



ENSURING THE EXPERTISE TO GROW SOUTH AFRICA

Engineering Qualifications in the Higher Education Qualifications Sub-framework

E-23-P

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1. PURPOSE OF THIS DOCUMENT

This document examines the qualification types defined in the Higher Education Qualifications Sub-framework (HEQSF) in the light of the education requirements for the various professional, candidate and specified categories defined in terms of the Engineering Professions Act. This document is informative, not normative and is likely to evolve over time. It identifies qualification types that may satisfy education requirements for various categories but does not require that every type be implemented. A number of issues in implementing various types are raised.

2. BACKGROUND TO ENGINEERING QUALIFICATIONS

Engineering is a wide field of study and practice, as evidenced by the substantial number of recognised disciplines, sub-disciplines and practice areas as well as engineer, engineering technologist, engineering technician, and certificated engineer roles that are required for typical engineering work. Development of engineering competence at a level where a person is able to practice independently has two stages:

- First, an educational foundation is laid through the attainment of a qualification; and
- Second, training and experience in the workplace completes the development of competency.

Standards for a number of engineering roles have been developed for both the educational and professional levels of development by the Research, Policy & Standards (RPS) committee for the Engineering Council of South Africa (ECSA). Higher educational qualification must conform to Higher Education Qualification Sub-framework (HEQSF) types. The professional roles covered by these standards that rely on HEQSF-compliant educational qualifications are:

- Professional Engineer (“engineers”);
- Professional Engineering Technologist (“engineering technologists”);
- Professional Engineering Technician (“engineering technicians”).

Each professional category has a corresponding candidate category, for example Candidate Engineer, with the category’s educational requirements as the sole admission requirement.

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Other roles for which the PDSG has developed standards are the Professional Certificated Engineer¹ and the Specified Categories of registration focussed on statutory health and safety function that ECSA is empowered to create. Specified categories created to date are

- Lift Inspector;
- Lifting Machinery Inspector;
- Medical Equipment Maintainer;
- Fire Protection Systems Inspector; and
- Civil Engineering Materials Technician.

Dedicated higher education qualifications are not currently implemented and accredited for these roles but have been developed for introduction in future.

The purpose of this document is to present the structure and underlying logic of engineering qualifications in the HEQSF. This structure makes provision for the engineer, certificated engineer, engineering technologist and engineering technician qualifications as well as opportunities for categories not at present served by dedicated higher education qualifications. This structure identifies multiple routes leading to the necessary graduate attributes for the various roles as well as routes for crossing over from one role to another.

Section 3 identifies the principles underlying engineering qualifications. Section 4 identifies pathways in terms of HEQSF-compliant qualifications.

3. PRINCIPLES UNDERLYING THE ENGINEERING QUALIFICATION STRUCTURE

Eight principles underlie the Engineering Qualification Structure. Key terms with the following definitions are used throughout this document:

¹ The Certificated Engineer qualifications do not follow the usual model as this form of registration with ECSA requires the prior attainment of a Government Certificate of Competence (GCC). The various authorities responsible for the GCC examinations use selected existing qualifications as part of the admission requirements for the examinations. It is assumed that these authorities will use HEQSF qualification types as these are introduced.

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Benchmark [for a category of registration]: the required educational achievement expressed in terms of minimum credits in total and at the exit-level, graduate attributes, the level of problem solving, and a knowledge profile, but not specifying the qualification(s), learning pathway(s) or programme(s) to achieve the benchmark.

Pathway: A prescribed/defined arrangement of teaching, learning and assessment within a programme.

Programme: a structured, integrated teaching and learning arrangement with a defined purpose, usually leading to a qualification.

Qualification: the formal recognition of a specified learning achievement, usually awarded on successful completion of a programme.

1. Five educational benchmarks are identified for the five forms of registration that can be attained by a defined qualification or combination of qualifications, namely:

Benchmark 1: Meeting the educational requirement for *engineers*;

Benchmark 2: Meeting the educational requirement for *engineering technologists*;

Benchmark 3: Meeting the educational requirement for *engineering technicians*;

Benchmark 4: Meeting the educational requirement for *certificated engineers*; and

Benchmark 5: Meeting the educational requirement for *specified categories*.

2. The educational requirement for each Benchmark is defined in terms of:

A professional purpose;

An NQF level, minimum total credits, and credits at the exit-level;

A set of graduate attributes;

A level descriptor for problem solving; and

A knowledge profile expressed both in terms of the minimum volume of credits in specific knowledge areas and the type of knowledge at the exit-level.

3. Standards for qualifications leading to Benchmarks 1, 2 and 3 define generic requirements across all disciplines, sub-disciplines or practice areas, not for specific disciplines. (The viability of this approach has been confirmed in practice.) Benchmark 4 has additional specific

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requirements for different types of certificated engineers. In the case of specified categories Benchmark 5, the ECSA standard is at present generic across all such categories.

4. In the interests of promoting progression toward and articulation between categories, the set of qualification standards attempts to identify all feasible pathways (that is, sequences of qualifications) to Benchmarks 1, 2, 3 and 4. A single pathway leads to Benchmark 5.

5. This document is an exploration of the possibilities for meeting engineering education benchmark requirements within the set of qualifications types defined in the HEQSF. As demonstrated below, every HEQSF qualification type (except for doctoral degrees) could be exploited on various pathways. There is no implied obligation on higher education providers to implement all pathways to benchmarks appropriate to the type of university.

6. Graduates completing pathways to benchmarks having different highest qualifications, while not necessarily completing identical curricula, are considered to be substantially equivalent for the purpose of proceeding to training and experience toward registration or equivalent competence in the relevant category. The standards for programmes along pathways must ensure this substantial equivalence at the threshold level.

7. A non-terminating programme on any pathway must have a defined, meaningful stand-alone purpose. The question to be addressed by standards developers is: “what could a holder of the qualification do if he/she does not complete the rest of the pathway”.

8. In the accreditation process, sets of actual programmes that constitute a pathway must be accredited against the standards in the light of their roles in the pathway. Accreditation decisions must be recorded for the programme in relation to the pathway and any other approved stand-alone purpose.

4. BENCHMARKS AND PATHWAYS

Five educational benchmarks associated with the four identified professional roles and the various specified categories are listed above. In the past, the number of pathways to

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Benchmarks 1, 2 and 3 has been limited. With the establishment of the HEQSF and the requirement to migrate existing qualifications to HEQSF-compliant types the range of potential pathways to each benchmark has increased. This document reviews the full range of possible pathways based on individual standards that the PDSG has generated. The next step is for the educational authorities (principally the DHET and the CHE) as well as the individual higher education providers of engineering programmes to determine which pathways are feasible and for individual providers to decide to implement in the light of their capabilities and the student market.

The five Benchmarks are considered in turn. Figure 1 provides a graphical overview of the pathways to benchmarks and their constituent qualifications. The set of qualifications available for the construction of pathways is listed in Table 1. Table 2 lists the pathways for consideration to the five benchmarks. Several routes to Benchmark 1 for engineer education exist and are well proven and will be considered first.

In the description of pathways that follows we identify each pathway by the notation Px.y where the first number, x, is the Benchmark (Bx as shown in Figure 1) and the second, y, is the pathway to that Benchmark. For example, P3.2 is the second defined pathway to Benchmark 3.

4.1 Pathways to Benchmark 1: Educational Requirements for Professional Engineers

Two existing and two possible future pathways to Benchmark 1 defining the educational requirements for Candidate and Professional Engineers have been identified by the PDSG.

Pathway P.1.1: This pathway is the longstanding route to meeting the educational requirements for Professional Engineers² via the Bachelor of Engineering degree (**E-02-PE**), also titled Bachelor of Science in Engineering, but equivalent in all respects. This pathway has

² In this document, we often refer only to the professional registration category, for example Professional Engineer. The same education requirements apply as the sole requirements for registration in the corresponding candidate category, for example Candidate Engineer. This should be taken as read in the engineer, certificated engineer, engineering technologist, engineering technician and specified category cases.

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existed in its present form for four decades and the present standard, dating from 2000 and periodically revised, is internationally benchmarked and is mature and fully tested.

Pathway P1.2: In a number of disciplines, the possibility exists for enhancing the educational experience by enabling a deeper study of the underlying natural sciences, or where the natural science base may be larger than usual, while laying the engineering science foundations. The pathway involves a three-year bachelor's degree (360-420 credits total) with a prescribed curriculum that is designed to give advanced entry to specific cognate BEng/BSc(Eng) programmes with at least 280 credits (two academic years), including at least 120 credits at the exit-level to be completed. The three-year degree may be titled Bachelor of Engineering Science or Bachelor of Science. In the latter case, major subject requirements may apply. This pathway allows universities not having BEng programmes to design and have accredited arrangements to feed students to those that have.

Pathway P1.3: This pathway is an option that arises from the new HEQSF-compliant qualifications for engineering technologist education, the BEng Tech (**E-02-PT**), developed as a consequence of the BTech being phased out. It seeks to build on pathway P2.1 for engineering technologists. The assumption is that qualifications on this pathway contain sufficient and appropriate mathematics, natural science and engineering fundamentals to function in a similar way as the BEngSc and BSc programmes in pathway P1.2. The Education Committee will have to evaluate the programmes along each pathway and come to a decision on each in terms of Principle 7 stated in Section 3.

Pathway P1.4: This pathway builds vertically on pathway P2.1 to seek to meet the engineer educational benchmark. The BEng Tech is followed by an Honours or PGDip degree in the same or cognate discipline. This alone will not give equivalence to the BEng. The BEng Tech must be followed by a combination of qualifications that together meet or exceed the requirements for the BEng. This is provided by an appropriately curriculated BEng Tech (Hons) (**E-09-PT**) or PGDip (Engineering) (**E-09-PGDip**), followed by a suitably structured Professional Master's Degree (**E-22-P**).

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Figure 1 suggests the possibility of pathway P1.4 building on P2.2 (which in turn builds on P3.1, 3.2 or 3.3). This option must still be tested.

4.2 Pathways to Benchmark 2: Educational Requirements for Professional Engineering Technologists

The Professional Engineering Technologist is envisaged as having mastery of and applying established technology to problems that are amenable to solution by that technology. The required education base is narrower than that of the engineer; mathematics and natural science foundations are therefore those underpinning the sub-discipline.

Models for the education of engineering technologists in countries that recognise this role fall into two patterns: first dedicated bachelor's degrees, typically of three years duration and, second, building on technician education, typically with one or more years additional study. Under NATED, the latter model prevailed with the BTech following on the National Diploma. Both routes are possible under the HEQSF and the PDSG standards seek to support both patterns.

The potential pathways to the Engineering Technologist Benchmark 2 are as follows.

Pathway P2.1: The Bachelor of Engineering Technology (BEng Tech) (E-02-PT) is a three-year professionally-oriented bachelor's degree benchmarked to international standards for technologist education.

Pathway P2.2: Along with the next two pathways, this one builds on technician education pathways, thus implementing the second pattern of technologist qualifications. Having completed the Dip Eng (E-02-PN) pathway P3.1 qualification for technicians, the student goes on to an Advanced Diploma (E-05-PT) in an engineering sub-discipline. The Advanced Diploma has graduate attributes that match those of the BEng Tech. The student will have completed 500 credits as opposed to the 420 of the BEng Tech.

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Pathways P2.3 and P2.4: These pathways build on technician education pathways P3.2 and P3.3 to by completing an Advanced Diploma. As in pathway P2.2, while as yet untested, these are not unlike the existing National Diploma followed by a BTech.

While the three routes are substantially equivalent at threshold level by virtue of the BEng Tech and Adv Dip Eng having the same set of graduate attributes, differences such as the absence of work-integrated learning in the BEng Tech may require different post-graduation training programmes designed to close gaps for graduates that have followed different pathways.

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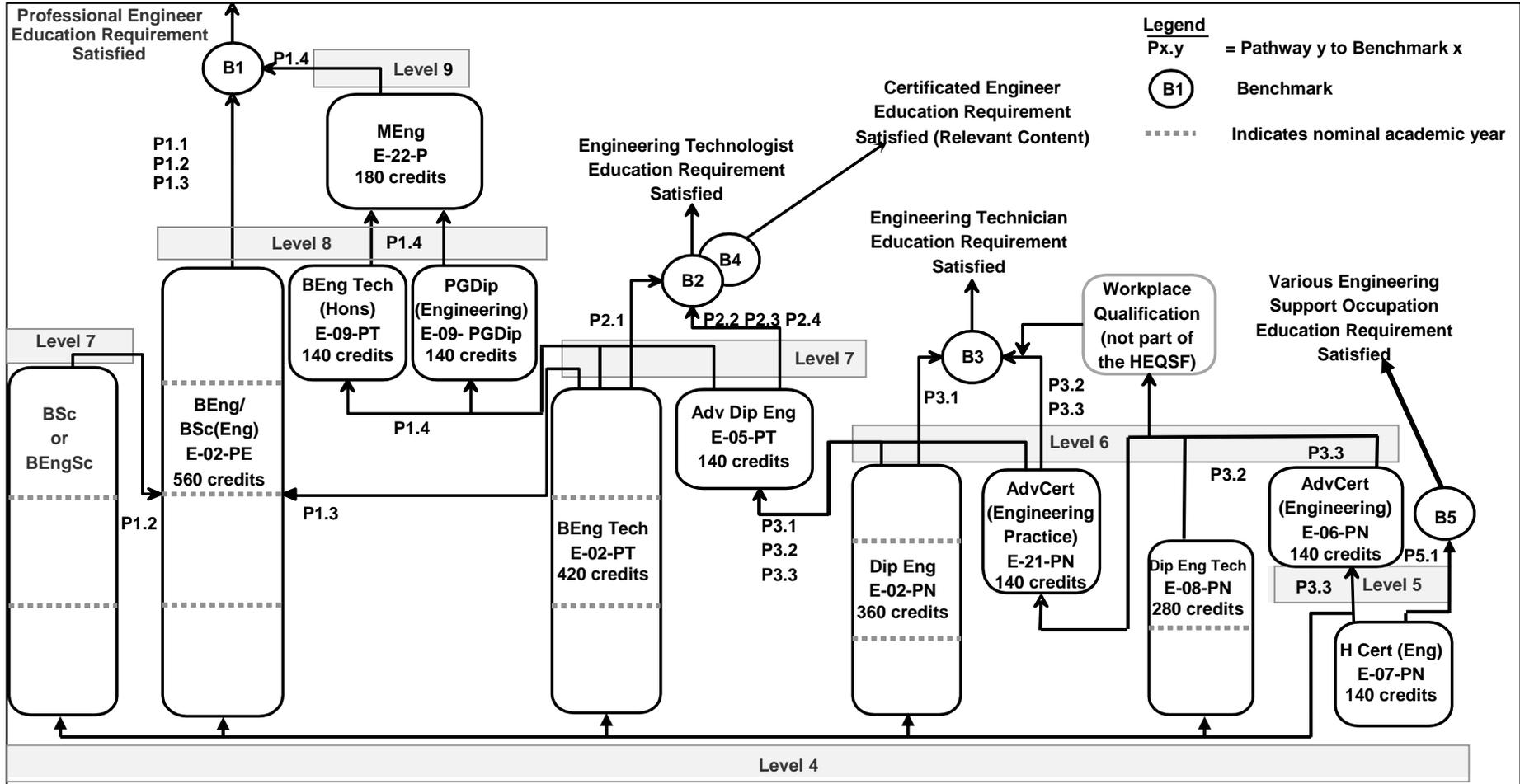


Figure 1: Graphical view of engineering qualifications in the HEQSF

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4.3 Pathways to Benchmark 3: Educational Requirements for Professional Engineering Technicians

The qualification for the engineering technician is a HEQSF-compliant 360 credit diploma incorporating work-integrated learning, the Diploma in Engineering (Dip Eng) (**E-02-PN**). The HEQSF provides further building blocks for engineering technician pathways: the Higher Certificate (**E-07-PN**), the Advanced Certificate and the 280 credit Diploma (**E-08-PN**). Two forms of Advanced Certificate are used here and are distinguished by work-integrated learning requirements as follows:

Advanced Certificate in Engineering (AdvCert (Engineering)) (**E-06-PN**) if the qualification does not incorporate work-integrated learning;

Advanced Certificate in Engineering Practice (AdvCert (Engineering Practice)) (**E-21-PN**) if the qualification incorporates work-integrated learning.

The possible pathways to Benchmark 3 from this palette of qualifications are as follows.

Pathway P3.1: A 360 credit Diploma, the Diploma in Engineering (Dip Eng) (**E-02-PN**) incorporating work-integrated learning defines this pathway. The diploma is awarded in an engineering sub-discipline or practice area. At least 30 credits (900 hours³) of work-integrated learning is required. With 900 hours of work-integrated learning, this leaves some five semesters for other provider-based learning.

Pathway P3.2: This pathway exploits the second Diploma variant, that is, a 280 credit Diploma that does not incorporate work-integrated learning. This form of Diploma may be attractive to small companies that do not need a high-level technician workforce and who may have limited training budgets. To distinguish this Diploma from the 360 credit Diploma in Engineering, the title Diploma in Engineering Technology (Dip Eng Tech) (**E-08-PN**) is specified in the standard. It, too, will be awarded in a sub-discipline or practice area. To attain substantial equivalence to Pathway 3.1, the student must complete an Advanced Certificate in Engineering Practice (AdvCert (Engineering Practice)) (**E-21-PN**). This AdvCert (Engineering Practice) must

³ The ECSA credit calculation formula (see E-01-P) assigns one credit per 30 hours of work-integrated learning.

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contain at least 30 credits (900 hours) of work-integrated learning together with the balance of 90-110 credits of other provider-based learning. The AdvCert (Engineering Practice) graduate must satisfy the graduate attributes defined in the Dip Eng that relate to work-integrated learning.

Pathway P3.3: This pathway uses the smallest possible building blocks toward the technician education Benchmark 3. It may thus be useful for mature persons progressing from technical qualifications or from artisan or similar qualifications who have met appropriate entry requirements into the pathway. The Dip Eng Tech in Pathway 3.2 is replaced by the combination of a Higher Certificate (**E-07-PN**) and an Advanced Certificate in Engineering (**E-06-PN**), which together are substantially equivalent to the Dip Eng Tech. Thus, while the ECSA standards allow work-integrated learning as a provider option, the designers of qualifications for pathways P3.2 and P3.3 will probably not exercise this option. Rather, the student must complete an Advanced Certificate in Engineering Practice (**E-21-PN**).

A possible variant on Pathways 3.2 and 3.3 is the substitution of an as yet unidentified industry-based programme/qualification for the AdvCert (Engineering Practice). Such a programme or qualification is not part of the HEQSF.

An open question is whether the achievement of sub-benchmark qualification on these pathways has a purpose related to employability. Put another way, what purpose(s) do the following combinations serve: the HCert (Engineering) alone; HCert (Engineering) + AdvCert (Engineering Technology); HCert (Eng) + AdvCert (Engineering Practice) – if this is permitted– and the Dip Eng Tech?

4.4 Pathways to Benchmark 4: Educational Requirements for Professional Certificated Engineers

The present higher educational qualification requirements for Professional Certificated Engineers are those used as part of the admission process, along with experience, to the Government Certificate of Competency (GCC) examinations set by the relevant authorities in the mining, factories and marine areas. The GCC is then the ECSA entry requirement for

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Candidate Certificate Engineer and in this context functions like a higher education qualification.

The generalised competency of a PCE is that of a professional engineering technologist. In the mining field the engineering knowledge is comparable to a professional engineering technologist in mining engineering. Specialised knowledge in mining health and safety and the applicable law distinguishes the PCE from the professional engineering technologist. In the factories/works and marine area, the broader engineering knowledge is drawn from the fields of electrical and mechanical engineering. Specialist knowledge relates to industrial or marine plant operation, occupational health and safety and the applicable law. Thus, programmes designed to educate PCEs would have substantial common content with the professional engineering technologist programmes in mining and selected electrical and mechanical engineering subjects but would cover the educational material specific to the GCC being targeted. Graduate attributes will be the same.

The possible future pathways for Certificated Engineers are therefore as for professional engineering technologists and will not be re-defined here.

4.5 Pathways to Benchmark 5: Educational Requirements for Specified Categories

Specified Categories are defined by ECSA to meet specific requirements of other legislation that requires an engineering-related function to be performed or engineering work to be carried out at a specifically-defined level. These functions are generally carried out in terms of defined codes or procedures in a narrow specific sub-discipline. In the past there has not been dedicated education for specified categories and persons have come to the categories from various backgrounds, for example an artisan progressing to lifting machinery inspector. ECSA has now defined educational requirements under the HEQSF Higher Certificate in Engineering. These are generic and applicable to all specified category practitioners.

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Table 1: Pathways to Benchmarks

Benchmark	Pathway	Qualifications on Pathway	Total Credits	HEQSF Level
1: "engineer"	P1.1	BEng/BSc(Eng)	560	8
	P1.2	BEngSci or BSc (prescribed curriculum) with advanced entry to BEng/BSc(Eng)	360-420 280	7 8
	P1.3	BEng Tech with advanced entry to BEng/BSc(Eng)	420 280	7 8
	P1.4	BEng Tech BEng Tech (Hons) // PGDip (Engineering) MEng	420 140 180	7 8 9
2: "engineering technologist"	P2.1	BEng Tech	420	7
	P2.2	Dip Eng Adv Dip Eng	360 140	6 7
	P2.3	Technician Route 3.2 AdvCert (Engineering Practice) + Adv Dip Eng	420 140 + 140	6 7
	P2.4	Technician Route 3.3 AdvCert (Engineering Practice) + Adv Dip Eng	420 140 + 140	6 7
3: "engineering technician"	P3.1	Dip Eng	360	6
	P3.2	Dip Eng Tech AdvCert (Engineering Practice) or equivalent	280 140	6 6
	P3.3	H Cert (Eng) Adv Cert (Engineering) Adv Cert (Engineering Practice) or equivalent	140 140 140	5 6 6
4: "certificated engineer"	P4.1	As for engineering technologist route 1 with PCE-oriented content in BEng Tech	As for P2.1	7
	P4.2	As for engineering technologist route 2 with PCE-oriented content in Adv Dip Eng	As for P2.2	7
	P4.3	As for engineering technologist route 3 with PCE-oriented content in Adv Dip Eng	As for P2.3	7
	P4.4	As for engineering technologist route 4 with PCE-oriented content in Adv Dip Eng	As for P2.4	7
5: "specified category"	P5.1	H Cert (Eng) + specified category	140	6

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