ENGINEERING COUNCIL OF SOUTH AFRICA *Standards and Procedures System*			
Discipline-specific Training Guideline for Professional Engineers in Industrial Engineering			ECSA
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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.

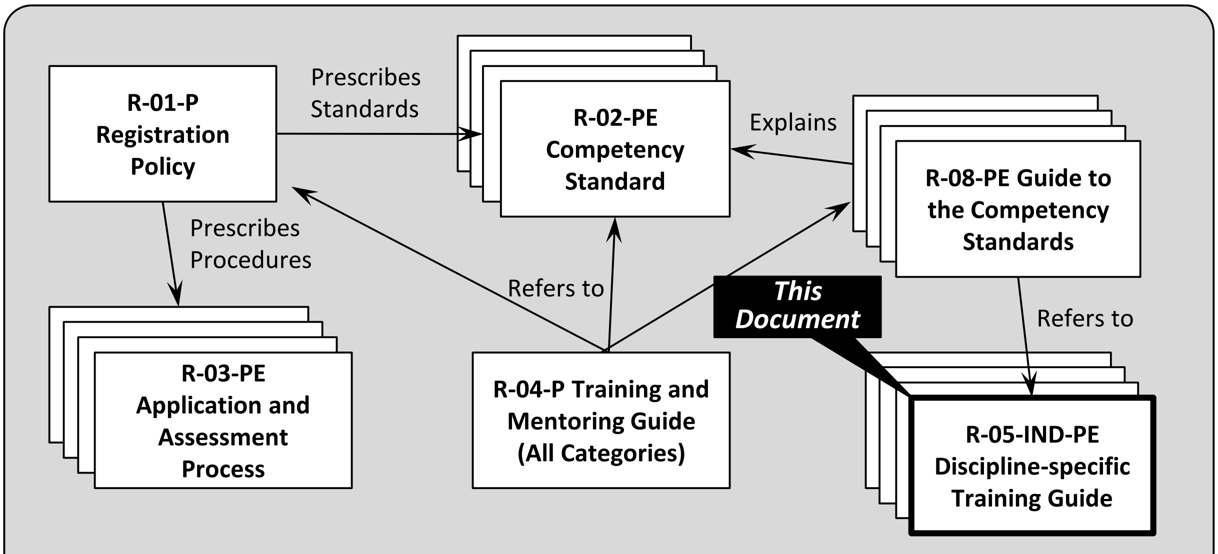

Figure 1: Documents defining the ECSA Registration System

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 Industrial 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 7.4).

4. Industrial Engineering

4.1 Origins

Industrial Engineering has its roots in the work of Fredrick Taylor, and Gillian and Frank Gillbreth, all of whom focused on the improvement of worker productivity in the latter part of the nineteenth century[i].

4.2 SAIIE Definition

Since then, the discipline has grown to encompass any methodical or quantitative approach to optimizing how a process, system, or organization operates[ii]. This is reflected in the more specific definition of Modern Industrial Engineering that has been adopted by the Southern African Institute for Industrial Engineering:

> The science of integrating resources and processes into cohesive strategies, structures and systems for the effective and efficient delivery of quality goods and services. It draws upon specialized knowledge and skills in the mathematical, physical, behavioral, and economic and management sciences, and combines them with the principles and methods of engineering analysis and design, to find optimal and practical solutions which contribute to the success and sustainability of a venture, thus making a fundamental contribution to the creation of wealth.

4.3 OFO Definition

The Organising Framework for Occupations (OFO) 2012[iii], offers a similar, though more simplified definition of our Profession:

> An Industrial Engineer investigates and reviews the utilisation of personnel, facilities, equipment and materials, current operational processes and established practices, to recommend improvement in the efficiency of operations in a variety of commercial, industrial and production environments.

4.4 Specialisation

The OFO also offers the following alternative Titles and Specialisations, which give an indication of the various areas of specialisation, many of which are industry specific:

- Agri Produce Process Engineer
- Automation and Control Engineer
- Clinical Engineer
- Enterprise Resource Management Engineer
- Fabrication Engineer
- Industrial Efficiency Engineer
- Industrial Machinery Engineer
- Manufacturing Logistics Engineer
- Manufacturing Technology Engineer
- Operations Research Engineer
- Plant Engineer
- Process Design Engineer

The OFO is a coded occupational classification system, adopted by the Department of Higher Education and Training for identifying, reporting and monitoring skills demand and supply in the South Africa labour market.

It provides a common language when talking about occupations, captures jobs in the form of occupations and groups occupations into successively broader categories and hierarchical levels based on similarity of tasks, skills and knowledge.

- Process Engineer
- Production Engineer
- Quality Management Engineer
- Robotics and Production Automation Engineer
- Safety Engineer
- Supply Chain Management Engineer
- Value Engineering

4.5 Skills Perspective

A further dimension of specialisation and sub disciplines is revealed when one views the Profession from a Skills Perspective.

A skill is defined as the ability to carry out the tasks and duties of a given job. The OFO considers skill specialisation in terms of four themes. Examples of specialised Industrial Engineering Skills in each of the four themes are listed below:

1. The field of knowledge required, which could include

   - Knowledge of the area of specialisation, and associated problem solving methods e.g. Value Engineering, Quality Assurance
   - Skills associated with phases in the life cycle of a business, programme, project, product or service, e.g. Asset and Maintenance Management, Project and Programme Management,
   - Industry specific knowledge, in as far as it presents the context in which a problem needs to be understood and ultimately solved, e.g. Fast Moving Consumer Goods, Warehousing & Transportation, Capital Investment

2. The tools and machinery used, which could be interpreted to include

   - Manufacturing, processing and fabrication techniques
   - Techniques and models, e.g. Operations Research
   - Modelling tools, e.g. Simulation and Optimisation Tools
   - System tools, e.g. Enterprise Resource Planning Systems
   - Philosophies, e.g. Just in Time

3. The materials worked on or with, which is typically closely related to Industry, e.g.

   - Agri-produce and Agri-processing
   - Petrochemical and Processing industries
   - Steel, and other Metals and Beneficiation, Smelters, Metal Works, Precision Manufacturing, Steel Fabrication

4. The kinds of goods and services produced, e.g.

   - manufacturing, processing, assembly
   - fabrication, construction and engineering contracting
   - complex systems
   - service industries
   - professional and management consulting services

It is evident from the above that, unlike many of the other engineering disciplines, Industrial Engineering is not limited to any one or more of the four dimensions of specialization. It is therefore no surprise that a growing number of industries are benefiting from an Industrial Engineering skill set. The list of such **industries** includes, but is not limited to:

- Primary industries and its downstream beneficiation industries, including mining, fisheries, forestry and agriculture
- Manufacturing industries, ranging from highly specialized capital and goods manufactured on order, to mass produced and fast moving consumer goods
- Chemical, petrochemical, agriculture, food, cosmetics and other processing industries
- Construction and engineering contracting
- Logistics and transport
- Medical and health industries
- Services industries, including banking, insurance and the various spheres of government
- Engineering consulting
- Information and Communication Technology, including business management systems, artificial intelligence, virtual reality, simulation and other decision support mechanisms

4.6 Problem Solving Methods

Industrial Engineering also continues to evolve in its response to the typical optimization challenges of particular industries. As knowledge and technology evolves, Industrial Engineering has embraced as sub-disciplines many problem solving techniques, methodologies, approaches and even philosophies. Some examples are:

- The Lean and Just in Time philosophies and associated techniques typically applied in manufacturing and construction supply chains
- Supply Chain Management and its associated disciplines in the areas of procurement, inventory and materials management, warehouse and logistics management, manufacturing management, production and process control, and sales and distribution management
- Methodologies and techniques associated with the planning and control of primary conversion processes, and the associated accounting practices
- Re-engineering of primary and support processes
- Total Quality Management, Six Sigma and other approaches to Quality Assurance and Management
- Theory of Constraints, and associated techniques
- Simulation and stochastic processes, statistical analysis, operations research and other associated quantitative problem solving techniques
- Maintenance Management, including Total Preventative Maintenance
- Systems design and systems engineering, including systems support over its entire life cycle
- System dynamics, policy planning and process design
- Cost and value engineering
- Facilities design and management
- Project Management
- Engineering economics

5. Implications for Industrial Engineering Training

Considering the dynamic nature of the profession, the diverse range of industries which Industrial Engineers could find themselves in, and the diverse range of sub-disciplines and specialised skills characterising the Profession, it is evident that it is virtually impossible to define a set of predetermined training paths for the Industrial Engineering Candidacy Phase.

Instead of predetermined paths, a set of guiding principles is proposed, whereby Candidates should shape the course of their own Candidacy Phase. The list of guiding principles is:

- To be involved with the solution of at least one complex problem, , through its entire life cycle, starting with problem definition, continuing to evaluation and selection of proposed solutions, solution design, as well as its implementation and post implementation support.
- To seek a fair balance between width of exposure and depth of specialisation, and not to compromise the one for the other
- To actively seek diversity across assignments, in terms of
  - the types of underlying complexity of problems exposed to
  - the management and leadership style of business leaders, managers and mentors exposed to
  - teams involved with, as well as team work and individual work
- To seek a level of continuity across at least one area of specialisation, e.g. industry, discipline or problem solving technique

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

In this section, we elaborate on the discipline-independent competency standards outlined in R-08-PE, highlighting specific competencies across the respective areas that are most relevant to Industrial Engineering.

6.1 Contextual Knowledge

Any successful solution or intervention takes the context in which it exists into consideration. The integrative nature of Industrial Engineering, the fact that it draws from a variety of specialised knowledge and skills, and the requirement to satisfy multiple objectives simultaneously place an added emphasis on the understanding and consideration of context.

Contextual knowledge includes, but is not limited to the following:

- Organisation vision, mission, aspirations, objectives and core strategy
- Business model
- Industry dynamics
- Risk, compliance and governance framework
- Legal and regulatory framework
- Cultural and social value systems
- Political and economic context
- Historic context
- Stakeholder and role player expectations, limitations and aspirations
- Behaviour, mind set, skills and capabilities context
- Physical environment
- Support context

Any successful Professional has developed the art and skill to discern which contexts are most important in the situation at hand, and makes an effort to understand the opportunities, limitations and rules of engagement associated with the particular environment and context he or she find themselves in.

6.2 Functions Performed

There are no particular requirements related to Functions Performed in addition to the stipulations of R-08-PE.

6.3 Industry Related Statutory Requirements

There is no public liability associated with the typical activities of Industrial Engineers, as outlined in the sections above.

The Generally Applicable legislation, listed in Appendix A of R-08-PE also applies to Industrial Engineers. This list does not necessarily include industry specific legislation and regulation which forms part of the contextual knowledge required of Industrial Engineers.

6.4 Recommended Formal Learning Activities

Possible formal learning activities for candidate engineers include all post graduate programs in Industrial Engineering and related fields such as Supply Chain Management and Project and Technology Management offered by Universities with accredited engineering degree programs.

There also is a variety of continued education programmes in the broad field of Industrial Engineering offered by the various academic institutions as well as commercial entities that offer formal training. These programs have various degrees of accreditation and the Candidate Engineer should verify the status of the educational programme before enrolling.

The Southern African Institute for Industrial Engineering offers an annual conference as well as specialist group meetings through which Candidate Engineers can pursue Continuous Professional Development (CPD). The Institute also provide a listing of possible CPD activities for which CPD points will be awarded.

Short courses offered by Training Institutions, accredited by SAIIE in terms of CPD, include courses of both a generalist and specialist nature.

Examples of courses that offer specialist skill are:

- Systems Engineering
- Project Management
- Change and Transformation Management
- Maintenance Management
- Strategic Sourcing

Examples of courses that offer generalist skills are:

- Negotiation and influencing
- Industrial relations
- Public speaking
- Professional writing

The learning activities listed above are normally augmented by in house training in the workplace.

7. Programme Structure and Sequencing

7.1 Degree of Responsibility

Table 4: Progression throughout the candidacy period of *R-04-P Training and Mentoring Guide* refers to the gradual increase in degree of responsibility that the Candidate Engineer is exposed to during his professional training. Considering the nature of work listed in this table, specific examples and outcomes appropriate to training in Industrial Engineering are given below:

Degree of Responsibility	**Nature of work** **The candidate …**	**Training in Industrial Engineering**
A: Being Exposed	… undergoes induction, observes processes and work of competent practitioners	• Understand the business environment and the dynamics that shape the business and industries it operates in. • Understand the business model, its key conversion processes and critical outcomes • Understand the value added by Industrial Engineers and by other professions in the business
B: Assisting	… performs specific processes under close supervision	• Develop insight and understanding of the different processes and systems in the transformation of inputs into goods and services • Develop an appreciation of the numerous resources at the disposal of the industrial engineer • Obtain experience in the day to day operations of the business, in order to gain insight and understanding of the different processes and systems in the transformation of inputs into goods and services, with specific emphasis on productivity and quality measurements
C: Participating	… performs specific processes as directed with limited supervision	• Gain first-hand experience of a broad range of industrial engineering activities, for example process design and re-engineering, planning and control, work study, value engineering, materials and information management, people management skills, logistics, specialists' inputs, tools and equipment and quality assurance • The problems and limitations of particular philosophies, methods and techniques should be noted, with emphasis on cost / effort and relative benefit
D: Contributing	… performs specific work with detailed approval of work outputs	• Involvement in for example the planning of production, the control of quality and costs of process study and work study and good materials handling and workplace layout, activity based costing, bench marking, business cases, process re-engineering, maintenance practice and procedures, project management and system specification, all working together in the economic use of people, materials and machines, is of particular importance. • Specific attention should also be given to human aspects concerning communication, interpersonal relationships and teamwork, training and cost analysis, budget control and profit accountability. These should proceed in parallel, applying industrial engineering techniques and by utilizing computers in problem solving
E: Performing	… works in team without supervision, recommends work outputs,	• Assume increasing technical responsibility and increasingly co-ordinate the work of others • Exposure to and development of skill in management

	responsible but not accountable	areas such as in labour relations, management accounting, business law and general business management are important in order to develop a fully rounded industrial engineer • Assignments that require judgment to be made, even when full information is not available leading to a position of professional responsibility is of great value and should be pursued.

7.2 Realities

The minimum period for the Candidacy Phase is stated as three years. The likelihood however is that it will take between three and five years to gain the required width and depth of experience required for Registration.

Whilst many Companies, including those who have signed a Commitment and Undertaking with ECSA, offer structured Engineer in Training Programmes, workplace realities may imply limited opportunities for rotation or even promotion, or it may imply the requirement to fulfil a specific role with less than ideal access to in-house mentors and to Industrial Engineering. This may have consequences in terms of the quality and rate of one's development as a Candidate Engineer.

What distinguishes people who achieve success in life and in their careers is their ability to understand the choices, albeit limited, open to them. Courses and other opportunities to develop one's professional skills outside of the work place may ultimately lead to access to other opportunities within the workplace. The investment made in one's own development offers a sense of empowerment, and virtually always has multiple returns on the medium to long term.

Candidate Engineers should evaluate their readiness for Registration by comparing their own development against the standards of competency for registration in R-02-P. It will also be helpful to consult with a mentor and/or supervisor as to their readiness to apply for Registration.

7.3 Considerations for generalists, specialists, researchers and academics

It is highly recommended that researchers and academics make use of part time assignments and/or sabbaticals to gain exposure to projects outside of Academia. The Competency Standard as defined in R-02-PE applies to generalists, specialists, researchers and academics alike.

7.4 Moving into or Changing Candidacy Programmes

This Guide assumes that the Candidate enters a programme of Industrial Engineering work 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 are qualified to provide mentoring in accordance with this document.

Candidate Engineers should ensure that their career development continues to be aligned with Table 4 of paragraph 6.1 above. Candidate Engineers from disciplines other than Industrial Engineering will have to demonstrate their competencies in Industrial Engineering in accordance with the Training and Mentoring Guide R-04-P.

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 instance 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 towards the next phase(s) of the Candidate's programme.

Revision History

Version	Date	Revised/Approved by	Nature of Revision
Rev 0: Concept A	2011/11/03	Carien Botha	Drafting of Par's 2 & 3
Rev 0: Concept B	2011/11/04	Schalk Claasen	Editing of Par 2 & 3
Rev 0: Concept C	2011/11/07	Carien Botha	Transfer Par 2 & 3 to template
Rev 0: Concept D	2012/09/06	Schalk Claasen & Carien Botha	Complete revision of document following the ECSA workshop on Discipline-specific Training Guidelines
Rev 0: Concept E	29 Oct 2012		Revision number corrected. Standard sections 1-3 inserted
Rev 1	12 Mar 2013	Registration Committee for Professional Engineers	

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[i] Groseclose F.F.. 2005. The Roots of Industrial Engineering. *Engineering Enterprise. The Alumni Magazine for ISyE at Georgia Institute of Technology* [online], 2005(3):6-9.

Available at: www.isye.gatech.edu/eemag/pdfs/20053Fall.pdf [Accessed 20 October 2011]

[ii] *Industrial Engineering* [online] Available at: http://www.wikipedia.org/wiki/Industrial_Engineering [Accessed 20 October 2011]

[iii] Department of Higher Education and Training; Republic of South Africa, 2012.