Session Three:

How can we make better use of Competency Based Assessment in Functional Safety?

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Abstract

The number of CFSE, ISA and TÜV Rheinland FS Engineer qualified people around the world has increased rapidly over the past few years.

The question comes up frequently, which is the 'better' qualification?

Both are well respected and widely used, but both qualifications are essentially an indication only of training and knowledge, not of competence.

IEC 61508 and IEC 61511 require that all personnel working with functional safety have the competencies appropriate for the activities assigned to them. The standards do not specify how competence should be defined or assessed.

In the UK the Institution of Engineering and Technology (the IET) published a detailed guide to functional safety competencies in 1999. The guideline was revised and reissued in 2007, in conjunction with the HSE UK and the British Computer Society.

The guideline is well structured, comprehensive and easy to apply. Here in Australia I&E Systems Pty Ltd has been using the IET competence guidelines since 2004.

For many years in Australia all vocational education and training has been based on nationally accepted competency standards. Competency based assessment has been applied very widely and successfully for at least the past 15 years across all industries, trades and professions – but it has not yet been widely applied to functional safety.

AS/NZS 4761 'Competencies for working with electrical equipment in hazardous areas' is a good example of a competency standard that is used widely and effectively in Australia.

So rather than asking "which is qualification is better?", the question should be:

"How can we make better use of competency based assessment in functional safety?"

1 INTRODUCTION

1.1 Why worry about competence?

Over the past 40 years we have seen one disaster after another:

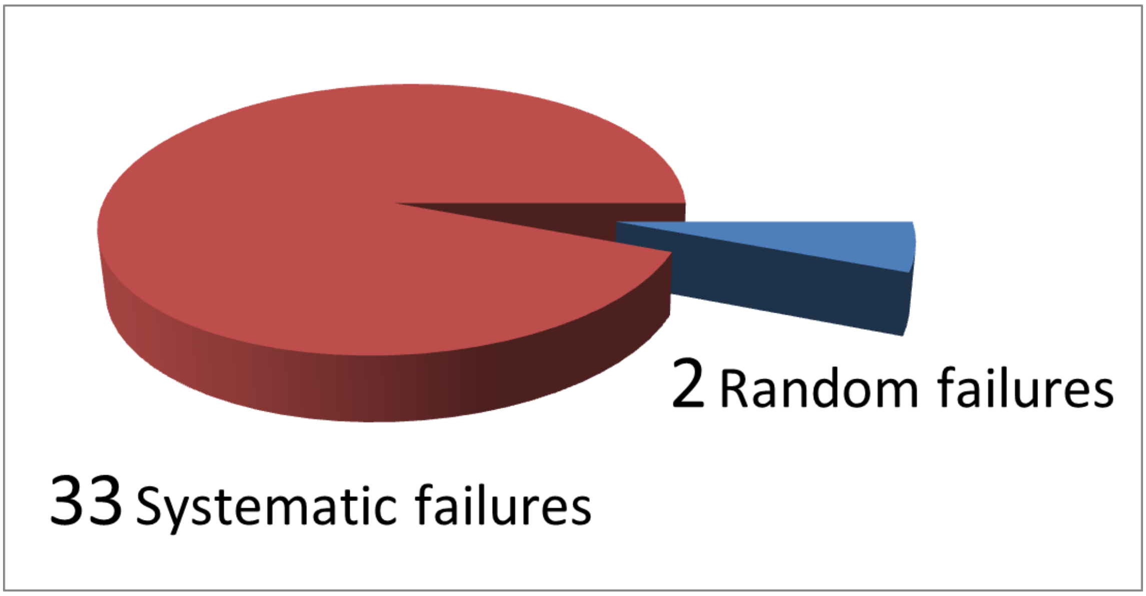
- Flixborough, UK, June 1974
- Seveso, Italy, July 1976
- Bhopal, India, December 1984
- Grangemouth 1987
- Piper Alpha 1988
- Pasadena 1989
- Longford 1998
- Texas City Refinery 2005
- Buncefield 2005
- Montara 2009
- Deepwater Horizon 2010
- Venezuela 2012

Fire after an explosion at the Amuay Oil refinery, Venezuela, August 2012. (Photo: Reuters)

1.2 Systematic Failures

Disturbingly, the stories often seem to be so similar. How can we avoid repeating the mistakes of the past?

Out of 35 major incidents 1987 to 2012 at least 90% were due to multiple *systematic* failures rather than due simply to random failures of equipment.[1]



IEC 61508-4 defines systematic failures:

> **3.6.6**
> **systematic failure**
> failure, related in a deterministic way to a certain cause, which can only be eliminated by a modification of the design or of the manufacturing process, operational procedures, documentation or other relevant factors
>
> NOTE 1 Corrective maintenance without modification will usually not eliminate the failure cause.
>
> NOTE 2 A systematic failure can be induced by simulating the failure cause.
>
> NOTE 3 Examples of causes of systematic failures include human error in
>
> – the safety requirements specification;
>
> – the design, manufacture, installation, operation of the hardware;
>
> – the design, implementation, etc. of the software.

Most systematic failures result from **human error** in specification, design, installation and in operation.

To some extent failures might be avoided by providing better training for engineers and technicians, but the underlying problems tend to be managerial or organisational rather than technological. Functional safety training courses have been directed almost exclusively at technologists rather than managers or leaders.

The long history of major accident events reveals recurring problems in these areas:

- Safety culture and leadership
- Clarity in organisational roles, responsibilities and interfaces
- Competencies – and in particular management competencies.

1.3 Management in functional safety

Effective management is essential for the avoidance and control of systematic failures. Both IEC 61508 and IEC 61511 begin with the requirements for management. The requirements are similar in both standards.

Successful application of functional safety depends on clear policy, an established management system, assignment of responsibilities and on competence. Refer for example to IEC 61511-1 section 5:

- Policy

  5.2.1.1 The policy and strategy for achieving safety shall be identified together with the means for evaluating its achievement and shall be communicated within the organization.

- Management System

  5.2.1.2 A safety management system shall be in place so as to ensure that where safety instrumented systems are used, they have the ability to place and/or maintain the process in a safe state.

- Responsibilities

  5.2.2.1 Persons, departments, organizations or other units which are responsible for carrying out and reviewing each of the safety life-cycle phases shall be identified and be informed of the responsibilities assigned to them (including where relevant, licensing authorities or safety regulatory bodies).

- Competence

  5.2.2.2 Persons, departments or organizations involved in safety life-cycle activities shall be competent to carry out the activities for which they are accountable.

  NOTE As a minimum, the following items should be addressed when considering the competence of persons, departments, organizations or other units involved in safety life-cycle activities:

  a) engineering knowledge, training and experience appropriate to the process application;

  b) engineering knowledge, training and experience appropriate to the applicable technology used (for example, electrical, electronic or programmable electronic);

  c) engineering knowledge, training and experience appropriate to the sensors and final elements;

  d) safety engineering knowledge (for example, process safety analysis);

  e) knowledge of the legal and safety regulatory requirements;

  f) adequate management and leadership skills appropriate to their role in safety life-cycle activities;

  g) understanding of the potential consequence of an event;

  h) the safety integrity level of the safety instrumented functions;

  i) the novelty and complexity of the application and the technology.

1.4 Competence

Competence is not simply about understanding standards, theory and technology:

- Competence must match accountability. The participants must be competent specifically “to carry out the activities for which they are accountable”.
- Competence in management and leadership must be addressed.

IEC 61511-2 gives further guidance:

> **5.2.2.2** The skills and knowledge required to implement any of the activities of the safety life cycle relating to the safety instrumented systems should be identified; and for each skill, the required competency levels should be defined. Resources should be assessed against each skill for competency and also the number of people per skill required. When differences are identified, development plans should be established to enable the required competency levels to be achieved in a timely manner. When shortages of skills arise, suitably qualified and experienced personnel may be recruited or contracted.

The key points are:

- Identify skills and knowledge for each activity
- Define the level of competence required
- Assess the resources against the requirements
- Address the differences, manage the shortfalls.

IEC 61508-1 reinforces the same principles (and emphasising competence in functional safety management and functional safety assessment):

> **6.2.13** Procedures shall be developed to ensure that all persons with responsibilities defined in accordance with 6.2.1 and 6.2.3 (i.e. including all persons involved in any overall, E/E/PE system or software lifecycle activity, including activities for verification, management of functional safety and functional safety assessment), shall have the appropriate competence (i.e. training, technical knowledge, experience and qualifications) relevant to the specific duties that they have to perform. Such procedures shall include requirements for the refreshing, updating and continued assessment of competence.
>
> **6.2.14** The appropriateness of competence shall be considered in relation to the particular application, taking into account all relevant factors including:
>
> a) the responsibilities of the person;
>
> b) the level of supervision required;
>
> c) the potential consequences in the event of failure of the E/E/PE safety-related systems – the greater the consequences, the more rigorous shall be the specification of competence;
>
> d) the safety integrity levels of the E/E/PE safety-related systems – the higher the safety integrity levels, the more rigorous shall be the specification of competence;
>
> e) the novelty of the design, design procedures or application – the newer or more untried these are, the more rigorous shall be the specification of competence;
>
> f) previous experience and its relevance to the specific duties to be performed and the technology being employed – the greater the required competence, the closer the fit shall be between the competences developed from previous experience and those required for the specific activities to be undertaken;
>
> g) the type of competence appropriate to the circumstances (for example qualifications, experience, relevant training and subsequent practice, and leadership and decision-making abilities);
>
> h) engineering knowledge appropriate to the application area and to the technology;
>
> i) safety engineering knowledge appropriate to the technology;
>
> j) knowledge of the legal and safety regulatory framework;
>
> k) relevance of qualifications to specific activities to be performed.

Persons must have "*appropriate competence […] relevant to the specific duties*" and there must be "*continued assessment of competence*".

The "*responsibilities of the person*" and the "*level of supervision required*" must be considered.

2 TRAINING AND QUALIFICATIONS

At least 5 different internationally recognised qualifications have been established to support the management of functional safety competencies:

- CFSE
- CFSP (TÜV Süd)
- FS Engineer (TÜV Rheinland)
- FS Expert (TÜV Rheinland)
- ISA84 SIS Expert (includes 3 separate certificates)

Other training courses are available. For instance IDC Technologies offers a course covering material similar to the TÜV Süd CFSP, TÜV Rheinland FSEng and ISA SFS courses. Underwriters Laboratories Inc. (UL) offers an introductory 1 ½ day workshop in functional safety systems development.[2]

2.1 CFSE Governance Board

2.1.1 Certified Functional Safety Expert (CFSE)

The CFSE qualification was the first internationally recognised certification program. The web page[3] at http://www.cfse.org describes its history:

> *The CFSE (Certified Functional Safety Expert) concept was originally developed by engineers from TÜV SÜD and exida with the support of other international safety experts to ensure that personnel performing SIS lifecycle activities are competent as required by the IEC 61508, 61511, and 62061 standards. The program is the now administered by exida. Certificates are issued by exida Certification S.A.*

The program was originally developed in 2000. It is intended to provide

> "t*he proof of competence demanded by safety standards and the confidence that their personnel have truly mastered an understanding of functional safety and the safety lifecycle*"

> "*[The required core competencies] are derived from the various phases of the IEC61508 standard's lifecycle and the activities involved in each of those phases. Core competencies are also derived from IEC61511 for process safety and IEC62061 for machine safety.*"

The 'Expert' level is achieved by scoring at least 80% in an exam, which is reputed to be comparatively difficult. The CFSE certification is intended to demonstrate an elite level of knowledge and skill:

> "*CFSE remains the "gold standard" of all programs. It has remained so because of its unmatched consistency and integrity as well as its unwavering focus on developing the knowledge and skills to be successful*"

> *"The CFSE is the higher level certification and is aimed at professionals who actively lead, coordinate and review the more complex and demanding activities in the Safety Lifecycle in leadership positions including SIL selection and SIL verification."*

2.1.2 Certified Functional Safety Professional (CFSP)

TÜV Süd launched the Functional Safety Certification Program (FSCP) in 2008.[4]

> *"The CFSP is targeted at professionals who need a thorough understanding of the Safety Lifecycle activities at the execution level without necessarily leading, coordinating or reviewing the more complex and demanding activities."*

CFSE Requirements	CFSP Requirements
10 years of equivalent experience (adjusted for education level) with a significant safety component	2 years of equivalent experience (adjusted for education level) with a significant safety component
Submit a case study that demonstrates the applicant's knowledge and safety experience.	No case study required
	Score > 80% on a single part exam containing multiple choice and short answer questions

The requirement for experience is reduced by 3 years for candidates who hold a bachelor degree in engineering. The requirement for CFSE is further reduced by 1 year for Licensed Professional Engineers.

As with the CFSE program, CFSP is administered by exida on behalf of the CFSE Governance Board.

2.2 TÜV Rheinland

The TÜV Rheinland Functional Safety Program was started in 2004[5]. Details are published on the TÜV-ASI website at http://www.tuvasi.com.

Qualifications are available at 2 levels, 'Engineer' and 'Expert'.

The TÜV Rheinland program is distinctly different from the TÜV Süd / exida program in that TÜV Rheinland does not prepare or prescribe the course material or examinations. It provides a certification service as a neutral third party.

Course presenters develop their own material and examinations. TÜV Rheinland assesses the material for completeness, consistency and compliance with the standards. TÜV Rheinland reviews the examination results and assesses candidates against the prescribed eligibility requirements before issuing the FS Engineer certificate.

2.2.1 FS Engineer (TÜV Rheinland)

The FS Engineer course is typically presented over 3 days with the examination following on the 4th day.

Different training specialisations are available:

- Safety Instrumented Systems
- Hardware/Software System Design
- Functional Safety of Machinery
- Automotive System Design (ISO 26262)

The FS Engineer qualification is restricted to engineers only; an engineering degree (or equivalent) is a pre-requisite. Candidates must have at least 3 years of experience specifically in the practice of functional safety.

2.2.2 FS Expert (TÜV Rheinland)

It is a requirement that FS Engineer course presenters must be qualified as FS Experts. To qualify as an Expert:

> *"Applicants have to submit documents, which substantiate their experience and competencies. These documents will be assessed acc. to the necessary requirements. In case of a positive assessment, the applicant will obtain a certificate including the TÜV Functional Safety Expert logo. The certificate confirms his specific knowledge and his competencies."*
>
> *"Furthermore he is an acknowledged trainer within the TÜV Functional Safety Program and can perform trainings/courses according to his special field.*
>
> *Only by means of support from these experts, who have a qualified education and many years of intensive experience a qualification program like the TÜV Functional Safety Program will be successful."*

Rather than passing an exam to become an Expert, candidates have to develop their own complete FS Engineer course and examination materials that meet the standard set by TÜV Rheinland.

Experts must be qualified engineers and in addition have at least 10 years of experience in the field of functional safety. They are required to demonstrate that they have achieved the level of expert through their career achievements.

2.2.3 TÜV Functional Safety Management

TÜV Rheinland offers certification of company safety management systems[6], but this does not extend to training or certification for managers.

2.3 International Society of Automation

The ISA functional safety certificate program was launched in 2008. Details can be found through the ISA website at www.isa.org.[7]

> *"ISA and the Automation Standards Compliance Institute (ASCI) introduce three certificate programs that are designed to increase knowledge and awareness of the ISA84 standard.*
>
> *The ISA84 specialist certificates are awarded to those who successfully complete a designated training program, prerequisites (for Certificates 2 and 3), and pass a multiple choice exam offered through the Prometric testing centers"*

The 3 certificates are:

Certificate 1: ISA84 SIS Fundamentals Specialist (4-day course)

Certificate 2: ISA84 SIL Selection Specialist (2-day course)

Certificate 3: ISA84 SIL Verification Specialist (2-day course)

The ISA confers the designation of ISA84 SIS Expert on individuals who achieve Certificates 1, 2, and 3.

2.4 Comparison

All 3 schools are well respected. The relative merits of the courses and qualifications have long been a topic of discussion. Each has its advocates.

Both CFSE[4] and ISA[8] have published comparisons of the various qualifications though it may be argued that the comparisons are not entirely disinterested.

The differences between the various qualifications are mainly in these areas:

- Prescriptive or interpretive
- Entry level or expert level
- Self-guided study versus classroom learning
- Prescribed or varying exams
- Pre-requisites for qualifications and experience
- Requirement for references

2.4.1 Prescriptive or interpretive

The differences seem to stem from whether a prescriptive or interpretive approach is taken.

The TÜV Rheinland approach is consistent with the view that the standards are subject to interpretation. Users are allowed some degree of latitude in applying the standards and many of the questions in functional safety do not have a single ‘correct’ answer.

The CFSE and ISA approach is consistent with a more prescriptive philosophy. The ‘correct’ application of the standards is taught and assessed against a prescribed benchmark.

2.4.2 Entry level or expert level

All of the programs (CFSE, TÜV Rheinland and ISA) distinguish between entry level or fundamental training and expert level accreditation.

At the entry level all of the qualifications require passing an examination to demonstrate knowledge and understanding.

For the expert level CFSE and ISA require the successful completion of additional examinations. TÜV Rheinland requires experts to demonstrate that they have been working at the level of an expert in industry.

2.4.3 Self-guided study versus classroom learning

Both CFSE / CFSP and ISA allow self-guided learning. Attending classes in person is not mandatory and on-line learning is supported.

TÜV Rheinland insists on learning in a classroom environment with face to face discussion and debate. On-line training is not supported because TÜV Rheinland considers that it does not provide sufficient interaction between students and between the students and their trainers.

2.4.4 Prescribed or varying exams

CFSE/CFSP and ISA both prescribe fixed exams. Each institution has its own fixed curriculum. This ensures that the successful candidates understand one common interpretation.

The TÜV Rheinland approach allows for more variability, interpretation and adaptation. Differences between experts and between courses are accepted but the courses are assessed for completeness and consistency.

2.4.5 Pre-requisites for qualifications and experience

The CFSE/CFSP program gives credit for engineering qualifications and professional registration in lieu of practical experience. The USA based qualifications are not restricted to engineers (the CFSE Governance Board's Whitepaper[4] explains that the term 'engineer' is restricted by legislation in many jurisdictions).

The TÜV Rheinland qualification is limited to candidates with a university degree or equivalent. In addition candidates must demonstrate at least 3 years' experience in functional safety.

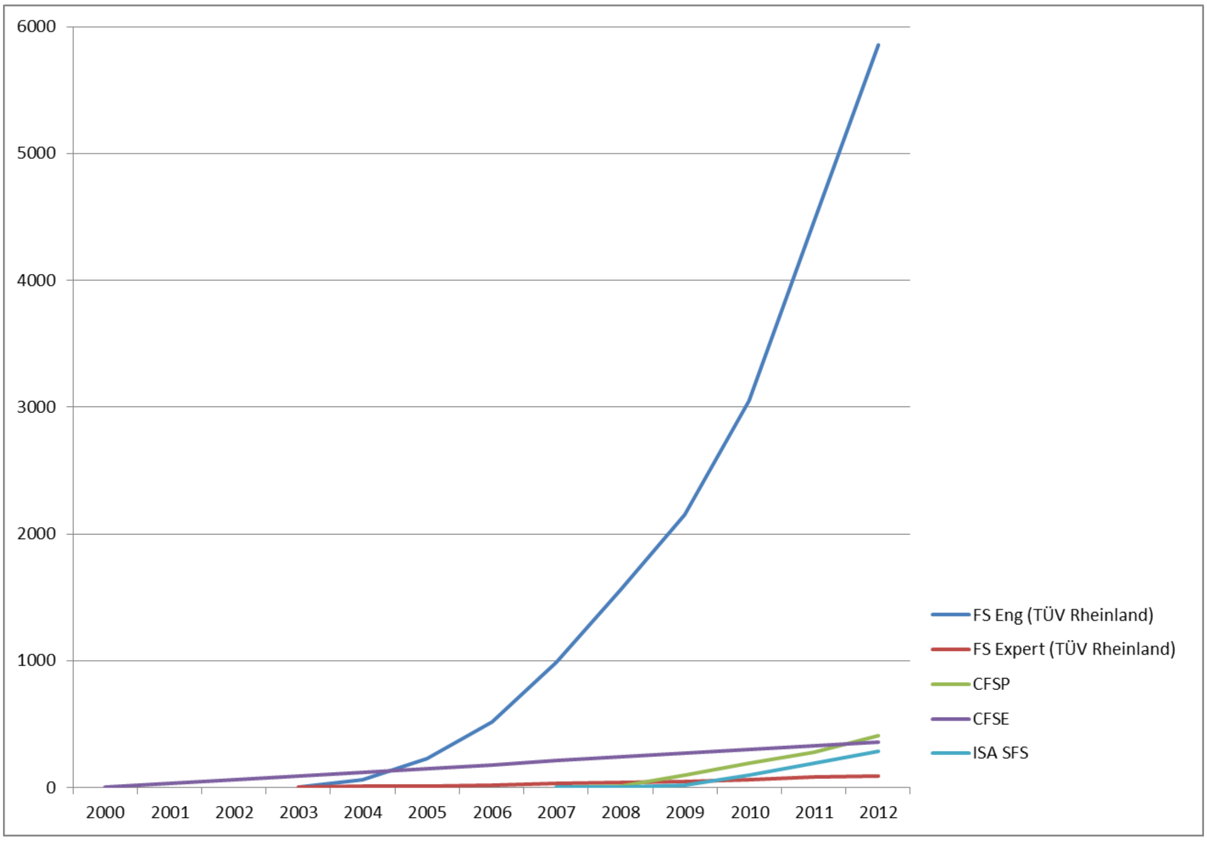
2.5 Popularity

While the original CFSE qualification gained the reputation of being exclusive and elite, the TÜV Rheinland FS Engineer program rapidly gained widespread acceptance. It was targeted at a broader market; being intended to facilitate understanding and application of the standards rather than to signify achievement of an elite status.

The number of CFSP and ISA SFS qualified individuals has been increasing steadily since 2008 but not nearly as rapidly as TÜV Rheinland FS Engineer.

FS Expert (TÜV Rheinland) seems to be the most exclusive qualification. It is essentially limited to individuals who prepare and present their own training courses.

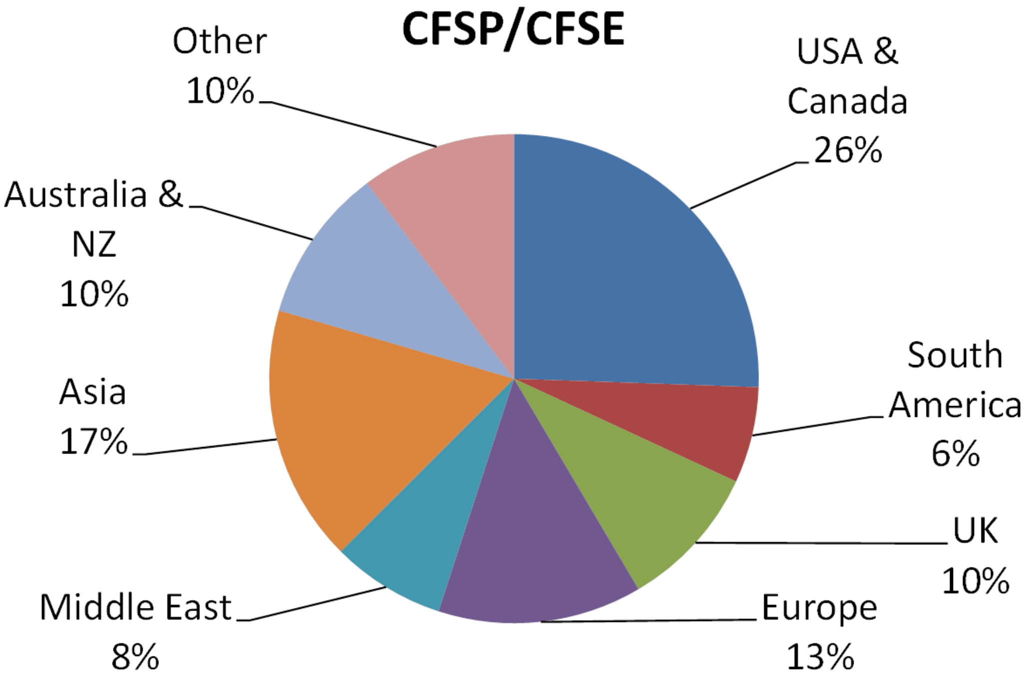
Comparison by number of qualified individuals

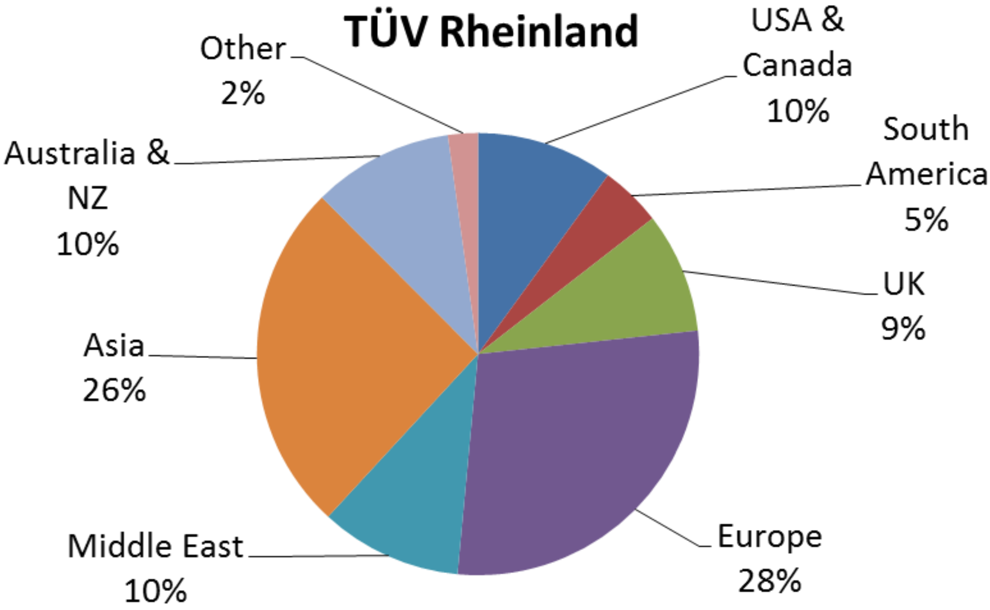


(Based on details of certificate holders published on CFSE, TÜV-ASI and ISA websites[3,5,7])

2.6 Global Acceptance

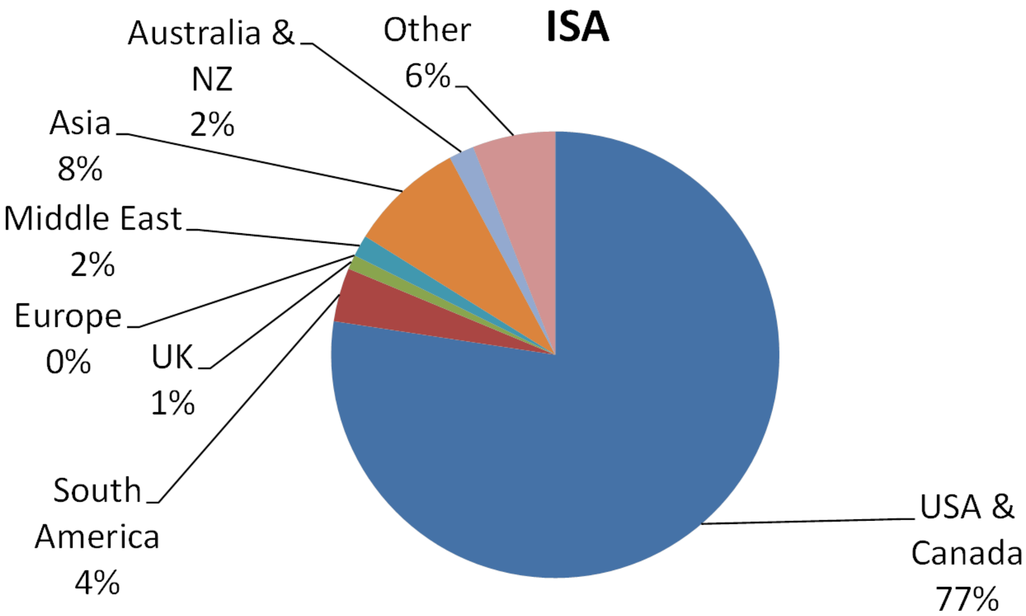
The CFSP/CFSE and the TÜV Rheinland qualifications are truly international. Qualified individuals are distributed widely across the globe:





The most notable difference is in the proportions between European certificate holders and those in USA and Canada.

Uptake of the ISA qualifications has been significantly better in USA and Canada than in the rest of the world:



3 COMPETENCE VS TRAINING

The question remains, which qualification is the best measure of competence in functional safety?

The short answer is 'none of them'. There are many essential competencies that are not and simply cannot be covered by any of the training and qualification programs.

There is a growing awareness that there is more to competence than passing examinations.

The ISA emphasises that the certificates provide recognition of education only and are not an indication of competence. The ISA makes a clear distinction between ***certificates*** and ***certification programs***:

> *"Certificate programs are typically associated with mastery of specific course content and may or may not require work experience. Certification programs are based on a job analysis identifying specific knowledge, skills, and attributes to perform a specific job and require that successful candidates demonstrate identified knowledge, skills, and attributes beyond any educational program."*

Wikipedia defines competence as the **ability** of an individual to do a job properly. It is a combination of knowledge, skills and behaviour.[9] This definition is consistent with the usage in IEC 61511 and 61508.

Training and examinations address competence only to a limited extent.

Through examination it is possible to assess whether a candidate has mastered knowledge and skills such as:

- Understanding of standards and legislative frameworks
- Understanding of safety lifecycle concepts
- Understanding of layers of protection
- Understanding of common cause failures
- Ability to carry out SIL assessment calculations
- Ability to calculate PFD and PFH for SIF verification
- Ability to assess hardware fault tolerance
- Understanding of systems architecture.

In an examination it is not practicable to assess behaviours and abilities such as:

- Ability to work in a collaborative team
- Ability to interpret relevance and confidence levels for failure rate data
- Ability to write robust software
- Ability to elicit requirements and to prepare complete and consistent Safety Requirements Specifications
- Ability to carry out verification with traceability to inputs
- Ability to inspect software
- Ability to plan validation with traceability to requirements
- Ability to plan the management of functional safety
- Ability to select techniques and measures appropriate to systematic capability
- Ability to implement a configuration management system
- Ability to lead a team, providing supervision and direction

- Ability to assess the impact of changes on functional safety
- Ability to assess competence.

3.1 Competency Based Assessment

3.1.1 History

Competency based assessment (CBA) was first developed in the USA in the 1980s.[10] The ideas were adopted and developed in the UK[11] and in Australia[12] over the next 2 decades.

Government policy and funding in the UK and Australia led to its widespread adoption while until recently CBA was largely ignored in the USA.[11]

By 2000 CBA was widely established in Australia, providing the basis for all vocational training across all industries, trades and professions.[13]

There has been a growing interest in the application of competency assessment for engineering education in the USA. In 1996 ABET, a non-government accrediting agency for US engineering programs developed Engineering Criteria 2000 (EC2000), a competency based framework.[14,15]

3.1.2 Difficulties

The implementation of CBA has not been without difficulties.[16]

In early applications users struggled with how to develop objective competence standards that provide an accurate and useful benchmark of the abilities required for a job. It has often been difficult to write performance criteria that are specific, objective and unambiguous. Application of a standard should not depend too heavily on the assessor’s personal judgement.

Another important issue that had to be resolved was how to grade the level of competency achieved. Some grading is needed to recognise that some individuals achieve higher levels of performance than others.

From the very beginnings of CBA, Dreyfus and Dreyfus[10] proposed that competence should be graded at a number of levels:

1. Novice: Rule-based behaviour, strongly limited and inflexible
2. Competent: Incorporates aspects of the situation
3. Proficient: Acting consciously from long-term goals and plans
4. Expertise: Sees the situation as a whole, intuitively appropriate action from personal conviction
5. Mastery: Unconscious and intuitive understanding without having to rely on principles

Most Australian national competence standards now provide several grades of achievement. Australian vocational education standards typically include Certificate III, Certificate IV and Diploma levels.

Some of the standards have been well written and have remained essentially unchanged for decades. Others have been subject to frequent revisions.

Acceptance has been good where there is a consensus among users that a standard provides a fair and accurate reflection of the requirements for a job.

To be successful CBA standards must also be easy to understand and easy to apply.

3.1.3 Examples

In Australia, aside from vocational training, there are several good examples of competence standards that are very well established and successful:

- AS/NZS 4761 ‘Competencies for working with electrical equipment in hazardous areas’
- Australian Institute of Project Management (AIPM): Project Management Competency
- Engineers Australia: Chartered Professional Engineer (CPEng)
- Frontline Management (resulting from the Karpin Report).[17]

3.2 Competency Principles

Each competence standard is structured into a number of **Units** (typically 10 to 15). **Elements** of skill, behaviour and knowledge are defined for each unit, including:

- Technical skills
- Behavioural skills
- Underlying knowledge
- Underlying understanding

Detailed **Performance Criteria** are described for each element and for each level (or grade) of achievement. The criteria describe the type of evidence that would demonstrate that a candidate has achieved the defined level of competence.

The usefulness (and success) of a CBA standard depends on the structure of the units and elements being complete, comprehensive and logical, and on the performance criteria being objective and easy to interpret.

3.3 Assessment and Evidence

Competence assessment itself is covered by competence standards defined in TAA04 Training and Assessment Training Package.[18] Qualifications are available for assessors at both Certificate IV and Diploma level.

Assessors are trained in how to interpret competence standards and how to assess evidence of competence.

Evidence can be in a wide variety of forms and can be taken from various sources.

Some competencies can be assessed through examination but many need to be assessed through evidence of experience in the workplace.

All Chartered Professional Engineers will be familiar with how career episode reports are used as evidence of engineering competence.

4 COMPETENCE STANDARDS FOR FUNCTIONAL SAFETY

4.1 Competence within FSM

Managing competence is an essential part of any functional safety management system.

Having a competency management system is a pre-requisite for a company to gain certification for its functional safety management (FSM).

Many of the large international SIS suppliers have developed their own in-house competence standards as part of their FSM program.

There is growing awareness of the need for competency management in the USA too. At the IDC Safety Systems conference in 2011 Ed Marszal described the competency management system implemented by Kenexis for work in risk studies.[19]

4.2 IET Functional Safety Competence Standard

In 1999 the Institution of Engineering and Technology (IET) published the '*Competence Criteria for Safety-related System Practitioners*' in conjunction with the Health and Safety Executive, UK and the British Computer Society.[20]

This standard can be applied by owners and operators as well as designers, developers and suppliers.

It covers all activities throughout the entire functional safety lifecycle.

It has not yet been widely adopted outside the UK even though it was published before any of the CFSE, TÜV or ISA training courses were established.

It has been proved to work well in practice. The standard was revised in 2007, but the changes were minor.

4.3 IET Competence Units

The units that make up the IET standard are:

Code	Competence Unit
CFM	Corporate Functional Safety Management
HF	Human Factors Safety Engineering
HRA	Safety Hazard & Risk Analysis
ISA	Independent Safety Assessment
PSM	Project Safety Assurance Management
SAD	Safety Related System Architectural Design
SHR	Safety Related System Hardware Realisation
SRM	Safety Related System Maintenance & Modification
SRP	Safety Related System or Services Procurement
SRS	Safety Requirements Specification
SSR	Safety Related System Software Realisation
SV	Safety Validation

These units correlate closely with the requirements of IEC 61508 and IEC 61511. All of the detailed requirements of the standards are covered – including those that cannot be or have not been addressed by training courses.

For example management and leadership competencies are defined clearly and in detail.

4.4 IET Competence Elements

Each unit is divided into elements covering 'Tasks' and 'Attributes' that identify the necessary technical and behavioural skills and the underpinning knowledge and understanding.

The example below shows elements that comprise the unit on software realisation:

SSR	**Safety Related System Software Realisation**
Tasks	
SSR1	Interpreting Given Safety Requirements
SSR2	Transposing from Requirements into design
SSR3	Analysing the Design
SSR4	Coding
SSR5	Analysing the Code
SSR6	Specifying Software Tests
SSR7	Executing Tests
Attributes	
SSR8	Software Safety Regulations and Standards
SSR9	Application Domain Knowledge
SSR10	Team Working
SSR11	Openness

4.5 IET Competence Levels

The IET characterises competence in 3 levels:

- Supervised Practitioner
- Practitioner
- Expert

The standard recognises that people develop competence by working under supervision by an experienced mentor. Competence may also have been developed in non-safety applications.

4.5.1 Supervised Practitioner

"The work of a supervised practitioner must be supervised by a practitioner or an expert. A supervised practitioner has sufficient knowledge and understanding of good practice, within the organisation or within the relevant industry sector, to be able to work on the tasks associated with the overall function without placing an excessive burden on the practitioner or expert who is responsible for checking their work.

Potential supervised practitioners may not have previous experience working on safety-related projects. Their competence is likely to have been developed through targeted training and work on non-safety-related projects. It may therefore be necessary for an assessor to consider evidence of technical skills derived from a non-safety-related project environment."

4.5.2 Practitioner

"A practitioner has sufficient knowledge and understanding of good practice, and sufficient demonstrated experience, to be able to work on tasks without the need for detailed supervision. A practitioner will maintain their knowledge and be aware of the current developments in the context in which they work."

4.5.3 Expert

"An expert will have a sufficient understanding of why things are done in certain ways, and sufficient demonstrated managerial skills, to be able to undertake overall responsibility for the performance of a task or function. An expert will be familiar with the ways in which systems, and previous safety management systems, have failed in the past.

An expert will keep abreast of technologies, architectures, application solutions, standards, and regulatory requirements, particularly in rapidly evolving fields such as programmable safety-related systems. An expert will have sufficient breadth of experience, knowledge and deep understanding to be able to work in novel situations. An expert is able to deal with a multiplicity of problems under pressure without jeopardising safety issues."

4.6 IET Performance Criteria

Each element has detailed competence criteria defined for each of the different levels.

The following example is taken from the unit "Project Safety Assurance Management". The first element of the unit is PSM1, "Defining the scope of the project". The task is described as:

"Seeks out and evaluates information in order to define the scope, objectives, context and safety-significance of a safety-related project".

The performance criterion for a Supervised Practitioner is:

"Can identify the main categories of information required to define the scope, context and safety significance of a safety related project and describe how this information is obtained and evaluated."

The Practitioner and Expert share the same performance criterion:

"Can illustrate, through design documents, working notes, minutes of meetings etc., how information has been collected to define the scope, context and safety significance of safety-related projects carried out within the organisation or relevant industry sector."

5 CASE STUDY – I&E SYSTEMS

I&E Systems Pty Ltd (IES) is an engineering consultancy that specialises in the design, implementation and integration and safeguarding systems for process industries.

In 2004 IES adopted a competency management system based on the IET competence criteria.

5.1 IES Assessment Spreadsheet

IES maintains a system in which an individual evidence assessment sheet is kept for each practitioner.

Candidates assess themselves against the guide and claim elements of competency.

A qualified and experienced assessor reviews the claim, evaluates the evidence and determines the level of performance that has been demonstrated.

IES applies 4 levels of competence:

Basic	Work is done under routine guidance with intermittent checking and within established routines, methods and procedures. Some degree of discretion and judgement is exercised, increasing as capabilities are developed.
Normal	Can work without direct supervision under broad guidance only. May supervise others and may take responsibility for the work of others. Applies abilities independently for both routine and non-routine work. Exercises judgement in planning own work and selecting appropriate equipment, services and techniques.
Senior	Works without supervision with limited guidance in line with a broad plan. May take responsibility and defined accountability for the work of others. Applies abilities independently in substantially non-routine work. Exercises significant judgement in planning, design and technical or supervisory functions. Substantial depth of knowledge across a number of areas and/or mastery of some specialised areas.
Lead	Works independently in accordance with a broad plan. Responsible and broadly accountable for the structure, management and output of the work of others. Applies abilities independently and non-routinely. Exercises significant high level judgement in planning, design and technical or management functions. Mastery of broad and/or specialised areas of knowledge in highly varied or specialised contexts.

5.2 Example assessment

Code	Competency	Description	Evidence & Context	Assessor's Notes	Level Claimed	Endorsed
ISA	**Independent Safety Assessment**		See Project 8256, eg Doc No.450-06619-1210-001; 8455_0145 NR2 FSA Report	Nov 11: See 8455 NR2 FSA. Upgraded to Senior Updated Sep 09. H carried out the FSA for the WAPL Coal Fired Boilers project.	Senior	Yes
ISA1	Scope and Context Appreciation	Acquires an appreciation of the context of a system and establishes the scope and objectives of an assessment, such that all necessary requirement of a safety assessment are capable of being satisfied.	Demonstrated on review of systems for TSC, job no 8256	8455 FSA carried out independently	Senior	Yes
ISA2	Assessment Strategy Selection	Selects an assessment strategy involving a range of techniques and measures which are capable of yielding sufficient evidence in a cost effective manner to enable a robust judgement to be made regarding the safety of a system.	Contributed to the development of assessment techniques and measures for TSC	8455 FSA carried out independently	Senior	Yes
ISA3	Planning	Originates and maintains a plan which encapsulates an agreed set of activities, including their interrelationship, scheduling and responsibilities, which, if conformed with, results in the objectives for the plan being satisfied in a cost-effective manner.	Contributed to the development of the assessment plan for CC system TSC	H. carried out the FSA for job 8455 independently, evidenced in project files	Senior	Yes
ISA4	Safety Auditing	Can perform an audit to arrive at a conclusion (based on evidence) regarding conformance to planned arrangement, using a non-confrontational but tenacious style for soliciting evidence.	Carried audit of Functional Safety Planning for CC system, demonstrated constructive style	8455 FSA carried out independently	Senior	Yes
ISA5	Reviewing Safety Documentation	Accurately and systematically reviews documents, supported by discussions to clarify ambiguities and understanding where necessary, to obtain evidence to support a judgement on whether a system has satisfied its functional safety requirement.	Reviewed Functional Safety Planning documents for CC system, contributed to discussions and summary reports	8455 FSA carried out independently	Senior	Yes
ISA6	Assessing Safety Analysis	Identifies where necessary, the requirements for further safety analyses and facilitates the completion of such safety analyses, to obtain evidence to support a judgement on whether a system has satisfied its functional safety objectives.	Produced issues register for CC system with requirements for further work	8455 FSA carried out independently	Senior	Yes

5.3 Evidence

The assessor has a reasonable degree of latitude regarding what evidence is can be accepted to justify a claim of competence.

The rules of evidence in competency assessment are:

- Valid: The evidence must be relevant and related to the criteria – and relevant to the application domain and technology in question
- Reliable: Evidence must be consistent and repeatable
- Flexible: Different assessment methods and different types of evidence are allowable
- Fair: The assessor must not discriminate unfairly; the assessment must not be too onerous or too pedantic.
- Sufficient: The evidence must be enough to cover all of the criteria
- Authentic: The evidence must be verifiable as the candidate's own work
- Current: Evidence must be reasonably current – usually within recent years - and it must relate to the current standard.

Evidence may be directly observed through personal interaction, indirect (from a third party) or it may be in written form.

In the workplace evidence can usually be found in the documents that an individual has produced through their assignments.

5.4 IES Competency Map

IES maps all of the activities on each project to units and/or elements of competence.

During project planning the project manager confirms that personnel have the appropriate competence for the activities for which they will be made accountable.

Supervisors are assigned to personnel who have sufficient competence to carry out activities under supervision. Supervised personnel are not authorised to sign deliverables as approved.

The following chart shows an example of a competency map for a particular project.

FS Competency Allocation Chart (to be used in conjunction with independence table)			**Project Personnel** A = Authorised Signatory, S = Supervised,								
Project Activity	**Role(s)**	**IET Competency Code**	Duong	Generowicz	Grewal	Hunt	Kurzeja	Huynh W	Merritt	North	Yap
Manage FS Project, write FSMP	Do	PSM		A	A				A	S	A
Hazards & risk assessment report (support Client)	Do	HRA						S			A
List of SIFs (support Client)	Do	HRA 6						S			A
SIL determination report (support Client)	Do	HRA		A				S			A
SIL Verification report	Do, Verify	SHR 4		A				S	A		S
System Architecture Specification	Do, Verify	SAD		A					A		A
Safety Requirements Specification	Do, Verify	SRS		A					A		A
System Design Specification - Hardware	Do, Verify	SHR 2	S			S		S	A		A
System Design Specification - Software	Do, Verify	SSR 2	S				A	S	A		A
Configuration Management Plan	Do, Verify	PSM		A	A				A	S	A
Hardware	Do, Verify	SHR, SHR 4				S		S	A		A
Code	Do, Verify	SSR 4, 5					A	A	A		A
Workpacks, Detailed drawings	Do, Verify	SRM 1 -3	S	A	A	S		A	A		
Verification - Software	Do, App	SSR 5					A	A	A		A
Verification - Hardware	Do, App	SHR 4				S		S	A		S
RQ,DQ,OQ Milestones Certification	Approve	PSM 4			A				A	S	A
Validation Plan	Do, Verify	SV 1					A	A	A		A
Software Test Procedure	Do, Verify	SV 2					A	A	A		A
Hardware Test Procedure	Do, Verify	SV 2					A	A	A		A
Conduct Validation testing (FAT, SAT)	Do, Verify	SV 3 - 6				S	A	A	A		A
Conduct FS Assessment	Do	ISA		A			S				
Last reviewed:			Aug 11	May 11	Nov 11	Nov 11	Nov 11	May 12	Sep 11	Aug 11	Sep 11

6 SUMMARY

6.1 Systematic Integrity and Management

Systematic integrity starts with management. According to IEC 61511 section 5 management starts with:

- Clear expectations
  - Policies and strategies
  - A system with plans, procedures and practices
- Clear responsibilities and accountabilities
- Competence

6.2 Competence

Training courses, certificates or qualifications on their own do not provide sufficient evidence of competence.

Training underpins competence. Competence is gained by experience, under supervision.

Competence is the **ability** of an individual to do a job properly. It is a combination of knowledge, skills and behaviour.

Competence must match accountability. Personnel must have the specific competencies required for the activities for which they are accountable.

Functional safety competence must consider leadership and management skills.

Competence is best demonstrated through evidence in the workplace rather than by examination.

6.3 IET Competence Criteria

The IET Competence Criteria are comprehensive and cover activities throughout the entire safety lifecycle.

The framework was established in 1999. It is easy to use and readily adaptable for any organisation involved with functional safety.

In particular this standard provides a clear description of management and leadership competencies.

6.4 Australian Experience in CBA

Competency based assessment has applied widely and successfully applied in Australia for at least 15 years.

I&E Systems Pty Ltd has applied the IET Competence Criteria to manage functional safety competencies since 2004.

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