ENGINEERING COUNCIL OF SOUTH AFRICA *Standards and Procedures System*		
Discipline-specific Training Guideline for Professional Engineer in Mechanical Engineering		
Status: Approved by Registration Committee for Professional Engineers		
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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.

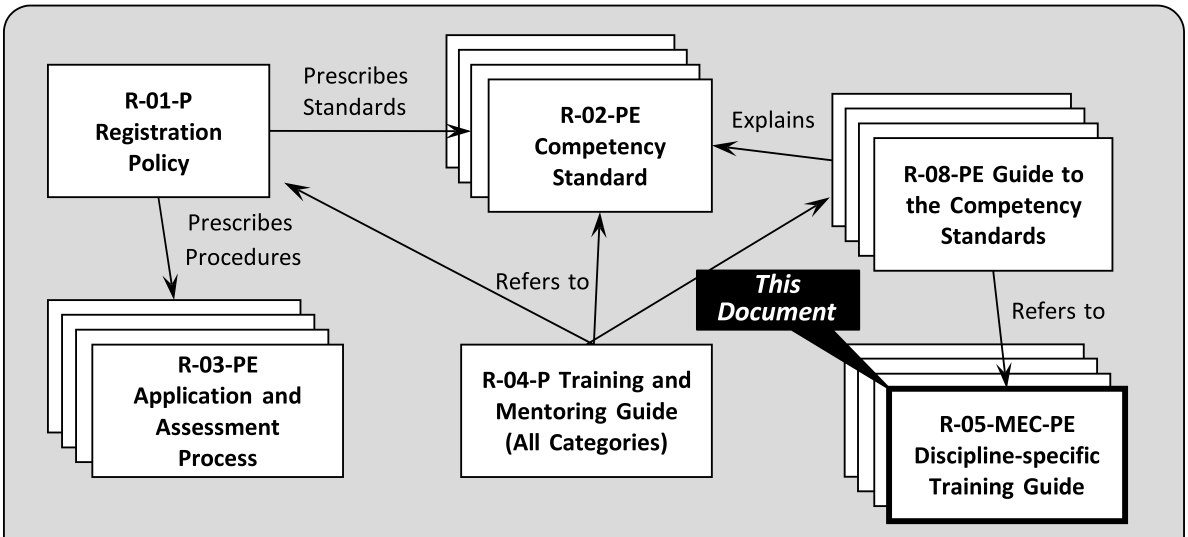

Figure 1: Documents defining the ECSA Registration System

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 Mechanical Engineering. 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 7.5).

4. Mechanical Engineering(OFO 2144)

Mechanical Engineers undertake the planning, design, construction, operation and maintenance of materials, components, machines plant and systems for lifting, hoisting and materials handling; turbines, pumps and fluid power; heating, cooling, ventilating and airconditioning; fuels, combustion, engines, steam plant , petrochemical plant, turbines; automobiles, trucks, aircraft, ships and special vehicles; fire protection; nuclear energy generation, lifts and escalators; advise on mechanical aspects of particular materials products or processes; through the application of engineering sciences: mechanics, solid mechanics, thermodynamics, fluid mechanics.

Typical tasks that a *Mechanical Engineer* may undertake include:

- Advising on and designing machinery and tools for manufacturing, mining, construction agricultural and other industrial purposes
- advising on and designing steam, internal combustion and other non-electric motors and engines used for propulsion of railway locomotives, road vehicles or aircraft or for driving industrial or other machinery

  Advising on and designing hulls, superstructures and propulsion systems of ships; mechanical plant and equipment for the release, control and utilization of energy, heating , ventilation and refrigeration systems, steering gear, pumps, pipe work, valves and other associated mechanical equipment

  Advising on and designing airframes, undercarriages and other equipment for aircraft as well as suspension systems, brakes, vehicle bodies and other components of road vehicles

  Advising on and designing non-electrical parts of apparatus or products such as word processors, computers, precision instruments, cameras and projectors

  Establishing control standards and procedures to ensure efficient functioning and safety of machines, machinery, tools, motors, engines, industrial plant, equipment or systems

  Ensuring that equipment operation and maintenance comply with design specifications and safety standards

Practising *Mechanical Engineers* generally concentrate in one or more of the following areas:

Air-conditioning Heating and Ventilation Incl. Fire Protection and Detection Engineer.
Automotive Engineer
Diesel Engineer
Fluid Mechanics Engineer
Forensic Engineer
Heating and Ventilation Engineer
Machine Design and Development Engineer
Maintenance Management Engineer
Mechanical Engineer Mines)
Mechatronics Engineer
Piping Engineer
Power Generation Engineer
Pressurised Vessels Engineer
Rotational Plant Engineer
Structural Steel Engineer
Thermodynamics Engineer
Transportation Systems Engineer

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

Mechanical 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, 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. Mechanical 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 both Groups A and B 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.

Problem solving in design, operational, construction and research environment is the core of mechanical engineering. It is a logical thinking process that requires engineers to apply their minds diligently in bringing solutions to technically complex problems. This process involves the analysis of systems or assembly of mechanical components, and integration of various elements in mechanical engineering through the application of basic and engineering sciences.

The problem solving experience may be obtained in any of the following work categories:

5.1 Design

Examples of acceptable designs would include, but are not limited to the design of:
- complex fluid systems, which includes rotating or reciprocating machines.
- complex machines/equipment or major parts thereof.
- complex energy systems involving heat transfer.
- complex pressure systems/HVAC systems.
- complex structures.

Acceptable complex design reviews would include reviews of major machine systems such as turbines/compressors with their auxiliary systems, power station systems and their major components, complex refrigeration systems, petrochemical and other production and manufacturing plant systems and the like.

5.2 Operations

This would mostly deal with investigating failure or underperformance of major equipment or systems and the synthesis of implemented and proven solutions to avoid recurrence of the problem. In addition this category of work will also involve the improvement projects necessary for optimising the operational efficiencies. The engineer must, in carrying out the above, apply professional engineering judgment to all work he or she does. This would include, but would not be limited to, the ability to assess design work against the following criteria:

- o Conformance to design specifications, health and safety regulations.
- o Ease of fabrication and assembly.
- o Constructability.
- o Maintainability.
- o Conformance to environmental requirements.
- o Ergonomic considerations.
- o Life cycle costs.
- o Alternative solutions

5.3 Research and Development

This type of work may be carried out in research and product development centers of business organizations or at the academic institutions. Candidates must undertake research and development work that is predominantly of mechanical engineering nature, and this work must include an in-depth application of the various aspects of mechanical engineering, including product or system testing under controlled experimental conditions.

6. Developing competency: Elaborating on sections in the Guide to the Competency

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

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

Applicants must show evidence of adequate training in this function through complex project work carried out in the analysis of problems and the synthesis of solutions. Evidence is required in the form of a separate comprehensive design report that should accompany the application. This report should describe a synthesized solution to sufficiently complex engineering problems to demonstrate that applicants have had an opportunity to apply their technical knowledge and engineering expertise gained through university education and practical work experience. In applying technical and scientific knowledge gained through academic training, the applicant must also demonstrate the financial and economic benefits of engineered solutions, synthesized from scientific and engineering principles at a sufficiently advanced level.

What is a sufficiently complex engineering problem?

We can summarise the definition of *complex* in *complex engineering problems* as follows:

> "Composed of many ***inter-related conditions***; requiring ***first principle empirical judgment*** to create a solution within a set of ***originally undefined circumstances*****"**

Mechanical engineering forms an integral part of broader engineering systems and infrastructure in technologically complex manufacturing, processing, mining, construction, product development and research environment. Applicants are required to undertake mechanical engineering projects that significantly enhance the operability and constructability of integrated engineering systems and infrastructure. Such project work must not be stand-alone type of assignment, but should be part of a solution to integrated engineering systems that requires a broader application of various theoretical aspects of mechanical engineering, ranging from fluid systems and energy systems, to structures and machines.

The design is a logical thinking process that requires engineers to apply their minds carefully in bringing solutions to technically complex problems. This process involves the analysis of systems or assembly of mechanical components, and integration of various elements in mechanical engineering through the application of basic and engineering sciences. Simple, straightforward calculation exercises and graphical representations from computer generated data are not considered as sufficiently complex engineering designs. The reason is because anybody with qualifications in basic science and engineering science can be able to perform this kind of work, and the professional registration requires advanced application of engineering **knowledge** in complex design problems.

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

Candidate Engineers must obtain experience in solving a variety of problems in their work environment, and the solution to these problems should also involve the use of fundamental and advanced mechanical engineering knowledge obtained at university. The problems that require scientific and engineering approach in solving them may be encountered in any engineering work environment that consists of integrated engineering systems, equipment, machinery and infrastructure. From their early training years, candidates must actively seek opportunities to obtain experience in the area of synthesizing solutions to real life engineering problems encountered at the workplace.

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

6.1 Contextual Knowledge

Candidates are expected to be aware of the requirements of the engineering profession. The Voluntary Associations applicable to the Mechanical Engineer and their functions and services to members, for example, provide a broad range of contextual knowledge for the Candidate Engineer through the full career path of the registered Engineer.

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

The Professional Advisory Committee (Mechanical) of ECSA carries out the review of the Candidate's portfolio of evidence at the completion of the training period.

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

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 Industry-related 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.
- Building Regulations – National Building Regulations and Building Standards Act, 1977 (Act No. 103 of 1977), as amended by Act No. 49 of 1995
- Machinery and Works Regulations
- Labour Relations Act
- 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

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 and to investigate whether any Acts are applicable in the particular work environment.

6.4 Recommended Formal Learning Activities

The following list of formal learning is a sample of some useful course types:

CPD courses on specific disciplines
Project Management
Value Engineering
Standard Conditions of Contract: NEC, FIDIC, GCC etc
Preparation of Specifications
Negotiation Skills
Engineering Finance
Risk Analysis
Quality Systems
Occupation Health and Safety
Energy Efficiency
Maintenance Engineering
Environmental Impacts
Management
Report Writing
Planning methods

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 cycle, to ensure that their designs are constructable, operable, and are designed considering life cycle costing and long-term sustainability

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 degree of responsibility E.

The Mentor and Candidate must identify at which level of responsibility an activity provides the compliance with and demonstration of the various ELOs. The evidence of the candidate's activities and acceptance by the Mentor will be recorded on the appropriate system such that it meets the requirements of the Training Elements Appendix. ECSA will specify the applicable recording system.

7.2 Orientation requirements

Introduction to Company
Company Safety Regulations
Company Code of Conduct
Company Staff Code and Regulations
Typical functions and activities
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 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.

Each candidate will effectively undertake a unique programme where the various activities carried out at the discipline specific level are then linked to the generic competency requirements of R-08-PE.

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

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

7.5 Moving into or Changing Candidacy 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 structure 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.

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 requirements of the new programme and plan at least the next phase of the candidate's programme.

Appendix: Training Elements

	Occupational		Work experience	Scope of WE
	tasks	contexts		
1	Solving problems based on engineering and contextual knowledge			
1.1		Conceptualisation of complex engineering problems		
1.1.1			Receive brief	
1.1.2			nvestigate/evaluate requirements	
1.1.3			Develop preliminary solutions	
1.1.4			Justify the preliminary design	
1.2		Design or development processes for complex engineering problems		
1.2.1			Detailed design or development processes	
1.2.2			Documentation development for Implementing Complex Engineering Solutions	
2	Implementing or operating engineering projects, systems, products or processes			
2.1		Planning processes for Implementation or Operations		
2.1.1			Develop business and stakeholder relationships	
2.1.2			Scope and plan	
2.2		Organising processes for Implementation or Operations		
2.2.1			Manage resources	
2.2.2			Optimisation of resources and processes	
2.3		Controlling processes for Implementation or Operations		
2.3.1			Monitor progress and delivery	
2.3.2			Monitor quality	
2.4		Close out Processes for Implementation or Operations		
2.4.1			Commissioning processes	
2.4.2			Development of operational documentation	
2.4.3			Handover processes	
2.5		Maintenance and repair processes		
2.5.1			Maintenance planning and scheduling	
2.5.2			Monitor quality	
2.5.3			Oversee repairs and/or implement remedial processes	
3	Risk and Impact Mitigation			
3.1		Impact and risk assessments		
3.1.1			mpact assessments	
3.1.2			Risk assessments	
3.2		Regulatory compliance processes		
3.2.1			Health and Safety	
3.2.2			Legal and regulatory	
4	Managing Engineering Activities			
4.1		Self Management Processes		
4.1.1			Manage own activities	
4.1.2			Communicates effectively	
4.2		Team environment		
4.2.1			Participate in and contribute to team planning activities	
4.2.2			Manage people	
4.3		Professional communication and relationships		
4.3.1			Establish and maintain professional and business relationships	
4.3.2			Communicates effectively	
4.4		Exercising Judgement and Taking Responsibility		
4.4.1			Ethical practices	
4.4.2			Exercise sound judgement in the course of complex engineering activities	

4.4.3			Be responsible for decision making on part or all of complex engineering activities
4.5		Competency development	
4.5.1			Plan own development strategy
4.5.2			Construct initial professional development record

Revision History

Version	Date	Revised/Approved by	Nature of Revision
Rev 0: Concept A	16 Sep 2011	PAC Mech	Initial draft
Rev 0: Concept B	4 July 2012		New template applied
Rev 0: Concept C	7th Sept 2012	PAC Mech	Revisions to Concept B
Rev 0: Concept D	29 Oct 2012		Standard sections 1—3 inserted, foratted
Rev 0: Concept E	27 Feb 2013	JIC	Revision to section 3
Rev 1	12 Mar 2013	Registration Committee for Professional Engineers	

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