COUNCIL ON HIGHER EDUCATION

Higher Education Qualifications Sub-Framework

Qualification standard

for

Diploma in Engineering

The process of drafting this standard is described in the Introduction.

February 2015

HIGHER EDUCATION QUALIFICATIONS SUB-FRAMEWORK

STANDARDS DEVELOPMENT: POLICY AND PROCESS

Introduction

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. Standards development is aligned with the *nested approach* incorporated in the HEQSF. In this approach, the outer layer providing the context for qualification standards are 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 is 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.

The CHE is engaged in a pilot study, involving a selection of qualification types, offered in various fields of study. The aim of the study is to explore the extent to which the principles, procedures, content and methodology of standards development meet the requirements of all relevant parties: the institutions awarding the qualifications, the CHE as quality assurer of the qualifications, the graduates of those qualifications, and their prospective employers.

The drafting of this standards statement is the work of a consultant recommended, and endorsed, by a group of academic experts in the field of study, convened by the CHE and comprising Deans of Engineering or their nominees. The draft standard was presented to, and endorsed by, a meeting of Engineering Deans held on 24 November 2014. On recommendation by the meeting, the draft was submitted, via the Engineering Council of South Africa to its Engineering Standards Generating Body (ESGB). Comments from both the Deans and the ESGB have been considered and, where appropriate, incorporated in the draft.

The CHE disseminates the draft standard for the consideration of all relevant and interested parties. Comments received by the CHE are referred, as appropriate, to the Engineering Deans for consideration. When all issues have been considered and reconciled, the Directorate: Standards Development submits to the Council a standards statement for approval.

QUALIFICATION TYPE AND VARIANT

Diploma

DIPLOMA: GENERAL CHARACTERISTICS

This qualification primarily has a vocational orientation, which includes professional, vocational, or industry specific knowledge that provides a sound understanding of general theoretical principles as well as a combination of general and specific procedures and their application. The purpose of the Diploma is to develop graduates who can demonstrate focused knowledge and skills in a particular field. Typically they will have gained experience in applying such knowledge and skills in a workplace context. A depth and specialisation of knowledge, together with practical skills and experience in the workplace, enables successful learners to enter a number of career paths and to apply their learning to particular employment contexts from the outset. Diploma programmes typically include an appropriate work-integrated learning (WIL) component.

(The Higher Education Qualifications Sub-Framework, CHE, 2013)

STANDARD FOR THE

DIPLOMA IN ENGINEERING

Preamble

The competence of a Professional Engineering Technician at the level required for independent practice, that is, on qualifying for registration, is generally developed in two stages. First, a Diploma meeting this standard provides the educational foundation enhanced by work-integrated learning. Second, competence must be further developed through training and experience, typically for three or more years. The educational foundation has an application-oriented theoretical basis of natural sciences and mathematics to underpin practically-oriented engineering science and engineering specialist knowledge. Conceptual knowledge is used in engineering applications and design. Work-integrated learning provides part of the required practical experience while training and experience after graduation develops contextual knowledge and the ability to solve problems in real-life situations using established methods.

As indicated in the qualification title definition, the qualification may be awarded as a result of programmes in several disciplines and cross disciplinary fields, including newly emerged fields. This standard specifies the generic knowledge profile and outcomes common to all programmes. Standards are not defined at the second qualifier level.

Note

Words and phrases having specific meaning are defined in section 11 of this document or in ECSA Document E-01-P. The method recommended for calculating credits is detailed in ECSA document E-01-P available at www.ecsa.co.za.

1. HEQSF specification

HEQSF Qualification Type	Diploma	
Variant	Vocationally -oriented	
NQF Exit Level	**Minimum Total Credits**	**Minimum Credits at Exit Level**
6	360	120

2. Qualification title

First Qualifier: Diploma in Engineering

Second Qualifier: The second qualifier must indicate an engineering sub-discipline or accepted practice area and normally contain the word *engineering.* The qualifier must be consistent with the engineering science content of the programme. Sub-disciplinary qualifiers include but are not limited to Clinical, Coal Mining, Computer Systems, Digital Systems, Electronic, Extractive Metallurgy, Manufacturing, Metalliferous Mining, High Frequency Technology, Physical Metallurgical, Power, Instrumentation, Telecommunications.

3. Purpose statement

The primary purpose of this vocationally-oriented diploma is to develop focused knowledge and skills as well as experience in a work-related context. The Diploma equips graduates with the knowledge base, theory, skills and methodology of one or more engineering sub-disciplines as a foundation for further training and experience towards becoming a competent engineering technician. This foundation is achieved through a thorough grounding in mathematics and natural sciences specific to the field, engineering sciences, engineering design and the ability to apply established methods. Engineering knowledge is complemented by methods for understanding of the impacts of engineering solutions on people and the environment.

Note: This standard is designed to meet the educational requirement towards registration as a Candidate or Professional Engineering Technician with the Engineering Council of South Africa.

4. Normal duration of study

Programmes have normal durations of three years, including work-integrated learning, with not less than 360 Credits.

5. Standard for the award of the qualification

The *purpose* and *level* of the qualification will have been achieved when the student has demonstrated:

- the knowledge defined in section 6 and
- the skills and applied competence defined in section 7.

6. Knowledge

Knowledge demonstrated by the graduate has the following characteristics:

6.1: At least the number of credits in the knowledge areas shown:

Knowledge area	Minimum Credits
Mathematical Sciences	35
Natural Sciences	28
Engineering Sciences	126
Design and Synthesis	28
Computing and Information Technology	21
Complementary studies	14
Workplace Practice	30

Note: These credits total 282. Credits in selected knowledge areas must be increased to satisfy the 360 minimum total credits.

6.2: The level of knowledge of mathematics, natural sciences and engineering sciences is characterized by:

- A coherent range of fundamental principles in mathematics and natural science underlying a sub-discipline or recognised practice area.
- A coherent range of fundamental principles in engineering science and technology underlying an engineering sub-discipline or recognised practice area.
- A codified practical knowledge in recognised practice area.
- The use of mathematics, natural sciences and engineering sciences, supported by established mathematical formulas, codified engineering analysis, methods and procedures to solve well-defined engineering problems.

6.3: A coherent progression of learning in mathematics, natural sciences and engineering fundamentals that provides a progression to the exit level.

6.4: Specialist knowledge of engineering methods at the exit-level in a sub-discipline or specialist field. Specialist study may take the form of compulsory or elective credits.

6.5: Practical knowledge that includes an understanding of workplace practices comprising not less than 30 credits.

6.6: This standard does not specify detailed curriculum content. The engineering fundamentals and specialist engineering science content must be consistent with the second qualifier.

7. Skills and Applied Competence

The graduate is able to demonstrate attributes 1 to 11:

1: Problem solving
Apply engineering principles to systematically diagnose and solve *well-defined* engineering problems.

Level Descriptor: *Well-defined engineering problems*:

a. Can be solved mainly by practical engineering knowledge, underpinned by related theory;

and have one or more of the characteristics:

b. are largely defined but may require clarification;
c. are discrete, focussed tasks within engineering systems;
d. are routine, frequently encountered, may be unfamiliar but in familiar context;

and have one or more of the characteristics:

e. can be solved in standardized or prescribed ways;
f. are encompassed by standards, codes and documented procedures; requires authorization to work outside limits;
g. information is concrete and largely complete, but requires checking and possible supplementation;
h. involve several issues but few of these imposing conflicting constraints and a limited range of interested and affected parties.

2: Application of scientific and engineering knowledge
Apply knowledge of mathematics, natural science and engineering sciences to applied engineering procedures, processes, systems and methodologies to solve *well-defined* engineering problems.

Range Statement: See section 6.2.

3: Engineering Design
Perform procedural design of components, systems, works, products or processes to meet requirements, normally within applicable standards, codes of practice and legislation.

Range Statement: Design problems used in assessment must conform to the definition of *well-defined* engineering problems:

1. A design project should be used to provide evidence of compliance with this outcome;
2. The problem would be typical of that which the graduate would participate in a typical employment situation shortly after graduation;
3. The selection of components, systems, engineering works, products or processes to be designed is dependent on the sub-discipline;
4. A design project should include one or more of the following impacts: social, economic, legal, health, safety, and environmental;

4: Investigations, experiments and data analysis

Conduct investigations of *well-defined* problems through locating and searching relevant codes and catalogues, conducting standard tests, experiments and measurements.

Range Statement: The balance of investigation should be appropriate to the discipline. An investigation should be typical of those in which the graduate would participate in an employment situation shortly after graduation.

Note: An investigation differs from a design in that the objective is to produce knowledge and understanding of a phenomenon.

5: Engineering methods, skills and tools, including Information Technology

Use appropriate techniques, resources, and modern engineering tools including information technology for the solution of *well-defined* engineering problems, with an awareness of the limitations, restrictions, premises, assumptions and constraints.

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

1. Sub-discipline-specific tools processes or procedures;
2. Computer packages for computation, simulation, and information handling;
3. Computers and networks and information infrastructures for accessing, processing, managing, and storing information to enhance personal productivity and teamwork;
4. Basic techniques from economics, management, and health, safety and environmental protection.

6: Professional and technical communication

Communicate effectively, both orally and in writing within an engineering context.

Range Statement: Material to be communicated is in a simulated professional context:

1. Audiences are engineering peers, academic personnel and related engineering persons using appropriate formats;
2. Written reports range from short (minimum 300 words) to long (a minimum of 2

000 words excluding tables, diagrams and appendices), covering material at the exit level;
3. Methods of providing information include the conventional methods of the discipline, for example engineering drawings, physical models, bills of quantities as well as subject-specific methods.

7: Sustainability and Impact of Engineering Activity

Demonstrate knowledge and understanding of the impact of engineering activity on the society, economy, industrial and physical environment, and address issues by defined procedures.

Range Statement: The combination of social, workplace (industrial) and physical environmental factors is appropriate to the sub-discipline of the qualification. Evidence may include case studies typical of the technical practice situations in which the graduate is likely to participate.

Issues and impacts to be addressed:

1. Are encompassed by standards and documented codes of practice.
2. Involve a limited range of stakeholders with differing needs.
3. Have consequences that are locally important and are not far reaching.
4. Are *well-defined* and discrete and part of an engineering system.

8: Individual, Team and Multidisciplinary Working

Demonstrate knowledge and understanding of engineering management principles and apply these to one's own work, as a member and leader in a technical team and to manage projects.

Range Statement:

1. The ability to manage a project should be demonstrated in the form of the project indicated in ELO 3.
2. Tasks are discipline specific and within the technical competence of the graduate.
3. Projects could include: laboratories, business plans, design, etc.;
4. Management principles include:
   - 4.1 Planning: set objectives, select strategies, implement strategies and review achievement;
   - 4.2 Organising: set operational model, identify and assign tasks, identify inputs, delegate responsibility and authority;
   - 4.3 Leading: give directions, set example, communicate, motivate;
   - 4.4 Controlling: monitor performance, check against standards, identify variations and take remedial action.

9: Independent Learning Ability

Engage in independent and life-long learning through well-developed learning skills.

Range Statement: The learning context is well-structured with some unfamiliar elements.

10: Engineering Professionalism
Understand and commit to professional ethics, responsibilities and norms of engineering practice.

Range Statement: Evidence includes case studies, memorandum of agreement, code of conduct, membership of professional societies etc typical of engineering practice situations in which the graduate is likely to participate.

11: Workplace practices
Demonstrate an understanding of workplace practices to solve engineering problems consistent with academic learning achieved.

Range Statement: Tasks to demonstrate this outcome should be designed to connect academic learning with workplace practice and may be performed in one or more of the following types of work-integrated learning:

1. Work-directed theoretical learning: in which theoretical forms of knowledge are introduced and sequences in ways that meet both academic criteria and are applicable and relevant to the career-specific components.
2. Problem-based learning: where students work in small self-directed groups to define, carry out and reflect on a task which is usually a real-life problem.
3. Project-based learning: that brings together intellectual enquiry, real world problems and student engagement in meaningful work.
4. Workplace-based learning: where students are placed in a professional practice or simulated environment within a training programme.
5. Simulated learning.

Note: While attribute 11 is specific to workplace practices, other attributes may be demonstrated simultaneously.

8. Contexts and conditions for assessment

Graduate attributes defined in 7 above are stated generically and may be assessed in various engineering disciplinary or cross-disciplinary contexts in a provider-based or an actual or simulated practice environment.

9. Award of the qualification

The qualification may be awarded when the qualification standard has been **met or exceeded**.

10. Progression

Completion of this 360-credit Diploma meets the minimum entry requirement for admission to an Advanced Diploma designed to support articulation to satisfy an engineering technologist education benchmark. This Diploma provides the base for the graduate to enter training and experience toward independent practice as an engineering technician and registration as a Professional Engineering Technician.

11. Guidelines

11.1 Pathway

This qualification lies on a HEQSF Vocational Pathway.

11.2 Definition of terms

Complementary Studies: cover those disciplines outside of engineering sciences, natural sciences and mathematics which are relevant to the practice of engineering including but not limited to engineering economics, management, the impact of technology on society, effective communication, and the humanities, social sciences or other areas that support an understanding of the world in which engineering is practised.

Computing and Information Technologies: encompasses the use of computers, networking and software to support engineering activity and as an engineering activity in itself as appropriate to the discipline.

Engineering fundamentals: engineering sciences that embody a systematic formulation of engineering concepts and principles based on mathematical and natural sciences to support applications.

Engineering Management: the generic management functions of planning, organising, leading and controlling, applied together with engineering knowledge in contexts including the management of projects, construction, operations, maintenance, quality, risk, change and business.

Engineering Design and Synthesis: is the systematic process of conceiving and developing materials, components, systems and processes to serve useful purposes. Design may be procedural, creative or open-ended and requires application of engineering sciences, working under constraints, and taking into account economic, health and safety, social and environmental factors, codes of practice and applicable laws.

Engineering Discipline (=Branch of engineering): a generally-recognised, major subdivision of engineering such as the traditional *disciplines* of Chemical, Civil, or Electrical Engineering, or a cross-disciplinary field of comparable breadth including combinations of engineering fields, for example Mechatronics, and the application of engineering in other fields, for example Bio-Medical Engineering.

Engineering Sub-discipline (=Engineering Speciality): a generally-recognised practice area or major subdivision within an engineering discipline, for example Structural and Geotechnical Engineering within Civil Engineering.

Engineering Sciences: have roots in the mathematical and physical sciences, and where applicable, in other natural sciences but extend knowledge and develop models and methods in order to lead to engineering applications and solve engineering problems.

Engineering Speciality: the extension of engineering fundamentals to create theoretical frameworks and bodies of knowledge for engineering practice areas.

Mathematical Sciences: an umbrella term embracing the techniques of mathematics, numerical analysis, statistics and aspects of computer science cast in an appropriate mathematical formalism.

Natural Sciences: physics (including mechanics), chemistry, earth sciences and the biological sciences which focus on understanding the physical world, as applicable in each engineering disciplinary context.

11. 4 International comparability of this qualification

This standard is designed to be substantially equivalent to the Dublin Accord Graduate Attributes. (See www.ieagreements.org.) The Dublin Accord is an agreement for the mutual recognition of the education base for engineering technicians. Dublin Accord signatories at June 2014 are accrediting agencies in Australia, Canada, Ireland, Korea, New Zealand, South Africa, United Kingdom, and the United States of America. Comparability of the standard achieved in accredited programmes is audited via a six-yearly Dublin Accord review of the Engineering Council of South Africa as signatory to the accord.

ANNEXURE A

NQF LEVEL DESCRIPTORS

The qualification is awarded at **level 6** on the National Qualifications Framework (NQF) and therefore meets the following level descriptors:

a. Scope of knowledge, in respect of which a learner is able to demonstrate: detailed knowledge of the main areas of one or more fields, disciplines or practices, including an understanding of and the ability to apply the key terms, concepts, facts, principles, rules and theories of that field, discipline or practice to unfamiliar but relevant contexts; and knowledge of an area or areas of specialisation and how that knowledge relates to other fields, disciplines or practices.

b. Knowledge literacy, in respect of which a learner is able to demonstrate an understanding of different forms of knowledge, schools of thought and forms of explanation within an area of study, operation or practice, and awareness of knowledge production processes.

c. Method and procedure, in respect of which a learner is able to demonstrate the ability to evaluate, select and apply appropriate methods, procedures or techniques in investigation or application processes within a defined context.

d. Problem solving, in respect of which a learner is able to demonstrate the ability to identify, analyse and solve problems in unfamiliar contexts, gathering evidence and applying solutions based on evidence and procedures appropriate to the field, discipline or practice.

e. Ethics and professional practice, in respect of which a learner is able to demonstrate an understanding of the ethical implications of decisions and actions within an organisational or professional context, based on an awareness of the complexity of ethical dilemmas.

f. Accessing, processing and managing information, in respect of which a learner is able to demonstrate the ability to evaluate different sources of information, to select information appropriate to the task, and to apply well-developed processes of analysis, synthesis and evaluation to that information.

g. Producing and communicating information, in respect of which a learner is able to demonstrate the ability to present and communicate complex information reliably and coherently using appropriate academic and professional or occupational conventions, formats and technologies for a given context.

h. Context and systems, in respect of which a learner is able to demonstrate the ability to make decisions and act appropriately in familiar and new contexts, demonstrating an understanding of the relationships between systems, and of how actions, ideas or developments in one system impact on other systems.

i. Management of learning, in respect of which a learner is able to demonstrate the ability to evaluate performance against given criteria, and accurately identify and address his or her task-specific learning needs in a given context, and to provide support to the learning needs of others where appropriate.

j. Accountability, in respect of which a learner is able to demonstrate the ability to work effectively in a team or group, and to take responsibility for his or her decisions and actions and the decisions and actions of others within well-defined contexts, including the responsibility for the use of resources where appropriate.