ENSURING THE
EXPERTISE TO GROW
SOUTH AFRICA

# Qualification Standard for

# Master of Engineering: NQF Level 9

## E-22-P

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ECSA

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## BACKGROUND

The documents that define the Engineering Council of South Africa (ECSA) system for accreditation of programmes meeting educational requirements for professional categories are shown in Figure 1 which also locates the current document.

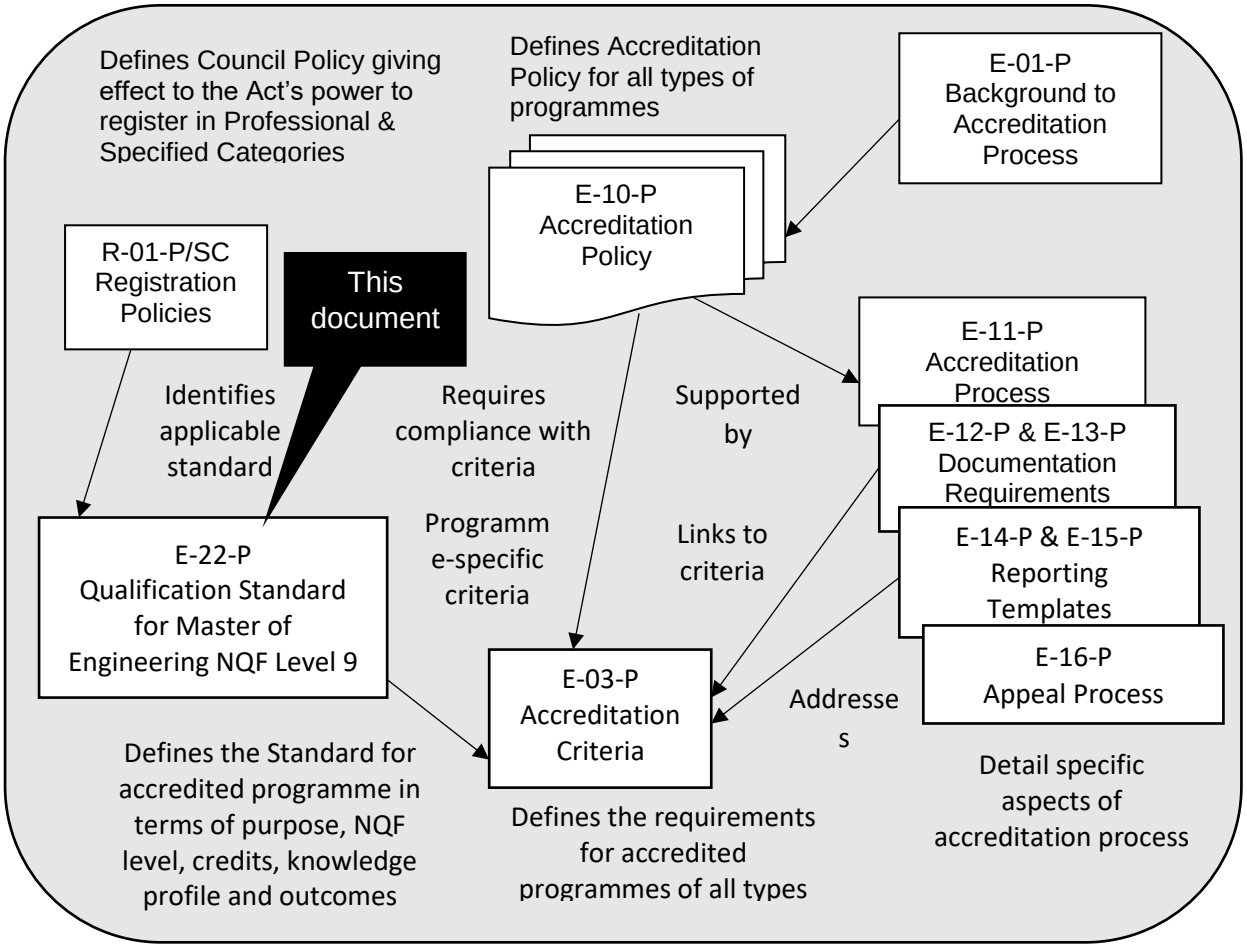


**Figure 1: Documents defining the ECSA Accreditation System**

## 1. PURPOSE OF THE QUALIFICATION

The Master of Engineering degree prepares a candidate for professional practice, enhances in-depth knowledge and understanding of the principles, specialist and contextual knowledge of a branch of engineering, cultivates a critical awareness of developments at the

forefront of the field, develops the capacity to conduct research, and meets the minimum entry requirement for admission to a NQF level 10 Doctoral Degree.

This qualification demands a high level of theoretical engagement and intellectual independence. A provider my elect to offer the Master of Engineering as part of a carefully curriculated combination of qualifications that when offered as a structured whole could be determined through a process of accreditation to meet the educational requirements for registration in the category candidate engineer. This pathway is described fully in **E-23-P**. A provider adopting this approach for their suite of qualifications on this pathway (P1.4) would need to ensure that the necessary knowledge content areas – specifically mathematics and natural science, and engineering design and synthesis – have been curriculated in such a way that on completion of this pathway, both the knowledge content areas and the developed Graduate Attributes meet or exceed the requirements of a Bachelor of Engineering qualification.

Engineering students completing this qualification will demonstrate competence in all the Graduate Attributes contained in this standard.

## 2. HEQSF AND NQF SPECIFICATION

| | |
|---|---|
| Field: | Manufacturing, Engineering and Technology |
| Sub-Field: | Engineering and Related Design |
| NQF Level: | Level 9 |
| Credits: | 180 credits total: Not less than 120 Credits shall be at NQF level 9 |
| Acceptable title: | Master of Engineering |
| Abbreviation: | MEng |

## 3. QUALIFIERS

The *qualification type* is the first name given to a qualification. The *designator* is the second name given to a qualification, to indicate its broad area of study, discipline or profession. The third name given to a qualification type is the *qualifier*.

All Degrees (Bachelor, Master and Doctor) have designators, but designators are not used for certificates and diplomas. The linking word between the qualification type and the designator is *of (e.g. Master of Engineering*), and when abbreviated the 'of' is omitted (e.g. MEng.).

The third name given to a qualification type is the qualifier. *Qualifiers* may be used in all qualification types in order to indicate a field of specialisation. The linking word between the qualification type or its designator and the qualifier is always *in* (e.g. Master of Engineering *in* Mechanical Engineering, abbreviated form: MEng. (Mechanical Engineering).

Examples of acceptable designations in accordance with HEQF policy are:
Master of Engineering in Electrical Engineering, abbreviated MEng. (Electrical Engineering)

## 4. CHARACTERISTIC PROFILE OF THE GRADUATE

- Work independently and responsibly, applying original thought and judgment to technical and risk-based decisions in *complex engineering* situations;
- Have a broad, fundamentals-based appreciation of engineering sciences, with depth in specific areas, together with knowledge of financial, commercial, legal, social and economic, health, safety, environmental and sustainability matters; and
- Professional expertise in a particular discipline and the ability to conduct r*esearch* and perform in-depth engineering investigations to solve *complex engineering* problems.

## 5. PROGRAMME STRUCTURE

The programme leading to the qualification shall contain a minimum of 180 credits including a research project of no less than 60 credits at NQF Level 9. Not less than 120 Credits shall be at NQF level 9. Credits shall be distributed in order to create a coherent progression of learning toward the exit level.

## 6. KNOWLEDGE PROFILE OF THE GRADUATE

The content of the educational programme when analysed by knowledge area shall not fall below the minimum credits in each knowledge area listed in Table 1.

**Table 1: Minimum credits in knowledge areas**

| Knowledge area | Minimum Credits |
|---|---|
| Mathematics and natural science | 30 |
| Engineering sciences | 30 |
| Engineering design & synthesis | 20 |
| Complementary studies | 10 |
| Engineering research project | 60 |

**Note:** The credits reflected in Table 1 total 150. Credits in selected knowledge areas must be increased to satisfy the 180 minimum total credits. Credits available for reallocation must be assigned to the knowledge areas to form a coherent and balanced programme. The method of calculation of credits and allocation to knowledge areas is defined in the ECSA document **E-01-P.**

## 7. CORE AND SPECIALIST REQUIREMENTS

The programme must have a coherent core of mathematics, natural science and fundamental engineering sciences that provides a viable platform for research and development, further studies and lifelong learning. The coherent core must enable development in a traditional discipline or in an emerging field. The coherent core includes fundamental elements. The provider may allow elective credits, subject to the minimum credits in each knowledge area and the graduate attributes being satisfied for all choices.

A programme must contain specialist engineering study at the exit level. Specialist study may lead to elective or compulsory credits. Specialist study may take on many forms including further deepening of a theme in the core, a new sub-discipline, or a specialist topic building on the core. It is recognised that the extent of specialist study is limited in view of the need to provide a substantial coherent core. Specialist study may take the form of compulsory or elective credits.

The area of complementary studies covers those disciplines outside of engineering sciences, natural science and mathematics which are relevant to the practice of engineering.

## 8. CURRICULUM CONTENT

This standard does not specify detailed curriculum content but the desired learning outcomes to be achieved. The fundamental and specialist engineering science content must be consistent with the designation of the degree.

## 9. ACCESS TO QUALIFICATION

This standard is specified as a set of graduate attributes and overall distribution of credits. Providers therefore have the freedom to construct programmes geared to different levels of preparedness of learners, including creating articulation pathways from other qualifications.

## 10. MINIMUM LEARNING ASSUMED TO BE IN PLACE

It is assumed that students have completed a suitably structured Bachelor of Engineering Technology Honours or a substantially equivalent qualification or combination of substantially equivalent qualifications.

## 11. SKILLS AND APPLIED COMPETENCE

**Graduate Attributes:** The graduate is able to demonstrate competence in the graduate attributes 1 to 11. The Graduate Attributes are stated generically and may be assessed in various engineering disciplinary or cross-disciplinary contexts in a provider-based or simulated practice environment. Words and phrases having specific meaning are defined in this document or in the ECSA document **E-01-P.**

**NQF Level Descriptors:** Refer to the normative information in Appendix A.

**Level Descriptor:** ***Complex engineering problems***

a) are characterised by an in-depth and emerging fundamental and specialised engineering knowledge;

***and have one or more of the characteristics:***

b) are ill-posed, under- or over specified, or require identification and refinement;

c) are high-level problems including component parts or sub-problems;

d) are unfamiliar or involve infrequently encountered issues;

***and their solution have one or more of the characteristics:***

e) are not obvious, require originality or analysis based on fundamentals;

f) are outside the scope of standards and codes;

g) require information from variety of sources that is complex, abstract or incomplete; and

h) involve wide-ranging or conflicting issues: technical, engineering and interested or affected parties.

This qualification also includes conducting and reporting research under supervision, worth at least 60 credits at NQF Level 9, in the form of a research project appropriate to the discipline or field of study, characterised by:

a) the ability to conduct in depth literature searches;

b) the ability to identify, locate and obtain required data;

c) the ability to design and conduct analytic, modelling and experimental investigations;

d) the ability to critically evaluate data and draw conclusions;

e) the ability to investigate the application of new and emerging technologies in their branch of engineering; and

f) the ability to report and communicate findings.

**Generalised Range Statement:** The competencies defined in the graduate attributes may be demonstrated in a university-based, simulated workplace context. Competencies stated generically may be assessed in various engineering disciplinary or cross-disciplinary contexts.

**Graduate Attribute 1: Problem solving**

Use a wide range of specialist skills to identify, conceptualise, design and implement methods of enquiry to solve *complex engineering problems* creatively with an understanding of the consequences of any solutions or insights generated within a specialised context.

Identify, formulate, analyse and solve complex engineering problems creatively and innovatively.

**Level descriptor:** *Complex engineering problems* are characterised by some or all of the following attributes:

- Require identification and analysis, and may be concrete or abstract, may be divergent and may involve significant uncertainty;
- May be infrequently encountered and occur in unfamiliar contexts;
- Approach to find solutions is creative;
- Information is complex and possibly incomplete, requiring validation and critical analysis;
- Solutions are based on theory, use of first principles and evidence, (which may be incomplete) together with judgment where necessary; and
- Involves a variety of interactions which may impose conflicting constraints, premises, assumptions and / or restrictions.

**Graduate Attribute 2: Application of scientific and engineering knowledge**

Apply specialist knowledge of mathematics, natural science, engineering fundamentals and an engineering speciality to solve *complex engineering problems*, conceptualise models and enable engagement with, and critique of, current and emerging research and practices.

**Level descriptor:** Knowledge of mathematics, natural science and engineering sciences is characterised by:

- Knowledge of mathematics using formalism, and oriented toward engineering analysis and modelling; deep knowledge of natural science: both as relevant to the discipline;
- Deep knowledge of a broad range of fundamental principles of an engineering discipline or cross-disciplinary field that is coherently and systematically organised;
- In-depth, theoretically based knowledge in limited specialist area(s), informed by current developments, and emerging issues; and
- The use of mathematics, natural science and engineering sciences in formal analysis and modelling of engineering situations, for reasoning about and conceptualising complex engineering problems.

**Note:** Problems used for assessment may provide evidence in the application of one, two or all three categories of knowledge listed above. It also requires working across engineering disciplinary boundaries through cross disciplinary literacy and shared fundamental knowledge.

**Range Statement:** Mathematics, natural science and engineering sciences are applied in formal analysis and modelling of engineering situations, and for reasoning about and conceptualising engineering problems.

**Graduate Attribute 3: Engineering design**

Perform creative, procedural and non-procedural design and synthesis of components, systems, engineering works, products or processes, demonstrate the ability to propose interventions at an appropriate level within a system based on an understanding of interdependent relations *and* address intended and unintended consequences of interventions.

**Range Statement:** Design problems used in exit-level assessment must conform to the definition of a *complex engineering* problem as defined under Graduate Attribute 1. A major design problem should be used to provide evidence. The design knowledge base and components, systems, engineering works, products or processes to be designed are dependent on the discipline or practice area.

**Graduate Attribute 4: Research, investigations, experiments and data analysis**

Demonstrate competence to conduct research, execute detailed technical investigations, implement strategies for the processing and management of information, including the review of current advances in the field, to produce new insights and solve *complex engineering* problems.

***Range Statement:*** The balance of investigation and experiment should be appropriate to the discipline. Research methodology must be applied in research or investigation where the student engages with selected knowledge in the research literature of the discipline.

**Note:** An investigation differs from a design in that the objective is to produce knowledge and understanding of a phenomenon and a recommended course of action rather than specifying how an artefact could be produced.

**Graduate Attribute 5: Engineering methods, skills and tools, including information technology**

Demonstrate competence to develop, select and apply appropriate and creative techniques, resources, and modern engineering tools, including information technology, prediction and modelling, for the solution of *complex engineering problems*, with an understanding of the limitations, restrictions, premises, assumptions and constraints.

***Range Statement:*** A range of methods, skills and tools appropriate to the disciplinary designation of the program including:

- Discipline-specific tools, processes or procedures including those for assessing and promoting sustainability.
- Computer packages for computation, modelling, simulation, and information handling;
- Computers and networks and information infrastructures for accessing, processing, managing, and storing information to enhance personal productivity and teamwork;

**Graduate Attribute 6: Professional and technical communication**

Demonstrate an ability to use the resources of academic, professional and occupational discourses to communicate and defend substantial ideas that are products of research, investigation or development in an area of specialisation; and a range of advanced and specialised skills and discourses appropriate to the field, discipline or practice, to communicate to a range of audiences with different levels of knowledge or expertise.

**Range Statement:** Material to be communicated is in an academic or simulated professional context. Audiences range from engineering peers, management and lay persons, using appropriate academic or professional discourse. Written reports range from short (300-1000 word plus tables and figures) to a substantial research project of 60 or more credits at NQF level 9, covering material at the exit-level. Methods of providing information include the

conventional methods of the discipline, for example engineering drawings, as well as subject-specific methods

**Graduate Attribute 7: Sustainability and the impact of engineering activity**

Demonstrate critical awareness of the sustainability and impact of engineering activity on the social, industrial and physical environment.

**Range Statement:** The combination of social, workplace (industrial) and physical environmental factors must be appropriate to the discipline or other designation of the qualification. Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: health, safety and environmental protection; risk assessment and management and the impacts of engineering activity: economic, social, cultural, environmental and sustainability.

**Graduate Attribute 8: Individual, team and multidisciplinary working**

Demonstrate competence to work effectively as an individual, in teams and in multidisciplinary environments.

**Range Statement:** Multidisciplinary tasks require co-operation across at least one disciplinary boundary. Co-operating disciplines may be engineering disciplines with different fundamental bases other than that of the programme or may be outside engineering.

**Graduate Attribute 9: Independent learning ability**

Demonstrate the ability to develop own learning strategies to sustain independent learning and academic and professional development, including effective interaction within the learning or professional group as a means of enhancing learning.

**Range Statement:** Operate independently in complex, ill-defined contexts requiring personal responsibility and initiative, accurately self-evaluate and take responsibility for learning requirements; be aware of social and ethical implications of applying knowledge in particular contexts.

**Graduate Attribute 10: Engineering professionalism**

Demonstrate critical awareness of the need to act professionally, ethically, and with integrity to exercise judgment and take responsibility within own limits of competence and where appropriate to account for leading and initiating processes and implementing systems, ensuring good resource and governance practices.

**Range Statement:** Evidence includes case studies typical of engineering practice situations in which the graduate is likely to participate. The contextual knowledge profile specified in the range statement of Graduate Attribute 7 is applicable here.

**Graduate Attribute 11: Engineering management**

Demonstrate knowledge and understanding of engineering management principles and economic decision making.

**Range Statement:** Basic techniques from economics, business management and project management applied to one's work, as a member and a leader of a team, to manage projects in multidisciplinary environments.

## 12. INTERNATIONAL COMPARABILITY

This standard has been intentionally written for the combination of the Bachelor of Technology Honours and Master of Engineering (Professional Practice) to meet or exceed the requirements of the European Network for the Accreditation of Engineering Education (ENAEE) Second Cycle (i.e. Master's level) EUR-ACE Framework Standard used for the accreditation of Professional Engineering Programmes in European (Bologna Accord signatory) countries (http://www.enaee.eu).

International comparability of engineering education qualifications is ensured through the Washington and Sydney Accords, all being members of the International Engineering Alliance (IEA).

The graduate attributes and level descriptors defined in this qualification are aligned with the International Engineering Alliance's Graduate Attributes and Professional Competencies for professional engineers (See www.ieagreements.org).

## 13. INTEGRATED ASSESSMENT

Providers of programmes shall, in the quality assurance process, demonstrate that an effective integrated assessment strategy is used. Clearly identified components of assessment must address summative assessment of the graduate attributes. Evidence should be derived from major work or multiple instances of limited scale work.

## 14. RECOGNITION OF PRIOR LEARNING

Recognition of prior learning (RPL) may be used to demonstrate competence for admission to this programme. This qualification may be achieved in part through recognition of prior learning processes. Credits achieved by RPL must not exceed 50% of the total credits and must not include credits at the exit level.

## 15. ARTICULATION POSSIBILITIES

A Master's degree at NQF Level 9 meets the requirements for admission to a Doctoral degree at NQF Level 10. A qualification may not be awarded for early exit from a Master of Engineering degree.

## 16. MODERATION AND REGISTRATION OF ASSESSORS

Providers of programmes shall in the quality assurance process demonstrate that an effective moderation process exists to ensure that the assessment system is consistent and fair.

## APPENDIX A: NQF LEVEL DESCRIPTORS

The qualification is awarded at level 9 on the National Qualifications Framework (NQF) and therefore meets the following level descriptors:

- *Scope of knowledge:* Demonstrate specialist knowledge to enable engagement with and critique of current research or practices, and an advanced scholarship or research in a particular field, discipline or practice.
- *Knowledge literacy:* Demonstrate an ability to evaluate current processes of knowledge production and to choose an appropriate process of enquiry for the area of study or practice.
- *Method & procedure:* The ability to demonstrate a command of and ability to design, select and apply appropriate and creative methods, techniques, processes or technologies to complex practical and theoretical problems.
- *Problem solving:* Demonstrate the use of a wide range of specialised skills in identifying, conceptualising, designing and implementing methods of enquiry to address complex and challenging problems within a field, discipline or practice; and an understanding of the consequences of any solutions or insights generated within a specialised context.
- *Ethics and professional practice:* The ability to make autonomous ethical decisions which affect knowledge production, or complex organisational or professional issues, an ability to critically contribute to the development of ethical standards in a specific context.
- *Accessing, processing and managing information:* Demonstrate the ability to design and implement a strategy for the processing and management of information, in order to conduct a comprehensive review of leading and current research in an area of specialisation to produce significant insights.
- *Producing and communicating information:* Demonstrate an ability to use the resources of academic and professional or occupational discourses to communicate and defend substantial ideas that are the products of research or development in an area of specialisation; use a range of advanced and specialised skills and discourses

appropriate to a field, discipline or practice, to communicate to a range of audiences with different levels of knowledge or expertise.

## HIGHER EDUCATION QUALIFICATIONS SUB-FRAMEWORK STANDARDS DEVELOPMENT: POLICY AND PROCESS

### Explanatory Notes

In terms of the National Qualifications Framework (NQF) Act, 67 of 2008, the Council on Higher Education (CHE) is the Quality Council (QC) for Higher Education. The CHE is responsible for quality assurance of higher education qualifications.

Part of the implementation of the Higher Education Qualifications Sub-Framework (HEQSF) is the development of qualification standards. The development of standards is aligned with the nested approach incorporated in the HEQSF. In this approach, the outer layer providing the context for qualification standards comprises the NQF level descriptors developed by the South African Qualifications Authority (SAQA) in agreement with the relevant QC. One of the functions of the QC (in the case of higher education, the CHE) is to ensure that the NQF level descriptors 'remain current and appropriate'. The development of qualification standards for higher education therefore needs to take the NQF level descriptors, as the outer layer in the nested approach, into account. An ancillary function is to ensure that they 'remain current and appropriate' in respect of qualifications awarded by higher education institutions.

A secondary layer for the context in which qualification standards are developed is the HEQSF. This framework specifies the types of qualification that may be awarded and, in some cases, the allowable variants of the qualification type. An example of variants is the provision for two variants of the Master's degree (including the 'professional' variant).

Another example is the distinction, in the Bachelor's degree type, between the 'general' and 'professionally-oriented' variants. The HEQSF also specifies the purpose and characteristics of each qualification type. However, as indicated in the Framework for Qualification Standards in Higher Education (CHE, 2013), neither NQF level descriptors nor the HEQSF are intended to address, or indeed capable of addressing, fully the relationship between generic qualification-type purpose and the specific characteristics of that qualification type in a particular field of study. One of the tasks of standards development is to reconcile the broad, generic description of a qualification type according to the HEQSF and the particular characteristics of qualifications awarded in diverse fields of study and disciplines, as defined by various descriptors and qualifiers.

Development of qualification standards is guided by the principles, protocols and methodology outlined in the Framework, approved by the Council in March 2013. The focus of a standards statement is the relationship between the purpose of the qualification, the attributes of a graduate that manifest the purpose, and the contexts and conditions for assessment of those attributes. A standard establishes a threshold. However, on the grounds that a standard also plays a developmental role, the statement may include, as appropriate, elaboration of terms specific to the statement, guidelines for achievement of the graduate attributes, and recommendations for above- threshold practice.