ENGINEERING COUNCIL OF SOUTH AFRICA *Standards and Procedures System*			
Discipline-specific Training Guideline for Candidate Engineers in Electrical Engineering			
Status: Approved by Registration Committee for Professional Engineers			
Document : R-05-ELE-PE	**Rev-1**	**12 March 2013**	

Background: ECSA Registration System Documents

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

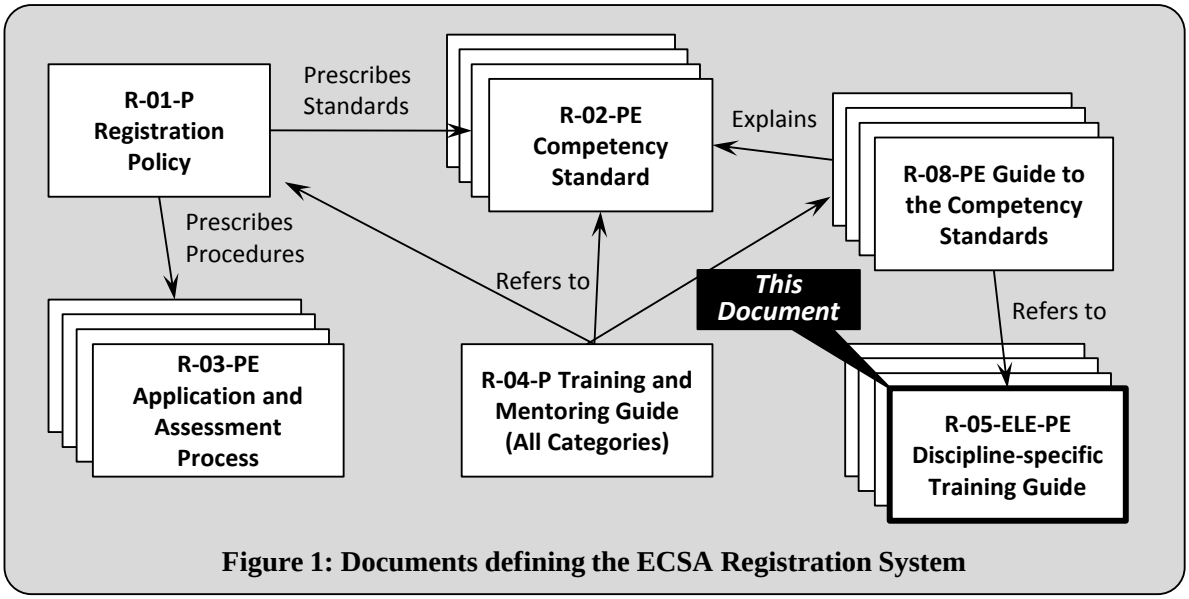


Figure 1: Documents defining the ECSA Registration System

1. Purpose

All persons applying for registration as Professional Engineers are expected to demonstrate the competencies specified in document R-02-PE at the prescribed level, irrespective of the trainee's discipline, though work performed by the applicant at the prescribed level of responsibility.

This document supplements the generic *Training and Mentoring Guide* R-04-P and *the Guide to the Competency Standards for Professional Engineers*, document R-08-PE. In document R-04-P attention is drawn to the following sections:

- 7.3.2 Duration of training and period working at level required for registration
- 7.3.3 Principles of planning training and experience
- 7.3.4 Progression of Training programme
- 7.3.5 Documenting Training and Experience
- 7.4 Demonstrating responsibility

The second document R-08-P provides both a high-level and outcome-by-outcome understanding of the competency standards as an essential basis for this discipline specific guide.

This Guide, as well as R-04-P and R-08-PE, are subordinate to the Policy on Registration, document R-01-P, the Competency Standard (R-02-PE) and the application process definition (R-03-PE).

2. Audience

This Guide is directed to candidates and their supervisors and mentors in the discipline of Electrical Engineering including bio-engineering, computer engineering, control engineering, electronic engineering, power engineering, software engineering, information engineering, telecommunications engineering and others. The Guide is intended to support a programme of training and experience incorporating good practice elements.

This guide applies to persons who have:

1. Completed the education requirements by obtaining an accredited BEng-type qualification, or a Washington-Accord Recognised qualification or through evaluation/assessment;
2. Registered as Candidate Engineers;
3. Embarked on a process of acceptable training under a registered Commitment and Undertaking (C&U) with a Mentor guiding the professional development process at each stage;

3. Persons not Registered as a Candidate or not Training under a C&U

All applicants for registration must present the same evidence of competence and be assessed against the same standards, irrespective of the development path followed. Application for registration as a Professional Engineer is permitted without being registered as a Candidate Engineer or without training under a C&U. 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 has no 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. . The Voluntary Association for the discipline should be consulted for assistance in locating an external mentor. A mentor should be in pace at all stages of the development process.

This guide is written for the recent graduate who is training and gaining experience toward registration. Mature applicants for registration may apply the guide retrospectively to identify possible gaps in their development.

Any applicants who have not enjoyed mentorship are advised to request an experienced mentor (internal or external) to act as an application adviser while they prepare their application for registration.

The guide 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 7.4).

4. Electrical Engineering

Electrical engineers form a collective group of engineers who conduct research on and design, advise, plan and direct the construction and operation of electronic, electrical and telecommunications systems, computer and software systems, components, motors and equipment. They organise and establish control systems to monitor the performance and safety of electrical and electronic components, assemblies and systems.

Electrical Engineers perform some of the following functions: planning, design, construction, operation and maintenance of materials, components, plant and systems for generating, transmitting, distributing and utilising electrical energy; electronic devices, apparatus and control systems for industrial systems, bio-medical, robotics and consumer products; computing, communication and software for critical applications, instrumentation and control of processes, through the application of electrical, electromagnetic and information engineering sciences.

Within the broad collective field of electrical engineering, engineers generally practice in areas of their specialities:

Electrical Power Engineering: covers electrical systems, components, motors and equipment, electrical engineering materials, products and processes.

Electronic Engineering: covers electronic systems, electronic engineering materials, products or processes

Telecommunications Engineering: is a broad specialisation of electrical engineering encompassing the design, construction and management of systems that carry out the transmission, processing and storage of information as electrical or optical signals and the control services based on this capability.

Computer and Software Engineering: addresses the relationship and interactions between software, hardware and external systems in solving real engineering problems. Computer engineering concentrates its effort on the ways in which computing ideas are mapped into working physical systems. Computer engineering rests on the intellectual foundations of electrical engineering, computer science, the natural sciences and mathematics.

Engineers also practise in combinations of the above specialities as well as in areas involving other disciplines, for example Mechatronics Engineering-involving robotic, prosthesis and process control.

Electrical Power Engineers: conduct research and advise on, design and direct the construction and operation of electrical systems, components, motors and equipment, advise on and direct their functioning, maintenance and repair and study and advice on technological aspects of electrical engineering materials, products and processes.

Typical tasks that an Electrical Power Engineer may undertake include:

- Conducting research and developing new or improved theories and methods related to Electrical Power Engineering
- Advising on and designing power stations and systems which generate, transmit and distribute electrical power

- Specifying Instrumentation, measurement and control of equipment for the monitoring and control of electrical generation, transmission and distribution systems
- Supervising, controlling, developing and monitoring the operation and maintenance of electrical generation, transmission and distribution systems
- Advising on and designing systems for electrical motors, electrical traction and other equipment or electrical domestic appliances
- Specifying electrical installation and application in industrial and other buildings and objects
- Establishing control standards and procedures to monitor performance and safety of electrical generating and distribution systems, motors and equipment
- Determining manufacturing methods for electrical systems as well as the maintenance and repair of existing electrical systems, motors and equipment
- Design and development of electrical apparatus
- And others

Practising Electric Power Engineers may concentrate on one or more of the following areas:

- Control Engineer
- Electrical Design Engineer
- Electrical Engineer (Mines)
- Electrical Power Generation Engineer
- Electromechanical Engineer
- Illumination Engineer
- Power Distribution Engineer
- Power Systems Engineer
- Power Transmission Engineer
- Power System Design Engineer
- Railway Signal Engineer
- Signalling and Communications Engineer
- Control and Instrumentation Engineers
- Power Product Sales Engineer
- Power Electronics Engineer
- Power Systems Protection Engineers
- Plant and Factory Engineers
- Mining Electrical Engineer
- Electrical Drive Engineer
- Energy Management Engineer
- And other

Electronics engineers conduct research and advise, on design and direct the construction, maintenance and repair of electronic systems and study and advice on technological aspects of electronic engineering materials products or processes.

Typical tasks that an Electronics Engineer may undertake include:

- Conducting research and developing new or improved theories and methods related to Electronics Engineering
- Advising on and designing electronic devices or components, circuits, semi-conductors and systems
- Specifying production or installation methods, materials and quality standards and directing production or installation work of electronic products and systems

- Supervising, controlling, developing and monitoring the operation and maintenance of electronic equipment and systems
- Establishing control standards and procedures to ensure efficient functioning and safety of electronic systems and equipment
- Organising and directing maintenance and repair of existing electronic systems and equipment
- Designing electronic circuits and components for use in fields such as aerospace, guidance and propulsion control, acoustics or instruments and control
- Determining manufacturing methods for electronic systems as well as the maintenance and repair of existing electronic systems and equipment
- Researching and advising on radar, telemetry and remote control systems, microwaves and other electronic equipment
- Designing and developing signal processing algorithms and implementing these through appropriate choice of hardware and software
- Developing apparatus and procedures to test electronic components, circuits and systems
- Designing, specifying and implementing Control and Instrumentation of plant and processes
- Designing, specifying, control and monitoring of equipment for fire and safety in plant and factories
- Robotics and process control of manufacturing plant
- Energy Efficiency PV
- And other

Practising Electronics Engineers may concentrate on one or more of the following areas:

- Communications Engineer (Army)
- Mechatronics Engineer
- Electronics Designer
- Information Engineer
- SCADA and Control Engineer
- Instrumentation Engineer
- Television Engineer
- Bio-medical Engineer
- Clinical Engineer
- Fire and Safety Engineer
- Rail Network Control
- Aircraft electronic systems Engineer
- Electronic Warfare Engineer
- And others

Telecommunications engineers conduct research and advise on, design and direct the construction, maintenance and repair of telecommunication systems and equipment. They study and advise on technological aspects of telecommunication engineering, materials products or processes. Plans, designs and monitors complex telecommunications networks and associated broadcasting equipment.

Typical tasks that a Telecommunication Engineer may undertake include:

- Conducting research and developing new or improved theories and methods related to Telecommunications Engineering

- Advising on and designing telecommunications devices or components, systems, equipment and distribution centres
- Specifying production or installation methods, materials, quality and safety standards and directing production or installation work of telecommunications products and systems
- Supervising, controlling, developing and monitoring the operation and maintenance of telecommunication systems. networks and equipment
- Determining manufacturing methods for telecommunication systems as well as the maintenance and repair of existing telecommunication systems, networks and equipment
- Organizing and directing maintenance and repair of existing telecommunication systems, networks and equipment
- Researching and advising on telecommunications equipment
- Planning and designing communications networks based on wired, fibre optical and wireless communication media
- Designing and developing signal processing algorithms and implementing these through appropriate choice of hardware and software
- Designing telecommunications networks and radio and television distribution systems including both cable and over the air
- And other

Practising Telecommunications Engineers may concentrate on one or more of the following areas:

- Broadcast Engineer
- Digital Signal Processing Designer
- Communications Engineer
- Fibre Optics Engineer
- Radio Frequency Design Engineer
- Radar Engineer
- Radio Engineer
- Radio and Telecommunications Engineer
- Mobile Radio Engineer
- Satellite Transmission Engineer
- Signal Processing Systems Engineer
- Communications Consulting Engineer
- Communications Specialist (ICT) Engineer
- Telecommunications Consulting Engineer
- Telecommunications Network Planning Engineer
- Telecommunications Specialist Engineer
- Microwave Engineer
- And others

Computer and Software Engineers conduct research and advise on, design and direct the construction, maintenance and repair of computer-based systems, software and equipment. They study and advise on the technological aspects of computer-based systems, software, products or processes. They perform system analysis on computer-based system requirements, software and specify the systems required. They plan, design and monitor

complex computer-based systems, software, networks and associated communication equipment.

Typical tasks that a Computer Engineer may undertake include:

- Conducting research and developing new or improved theories and methods related to Computer and Software Engineering
- Advising on and designing computer-based systems or components, systems equipment, software and distribution centres
- Specifying production or installation methods, materials, quality and safety standards and directing production or installation work of computer-based products, software and systems
- Supervising, controlling, developing and monitoring the operation and maintenance of computer-based systems, software, networks and equipment
- Organizing and directing maintenance and repair of existing computer-based systems, programmes and equipment
- Researching and advising on computer-based equipment and software
- Planning and designing computer-based communications networks based on wired, fibre optical and wireless communication media and ultra high speed data networks
- System Analysis, designing and developing complex computer-based systems and implementing these through appropriate choice of hardware and managing the development the necessary software.
- Determining manufacturing methods for computer-based systems as well as the maintenance and repair of existing computer-based systems, networks and equipment
- And other

Practising Computer Engineers may concentrate on one or more of the following areas:

- Computer Engineer
- Computer System Analyst Engineer
- Computer System Design Engineer
- Computer Communication Specialist Engineer
- Computer Network Design Engineer
- Computer Network Sales Engineer
- Software Engineer
- Systems Engineer
- And others

This guide first presents information that is relevant to all candidate Engineers whose area is in the broad field of electrical engineering. Information specific to sub-disciplines is given in later sections. Special considerations for training in different environments, for example consulting and contracting, are also given.

5. Training Implications of the Nature and Organisation of the Industry

Electrical engineers may be employed in both the private and public sector.

Typically in the private sector they would be involved in consulting, 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, and 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. Electrical 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, there may be situations where the opportunuties in-house are not sufficiently diverse to develop all the competencies required in all the groups noted in document R-02-PE. For example the opportunity for developing problem solving competence (including design or developing solutions) and for managing engineering activities (including implementing or constructing solutions) may not both be available to the candidate. In such cases employers are encouraged to put a secondment system in place.

It has been fairly common practice that where an organisation is not able to provide training in certain areas that secondments are arranged with other organisations, so that the candidate is able develop all the competencies required for registration.

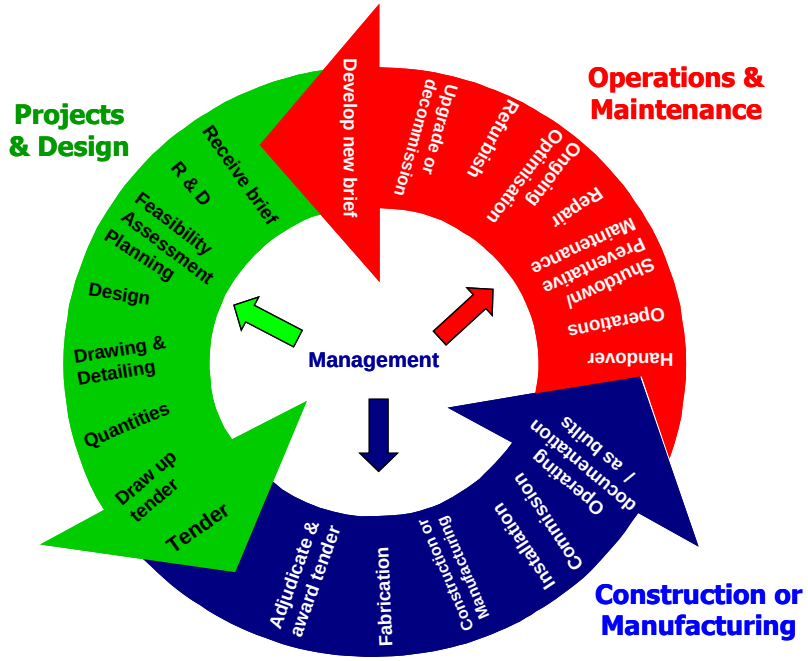
These secondments are usually of a reciprocal nature so both employers and their respective employees get the mutual benefit from the other party. Secondments between consultants and contractors and between the public and private sector should be possible.

5.1 Location of training in overall engineering lifecycle and functions performed.

The areas where electrical engineers work generally follow the conventional stages of the project (or product) life cycle:

a) Research and development to develop new products or systems or solve some system problem or obsolescence.
b) System or product design to develop a new system or product, or to solve system or product problem, or to achieve a particular desired result, or to select equipment for a particular purpose.
c) Project engineering to install and test and commission the necessary equipment or system for the desired result.

d) Operation and maintenance of the system or network, or support of the product.
e) Decommissioning of a system or network



It is not expected that candidates will have to change work in order to work in all the areas as listed above. Candidates however must ensure that in whatever area they are employed they undertake tasks that provide experience in all the generic engineering competencies of problem solving, implementation or operation, risk and impact mitigation and management of engineering activities.

In the Appendix, a schema is presented for the functions that a candidate should become competent to do in the various phases of a project:

1. Solving problems based on engineering and contextual knowledge;
2. Implementing or operating engineering projects, systems, products or processes;
3. Risk and impact mitigation;
4. Managing engineering activities.

Three levels of description are given. To the third level the description is largely independent of the discipline. Discipline specifics may be included as a fourth and fifth level as required. These would include the types of evidence of performance that would be appropriate at each line and record keeping of the evidence.

6. Developing competency: Elaborating on sections in the Guide to the Competency Standards, document R-08-PE.

6.1 Contextual Knowledge

Candidates are expected to be aware of the engineering profession, the Voluntary Associations applicable to the Electrical Engineer and their functions and services rendered to members

6.2 Functions Performed

Special considerations in the discipline, sub-discipline or speciality must be given to the competencies specified in the following groups:

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

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

It should be noted that the Candidate working at Responsibility level E carries the responsibility appropriate to that of a registered person except that the Candidates supervisor is accountable for the Candidates recommendations and decisions.

6.3 Special industry and statutory requirements

Candidates are expected to have a working knowledge of the following regulations and Acts and how they affect their working environment:

- ECSA – Engineering Profession Act, 2000, (Act No. 46 of 2000)' its Rules and the Code of Conduct
- OHSAct – Occupation Health and Safety Act, 1993 (Act No. 85 of 1993), as amended by Act No. 181 of 1993.
- Wiring Code – SANS 10142
- Building Regulations – National Building Regulations and Building Standards Act, 1977 (Act No. 103 of 1977), as amended by Act No. 49 of 1995, SANS 10400
- Factory Regulations
- Machinery and Works Regulations
- Labour Relations Act – Act, 1995, (Act No.66 of 1995)

- Environment Conservation Act, 1989 (Act No. 73 of 1989), as amended by Act No. 52 of 1994 and Act No. 50 of 2003.
- Mine Health and Safety Act. 1996 (Act No. 29 of 1996)
- Industry Specific Work Instructions
- Others

Many other Acts not listed here may also be pertinent to a candidates work environment. Candidates will be expected to have a basic knowledge of the applicable Acts

6.4 Desirable Formal Learning Activities

The following list of formal learning activities is by no means extensive and is purely a sample of some useful courses

- Project Management
- Conditions of Contract\Value Engineering – NEC, JBCE etc
- Standard Specifications
- Preparation of Specifications
- Negotiation Skills
- Engineering Finance
- Risk Analysis
- Quality Systems
- Occupation Health and Safety
- Discipline Specific Courses
- Quality Systems
- Energy Efficiency
- Electrical Tariffs
- Maintenance Engineering
- Environment Impacts
- Management
- Report Writing
- Planning Methods
- System Engineering
- Industrial Relations
- Public Speaking

7. Programme Structure and Sequencing

7.1 Best Practice

There is no ideal training programme structure or a unique sequencing that constitutes best practice.

The training programme for each candidate will depend on the work opportunities available at the time for the employer to assign to the candidate

It is suggested that the candidate works with their mentors to determine appropriate projects to gain exposure to elements of the asset life cycle, to ensure that their designs are constructable, operable, and are designed considering life cycle costing and long-term sustainability. A regular reporting structure with suitable recording of evidence of achievment against the competency outcomes and responisbility need to be put in place

The training programme should be such that candidate progresses through levels of work capability, which is described in 7.3.4 of R-04-P, such 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 at the degree of responsibility E.

7.2 Orientation requirements

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

7.3 Realities

Generally, irrespective of the discipline, it is unlikely that the period of training will be less than three years, the minimum time required by ECSA. Typically, it will be longer and would be determined amongst others by the availability of functions in the actual work situation.

7.4 Considerations for generalists, specialists, researchers and academics;

Section 10 of document R-08-PE adequately describes what would be expected of persons whose formative development has not followed a conventional path, for example academics, researchers, and specialists.

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

7.5 Moving into or Changing Candidacy Training Programmes

This Guide assumes that the candidate enters a programme after graduation and continues with the programme until ready to submit an application for registration. It also assumes that the candidate is supervised and mentored by persons who meet the requirements in document R-04-P section 7.2. In the case of a person changing from one candidacy programme 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 (TER) 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 by the relevant supervisor.
- On entering the new programme, the Mentor and Supervisor should review the candidate's development in the light of the past experience and opportunities and the requirements of the new programme and plan at least the next phase of the candidate's programme.

Appendix: Training Elements

1	Introduction				
1.1		Induction programme	(Typically 1 to 5 days)		
1.1.1			Company structure		
1.1.2			Company policies		
1.1.3			Company Code of Conduct		
1.1.4			Company safety regulations		
1.1.5			Company staff code		
1.1.6			Company regulations		
1.2		Exposure to Practical Aspects of Engineering	(Typically 6 to 12 months) and cover how things are:		
1.2.1		(Experience in one or more of these but not all)	Manufacturing		
1.2.2		(Responsibility level A & B)	Construction		
1.2.3			Erection		
1.2.4			Field Installation		
1.2.5			Testing		
1.2.6			Commissioning		
1.2.7			Operation		
1.2.8			Maintenance		
1.2.9			Fault location		
1.2.10			Problem Investigation		

2	Design				
2.1		Experience in design and application of design knowledge	(Typically 12 to 18 months) and would focus on planning, design and application		
2.1.1		(In one or more of the above sectors)	Analysis of data and systems		
2.1.2		(Responsibility level C & D)	Planning of networks and systems		
2.1.3			System modeling and integration		
2.1.4			System design		
2.1.5			Network/circuit design		
2.1.6			Component/product design		
2.1.7			Software design		
2.1.8			Research and investigation		
2.1.9			Preparation of specifications and associated documentation		
2.1.10			Preparation of contract documents and associated documentation		
2.1.11			Development of standards		
2.1.13			Application of quality systems		
2.1.14			Configuration management		

3	Engineering tasks				
3.1		Experience in the execution of engineering tasks	Rest of training period Focus should be on projects and project management		
3.1.1		(Responsibility Level E)	Design		
3.1.2		(Working in one or more of these but not in all)	Manufacture		
3.1.3			Construction		
3.1.4			Erection		
3.1.5			Installation		
3.1.7			Commissioning		
3.1.8			Maintenance		
3.1.9			Modifications		
3.2		Organising for Implementation of 3.1			
3.2.1		(Responsibility Level E)		Manage resources	
3.2.2				Optimisation of resources and processes	
3.3		Controlling for Implementation or Operation of 3.1			
3.3.1		(Responsibility Level E)		Monitor progress and delivery	
3.3.2				Monitor quality	
3.4		Completion of 3.1			
3.4.1		(Responsibility Level E)		Commissioning	
3.4.2				Completion documentation Completion documentation	
3.4.3				Handover	

3.5		Maintenance and repair of 3.1			
3.5.1		(Responsibility Level E)		Maintenance planning and scheduling	
3.5.2				Monitor quality	
3.5.3				Oversee maintenance and repair	

4	Risk and impact mitigation				
4.1		Impact and risk assessments			
4.1.1		(Responsibility Level E)	Impact assessments		
4.1.2			Risk assessments		
4.2		Regulatory compliance			
4.2.1		(Responsibility Level E)	Health and Safety		
4.2.2			Codes and standards		
4.2.3			Legal and regulatory		

5	Managing engineering activities				
5.1		Self Management			
5.1.1			Manage own activities		
5.1.2			Communicates effectively		
5.2		Team environment			
5.2.1			Participate in and contribute to team planning activities		
5.2.2			Manage people		
5.3		Professional communication and relationships (Networking)			
5.3.1			Establish and maintain		

			professional and business relationships		
5.3.2			Communicates effectively		
5.4		Exercising Judgment and Taking Responsibility			
5.4.1		(Responsibility Level E)	Ethical practices		
5.4.2			Code of Conduct		
5.4.3			Exercise sound judgment in the course of complex engineering activities		
5.4.4			Be responsible for decision making on part or all engineering activities		
5.5		Competency development			
5.5.1			Plan own development programme		
4.5.2			Construct initial professional development record		

Revision History

Version	Date	Revised/Approved by	Nature of Revision
Rev 0: Concept A	26 Jan 2012		Initial attempt at Electrical DSTG
Rev 0: Concept B	10 Jun 2012		Further attempt with schedule RAH
Rev 0: Concept C	9 Sept 2012		
Rev 0: Concept D	29 Oct 2012		Standard sections 1-3. Formatting
Rev 0:Concept D(3)	11 Jan 2013		Software added and other corrections
Rev 1	12 Mar2013	Registration Committee for Professional Engineers	