ENGINEERING COUNCIL OF SOUTH AFRICA *Standards and Procedures System*			
Discipline-Specific Training Guideline for Candidate Engineers in Chemical Engineering			
Status: Approved by Registration Committee for Professional Engineers			
Document : R-05-CHE-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.

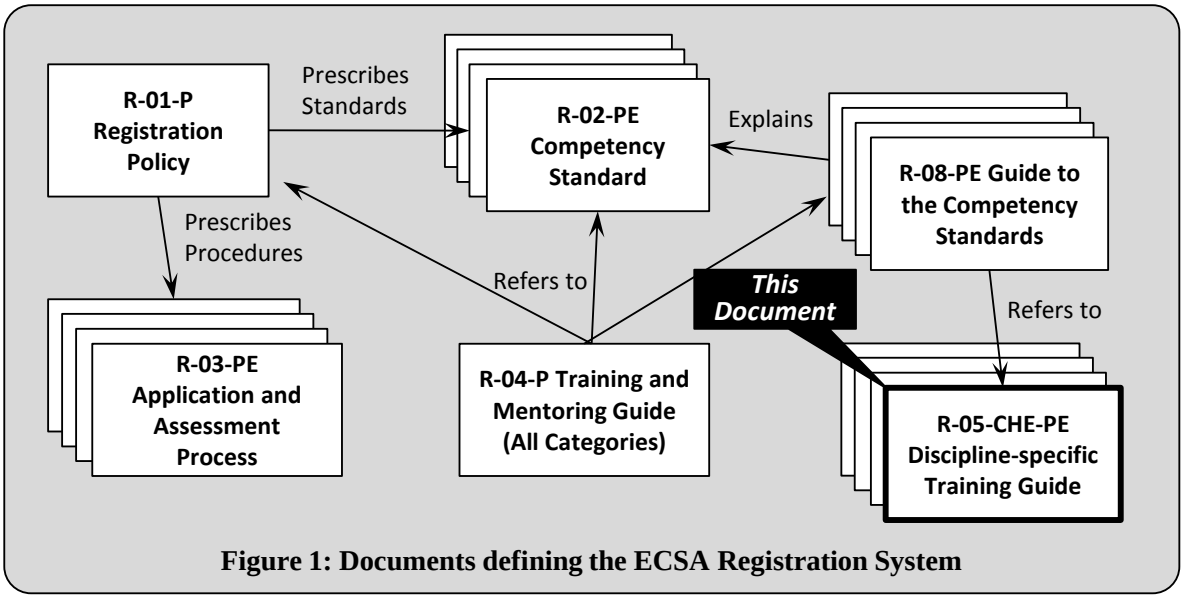

Figure 1: Documents defining the ECSA Registration System

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 Chemical 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 7.3).

4. Chemical Engineering

Chemical Engineering: The planning, design, development, operation and maintenance of industrial-scale processes to convert raw and recycled materials to products through chemical and physical processes using engineering science such as thermodynamics, fluid mechanics and transfer processes.

Typical tasks that a Chemical Engineer may undertake include the following (note that this is not an exhaustive list):

- Conducting research, advising on and developing commercial-scale processes to produce substances and items such as petroleum derivatives, chemicals, food and drink products, pulp and paper, pharmaceuticals or synthetic materials such as polymers and plastics
- Specifying chemical production methods, equipment, materials and quality standards and ensuring that they conform to specifications and accepted industry practices and standards
- Establishing control standards and procedures to ensure safety of production operations and safety of workers operating equipment or working in close proximity to on-going chemical reactions or processes
- Designing chemical plant and equipment and devising processes for manufacturing chemicals and other products while meeting targeted efficiencies
- Performing tests throughout stages of production to determine degree of control over process variables including composition, temperature, density, specific gravity and pressure
- Developing operating procedures to be employed during design and operating phases (including start-up, shutdown and emergency)
- Preparing estimates of production costs (capex, opex and lifecycle) and production progress reports for management
- Performing laboratory studies of steps in manufacture of new products and testing proposed process(es) in small scale operation such as a pilot plant
- Plant operation and/or management
- Optimising of processes for improvement of prescribe performance indices such as profitability, sustainability, energy, environmental and carbon efficiency.
- Develop process control philosophies and/or advanced process control (APC) systems
- Evaluate environmental and legal considerations
- Participate in and lead risk assessment studies (such as hazard and operability studies) during the design or operations phase

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

5.1 Areas within Chemical Engineering

The areas where chemical engineers work follow the conventional stages of the project life cycle:

- Research and development to develop a new product or process, or fix a process problem
- Process design to solve a process-related problem, or achieve a particular desired result, or to select equipment for a particular purpose (including conceptualisation, examination of alternatives, trade-off studies, basic and detailed design)
- Project management to install the necessary equipment for the desired process (including project planning, project controls (budgets, resources, schedules) etc.)
- Plant operation to manufacture the product and make process improvements

It is not expected that applicants will have to change jobs in order to work in all four areas (although that is often a good way, followed by many candidate engineers, of being sure of getting the broadest possible experience).

What is expected for ECSA registration is that in whatever area they are employed, applicants ensure that they undertake tasks that provide experience in the 3 generic engineering competence elements: of problem investigation and analysis; problem solution and execution/ implementation. It should not take too much thought to realize that problem investigation; problem solution; execution/ implementation are all required in every one of the areas above, to a greater or lesser extent. It should be possible, by judicious selection of work task opportunities with the same employer, to gain experience in all three elements, as expanded in the functions described in Section 5.2.

It is also important that the applicants be able to demonstrate that they have gained experience at increasing levels of responsibility ultimately operating at the level expected of a professional engineer within the areas of problem investigation and analysis; problem solution and execution/ implementation. To this end, it is important for candidate engineers to work closely with their mentors and employers to plan workplace opportunities in order to gain the necessary experience and expertise.

5.2 Engineering Lifecycle Considerations

The typical engineering industry lifecycle is depicted in Figure 1 below:

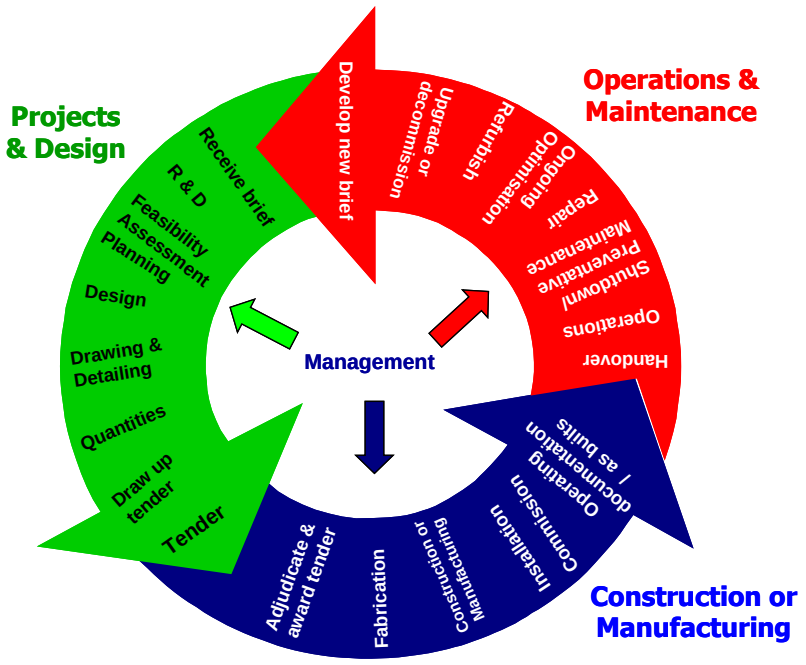

Figure 1 Typical Engineering Industry Life Cycle

The Chemical Engineering professional will generally work in one of two broadly defined working environments:

- Projects and design
- Operations

In the Appendix, a table is presented for the functions that a candidate must become competent to do in each of the phases of a project:

1. Solving complex problems based on engineering and contextual knowledge
2. Implementing projects or operating engineering systems or processes

3. Risk and impact mitigation
4. Managing engineering activities

Within each group, three levels of description are given. Expansion to a fourth level is available in electronic form. To the third and largely to the fourth, the description is independent of the discipline. Discipline specifics may be included as a fifth level as required. These would include the types of evidence of performance that would be appropriate at each line.

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

6.1 Contextual Knowledge

Candidates are encouraged to familiarise themselves with the Process Industries in general by reading journals, joining industry associations, attending training courses and conferences. This includes gaining knowledge of industry standards and specifications (such as ASME, TEMA, NFPA) and industry practices (such as API).

6.2 Functions Performed

The functions in which all chemical engineers need to be proficient, and are required to a greater or lesser extent in all the areas of employment, are listed below. The parallels with the generic competence elements required by the competency standard R-02-PE should be clear.

- Investigation/trouble-shooting
- Process plant and equipment design
- Process safety and environmental considerations
- Project management
- Plant construction support, hand-over and commissioning/de-commissioning
- Plant operation

Applicants need to gain experience in these functions, even if it is not their core job function.

6.2.1 Investigation/ trouble-shooting (i.e. thinking about or evaluating a problem)

- Identification of the cause(s) of process problems in a systematic manner
- Identification of opportunities for improving current operations, extending the product range/yield, changing the feed source, developing new methods for processing, developing new applications for products, developing new methods/technologies to address shortfalls in currently available methods/technologies or evaluation of processing alternatives
- Planning and carrying out experimental investigations in a scientific manner on a laboratory, pilot plant or industrial plant scale
- Evaluation of experimental or theoretical results, or evaluation of a proposed major project (techno-economic evaluation); deriving conclusions in a logical way and formulating recommendations based on these conclusions
- Motivating research, development or plant modification projects based on technical, economic, safety and environmental considerations

6.2.2 Process plant design (i.e. doing something about the problem)

- Preparation of a design basis, process flow sheets, mass and energy balances (can involve simulation and/or computational fluid dynamics)
- Optimization of the plant system design; using models (normally computerized) to determine configuration options
- Selection, design and specification of equipment and service requirements, with reference to the applicable codes and consideration of the suitability of materials used, costs and lifecycle requirements
- Checking the reliability of data on the properties of materials to be processed or produced, economics, instrumentation, quality control, logistics, safety, spillage/containment management and the effect on the environment
- Definition and development of process control and operating philosophies
- Checking of working drawings for suitability with respect to the process, space, accessibility, maintenance etc.

6.2.3 Process safety and environmental considerations

- Consideration of the process safety aspects of projects, which arise from the use of hazardous materials
- Consideration of process safety when selecting the materials of construction
- Assessing the environmental impact of process industry activities, and compliance with legal requirements (including requirements for final de-commissioning, shutdown and/or facility closure)
- Use of risk assessment and HAZOP techniques to improve plant design safety
- Application of process safety management systems to ensure safe operation and contingency measures

6.2.4 Project management

- Project management during all phases of project development, including conceptual design, basic and detailed engineering, EPCM – engineering procurement, construction management and commissioning/hand-over
- Responsibility for or involvement in project controls – including cost control, estimating (resources, capital, operating and/or lifecycle costs), planning and scheduling
- Liaison and responsibility for communication and overall control of engineering team and interfacing with client/legal entities

6.2.5 Plant construction support, hand-over and commissioning/de-commissioning

- Plant hand-over: including ‘as-built’ documentation, construction punch-out, planning and execution of punch-out and hand-over
- Plant commissioning: measurement and analysis of plant performance versus design data; responsibility for acceptable plant performance; elimination of operability and other problems and unacceptable bottlenecks; checking on compliance with safety standards
- Preparation of operating, start up, shutdown and emergency procedures
- Plant de-commissioning and consolidation for shutdown or closure

6.2.6 Plant operation

- Management of production resources : raw materials, manpower, energy, maintenance
- Quality control; monitoring quality and meeting specifications;
- Measurement analysis and evaluation of performance data; on-going plant monitoring and plant optimization, performance and operating costs
- Involvement in budgets, cost control, planning and production scheduling

6.3 Industry-related statutory requirements

The candidate engineer should become familiar with the legal requirements of the process industries including those acts that are generally applicable such as the OHS Act, and the Engineering Profession Act. The candidate engineer will be expected to have knowledge and understanding of the statutory requirements pertaining to the work and projects that are included in the experience report.

6.4 Recommended Formal Learning Activities

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

- Risk assessment and analysis techniques (including HAZOPs)
- Project management techniques and tools, including conditions of contract, finance and economics and quality systems
- Simulation tools, e.g. Aspen, SimSci, ChemCAD, AFT, Metsim
- Occupation Health and Safety including the OHS Act and "safety in design"
- Formally registered CPD courses in Chemical/Process Engineering and associated disciplines
- Value Engineering and other Value Improvement Practices (VIPs)
- Preparation of Specifications
- Environmental aspects of projects
- Professional skills such as report writing, presentations, review meeting facilitation and negotiation skills
- Project and Operations planning methods

7. Programme Structure and Sequencing

7.1 Best Practice

There is no ideal training programme structure or 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. This means that each candidate will effectively undertake a unique programme where the various activities carried out at the discipline specific level must then be linked to the generic competency requirements of R-08-PE.

7.2 Realities

Candidate Engineers are advised that although 3 years is the minimum period of experience following graduation, in practice it is found that very seldom do chemical engineers meet the experience requirements in this time, and then only if they have followed a structured training program. Applicants are advised to gain at least 5 years of experience before applying. Furthermore, as the application procedure only allows deferral for 1 year (plus a possible additional 1 year extension of

deferral in specific circumstances), applicants will lose their application fee if they cannot achieve the necessary competency within that deferral time period.

7.3 Considerations for generalists, specialists, researchers and academics

Chemical engineers often work in areas such as academia, Research & Development or highly specialised fields where it is often difficult to gain the breadth of experience required for registration. These candidates must still obtain the necessary experience to enable them to demonstrate that they have met the competencies specified in document R-02-PE at the level expected of a professional engineer. It is expected that this will take longer than it would for candidates working in more general areas.

7.4 Moving into or between 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 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 in the appropriate manner.
- 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 tasks	Occupational contexts	Work experience	Scope of WE
1	Solving problems based on engineering and contextual knowledge			
1.1		Conceptualisation of complex engineering problems		
1.1.1			Receive brief	
1.1.2			Investigate/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 projects or operating engineering systems 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			Impact 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	10 May 2012		Initial draft of Chemical DSTG in New template
Rev 0: Concept B	24 Aug 2012		Update following workshop
Rev 0:Concept C	29 Oct 2012		Standard sections 1-3 inserted
Rev 0: Concept D	31 Jan 2013		Updated to incorporate further clarifications and requirements
Rev 1	12 Mar 2013	Registration Committee for Professional Engineers	