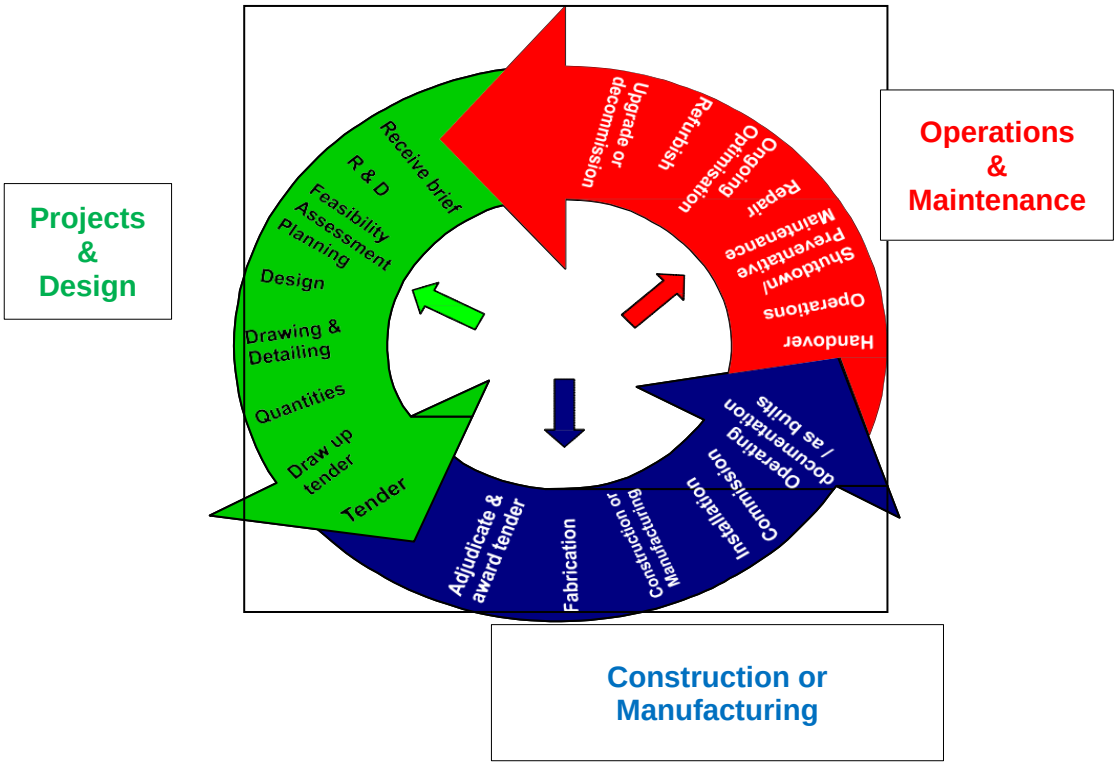

Figure 2: Conventional stages of the project (or product) life cycle

Candidates are not expected to change their occupation to work in all the areas listed above. Candidates must, however, ensure that in whatever area they are employed, they undertake tasks that provide experience in all the 11 outcomes where competencies are being assessed.

In Appendix B, a generic schematic is presented for the outcomes applicable to all disciplines that a candidate should become competent to do in the various phases of a project or task:

(a) Solving problems based on broadly defined engineering and contextual knowledge.

(b) Managing engineering activities.

(c) Understanding risks and impacts of engineering activities.

(d) Judgement, responsibility and ethical behaviour during engineering activities.

(e) Further professional development since graduation.

6. DEVELOPING COMPETENCY: ELABORATING ON SECTIONS IN THE GUIDE TO THE COMPETENCY STANDARDS, DOCUMENT R-08-PCE

Applicants are required to demonstrate the insight and ability to use and interface various engineering aspects through verifiable work carried out in providing engineered and innovative solutions to practical broadly defined problems experienced in their operating work environment where they are legally appointed. In addition, applicants must develop the skills required to demonstrate the use of fundamental or specialist engineering knowledge in optimising the efficiency of operations or the constructability of projects.

Candidates must be able to demonstrate that they have been actively involved in a work environment participating in the execution of practical work such that they have learnt sufficient details on fundamental engineering knowledge to be able to exercise judgment in the workplace thereafter.

Candidates must show evidence of adequate training in this function through broadly defined project work carried out in the analysis of problems and the synthesis of solutions. Evidence is required in the form of a separate comprehensive engineering report that should accompany the application. This report should describe a synthesised solution to sufficiently broadly defined engineering problems to demonstrate that candidates have had an opportunity to apply their engineering knowledge and expertise gained through GCC qualification education and practical work experience.

In applying engineering knowledge gained through academic training, the applicant must also demonstrate the financial and economic benefits of engineered solutions synthesised from scientific and engineering principles at a sufficiently broadly defined level.

What is a sufficiently broadly defined engineering (Appendix A) problem?

“Broadly defined” in broadly defined engineering problems can be defined as follows:

"Composed of ***inter-related conditions***; requiring ***underpinning engineering knowledge judgment*** to create a solution within a set of ***original broadly-defined circumstances***"

Mechanical and electrical engineering forms an integral part of broader engineering systems and infrastructure in technologically complex manufacturing, processing, mining, construction, maintenance, and marine environment. Applicants are required to undertake engineering projects that significantly enhance the operability and constructability of integrated engineering systems and infrastructure. Such project work must not be a stand-alone type of assignment but should be part of a solution to integrated engineering systems that requires a broader application of various theoretical aspects of engineering.

The engineering problem solving is a logical thinking process that requires Certificated Engineers to apply their minds carefully in bringing solutions to broadly defined engineering problems. This process involves the analysis of systems or assembly of components, and integration of various elements in engineering through the application of fundamental and specialist knowledge in engineering sciences. Simple, straightforward calculation exercises and graphical representations from computer generated data are not considered as sufficiently broadly defined engineering solutions. The reason is because anybody with qualifications in basic science and engineering science is able to perform this kind of work, and professional registration requires an in-depth analysis and original application of engineering **knowledge** in broadly defined engineering problems.

Candidate *Certificated Engineers* must obtain experience in solving a variety of problems in their work environment, and the solution to these problems should also involve the use of fundamental and advanced engineering knowledge obtained from the GCC qualification underpinned by engineering education from accredited academic engineering programmes where applicable. The problems that require scientific and engineering approach in solving them may be encountered in any engineering work environment that consists of integrated engineering systems, equipment, machinery and infrastructure.

From their early training years, candidates must actively seek opportunities to obtain experience in the area of synthesising solutions to real-life engineering problems encountered in the workplace.

6.1 Contextual knowledge

Candidates are expected to be aware of the requirements of the engineering profession. The recognised VA applicable and its functions and services to members, for example, provide a broad range of contextual knowledge for the candidate *Certificated Engineer* through the full career path

of the registered *Professional Certificated Engineer*. The practice area of *Professional Certificated Engineer* identifies specific contextual activities that are considered an essential component of the development of competence. These include awareness of basic workshop, manufacturing, fabrication, mining and on site or on-board activities and the competencies required of the *Certificated Engineer*.

Candidate Certificated Engineers in mining should demonstrate appropriate exposure and experience in:

- mineral excavation processes
- mine planning and development
- maintenance and asset management
- project execution
- incident and accident investigations
- supervision and management
- technical and financial evaluation
- mine health and safety and environmental management.

This should be done in one or more of the following sub-sectors/contexts of the SA Mining Industry:

- U/G Narrow Tabular Hard Rock
- U/G Massive Hard Rock
- U/G Coal Mining
- Surface Mining inclusive of Open Pits, Open Cast and Quarrying operations.

6.2 Functions Performed

Special consideration in the *Certificated Engineer* group and each specific type of system or specialty must be given to the Degree of Responsibility as described in the scales in document **R-04-T&M-GUIDE-PC**, Table 4 – provided here in section 7.1, on the competencies specified in the following groups:

- Knowledge based problem solving
- Management and Communication
- Identifying and mitigating the impacts of engineering activity

- Judgement and responsibility
- Independent learning

6.3 Discipline-specific requirements

Activities should be selected to ensure that the candidate reaches the required level of competency and responsibility. It is useful to measure the progression of the candidate's competency by making use of the Degree of Responsibility, Problem Solving and Engineering Activity scales as specified in the relevant documentation and outlined below.

A: Being Exposed	B: Assisting	C: Participating	D: Contributing	E: Performing

Degree of responsibility E means performing at the level required for registration. This corresponds to the range statement in outcome 10 in the Competency Standard **R-02-STA-PE/PT/PCE/PN** which requires the applicant to display responsibility "for the outcomes of significant parts of one or more broadly-defined engineering activities".

It should be noted that the candidate *Certificated Engineer* working at Responsibility level E on the Degree of Responsibility Scale carries the responsibility for work thus performed appropriate to that of a registered person except that the candidate *Certificated Engineer's* supervisor is accountable for the candidate's recommendations and decisions.

6.4 Industry-related statutory and other requirements

Candidates are expected to have a working knowledge of the regulations, Acts and standards applicable to their working environment. The following list includes but is not limited to:

- ECSA – Engineering Profession Act, 46 of 2000, its Rules and the Code of Conduct
- OHS Act – Occupation Health and Safety Act, 85 of 1993, as amended by Act 181 of 1993
- Mine Health and Safety Act. 29 of 1996
- Environment Conservation Act, 73 of 1989, as amended by Act 52 of 1994 and Act 50 of 2003
- Machinery and Works Regulations
- Labour Relations Act, 66 of 1995
- Building Regulations – National Building Regulations and Building Standards Act, 103 of 1977, as amended by Act 49 of 1995

- Water Services Act, 108 of 1997
- National Water Act, 36 of 1998
- Minerals Act, 50 of 1991 and Regulations
- Industry specific work instructions including manufacturer instructions applicable to specific lifting equipment types
- SANS and other international standards such as ISO, EN, DIN or US Federal Standards.

Many other Acts not listed here may also be pertinent to a candidate Certificated Engineers work environment. Candidate Certificated Engineers are expected to have a basic knowledge of the applicable Acts and to investigate whether any Acts are applicable to a particular work environment.

6.5 Recommended formal learning activities

The following list of formal learning is a sample of useful course types:

- Conditions of Contract\Value Engineering – NEC, JBCE etc. Standard Specifications
- Contract Management
- Preparation of Specifications
- Engineering Finance
- Energy Efficiency
- Electrical Tariffs
- Management
- System Engineering
- Industrial Relations
- Public Speaking
- Project Management
- Negotiation Skills
- Risk Analysis
- Root-cause Analysis
- Quality Systems
- Occupation Health and Safety
- Maintenance Engineering

- Environmental Impacts
- Value Engineering
- Report writing and communication
- Planning methods
- Asset Management
- CPD courses on specific disciplines and equipment types.

7. PROGRAMME STRUCTURE AND SEQUENCING

7.1 Best practice

There is no ideal training programme structure or a unique sequencing that constitutes best practice. The training programme for each candidate Certificated Engineer depends on the work opportunities available at the time for the employer to assign to the candidate.

It is suggested that candidate Certificated Engineers work with their mentors to determine appropriate projects to gain exposure to elements of the asset cycle, to ensure that their designs are constructible, operable, and are designed considering life cycle costing and long-term sustainability.

The training programme should be such that candidate Certificated Engineer progresses through levels of work capability, which is described in document **R-04-T&M-GUIDE-PC**, such that by the end of the training period, the candidate Certificated Engineer must perform individually and as a team member meeting the engineering outcomes as well as the discipline-specific requirements at the level required for registration and exhibit degree of Responsibility Level E.
The nature of work and degrees of responsibility are defined in document **R-04-T&M-GUIDE-PC**.

Table 4: Nature of work and degrees of responsibility

A: Being Exposed	B: Assisting	C: Participating	D: Contributing	E: Performing
Undergoes induction, observes processes, 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 appropriate to a registered person, supervisor is accountable for applicant's decisions.

The mentor and the candidate Certificated Engineer must identify the level of responsibility an activity provides compliance with and demonstration of the various outcomes. The evidence of the candidate's activities are recorded on the appropriate system such that it meets the requirements of the Training Elements, Table 4.

Depending on the nature and extent of the engineering-related work undertaken by an employer, the employer should be able to develop Candidate Certificated Engineer-specific development programmes that provide opportunities for the candidate to undertake the necessary exposure/experience in a phased approach.

7.2 Realities

Generally, irrespective of the type of certificate, it is unlikely that the period of training will be 3 years, the minimum time ECSA requires. Typically, it will be longer and would be determined among others by the availability of functions in the actual work situation.

Each candidate will effectively undertake a unique programme where the various activities carried out at the discipline-specific level are then linked to the generic competency requirements of **R-08-CS-GUIDE-PCE** and the compulsory discipline-specific requirements to be met during the candidacy.

7.3 Considerations for generalists, specialists, researchers and academics

Document **R-08-CS-GUIDE-PCE** adequately describes what would be expected of persons whose formative development has not followed a conventional path, for example academics, researchers, specialists and those who have not followed a candidate training programme.

This unconventional path is not normally applicable to Certificated Engineering candidates. The overriding consideration is that, irrespective of the route followed, the candidate must provide evidence of competence against the standard and the discipline-specific requirements.

7.4 Compulsory discipline-specific requirements to be met during the candidacy

Evidence on *broadly defined* Engineering Competency, eventually at Level E, is presented in TERs attached to the *Application Form for Registration as a Professional Certificated Engineer*.

The applicable legislation and regulations require specific responsibilities to be designated to Competent Persons. Specific training during the candidacy period must be aimed at developing the candidate to achieve the competency required to accept this responsibility. In addition to assessing candidates for engineering responsibility at Level E, discipline-specific requirements are assessed as well to confirm legal responsibility, also at Level E.

While the emphasis in the candidate Certificated Engineers' training is on developing engineering competency to address broadly defined engineering problems and perform broadly defined engineering activities, the emphasis in meeting the discipline-specific requirements must be development towards accepting legal responsibility.

Candidates, assisted by mentors and supervisors, must during candidacy ensure that they are conversant with the legal knowledge set out in appendix A below and submit evidence as such as part of the Application for Registration form. Although the focus in this form is not on broadly defined problems and activities as such, the integration between the legal appointment and application of engineering principles is important.

REVISION HISTORY

Revision number	Revision date	Revision details	Approved by
Revision A	10 April 2017	Initial attempt at PCE DSTG based on R-05-ELE/MEC/MIN-PT and R-05-FPSS-SC. Needs editing from Professional Certificated Engineers.	For Approval by the PDSGC
Revision B	12 April 2017	Revisions to the Discipline-Specific Requirements Report (Form R-05-DSRR-PCE) initiated by Mr Botsane and other minor editing	Revised by the Working Group
Revision C	30 April 2017	Revisions to the entire document initiated by Mr Botsane.	Revised by the Working Group
Revision C	5 may 2017	Revisions proposed by Mr Klopper and Dr Stidworthy incorporated. Emphasis on the Outcomes, Competency Indicators, Range Statements in line with the broadly defined definitions confirmed. Option 2 will introduce a unique approach applicable to Professional Certificated Engineers only.	Revised by the Working Group
Revision C	3 July 2017	Approved	Approval by PDSGC
Revision C	17 August 2017	Approved	Approval by Council
Rev. 0 draft 1	30 July 2021	Draft DSTG for Candidate Certificated Engineers (Mine and Works) separated from these disciplines: R-05-FE-PCE, R-05-ME-PCE and R-05-MM-PCE	Working Group and RPS BU
Rev. 0 draft 2	11 August 2021	Final Draft Reviewed	RPS BU
Rev. 0 draft 3	17 August 2021	Reviewed by Executive	RPS Executive
Rev. 0 Draft D	1 September 2021	Recommendation for broader consultation	RPSC
Rev. 0 Draft E	28 October 2021	Consideration of collated inputs from broader consultation	Working Group, RPS BU
Rev. 0 Draft F	24 January 2022	Review and Recommendation for Approval	Executive RPS: EL Nxumalo
Rev. 0	09 February 2022	Approval	RPSC

The Discipline-Specific Training Guide for:

Candidate Certificated Engineers (Mines and Works)

Revision 0 dated 09 February 2022 and consisting of 34 pages, has been reviewed for adequacy by the Business Unit Manager and is approved by the Executive: Research, Policy and Standards (RPS).

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Business Unit Manager

09/03/2022

Date

Executive: RPS

2022/03/09

Date

This definitive version of this policy is available on our website.

APPENDIX A: Training Discipline-Specific Requirements Report

form R-05-DSRR-PCE

Surname and Initials: _____

Use this form to report in about 100 words per requirement applicable, on the applicant's personal knowledge.

Attach to this report the actual applicable policies, procedures, standard forms, schedules, etc. for the Certificate selected, done by the applicant under the supervision of an ECSA registered Professional Certificated Engineer.

Tick off (✓) the specific certificate(s) applicable to your registration application:			
1. Electrical Engineer's Certificate of Competency issued in terms of the Mines Health and Safety Act, 1996		5. Manager's Certificate of Competency (Metalliferous) issued in terms of the Mines Health and Safety Act, 1996	
2. Mechanical Engineer's Certificate of Competency issued in terms of the Mines Health and Safety Act, 1996		6. Manager's Certificate of Competency (Coal) issued in terms of Mines Health and Safety Act, 1996	
3. Electrical Engineer's Certificate of Competency issued in terms of the Occupational Health and Safety Act, 1993		7. Chief Engineer Officer – Foreign Going Certificate of Competency issued in terms of the Merchant Shipping Act, 1951	
4. Mechanical Engineer's Certificate of Competency issued in terms of the Occupational Health and Safety Act, 1993			

REPORT

Item	Requirements	Report
1.	Briefly set out your area of responsibility as stipulated in your letter of appointment as the responsible person.	
2.	Explain the rationale behind your appointment.	
3.	List the Acts and Regulations applicable to your specific responsibility	

Item	Requirements	Report
4.	List your duties as a responsible engineer appointed under the regulations.	
5.	Explain the action plans you have taken to deliver on the duties listed above.	
6.	What are the standard operating procedures applicable to your areas of responsibility, which standards/ procedures did you review and what were the recommendations?	
7.	Briefly explain the relevance of your engineering knowledge in carrying out your appointed mandate.	
8.	Describe the steps you have taken to train and develop people within your jurisdiction to adhere to the requirements of the Acts and Regulations, and what measures you took to declare people competent to perform work.	
9.	How do you deal with contraventions of the applicable Act and Regulations?	
10.	Elaborate on incident reporting and corrective measures taken to address the non-conformance.	
11.	Describe the measures you took to ensure that you did undertake your responsibility ethically and diligently according to your letter of appointment and the corresponding Acts and Regulations.	
12.	Explain how the engineering equipment under your control and responsibility is evaluated and handled in terms of the particular Act and Regulations.	

APPENDIX B: Training Elements

Synopsis: A candidate certificated engineers should achieve specific competencies at the prescribed level during his/her 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 to all engineering work performed after professional registration regardless of the level of responsibility at any particular stage of an engineering career:

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

Broadly defined engineering work is usually characterised by the application of novel technology 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 Certificated Engineer	Explanation and responsibility level
1. Purpose This standard defines the competence required for registration as a Professional Certificated Engineer. Definitions of terms having particular meaning within this standard are given in text in Appendix D.	Discipline Specific Training Guides (DSTGs) give context to the purpose of the Competency Standards. Professional Certificated Engineers operate within the nine disciplines recognised by ECSA. Each discipline can be further divided into sub-disciplines and finally into specific workplaces as given in Clause 4 of the specific DSTG. DSTGs are used to facilitate experiential development towards ECSA registration and assist in compiling the required portfolio of evidence (specifically the Engineering Report in the application form). **NOTE:** The training period must be utilised to develop the competence of the trainee towards achieving the standards. below at a Responsibility Level E, i.e., Performing. (Refer to 7.1 in the specific DSTG).
2. Demonstration of competence Competence must be demonstrated within broadly defined engineering activities, defined below, by integrated performance of the outcomes defined in section 3 at the level defined for each outcome. Required contexts and functions may be specified in the applicable DSTG. **Level descriptor:** Broadly defined engineering activities (BDEAs) have several of the following characteristics: a) Scope of practice area is linked to technologies used and changes by adoption of new technology into current practice. b) Practice area is located within a wider, complex context, requires teamwork and has interfaces with other parties and disciplines.	Engineering activities can be divided into (approximately): • 5% Complex (Professional Engineers) • 5% Broadly Defined (Professional Certificated Engineers/Professional Engineering Technologists) • 10% Well-defined (Professional Certificated Engineers/Professional Engineering Technologists) • 15% Narrowly Well-defined (Registered Specified Categories) • 20% Skilled Worker (Engineering Artisan) • 55% Unskilled Worker (Artisan Assistant) The activities can be in-house or contracted out; evidence of integrated performance can be submitted irrespective of the situation. **Level Descriptor:** BDEAs in the various disciplines are characterised by several of or all the following:

c) Involve the use of a variety resources, including people, money, equipment, materials, technologies. d) Require 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. **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.	g) 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. h) Practice area varies substantially with unlimited location possibilities and an additional responsibility to identify the need for advice on complex activities and problems. Broadly defined activities in the sub-discipline need interfacing with professional engineers, professional technologists, artisans, architects, financial staff, etc. as part of the team. i) The bulk of the work involves familiar, defined range of resources, including people, money, equipment, materials, but new technologies are investigated and implemented. j) 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. k) 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.) l) 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; engineering operations; maintenance; project management. For Certificated Engineers, research, development and commercialisation happen more frequently in some disciplines and are seldom encountered in others.

3. Outcomes to be satisfied:	Explanation and responsibility level
Group A: Engineering Problem Solving	
Outcome 1: Define, investigate and analyse *broadly defined* engineering problems.	**Responsibility Level E** Analysis of an engineering problem means the "separation into parts possibly with comment and judgement". *Broadly* means "not minute or detailed" and "not kept within narrow limits".
Broadly defined engineering problems have the following characteristics: a) Require coherent and detailed engineering knowledge, underpinning the technology area *and one or more of:* • Are ill-posed, under- or over-specified, require identification and interpretation into the technology area • Encompass systems within complex engineering systems • Belong to families of problems that are solved in well-accepted but innovative ways *and one or more of:* • Can be solved by structured analysis techniques • May be partially outside standards and codes; must provide justification to operate outside • Require information from practice area and sources interfacing with practice area that is complex and incomplete	a) Coherent and detailed engineering knowledge for Certificated Engineers means the problem encountered cannot be solved without the combination of all the relevant detail including engineering principles applicable to the situation. b) The nature of the problem is not immediately obvious and further investigation to identify and interpret the real nature of the problem is necessary. c) The problem is not easily recognised as part of the larger engineering task, project or operation and may be obscured by the complexity of the larger system. d) Recognise that the problem can be classified as a falling within a typical solution requiring innovative adaptation to meet the specific situation. e) Solving the problem needs a step-by-step approach adhering to proven logic. f) The standards, codes and documented procedures must be analysed to determine to what extent they are applicable to solve the problem and justification must be given to operate outside these.

3. Outcomes to be satisfied:	Explanation and responsibility level
• Involve a variety of issues which may impose conflicting constraints: technical, engineering and interested or affected parties *and one or both of:* • Require judgement in decision-making in practice area, considering interfaces to other areas • Have significant consequences which are important in practice area but may extend more widely.	• The responsibility lies with the Certificated Engineer to verify that some information received as part of the problem encountered may remain incomplete and solutions to problems may need justified assumptions. • The problem handled by a Certificated Engineer may be solved by alternatives that are unaffordable, detrimental to the environment, socially unacceptable, not maintainable, not sustainable, etc.; the Technologist will have to justify his / her recommendation. • 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. • Certificated Engineers must realize that their actions might seem to be of local importance only but may develop into significant consequences extending beyond their ability and practice area.
Assessment criteria: A structured analysis of broadly defined problems typified by the following performances is expected: 1.1 Performed in or contributed to defining engineering problems leading to an agreed definition of the problems to be solved. 1.2 Performed in or contributed to investigating engineering problems including collecting, organising and evaluating information. 1.3 Performed in or contributed to analysis of engineering problems using conceptualisation, justified assumptions, limitations and evaluation of results.	To perform an engineering task, a Certificated Engineer will typically receive an instruction from a senior person (customer) to do a specific task, and must: 1.1 make sure that 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 segregate the engineering problem and related information 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 clause 4 of the specific DSTG.
Outcome 2: Design or develop solutions to broadly defined engineering problems	**Responsibility Level C and D** Design means “drawing or outline from which something can be made”. Develop means “come or bring into a state in which it is active or visible”.
Assessment criteria: This outcome is normally demonstrated after a problem analysis as defined in outcome 1. Working systematically to synthesise a solution to a broadly defined problem, typified by the following performances is expected: 2.1 Designed or developed solutions to broadly defined engineering problems. 2.2 Systematically synthesised solutions and alternative solutions or approaches to the problem by analysing designs against requirements, including costs and impacts on outside parameters. (Requirements.)	After the task received is fully understood and interpreted, a solution to the problem posed can be developed (designed). To synthesise a solution means “the combination of separate parts, elements, substances, etc. into a whole or into a system” by the following: 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 Certificated Engineer 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

3. Outcomes to be satisfied:	Explanation and responsibility level
2.3 Drawing up of detailed specification requirements and design documentation for implementation to the satisfaction of the client.	for the alternative recommended. Selection of alternatives might be based on tenders submitted with alternatives deviating from those specified. 2.3 The best complete and final solution selected must be followed up with a detailed technical specification, supporting drawings, bill of quantities, etc., for the execution of work to meet customer requirements.
Range Statement: Solutions are those enabled by the technologies in the Candidate's practice area.	Applying theory to do broadly defined engineering work is mostly done in a way that has been used before, probably developed by engineers in the past and documented in written procedures, specifications, drawings, models, examples, etc. Certificated Engineers must seek approval of any deviation from these established methods, but 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 a Certificated Engineer practices is given in clause 4 of the specific **DSTG.**
Assessment criteria: This outcome is normally demonstrated in the course of design, investigation or operations. 3.1 Applied engineering principles, practices, technologies, including the application of BTech theory in the practice area.	Design work for Certificated Engineers is based on BTech, BSc or BEng theory and is mostly the utilisation and configuration of manufactured components and selected materials and associated novel technology. Certificated Engineers develop and apply codes and procedures in their design work. Investigation would be on broadly defined be incidents and condition monitoring, and operations mostly on developing and improving engineering systems and operations. 3.1 Calculations at BTech, BSc or BEng theoretical level confirming the correct application and utilisation of equipment, materials and systems listed in Clause 4 of the specific DSTG must be done on broadly defined activities.

3. Outcomes to be satisfied:	Explanation and responsibility level
3.2 Indicated working knowledge of areas of practice that interact with practice area to underpin teamwork. 3.3 Applied related knowledge of finance, statutory, safety and management.	3.2 The understanding of broadly defined procedures and techniques must be based on fundamental mathematical, scientific and engineering knowledge, as part of personal contribution within the engineering team. 3.3 The ability to manage the resources within legal and financial constraints must be evident.
Range statement: Applicable knowledge includes the following: 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, maintenance management, regulation, project and construction 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, Certificated Engineers 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 Certificated Engineers 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 or as “competent person” for compliancy with Mine Health and Safety Act.

3. Outcomes to be satisfied:	Explanation and responsibility level
Group B: Managing Engineering Activities	**Explanation and Responsibility Level**
Outcome 4: Manage part or all of one or more broadly defined engineering activities.	**Responsibility Level D** Manage means “control”.
Assessment criteria: The candidate is expected to display personal and work process management abilities: 4.1 Managed self, people, work priorities, processes and resources in broadly defined engineering work. 4.2 Role in planning, organising, leading and controlling broadly defined engineering activities evident. 4.3 Knowledge of conditions and operation of contractors and the ability to establish and maintain professional and business relationships evident.	In engineering operations, Certificated Engineers will typically be 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 management must be applied to broadly defined engineering work. 4.3 Depending on the project, Certificated Engineers 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 or 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	5.1 Refer to Range Statement for Outcome 4 and 5 below. 5.2 Refer to Range Statement for Outcome 4 and 5 below.

3. Outcomes to be satisfied:	Explanation and responsibility level
5.3 oral presentations made using structure, style, language, visual aids and supporting documents appropriate to the audience and purpose.	5.3 Presentation of point of view mostly occurs in meetings and discussions with immediate supervisor.
Range statement for Outcomes 4 and 5: Management and communication in well-defined engineering involves: a) Planning broadly defined activities b) Organising broadly defined activities c) Leading broadly defined activities d) Controlling broadly defined activities.	a) Planning means “the arrangement for doing or using something, considered in advance”. b) Organising means “put into working order; arrange in a system; make preparations for”. c) Leading means to “guide the actions and opinions of; influence; persuade”. d) Controlling means the “means of regulating, restraining, keeping in order; check”. Certificated Engineers 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.

3. Outcomes to be satisfied:	Explanation and responsibility level
Group C: Impacts of Engineering Activity	**Explanation and Responsibility Level**
Outcome 6: Recognise the foreseeable social, cultural and environmental effects of broadly defined engineering activities generally.	**Responsibility level B** Social means “people living in communities; of relations between persons and communities”. Cultural means” all the arts, beliefs, social institutions, etc. characteristic of a community”. Environmental means “surroundings, circumstances, influences”.
Assessment criteria: This outcome is normally displayed in the course of analysis and solution of problems. The Candidate typically: 6.1 has the ability to identify interested and affected parties and their expectations in regard to interactions between technical, social, cultural and environmental considerations shown; 6.2 takes 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 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.

3. Outcomes to be satisfied:	Explanation and responsibility level
Outcome 7: Meet all legal and regulatory requirements and protect the health and safety of persons in the course of his or 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 identified risk and applied risk management strategies.	7.1 The Mine Health and Safety Act supersedes any act, regulation, 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 Certificated Engineer seeks advice from knowledgeable and experienced specialists if the slightest doubt exists that safety and sustainability cannot be guaranteed.
Range statement for Outcomes 6 and 7: Impacts and regulatory requirements include: a) both explicit regulated factors and those that arise in the course of particular work b) impacts considered extend over the lifecycle of the project and include the consequences of the technologies applied c) effects to be considered include direct and indirect, immediate and long-term related to the technology used d) safe and sustainable materials, components and systems e) regulatory requirements that are explicit for the context in general.	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 and are identified and studied by the Certificated Engineer before starting the work. b) The Competent/Responsible Person appointed in accordance with the OHS Act usually confirms or checks that the instructions are in line with regulations. The Certificated Engineer is responsible to see that this is done, and if not, he/she establishes which regulations apply and ensures that they are adhered to. Usually, the people working on site are strictly controlled w.r.t. health and safety, but the Certificated Engineer 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

3. Outcomes to be satisfied:	Explanation and responsibility level
	be avoided and safety measures like barricading and warning signs must be used and maintained. c) Effects associated with risk management are mostly well known if not obvious, and methods used to address, clearly defined. Risks are mostly associated with elevated structures, subsidence of soil, electrocution of people and moving parts on machinery. The Certificated Engineer needs to identify, analyse and manage any long -term risks, and develop strategies to solve these by using alternative technologies. d) The safe and sustainable materials, components and systems must be selected and prescribed by the Certificated Engineers, or other professional specialists must be consulted. It is the Certificated Engineer's responsibility to use his/her knowledge and experience to confirm that prescriptions by others are correct and safe. e) Application of regulations associated with the particular aspects of the project must be carefully identified and controlled by the Certificated Engineer.
Group D: Exercise judgment, take responsibility, and act ethically	**Explanation and Responsibility Level**
Outcome 8: Conduct engineering activities ethically.	**Responsibility level E** Ethically means "science of morals; moral soundness". Moral means "moral habits; standards of behaviour; principles of right and wrong".
Assessment criteria: Sensitivity to ethical issues and the adoption of a systematic approach to resolving these issues is expected, typified by: 8.1 conversance and operation in compliance with ECSA's Rules of Conduct for registered persons confirmed	Systematic means "methodical; based on a system". 8.1 ECSA's Code of Conduct, as per ECSA's website, is known and adhered to.

3. Outcomes to be satisfied:	Explanation and responsibility level
8.2 how ethical problems and affected parties were identified, and the best solution to resolve the problem selected.	8.2 Ethical problems that can occur include tender fraud, payment bribery, alcohol abuse, sexual harassment, absenteeism, favouritism, defamation, fraudulent overtime claims, fraudulent expenses claimed, fraudulent qualifications, misrepresentation of facts, etc.
Outcome 9: Exercise sound judgement in the course of broadly defined engineering activities.	**Responsibility Level E** Judgement means “good sense: ability to judge”.
Assessment criteria: Judgement is displayed by the following performance: 9.1 Judgement exercised in arriving at a conclusion within the application of technologies and their interrelationship to other disciplines and technologies. 9.2 Factors taken into consideration given, bearing in mind, risk, consequences in technology application and affected parties.	9.1 The extent of a project given to a junior Certificated Engineer is characterised by 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	In Engineering about 5% of engineering activities can be classified as broadly defined where the Certificated Engineer 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 by the following: 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.

3. Outcomes to be satisfied:	Explanation and responsibility level
c) ranges of interested and affected parties with widely varying needs.	c) Interested and affected parties with defined needs that may be in conflict, e.g., need for a service irrespective of environmental damage, local traditions and preferences, etc. needs sound management and judgement.
Outcome 10: Be responsible for making decisions on part or all of all of one or more broadly defined engineering activities.	**Responsibility level E** Responsible means "legally or morally liable for carrying out a duty; for the care of something or somebody in a position where one may be blamed for loss, failure, etc.".
Assessment criteria: Responsibility is displayed by the following performance: 10.1 Engineering, social, environment and sustainable development taken into consideration in discharging responsibilities for significant parts of one or more activities. 10.2 Advice sought from a responsible authority on matters outside area of competence. 10.3 Academic knowledge of at least BTech level combined with past experience used in formulating decisions.	10.1 All interrelated factors taken into consideration are indicative of professional responsibility accepted working on broadly defined activities. 10.2 The Certificated Engineer does not operate on tasks at a higher level than broadly defined and consults professionals at engineer level if elements of the project to be done are beyond his/her education and experience, e.g., power system stability. 10.3 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, form an important element. The calculations, for example fault levels, load calculations, losses, etc. are done to ensure that the correct material and components are utilised.
Range statement: Responsibility must be discharged for significant parts of one or more broadly defined engineering activities.	The responsibility is mostly allocated within a team environment with an increasing designation as experience is gathered.
Note 1: Demonstrating responsibility would be under supervision of a competent engineering practitioner but he/she is expected to perform as if he/she is in a responsible position.	

3. Outcomes to be satisfied:	Explanation and responsibility level
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 in regard to 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 be in charge of experiential development towards Professional Certificated Engineer level.
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 some training department. It is up to the Certificated Engineer to manage his/her own experiential development. Certificated Engineers 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 Certificated Engineer is vital to his / her success. Information is readily available, and most senior personnel in the workplace are willing to mentor, if approached.