

A photograph of a multi-story building under construction. A concrete pump truck with a long, articulated boom is positioned on the right, pouring concrete into the structure. A yellow tower crane stands in the background. The building's concrete frame is visible, with red rebar protruding from the upper levels. The sky is clear and blue.

ENSURING THE EXPERTISE TO GROW SOUTH AFRICA

**Sub Discipline-specific Training Guideline for Candidate Certificated
Engineers (Factories)**

R-05-FE-PCE

REVISION No. 0: 09 February 2022

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 2 of 46

TABLE OF CONTENTS

DEFINITIONS	3
ABBREVIATIONS	5
1. PURPOSE OF THIS DOCUMENT	6
2. AUDIENCE	7
3. PERSONS NOT REGISTERED AS CANDIDATES OR NOT BEING TRAINED UNDER C&U	10
4. ORGANISATIONAL FRAMEWORKS FOR OCCUPATION	11
5. NATURE AND ORGANISATION OF THE INDUSTRY	14
5.1 Investigation and problem analysis	15
5.2 Design and manufacturing	17
5.3 Operations and maintenance	18
5.4 Research and development	18
5.5 Risk management and impact mitigation.....	18
6. DEVELOPING COMPETENCY: DOCUMENT R-08-PCE	19
6.1 Contextual knowledge.....	19
6.2 Functions performed.....	20
6.3 Statutory and regulatory requirements	21
6.4 Desired formal learning.....	23
7. PROGRAMME STRUCTURE AND SEQUENCING	24
7.1 Best practice	24
7.2 Realities.....	25
7.3 Generalists, specialists, researchers and academics.....	25
7.4 Orientation requirements	25
7.5 Moving into or changing candidacy programmes	25
7.6 Compulsory discipline-specific requirements to be met during the candidacy	26
REVISION HISTORY	28
APPENDIX A: Training Discipline-specific Requirements Report	30
APPENDIX B: Training Elements	32

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Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 3 of 46

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 a problem 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

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Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 4 of 46

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

(e) maintain 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 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 Level 5 related to an identified need to protect the public safety, health and interest or the environment, in relation to an engineering activity.

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Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 5 of 46

ABBREVIATIONS

AC	Alternating current
C&U	Commitment and Undertaking
CPD	Continuous Professional Development
ECSA	Engineering Council of South Africa
FIDIC	International Federation of Consulting Engineers
GCC	Government Certificate of Competence
HVAC	Heating, Ventilating and Air-Conditioning
ICMEESA	Institution of Certificated Mechanical and Electrical Engineers, South Africa
IPD	Initial Professional Development
SAIEE	South African Institute of Electrical Engineers
SAIMechE	South African Institution of Mechanical Engineering
SCADA	Supervisory Control and Data Acquisition
VA	Voluntary Association

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Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 6 of 46

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.

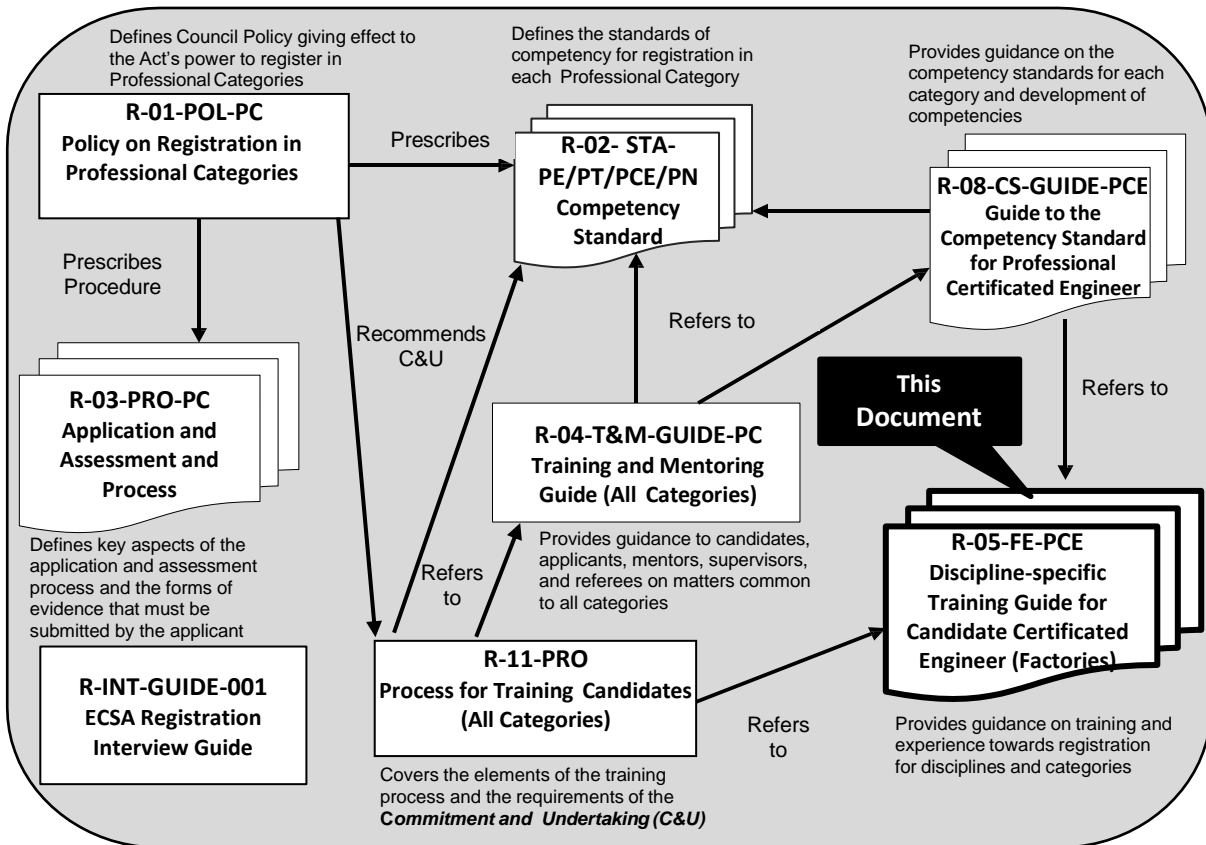


Figure 1: Documents defining the ECSA Registration System


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

This document supplements the *Training and Mentoring Guide for Professional Categories (R-04-T&M-GUIDE-PC)*, *Guide to the Competency Standards for Registration as a Professional*

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Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 7 of 46

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 DSTG, **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-POL-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

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Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 8 of 46

- 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	1. Electrical Engineer's Certificate of Competency issued in terms of the Mines Health and Safety Act 2. Electrical Engineer's Certificate of Competency issued in terms of the Occupational Health and Safety Act 3. Mechanical Engineer's Certificate of Competency issued in terms of the Mines Health and Safety Act 4. Mechanical Engineer's Certificate of Competency issued in terms of the Occupational Health and Safety Act 5. Manager's Certificate of Competency (Metalliferous) issued in terms of the Mines Health and Safety Act 6. Manager's Certificate of Competency (Coal) issued in terms of the Mines Health and Safety Act 7. Chief Marine Engineer Officer Class 1 Certificate of Competency issued in terms of the Merchant Shipping Act	3 years	1 year
Notes:	a) Training and experience must incorporate legal requirements stipulated in laws, regulations and standards applicable. b) Training and experience must incorporate practical requirements executed to meet any legal requirements applicable to the particular legal appointment.		

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Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 9 of 46

Pathway	Qualification	Post qualification total training and experience in the specific sub-discipline	Post qualification experience (part of total) with legal appointment
	<p>c) 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.</p> <p>d) 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.</p> <p>e) In the case of marine engineers, as an alternate to the specified experience above, the following will be considered: 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</p>		

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.

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Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 10 of 46

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 (VAs) 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 the policy for registration in professional categories **R-01-POL-PC**. Mature applicants for registration may apply the guide retrospectively to identify possible gaps in their development.

Applicants who have not been through a mentorship programme are advised to request an experienced mentor (internal or external) to act as an application adviser while they prepare their applications for registration. To achieve ECSA registration the trainee's employer should design the training programme to achieve the following:

- Expose the applicant to experience and training enabling the applicant 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 of achieving the duration and level detailed in **Section 7.1** of this document).

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Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 11 of 46

- 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 A**, and the discipline specific requirements referred to **Section 7.6**.

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**).

4. ORGANISATIONAL FRAMEWORKS FOR OCCUPATION

Certificated Engineers (Factories) Organising Framework for Occupations (OFO)


Certificated Engineers undertake the planning, design, construction, operation and maintenance of materials, components, plant and equipment or processes through the application of engineering sciences: applied mechanics, strengths of materials and structures, thermodynamics, fluid mechanics, electrical technology, energy management, power transmission, industrial electronics and digital technology, power machines, mechatronics and mechanical technology.

Candidate Certificated Engineers must be knowledgeable and experienced with the following plant, equipment, practices and processes at factories with emphasis on the general design, layout, production capacity, reticulation, energy requirements, motion characteristics, economic operation, efficiency testing, commissioning, asset lifecycle management, maintenance, safety precautions and safety devices and equipment.

- Legal liability and responsibility associated with the operation and maintenance of machinery as a competent person appointed (Regulation GMR 2.1 or 2.7) in terms of the Occupational Health and Safety Act, 85 of 1993 and the assurance of compliance with this legislation and related regulations.
- Risk management including base-line risk assessment, accident prevention, management of safe work permit system.
- Sound engineering principles by establishing control standards and procedures to ensure efficient functioning and safety of machines, machinery, tools, motors, engines, industrial plant, equipment or systems and ensuring that equipment operation and maintenance comply with design specifications and safety standards.

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Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 12 of 46

- Facilities management including buildings, roads and parking lots, roofing structures, flooring surfaces, thermal building installation, heating ventilating and air-conditioning (HVAC), emergency power, illumination, energy and water management, sanitation and housekeeping.
- Organisation of the plant engineering function with respect to principles of maintenance, classification of maintenance work, work identification, asset lifecycle management, inventory control and maintenance spare parts, training and other human resources (HR) tasks, management of security measures, budgeting and cost control, workshop organisation, maintenance and repair technology.
- Project engineering including planning (Gantt charts), management (critical path scheduling), commissioning and development of a planned maintenance scheme, loss control management, incident investigations and corrective actions.
- Electrical plant and equipment including power generation, transmission and distribution, transforming, rectification, control and measurement, testing and repairing of electric motors, phasing and synchronising AC motors operating in tandem, motor control, fault detection in electric systems, emergency and standby electric plant, explosion-proof equipment, measuring instruments, automatic control and SCADA systems.
- Hydraulics including hydrostatic drives-classification and characteristics, hydraulic pumps, actuators and circuits for sequence operation; general properties of lubricants and additives to lubricants (oil and grease), lubrication systems and pneumatic systems.
- Mechanical power transmission including gears and gear drives, bearings, shaft drives and flexible couplings, belt and chain drives and fluid seals.
- Material handling equipment including planning, containerisation, mobile equipment, conveyors, robotics, and warehouse and storage.
- Pressure equipment and plant including boiler, super heater and economiser efficiencies, turbines, vessels under pressure inspection and testing, steam ancillary equipment and pipe systems; maintenance and fault diagnosis of compressors, refrigeration compressor and systems; heat transfer and thermal properties of materials, pumps, pump stations and fluid mechanics; gas fuel system maintenance and safety, piping systems design and valves.
- Factory equipment and plant including lifting and conveying machinery, i.e., lifts, belt conveyors, aerial ropeways, lift trucks, steel rope, chains and connections, welders, heat treatment plant, lathes, drills, the maintenance, inspection and testing and repairs of all typical machinery used in factories; flammable and hazardous substance environments, machinery and equipment.

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Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 13 of 46

- Strengths and structures of plant including steel structures (stresses), beams, mechanical properties of fabrication materials, heat treatment and application of steel alloys and manufactured products (i.e., nylons), abrasion and protection of structures (steel and other materials); utilisation of concrete, reinforcement, composite beams, curing, chemical protection and wear, causes of corrosion and deterioration of systems, paints and protective coatings.
- Environmental engineering including ventilation systems, plant pressurisation systems, air-conditioning systems, dust suppression, emission control of diesel engines, occupational noise originated by machines and hearing protection, vibration suppression, illumination types, water treatment and cooling systems, environmental impact assessments, effects and efficiencies.
- Safety equipment and systems includes machine guarding, automatic control systems, detection systems, safety precautions and safety devices as found and used on all types of machines, process safety equipment, toxic substances and radiation hazards.
- Fire prevention equipment and systems, flammable and hazardous substance plants and continuous plants.
- The duties of the responsible engineer and his or her staff include having 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 or her staff are also 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 that 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.

It must be emphasised that the Factories Plant Certificated Engineer is a multi-disciplined generalist with the legal responsibility to ensure plant and equipment are safely operated and maintained through training, experience, qualification and certification.

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Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 14 of 46

5. NATURE AND ORGANISATION OF THE INDUSTRY

Professional Certificated Engineers may be employed in both the private and the public sectors and have legal appointments as competent persons.

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


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

An extension of the public sector would include tertiary academic institutions and research organisations. Depending on where the candidate is employed, in-house opportunities may be insufficiently diverse to develop all the competencies required in both Groups A and B noted in document **R-02-PE/PT/PCE/PN**. For example, the opportunity to develop problem solving competence (including design or developing solutions) and to manage engineering activities (including implementing or constructing solutions) may not both be available to the candidate. In such cases, employers are encouraged to appoint an external mentor.

It has been fairly common practice that where an organisation is unable to provide training in certain areas, secondments are arranged with other organisations so that the candidate is able to develop all the competencies required for registration.

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Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 15 of 46

These secondments are usually reciprocal in nature so both employers and their employees get mutual benefit from the other party. Secondments between consultants and contractors, and between the public and private sectors should be possible.

5.1 Investigation and problem analysis

Problem solving in design, operational, maintenance, construction and research environment is the core of engineering. A logical thinking process requires Certificated Engineers to apply their minds diligently in bringing solutions to technical, broadly defined problems. This process involves the analysis of systems or assembly of plant equipment components and integration of various elements in mechanical and electrical engineering through the application of basic and engineering sciences.


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

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

Applicants 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 design report that should accompany the application. This report should describe a synthesised solution to sufficiently broadly defined engineering problems to demonstrate that applicants have had an opportunity to apply their technical knowledge and engineering expertise gained through university education and practical work experience. In applying technical and scientific knowledge gained through academic training, the applicant must also demonstrate the financial and economic benefits of engineered solutions synthesised from scientific and engineering principles at a sufficiently advanced level.

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Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 16 of 46

What is a sufficiently broadly defined engineering problem?

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

“Composed of many *inter-related conditions*; requiring *underpinning methods, procedures and technical judgment* to create a solution within a set of *originally broadly defined circumstances*.”

Plant engineering forms an integral part of broader engineering systems and infrastructure in technologically complex manufacturing, processing, construction, product development and research environments. Applicants are required to undertake diverse 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 plant engineering, ranging from fluid systems, processes and energy systems to structures, asset management and plant and equipment.


The design is a logical thinking process that requires Certificated Engineers to apply their minds carefully in bringing solutions to technically broadly defined problems. This process involves the analysis of systems or assembly of plant and equipment components and integration of various elements and processes through the application of basic and engineering sciences.

Simple, straightforward calculation exercises and graphical representations from computer-generated data are not considered as sufficiently broadly defined engineering designs because anybody with qualifications in basic science and engineering science could perform this kind of work, whereas professional registration requires advanced application of engineering knowledge in broadly defined design problems.

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

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 17 of 46

Candidate Certificated Engineers must obtain experience in solving a variety of problems in their work environment, and the solution to these problems should involve the use of fundamental and advanced plant engineering knowledge obtained at a tertiary educational institution. The problems that require scientific and engineering approach to solve 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 of synthesising solutions to real-life engineering problems encountered in the workplace.

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

5.2 Design and manufacturing


Examples of acceptable designs, development and manufacturing would include but are not limited to the following:

- Broadly defined electrical systems, mechatronics, automation and illumination
- 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 and plant layout
- Broadly defined material transfer and storage systems.

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, steam generating plant and auxiliary equipment, broadly defined refrigeration systems, petrochemical and other production, manufacturing plant systems and the like.

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 18 of 46

5.3 Operations and maintenance

Operations and maintenance would mostly deal 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 will also involve the improvement projects necessary for optimising the operational efficiencies. The Candidate Certificated Engineer when performing the aforementioned work must apply professional engineering judgment to all work done in the management of operations. This would include but would not be limited to the ability to assess design work against the following criteria:

- conformance to design specifications
- conformance to health and safety regulations
- ease of fabrication and assembly
- constructability
- maintainability
- conformance to environmental requirements
- ergonomic considerations
- life cycle costs
- fit for purpose, and/or
- alternative solutions.

5.4 Research and development


This type of work may be performed in research and product development centres of business organisations or at the academic institutions. Candidates must undertake research and development work that is predominantly plant engineering in nature, and this work must include an in-depth application of the various aspects of electrical and mechanical engineering, including operation and maintenance of equipment, and product or system testing under controlled experimental conditions.

5.5 Risk management and impact mitigation

The potential impact of ethically bound and evaluated Certificated Engineers, who are professionally registered and conducting their daily duties in a prescribed manner is incalculable. Their proactive identification of potential hazards and risks/incidents will definitely lead to fewer incidents/accidents, as well as minimising loss of life and injury and lost productivity with a reduction in environmental impacts.

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 19 of 46

The following steps should be considered when performing broadly defined plant engineering tasks:

- Risk management process during project management or plant operation or performing any engineering task by considering social, cultural, environmental, legal and regulatory requirements.
- Certificated Engineers may be involved in risk management, identification and analysis within the plant, system or project life cycle.
- Undertake risk assessments prior to conducting plant maintenance, test work, installations, renovations, demolition or operations.
- Compile risk assessment plans, risks registers, risk mitigation plans and work permits.
- Use risk analysis tools to undertake risk impact analysis and develop impact mitigation strategies.
- Consider risk attributes or factors during risk assessments such as cost, programme, quality, labour, profitability, logistics, political, social, cultural and environmental, legislation, technology, etc.
- In process safety engineering, consider inherent safety risk during risk response and control processes.
- Compile risk management stakeholder and communication plan.
- Undertake statutory review and compliance

6. DEVELOPING COMPETENCY: DOCUMENT R-08-PCE


6.1 Contextual knowledge

Candidates are expected to be aware of the requirements of the engineering profession. The VAs applicable to Certificated Engineers and their functions and services to members, for example, provide a broad range of contextual knowledge for the Candidate Certificated Engineer through the Professional Certificated Engineer's full career path.

The profession identifies specific contextual activities considered essential to the development of the Certificated Engineer's competence. These include awareness of basic workshop, manufacturing and fabrication activities and the competencies required of the engineer, technologist, technician and artisan. Exposure to practice in these areas will be identified in each programme within the employer environment.

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 20 of 46

ECSA's Professional Certificated Engineer Registration peer evaluation process carries out the assessment, review and moderation of the candidate's portfolio of evidence at the completion of the training period.

6.2 Functions performed

Special consideration in the discipline, sub-discipline or specialty must be given to the competencies specified in the following groups as described in the Degree of Responsibility scales in document **R-04-T&M-GUIDE-PC**:

- Group A: Knowledge based problem solving (this should be a strong focus)
- Group B: Management and communication
- Group C: Identifying and mitigating the impacts of engineering activity
- Group D: Judgement and responsibility
- Group E: Independent learning.


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

Appendix B has been developed against the Degree of Responsibility Scale. Activities should be selected to ensure the candidate reaches the required level of competency and responsibility. It should be noted that the candidate working at Degree of Responsibility Level E carries the responsibility appropriate to that of a registered person except that the candidate's supervisor is accountable for the candidate's recommendations and decisions. The nature of work and degrees of responsibility defined in document **R-04-T&M-GUIDE-PC** are used here (and in **Appendix B** below):

A: Being Exposed	B: Assisting	C: Participating	D: Contributing	E: Performing
Undergoes induction, observes processes and work of competent practitioners.	Performs specific processes, under close supervision.	Performs specific processes as directed with limited supervision.	Performs specific work with detailed approval of work outputs.	Works in team without supervision, recommends work outputs; responsible but not accountable.

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 21 of 46

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 candidate must identify at which level of responsibility an activity provides the compliance with and demonstration of the various outcomes. Evidence of the candidate's activities and acceptance by the mentor will be recorded on the appropriate system such that it meets the requirements of the Training Elements **Appendix A**. ECSA specifies the applicable recording system.


6.3 Statutory and regulatory requirements

Candidates are expected to have a thorough knowledge of the Occupation Health and Safety Act, 85 of 1993, as amended, as this is a requirement for the Engineer's Certificate of Competency, and have a working knowledge of the following regulations and Acts and how they affect their working environment:

- Engineering Profession Act, 46 of 2000
- Engineering Council of South Africa – its Rules and the Code of Conduct
- Basic Conditions of Employment Act, 75 of 1997
- Carbon Tax Act, 15 of 2019
- Compensation for Occupational Injuries and Diseases Act, 130 of 1993
- Electricity Regulation Act, 4 of 2006
- Employment Equity Act, 55 of 1998
- Environment Conservation Act, 73 of 1989, as amended
- Mine Health and Safety Act, 29 of 1996
- Industry Specific Work Instructions
- South Africa Bureau of Standards (SABS) Act 24 of 1945; Act 29 of 2008
- SANS 10248, 1023: Waste Classification and Management Regulations from South Africa
- Constitution Act, 108 of 1996
- Hazardous Substances Act, 5 of 1973

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 22 of 46

- Labour Relations Act, 66 of 1995
- National Building Regulations and Building Standards Act, 103 of 1977, as amended and the SANS 10400 (SABS 0400) – Code of Practice for the application of the National Building Regulations
- National Energy Act, 34 of 2008
- National Environmental Management Act, 107 of 1998
- National Environmental Management: Air Quality Act, 39 of 2004
- National Environmental Management: Biodiversity Act, 10 of 2004
- National Environmental Management: Waste Act, 59 of 2008
- National Health Act, 61 of 2003
- National Radioactive Waste Disposal Institute Act, 53 of 2008
- National Road Traffic Act, 85 of 1993
- National Nuclear Regulator Act, 47 of 1999
- Nuclear Energy Act, 46 of 1999
- National Water Act, 36 of 1998
- Applicable SANS and other international standards such as ISO, EN, DIN or US Federal Standards
- SANS Codes incorporated by section 44 of the Occupation Health and Safety Act, 85 of 1993 and Regulations
- Fire Protection Standard SANS Code 10139: 2012 for fire detection and alarm systems for buildings – system design, installation and servicing
- The Wiring of Premises – SANS 10142 – Part 1: Low-voltage installations
- The Wiring of Premises – SANS 10142 – Part 2: Medium-voltage installations above 1 kV a.c. not exceeding 22 kV a.c. and up to and including 3 MVA installed capacity
- ISO 9001: 2015 – Quality management system
- ISO 45001:2018 – Occupational health and safety management systems – Requirements with guidance for use
- Project and Construction Regulations Management Professions Act, 48 of 2000
- Water Services Act, 108 of 1997.

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 23 of 46

Other Acts not listed here may also be pertinent to a candidate's work environment. Candidates are expected to have a basic knowledge of the applicable Acts and to investigate whether any Acts are applicable in the particular work environment.


6.4 Desired formal learning

Candidate Certificated Engineers should register with the relevant VA to access lists of training, conferences and seminars and other relevant information. The following list of formal learning is a sample of some useful course types:

- CPD courses on specific disciplines
- Occupation health and safety legal liability
- Asset life cycle management
- Project management
- Value engineering
- Standard conditions of contract: NEC, FIDIC, GCC etc.
- Preparation of specifications
- Negotiation skills
- Engineering finance
- Risk analysis
- Quality systems
- Energy efficiency
- Water management and treatment
- Maintenance engineering
- Environmental impacts management
- Engineering management
- Technical report writing
- Professional skills report writing and communication planning methods
- Computers and IT knowledge
- Construction regulations
- Problem solving and analysis tools.

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 24 of 46

7. PROGRAMME STRUCTURE AND SEQUENCING

7.1 Best practice

Best practice is a developmental process that assists candidates to register as Professional Certificated Engineers. Best practice comprises the process for the candidate's continuous development. A number of courses (technical and managerial) must be attended to gain the Initial Professional Development (IPD) points required for registration. This is in addition to on-the-job learning at the organisation where the candidate is employed. Refer to the Institution of Certificated Mechanical and Electrical Engineers (ICMEESA), the South African Institute of Mechanical Engineers (SAIMechE), or South African Institute of Electrical Engineers (SAIEE) for best practice ideas. Candidates may register with these bodies to gain access to courses, articles and relevant information for their development. This may also extend to the opportunity to meet with experts during seminars.

It is suggested that Candidate Certificated Engineers work with their mentors to select appropriate plant and equipment types to gain exposure to eventual responsibility, such as inspection and load testing on the lifting machines, boiler inspections, other statutory inspections, etc. A regular reporting structure with suitable recording of evidence of achievement against the competency outcomes and responsibility should be in place.


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

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

The training programme should be such that the candidate progresses through levels of work capability that are described in document **R-04-T&M-GUIDE-PC**, so that by the end of the training period, the candidate must perform individually and as a team member at the level of problem solving and engineering activity required for registration and exhibit Degree of Responsibility Level E.

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 25 of 46

7.2 Realities

Generally, irrespective of the discipline, it is unlikely that the training period 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 described in document **R-08-CS-GUIDE-PCE**.

7.3 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, inspectors and those who have not followed a candidate training programme.

The overriding consideration is that, irrespective of the route followed, the applicant must provide evidence of competence against the standard.

7.4 Orientation requirements


- Company Safety Regulations
- Company Code of Conduct
- Company Staff Code and Regulations
- Company records and record-keeping
- Typical functions and activities in the company
- Hands-on experience and orientation in each of the major company divisions.

7.5 Moving into or changing candidacy programmes

This DSTG assumes that Candidate Certificated Engineers enter a programme after attaining the Certificate of Competency and after holding a legal appointment as noted in section 2 of this document and continue with the programme until ready to submit an application for registration. It assumes that candidates are supervised and mentored by persons who meet the requirements in document **R-04-T&M-GUIDE-PC**. In the case of a person changing from one candidacy programme

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 26 of 46

to another or moving into a candidacy programme from a less structured environment, it is essential that the following steps be completed:

- The candidate must complete the Training and Experience Summary (TES) and Training and Experience Reports (TERs) for the previous programme or unstructured experience. In the latter case it is important to reconstruct the experience as accurately as possible. The TERs must be signed off.
- On entering the new programme, the mentor and supervisor should review the candidate's development while being mindful of the experience and opportunities and requirements of the new programme and plan at least the next phase of the candidate's programme.

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

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


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 also assessed to confirm legal responsibility, also at Level E.

While the emphasis in 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 the **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.

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 27 of 46

Applications for Professional Certificated Engineers must submit the Discipline-specific Requirements Report (DSRR) form **R-05-DSRR-PCE**.

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 28 of 46

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 A	30 July 2021	Draft DSTG for Candidate Certificated Engineers (Factories) separated from these disciplines: R-05-MW-PCE, R-05-ME-PCE and R-05-MM-PCE	Working Group and RPS BU
Rev. 0 draft B	11 August 2021	Final Draft Reviewed	RPS BU
Rev. 0 draft C	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

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 28 of 45

The Discipline-specific Training Guide for:

Candidate Certificated Engineers (Factories)

Revision 0 dated 09 February 2022 and consisting of 28 pages, has been reviewed for adequacy by the Business Unit Manager and is approved by the Executive: Research, Policy and Standards (RPS).



Business Unit Manager

09/03/2022

Date



Executive: RPS


2022/03/09

Date

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

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 30 of 46

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	

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 31 of 46

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.	

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 32 of 46

APPENDIX B: Training Elements

Synopsis: A Candidate Certificated Engineer 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 is not available.
10. Accept responsibility for own work by using theory to support decisions, seeking advice when uncertain and evaluating shortcomings.
11. Become conversant with your employer's training and development 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.

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 33 of 46

Competency standards for registration as a Professional Certificated Engineer	Explanation and responsibility level
<p>1. Purpose</p> <p>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.</p>	<p>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).</p> <p>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).</p>
<p>2. Demonstration of competence</p> <p>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.</p> <p>Level descriptor: Broadly defined engineering activities (BDEAs) have several of the following characteristics:</p> <p>a) Scope of practice area is linked to technologies used and changes by adoption of new technology into current practice.</p> <p>b) Practice area is located within a wider, complex context, requires teamwork and has interfaces with other parties and disciplines.</p> <p>c) Involve the use of a variety resources, including people, money, equipment, materials, technologies.</p>	<p>Engineering activities can be divided into (approximately):</p> <ul style="list-style-type: none"> • 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) <p>The activities can be in-house or contracted out; evidence of integrated performance can be submitted irrespective of the situation.</p> <p>Level Descriptor: BDEAs in the various disciplines are characterised by several of or all the following:</p> <p>a) Scope of practice area does not cover the entire field of the discipline (exposure limited to the sub-discipline and specific workplace). Some technologies used are well established and adoption of new technologies needs investigation and evaluation.</p>

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 34 of 46

<p>d) Require resolution of occasional problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues.</p> <p>e) Are constrained by available technology, time, finance, infrastructure, resources, facilities, standards and codes, and applicable laws.</p> <p>f) Have significant risks and consequences in the practice area and in related areas.</p> <p>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.</p>	<p>b) 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.</p> <p>c) The bulk of the work involves familiar, defined range of resources, including people, money, equipment, materials, but new technologies are investigated and implemented.</p> <p>d) Most of the impacts in the sub discipline are on wider issues, but some arise from conflicting technical and engineering issues that have to be addressed by the application of broadly defined non-standard engineering principles.</p> <p>e) The work packages and associated parameters are constrained by operational context with variations limited to different locations only. (Cannot be covered by standards and codes.)</p> <p>f) Even locally important minor risks can have far reaching consequences.</p> <p>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.</p>
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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 35 of 46

3. Outcomes to be satisfied:	Explanation and responsibility level
Group A: Engineering Problem Solving	
Outcome 1: Define, investigate and analyse <i>broadly defined</i> engineering problems.	<p>Responsibility Level E</p> <p>Analysis of an engineering problem means the “separation into parts possibly with comment and judgement”.</p> <p><i>Broadly</i> means “not minute or detailed” and “not kept within narrow limits”.</p>
<p><i>Broadly defined engineering problems have the following characteristics:</i></p> <p>a) Require coherent and detailed engineering knowledge, underpinning the technology area <i>and one or more of:</i></p> <p>b) Are ill-posed, under- or over-specified, require identification and interpretation into the technology area</p> <p>c) Encompass systems within complex engineering systems</p> <p>d) Belong to families of problems that are solved in well-accepted but innovative ways <i>and one or more of:</i></p> <p>e) Can be solved by structured analysis techniques</p> <p>f) May be partially outside standards and codes; must provide justification to operate outside</p> <p>g) Require information from practice area and sources interfacing with practice area that is complex and incomplete</p>	<p>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.</p> <p>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.</p> <p>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.</p> <p>d) Recognise that the problem can be classified as a falling within a typical solution requiring innovative adaptation to meet the specific situation.</p> <p>e) Solving the problem needs a step-by-step approach adhering to proven logic.</p> <p>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.</p> <p>g) 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.</p>

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 36 of 46

3. Outcomes to be satisfied:	Explanation and responsibility level
<p>h) Involve a variety of issues which may impose conflicting constraints: technical, engineering and interested or affected parties <i>and one or both of:</i></p> <p>i) Require judgement in decision-making in practice area, considering interfaces to other areas</p> <p>j) Have significant consequences which are important in practice area but may extend more widely.</p>	<p>h) 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.</p> <p>i) Practical solutions to problems include knowledge and judgement of the roles displayed by the multi-disciplinary team and impact of own work in the interactive environment.</p> <p>j) 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.</p>
<p>Assessment criteria: A structured analysis of broadly defined problems typified by the following performances is expected:</p> <p>1.1 Performed in or contributed to defining engineering problems leading to an agreed definition of the problems to be solved.</p> <p>1.2 Performed in or contributed to investigating engineering problems including collecting, organising and evaluating information.</p> <p>1.3 Performed in or contributed to analysis of engineering problems using conceptualisation, justified assumptions, limitations and evaluation of results.</p>	<p>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:</p> <p>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</p> <p>1.2 segregate the engineering problem and related information from the bulk of the information investigated and evaluated</p> <p>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.</p>
<p>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</p>	<p>Please refer to clause 4 of the specific DSTG.</p>

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 37 of 46

3. Outcomes to be satisfied:	Explanation and responsibility level
understanding of a problem: Outcome 2 is concerned with the solution.	
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”.
<p>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:</p> <p>2.1 Designed or developed solutions to broadly defined engineering problems.</p> <p>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.)</p> <p>2.3 Drawing up of detailed specification requirements and design documentation for implementation to the satisfaction of the client.</p>	<p>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:</p> <p>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.</p> <p>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 for the alternative recommended. Selection of alternatives might be based on tenders submitted with alternatives deviating from those specified.</p> <p>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.</p>
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

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 38 of 46

3. Outcomes to be satisfied:	Explanation and responsibility level
	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.	<p>Responsibility level E</p> <p>Comprehend means “to understand fully”.</p> <p>The jurisdiction in which a Certificated Engineer practices is given in clause 4 of the specific DSTG.</p>
<p>Assessment criteria: This outcome is normally demonstrated in the course of design, investigation or operations.</p> <p>3.1 Applied engineering principles, practices, technologies, including the application of BTech theory in the practice area.</p> <p>3.2 Indicated working knowledge of areas of practice that interact with practice area to underpin teamwork.</p> <p>3.3 Applied related knowledge of finance, statutory, safety and management.</p>	<p>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 incidents and condition monitoring, and operations mostly on developing and improving engineering systems and operations.</p> <p>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.</p> <p>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.</p> <p>3.3 The ability to manage the resources within legal and financial constraints must be evident.</p>

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 39 of 46

3. Outcomes to be satisfied:	Explanation and responsibility level
<p>Range statement: Applicable knowledge includes the following:</p> <p>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.</p> <p>b) A working knowledge of interacting disciplines (engineering and other) to underpin teamwork.</p> <p>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.</p>	<p>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.</p> <p>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.</p> <p>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.</p>
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”.
<p>Assessment criteria: The candidate is expected to display personal and work process management abilities:</p> <p>4.1 Managed self, people, work priorities, processes and resources in broadly defined engineering work.</p> <p>4.2 Role in planning, organising, leading and controlling broadly defined engineering activities evident.</p>	<p>In engineering operations, Certificated Engineers will typically be given the responsibility to carry out projects.</p> <p>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.</p>

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 40 of 46

3. Outcomes to be satisfied:	Explanation and responsibility level
4.3 Knowledge of conditions and operation of contractors and the ability to establish and maintain professional and business relationships evident.	<p>4.2 The basic elements of management must be applied to broadly defined engineering work.</p> <p>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.</p>
Outcome 5: Communicate clearly with others in the course of his or her broadly defined engineering activities	Responsibility Level C
<p>Assessment criteria: Demonstrates effective communication by:</p> <p>5.1 ability to write clear, concise, effective technical, legal and editorially correct reports shown</p> <p>5.2 ability to issue clear instructions to stakeholders using appropriate language and communication skills evident</p> <p>5.3 oral presentations made using structure, style, language, visual aids and supporting documents appropriate to the audience and purpose.</p>	<p>5.1 Refer to Range Statement for Outcome 4 and 5 below.</p> <p>5.2 Refer to Range Statement for Outcome 4 and 5 below.</p> <p>5.3 Presentation of point of view mostly occurs in meetings and discussions with immediate supervisor.</p>
<p>Range statement for Outcomes 4 and 5: Management and communication in well-defined engineering involves:</p> <p>a) Planning broadly defined activities</p> <p>b) Organising broadly defined activities</p> <p>c) Leading broadly defined activities</p> <p>d) Controlling broadly defined activities.</p>	<p>a) Planning means “the arrangement for doing or using something, considered in advance”.</p> <p>b) Organising means “put into working order; arrange in a system; make preparations for”.</p> <p>c) Leading means to “guide the actions and opinions of; influence; persuade”.</p> <p>d) Controlling means the “means of regulating, restraining, keeping in order; check”.</p> <p>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</p>

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 41 of 46

3. Outcomes to be satisfied:	Explanation and responsibility level
	audit reports, write commissioning reports, prepare and present motivations for new projects, compile budget reports, report on studies done and calculations carried out, report on customer requirements, report on safety incidents and risk analysis, report on equipment failure, report on proposed system improvement and new techniques, report on cost control, etc.
Group C: Impacts of Engineering Activity	Explanation and Responsibility Level
Outcome 6: Recognise the foreseeable social, cultural and environmental effects of broadly defined engineering activities generally.	<p>Responsibility level B</p> <p>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”.</p> <p>Environmental means “surroundings, circumstances, influences”.</p>
<p>Assessment criteria: This outcome is normally displayed in the course of analysis and solution of problems. The Candidate typically:</p> <p>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;</p> <p>6.2 takes measures taken to mitigate the negative effects of engineering activities evident.</p>	<p>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.</p> <p>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.</p>
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

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 42 of 46

3. Outcomes to be satisfied:	Explanation and responsibility level
<p>Assessment criteria:</p> <p>7.1 Identified applicable legal and regulatory requirements including health and safety requirements for the engineering activity.</p> <p>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.</p>	<p>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.</p> <p>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.</p>
<p>Range statement for Outcomes 6 and 7:</p> <p>Impacts and regulatory requirements include:</p> <p>a) both explicit regulated factors and those that arise in the course of particular work</p> <p>b) impacts considered extend over the lifecycle of the project and include the consequences of the technologies applied</p> <p>c) effects to be considered include direct and indirect, immediate and long-term related to the technology used</p> <p>d) safe and sustainable materials, components and systems</p> <p>e) regulatory requirements that are explicit for the context in general.</p>	<p>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.</p> <p>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 be avoided and safety measures like barricading and warning signs must be used and maintained.</p> <p>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</p>

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 43 of 46

3. Outcomes to be satisfied:	Explanation and responsibility level
	<p>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.</p> <p>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.</p> <p>e) Application of regulations associated with the particular aspects of the project must be carefully identified and controlled by the Certificated Engineer.</p>
Group D: Exercise judgment, take responsibility, and act ethically	Explanation and Responsibility Level
Outcome 8: Conduct engineering activities ethically.	<p>Responsibility level E</p> <p>Ethically means "science of morals; moral soundness".</p> <p>Moral means "moral habits; standards of behaviour; principles of right and wrong".</p>
<p>Assessment criteria: Sensitivity to ethical issues and the adoption of a systematic approach to resolving these issues is expected, typified by:</p> <p>8.1 conversance and operation in compliance with ECSA's Rules of Conduct for registered persons confirmed</p> <p>8.2 how ethical problems and affected parties were identified, and the best solution to resolve the problem selected.</p>	<p>Systematic means "methodical; based on a system".</p> <p>8.1 ECSA's Code of Conduct, as per ECSA's website, is known and adhered to.</p> <p>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.</p>
Outcome 9: Exercise sound judgement in the course of broadly defined engineering activities.	<p>Responsibility Level E</p> <p>Judgement means "good sense: ability to judge".</p>

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Document No.: R-05-FE-PCE	Revision No.: 0	Effective Date: 09/02/2022	
Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 44 of 46

3. Outcomes to be satisfied:	Explanation and responsibility level
<p>Assessment criteria: Judgement is displayed by the following performance:</p> <p>9.1 Judgement exercised in arriving at a conclusion within the application of technologies and their interrelationship to other disciplines and technologies.</p> <p>9.2 Factors taken into consideration given, bearing in mind, risk, consequences in technology application and affected parties.</p>	<p>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.</p> <p>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.</p>
<p>Range statement for Outcomes 8 and 9: Judgement in decision-making involves:</p> <p>a) taking several risk factors into account; or</p> <p>b) significant consequences in technology application and related contexts; or</p> <p>c) ranges of interested and affected parties with widely varying needs.</p>	<p>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:</p> <p>a) Getting the work done in spite of numerous risk factors needs good judgement and substantiated decision-making.</p> <p>b) Consequences are part of the project, e.g., extra cost due to unforeseen conditions, incompetent contractors, long term environmental damage, etc.</p> <p>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.</p>

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Subject: Sub Discipline-specific Training Guideline for Candidate Certificated Engineers (FACTORIES)			
Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 45 of 46

3. Outcomes to be satisfied:	Explanation and responsibility level
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.”.
<p>Assessment criteria: Responsibility is displayed by the following performance:</p> <p>10.1 Engineering, social, environment and sustainable development taken into consideration in discharging responsibilities for significant parts of one or more activities.</p> <p>10.2 Advice sought from a responsible authority on matters outside area of competence.</p> <p>10.3 Academic knowledge of at least BTech level combined with past experience used in formulating decisions</p>	<p>10.1 All interrelated factors taken into consideration are indicative of professional responsibility accepted working on broadly defined activities.</p> <p>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.</p> <p>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.</p>
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.	
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

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Compiler: MB Mtshali	Approving Officer: EL Nxumalo	Next Review Date: 09/02/2026	Page 46 of 46

3. Outcomes to be satisfied:	Explanation and responsibility level
<p>Assessment criteria: Self-development managed typically:</p> <p>11.1 Strategy independently adopted to enhance professional development evident.</p> <p>11.2 Awareness of philosophy of employer in regard to professional development evident.</p>	<p>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.</p> <p>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.</p>
<p>Range statement: Professional development involves:</p> <p>a) planning own professional development strategy</p> <p>b) selecting appropriate professional development activities</p> <p>c) recording professional development strategy and activities, while displaying independent learning ability.</p>	<p>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.</p> <p>b) Preference must be given to engineering development rather than developing soft skills.</p> <p>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.</p>

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