WHITE PAPER

Process Safety Competency

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Professional training is undergoing a revolution in terms of both form and content. The arrival of new information technologies is partly responsible, as well the extensive and sometimes abusive reliance on PowerPoint presentations. We're hearing about the progressive replacement of conventional face-to-face training sessions by e-learning, and the arrival of serious games representing a market of several billion euros. The real cause of this development lies much deeper than new technologies though, as it is associated with changes in how companies are managing their competencies. It is no longer simply a question of training employees and ticking training boxes, but of proving and managing competencies. Human resources departments, to which these responsibilities were generally assigned, are now progressively being renamed as Talent Management Centers, Competency Development Centers, etc.

The management of process safety competencies is at the heart of companies' progress-oriented approach. It's no longer simply a question of receiving and providing training, but transferring, internalizing, assuring, certifying and maintaining competencies within the organization.

Given the potential seriousness of major accidents, in the domain of process safety even more than in others, it is essential to offer the interested parties a guarantee or even proof that the individuals and the organization have the required degree of competency. Unfortunately, recent industrial history has repeatedly demonstrated that the regulations governing hazardous industrial activities are insufficient in themselves to prevent major accidents and that the process safety culture and proficiency[1] of organizations are key determinants of performance in this field.

1. What Process Safety Competencies?

In terms of process safety, the chemical industry has often led the way – sometimes by necessity, following tragic accidents. Trevor Kletz was one of the pioneers at ICI and contributed substantially to the development and formalization of the fundamental principles. Numerous manufacturers (BASF, Dupont de Nemours, Dow Chemical, Rhône-Poulenc, etc.) followed suit and were keen to develop specific technical competencies for their engineers, managers and technicians and operational competencies for the operating personnel.

[1] See the conclusions of the Baker report following the Texas City accident in 2005.

Table 1 illustrates the key discipline requirements across a few industrial sectors. Obviously, this corpus must be defined according to the type of industry and the specific characteristics of the company. For example, competency in the thermal runaway of chemical reactions is essential in the chemical industry[2] as is competency in gas deflagration and detonation in the petroleum industry.

In addition, modules specific to the particular hazards associated with substances used by certain industries must be developed (peroxides, hydrogen, chlorine, silane, ammonia, etc.) in order to correspond to the specific competencies required to control the risks associated with these substances.

		Sector of the process industry				
Category	Discipline	Chemical	Petroleum and Gas	Food Processing	Cosmetics	Pharmaceutical
Process engineering						
	Knowledge of Processes	✓	✓	✓	✓	✓
	Diagrams (PID, ...) and engineering standards	✓	✓	✓	✓	✓
	Thermodynamics	✓	✓	–	–	✓
	Fluid dynamics	✓	✓	–	✓	✓
Hazards / fundamentals						
	Fire	✓	✓	✓	✓	✓
	Detonation	–	✓			–
	Gas explosion	✓	✓	✓	✓	✓
	Dust explosion	✓		✓	✓	✓
	Physical explosions and BLEVE	✓	✓	✓	✓	✓
	Thermal runaway	✓			–	✓
	Corrosion, Materials	✓	✓		–	✓
	Toxicity	✓	✓	✓	✓	✓
Methods						
	Risk analysis (PHA/HAZOP)	✓	✓	✓	✓	✓
	Evaluation of consequences and QRA	✓	✓			–
	Change management	✓	✓	✓	✓	✓
	Local regulation of major hazards	–	✓			–
Feedback						
	Knowledge of accidents	✓	✓	✓	✓	✓
	Expert assessment, accident analysis	✓	✓	✓	✓	✓
Protective barriers and safeguards						
	Fire protection	✓	✓	✓	✓	✓
	Functional safety, safety instrumented systems	✓	✓	✓	✓	✓
	Relief valves and rupture diaphragms	✓	✓	✓	✓	✓
	Emergency vents for reactive systems (DIERS)	✓				✓
	Emergency plans	✓	✓	✓	✓	✓

Table 1: Process safety competencies of a process safety engineer/technician by industrial sector (non exhaustive)

[2] It was also one of the Chemical Safety Board's main recommendations following the accident at T2 Laboratories in 2008 where competency in thermal runaway was clearly absent.

Going further than this, many organizations are now prescribing the competencies required in individual roles – such that competency can become integral to the recruitment process as well as downstream training and personal development processes. An example of a typical competence matrix for different organizational roles is provided in Figure 1.

Specialized process safety training programs exist, but the training provided to process safety engineers and managers is often deficient… As in other areas, these latter programs provide basic knowledge but they do not adequately introduce young graduates to the concerns of manufacturers and the realities in the field. They introduce skills, but by no means embed them.

Topic	Operating Technicians (Incl. Control Room Operators)	R&D Scientists (and Technologists)	Pilot Plant Technicians	Plant & Pilot Plant Supervisors	EHS Safety Specialists	EHS Process Safety Specialist	EHS Manager (this person may also be the Safety Specialist)	Environmental Care Specialists (incl. Environment Manager)	Technology Manager (Incl. Technical Manager)	Directors (incl. Leadership Team)	Operations Manager (incl. Regional Operations Manager)	Plant Chemical (& Process) Engineers	Engineering Manager (Incl. Regional Engineering Manager)	Maintenance Staff (incl. Fitters, Technicians)	Project Engineers & Managers	I&E Engineers (incl. CE&I Engineers)	Mechanical Engineers
The Essentials of Managing Process Safety	2	2	2	2	1	2	2	1	2	2	2	2	2	1	2	1	1
Process Safety Information	2	1	2	2	1	2	2		1		1	2	2		2	1	
Dust Explosions	1		1	1	1	2	1		1	1	1	2	2		1		1
Gas/Vapor Explosions	1		1	1	1	2	1		1	1	1	2	2		1		1
Chemical reaction hazards and thermal stability of materials	1	2	2	1	1	2	1	1	1	1	1	2	2		2		1
Ignition sources including electrostatics hazards	1		1	1		2	1		1		1	2	2	1	1	1	
Practical Process Hazards Analysis	1		1	1	1	2	1				1	2	2	1	1	1	
Consequence modeling						2	1	1		1	1	2	1		1		
Quantitative risk assessment (QRA)						2	1	1		1		2	1				
Facilities Siting Risk Assessment				1	1	2	2					2	2		1		
Protection against deflagration (vapors and powders)	1		1	1		2	2					2	1	1			1
Classification and Management of Hazardous areas	1		1	1	1	2	1					2	2	1	1	2	2
Design of Emergency Relief Systems					1	1	1	1				2	2	1	1		2
Asset and Mechanical Integrity					1	2		1			2	2	2	2			2
Creating a Management of Change Program	1	1	1	1	1	2	2	1	1		2	2	2	2	1	1	2
Pre-start up safety reviews (PSSR's)	1	1	1	1	1	2	2		1		1	2	1	1	1		
Functional safety management & SIL Assessments					1	2	2				1	2	2	1	1	2	
Efficient process safety management system auditing					1	2	2					1	1				
Process Safety Metrics / Leading & Lagging Indicators	1		1	1	2	2	2	1	1	2	2	1	1	1	1	1	
Incident Investigation: Methods & Case Studies					2	2	2				1	1	1		1		
Lessons from accidents in the process industries	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

(Key: Level 1 = Awareness; Level 2 = Detailed technical knowledge)

Figure 1: Process safety competencies of a process safety engineer/technician by industrial sector (non exhaustive)

2. How Can Process Safety Competencies Be Assured?

For the past few years, several frameworks have appeared in the various process safety disciplines:
>> Qualifying training (in fact, all training is or can claim to be);
>> Certification training, under a voluntary scheme
>> (e.g. ISM-ATEX, CompEx);
>> Certification training, under an accreditation scheme (e.g. IECEx COP).

Some are recognized and validated by professional organizations or associations (IChemE, UIC, etc.), while some operate with continuous development point schemes (VDI Punkt, CEU, etc.). Depending on the country, certain training programs can be "subsidized" and included in professional training budgets.

The last initiative to date is that of the IChemE[3] which started in 2012 and is aimed towards its members (generally chemical engineers) and which establishes, via a standard, the process for professional recognition in the field of process safety. IChemE's personnel certification scheme evaluates the candidates according to 3 main orientations: knowledge, experience and commitment. Table 2 details the various technical competencies on which the evaluation is based. The approach's originality is based on interviews and discussions with recognized experts in the field.

If we look more specifically at proficiency in the field of explosion hazards, often grouped under the acronym ATEX which refers to the European regulation of the same name, the offer also evolves. The most recent initiative is certainly the IECEx05 scheme for certification of personnel competencies[4], which more specifically concerns operational personnel working in explosive atmospheres.

The IECEx05 scheme (illustrated in Figure 2: IECEx05 personnel certification scheme) is an actual competency certification scheme in the sense that the certifying organization must itself be accredited in accordance with ISO/IEC 17024[5], a more general standard which sets out criteria for

Competencies
Process safety principles
Hazard identification
Evaluation of consequences
Prevention and control of hazards
Risk analysis
Application of regulations
Protection of the public
Accident assessment and feedback
Emergency plans
Process safety management

Table 2 : The process safety competencies of the IChemE (UK) scheme

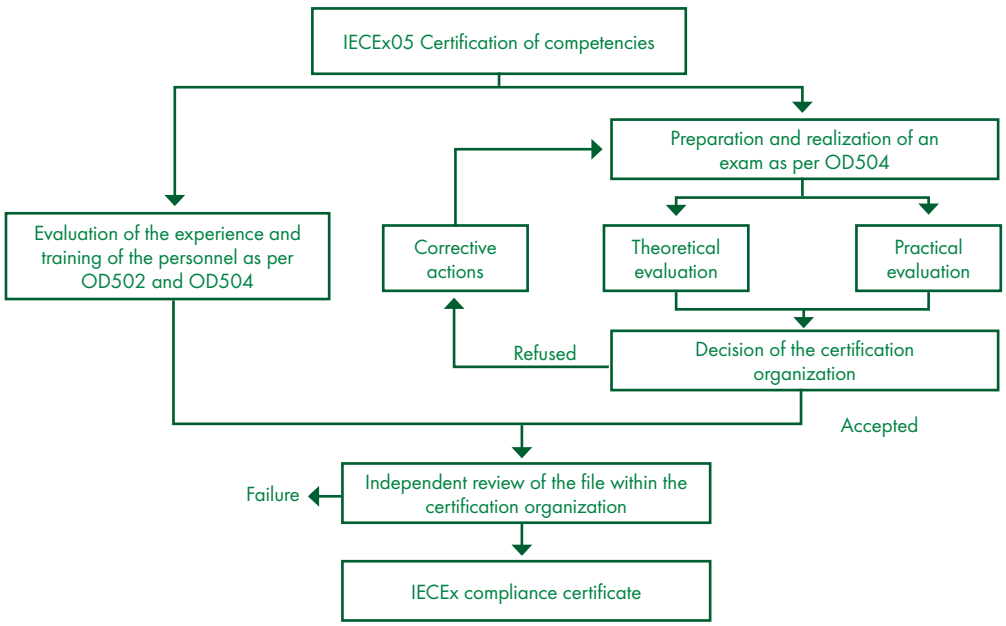
an organization's certification program for individual persons. At the time of publication of this document, the IECEx05 accredited organizations[6] reside solely in Europe. The scheme presents an interesting approach in the sense that it establishes competency elements (often in reference to standards) but does not define in itself the content or the format or mode of the training needed to take the exam. It also defines the various types of competency modules, by function type, within the company, as shown in Table 3: IECEx05 – Modules and functions. To make a somewhat simplistic comparison, the IECEx05 scheme resembles an explosive atmosphere driver's license, even to the extent that a personalized card is issued. The register of certified individuals is public and can be consulted online on the IECEx website. But even though the examination and evaluation process are formal, the driving school's requirements are quite low.

[3] http://www.icheme.org/membership/peng process safety.aspx
[4] http://www.iecex.com/certified_persons.htm
[5] ISO/IEC 17024:2012 - Conformity assessment. General requirements for bodies operating certification of persons
[6] The ExCB in late 2012: SIRA, SGS BASEEFA, INERIS, DEKRA

Position	Module
Plant Manager	Unit Ex 001 Apply basic principles of protection in explosive atmospheres
Safety Officer	Unit Ex 001 Apply basic principles of protection in explosive atmospheres
	Unit Ex 002 Perform classification of hazardous areas
Manager Electricity/ Instrumentation	Unit Ex 001 Apply basic principles of protection in explosive atmospheres
	Unit Ex 003 Install explosion-protected equipment and wiring systems
	Unit Ex 004 Maintain equipment in explosive atmospheres
	Unit Ex 008 Perform detailed inspection of electrical installations in or associated with explosive atmospheres
Electrical/ Instrumentation Engineer/Technician	Unit Ex 001 Apply basic principles of protection in explosive atmospheres
	Unit Ex 003 Install explosion-protected equipment and wiring systems
	Unit Ex 004 Maintain equipment in explosive atmospheres
	Unit Ex 007 Perform visual & close inspection of electrical installations in or associated with explosive atmospheres

The two aforementioned scheme examples clearly illustrate the paradigm shift in terms of managing process safety competency. We are gradually moving from a situation where the candidate has been trained in a classroom setting and been awarded a certificate of attendance at the end of the session (abusively referred to as a training certificate) to a situation where the candidate's experience and acquired knowledge have been reviewed and evaluated by a commission (sometimes self-appointed, sometimes actually accredited according to a referencing procedure). Said commission, after making its decision, will decide on whether or not a certificate of competency is issued.

The certificate of competency sometimes represents the prerequisite pass to work in companies that require it for their personnel and subcontractors, or to participate in certain projects. On an individual basis, it is the person's employability that is at stake because certification is obviously nominative and personal. For the employee, the certificate's value is associated with his/her recognition by companies.



3. Sustainability of the Knowledge acquired – Maintenance of Competencies

The crucial question which then arises is, of course, that of maintaining, developing and sustaining the knowledge acquired.

Just as it is clear that one really doesn't know how to drive a car the day after getting one's driver's license, it would be a mistake to think that one could operate an industrial facility or perform HAZOP analyses immediately (and competently) after completing a training program, albeit qualifying. Only individual mentoring (sponsorship), regular exposure to process safety problems and experience in dealing with industrial situations in the field, particularly the understanding and study of accidents, enables proficiency to fully develop and be maintained.

Certain qualifying or certifying schemes generally foresee a validity period – generally three years – followed up by refresher training. However, one might question the efficiency of this measure and the interest in repeating the same program every three years. Others have opted toward a complete or modular training program. Finally, as mentioned previously, a system of continuous professional development points, where e-learning also has its place, has been implanted in the English speaking world.

Another underlying trend is obviously self-study via the Internet and notably in specialized groups on professional social networks. Although it is undeniable that this is a major change, the enormous wealth of information available and the multiplicity of opinions complicate the task for those wanting to make a go of it on their own. There again, it is obvious that a simple connection to the Internet is not enough to maintain and develop an organization's process safety competencies.

4. Training and Competency of Training Organizations

Another absolutely vital issue concerns the competency of the training organization itself and particularly that of its training staff.

It is a fact that the increasing user-friendliness of computer tools and the abundance of freely accessible resources potentially allows anyone with the least bit of knowledge to provide process safety training. Let us not deceive ourselves, the pedagogical efficiency of a process safety training program, as in other fields, is not simply based on the quality of PowerPoint slides, but primarily the trainer's experience, charisma, passion and ability to impart knowledge that allows him/her to maximize the successful transmission of knowledge to his audience.

Certain programs, such as INERIS' ISM-ATEX training program, train trainers to deliver a set of slides and foresee regular reevaluation including the updating of training materials and the actual practice of training given after issuance of their diploma. As in many other fields, only regular exposure to various audiences allows the trainer to maintain and develop his/her teaching skills.

Our practice is instead based on progressively accompanying our trainers through an internal program until they are sufficiently operational to teach the various modules of the process safety program on their own[7]. In particular, it seems essential to us to have accumulated enough real-world examples (and counterexamples), to have first-hand experience in order to know the limitations, assumptions and the pitfalls in the various fields of process safety.

Process safety is a discipline that lends itself particularly well to teaching using examples[8]. The daily routine of a process safety specialist who performs risk analyses, accident assessment or investigations is full of facts and anecdotes illustrating the concepts of the discipline, ranging from the explanation of a phenomenon to the analysis of an organization based on its cultural approach to process safety.

5. What Approach Should Be Chosen to Develop Process Safety Competency?

Ensuring process safety competency is one of the key elements of a performance-based process safety approach. Should this process be developed inhouse or be outsourced?

Our 25 years of experience in the field with our customers and our process safety program, which includes more than 50 different training modules, has taught us that there is no perfect way to go about it. The ideal solution is for the organization to "own" its own process safety programs and proficiencies.

[7] DEKRA Process Safety Academy: http://www.dekra-process-safety.com/process-safety-academy

[8] Trevor Kletz himself swore only by "Kletz sessions", short brainstorming sessions about an industrial accident or near-accident at the site or in the literature.

However, introverted organizations often find their own practices diverging from, or failing to keep pace with, best practices in the wider process safety community.

Today, we are seeing a significant trend, particularly within multinational oil and chemical companies, to create and structure their own process safety programs. Obviously, the proportion of internal and external activities varies greatly depending on their size, their resources and alignment with their strategic objectives in this area. One of the difficulties concerns the homogeneous development of competencies at the global level, for simple questions of language, for example.

Conversely, some multinationals significantly rely on extensive outsourcing and require, for example, that all their employees likely to work in potentially explosive atmospheres be certified by a thirdparty (IECEx, CompEx, ISMATEX, etc.).

They should be reminded that it is essential to not only rely on the presence of a certificate, albeit difficult to obtain. Bookish knowledge of standards, unfortunately, cannot guarantee the behavior in the field. Having personally trained many operators in electrostatic hazards, we know that the success of a training session is measured more by the fact that an operator has understood that it's his own life that he puts in danger if he doesn't comply with the grounding principles rather than his understanding of the fundamental laws of electrostatics.

The right approach is obviously a balanced mix of the two approaches. The proportionality is associated with the specific nature of the company's activity. Indeed, it seems logical and essential to maintain competency in thermal runaway when working with fine chemicals and consequently to assign internal experts a goal of sharing and transferring their knowledge across all disciplines. One of the challenges is to ensure that this knowledge takes root and is distributed within the organization within a veritable knowledge base and not concentrated in the hands or office of just a few critical employees (sadly, a very common occurrence from our experience).

6. Conclusion

The process safety training market is growing globally, even if it remains highly fragmented. There are plenty of training organizations: independent organizations, vocational training centers, brokers, small specialized companies, large groups or even public institutions (OSHA or INRS type). In short, from the most generalized to the most specialized. The vast amounts of freely accessible information available on line and the increasing numbers of specialized webinars allows one to become trained or to train oneself. With so much to choose from, the key issue remains the same: how does one decide and make the right choice in relation to the company's proficiency management requirements?

Approaches such as the IECEx scheme for explosive atmospheres or that by IChemE, more generally for process safety, will certainly contribute to structure and consolidate the players in these areas as they evaluate professional competency in a more comprehensive manner. One could suppose that the training organizations themselves, highly competent and specialized in these disciplines, will benefit from greater recognition by evaluation commissions than others and thus attract the bulk of companies that are truly committed to managing their competencies.

Generally speaking, one only remembers pedagogue and charismatic teachers 15 or 20 years down the road. Only the lessons learned that are used regularly become acquired knowledge. The same is true in the realm of process safety. To ensure and develop the competency of your staff, our advice is to first assess the trainer's technical and pedagogical skills.

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Stephen Rowe currently manages the activities of the UK headquarters of DEKRA Process Safety. He has a career background in the assessment of chemical reaction hazards and the laboratory assessment of a full range of process safety hazards including dust, gas and vapor flammability and explosives characterization. He is an experienced trainer and regular contributor to national and international process safety conferences and symposia. He oversees and has been central to the development and management of the company's quality and safety management systems (ISO9001 and ISO18001). He is a member of the DEKRA Insight Leadership Team and is actively engaged in establishing Process Safety strategy for the group, and its customers.

DEKRA Process Safety

The breadth and depth of expertise in process safety makes us globally recognized specialists and trusted advisors. We help our clients to understand and evaluate their risks, and work together to develop pragmatic solutions. Our value-adding and practical approach integrates specialist process safety management, engineering and testing. We seek to educate and grow client competence to provide sustainable performance improvement. Partnering with our clients we combine technical expertise with a passion for life preservation, harm reduction and asset protection. As a part of the world's leading expert organization DEKRA, we are the global partner for a safe world.

Process Safety Management (PSM) Programs

>> Design and creation of relevant PSM programs
>> Support the implementation, monitoring, and sustainability of PSM programs
>> Audit existing PSM programs, comparing with best practices around the world
>> Correct and improve deficient programs

Process Safety Information/Data (Laboratory Testing)

>> Flammability/combustibility properties of dusts, gases, vapors, mists, and hybrid atmospheres
>> Chemical reaction hazards and chemical process optimization (reaction and adiabatic calorimetry RC1, ARC, VSP, Dewar)
>> Thermal instability (DSC, DTA, and powder specific tests)
>> Energetic materials, explosives, propellants, pyrotechnics to DOT, UN, etc. protocols
>> Regulatory testing: REACH, UN, CLP, ADR, OSHA, DOT
>> Electrostatic testing for powders, liquids, process equipment, liners, shoes, FIBCs

Specialist Consulting (Technical/Engineering)

>> Dust, gas, and vapor flash fire and explosion hazards
>> Electrostatic hazards, problems, and applications
>> Reactive chemical, self-heating, and thermal instability hazards
>> Hazardous area classification
>> Mechanical equipment ignition risk assessment
>> Transport & classification of dangerous goods

We have offices throughout North America, Europe, and Asia.
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