Establishing a competence matrix for process safety expertise

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INTRODUCTION

In the process industry, *process safety expertise* (PSE) comprises many different dimensions: from engineering education over technological knowledge to safety culture and leadership skills. Such dimensions can be available within a single person or may be shared among different people in one organisation. Dealing with these competences is a challenge, both for the individual engineer as for organisations.

This paper proposes a PSE-competence matrix which comprises the different knowledge levels and skills related to process safety expertise, in 18 different domains and allows assessing the level of depth in each of the fields on a 5-grade scale.

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Such matrix is valuable for organisations to identify the desired competences related to process safety expertise. It is also useful for individuals to position themselves within the process safety context. Thirdly, it can be used by organisations to assess the quality of competences of external process safety experts in a more transparent and objective way. Finally, it allows safety engineering education to critically assess its programs.

This PSE-competence matrix has been developed by a team of safety engineers and university staff in cooperation with process safety experts from different leading organisations in the Benelux and is fuelled with many years of relevant experience. It has been proof tested in two companies.

1 CONTEXT

Personal safety in the process industry improved drastically in the last decades. However, it is remarkable that the downward trend in accident frequency is not observed for major accidents (Seveso definition [1, 2]); still many major accidents happen. In general, the Seveso companies put a lot of effort in the prevention of these accidents, and so do governments and international organisations that provide guidelines and control systems with the clear intention to help and stimulate companies to improve the technical safety of their installations. But nevertheless, accidents still happen which indicates that not all aspects are fully understood nor fully under control, as process safety is very complex and subject to many different influences.

Organisational factors as well as human failures are often indicated as the main root causes of these accidents, together with a lack of operational discipline. The complexity of the process and the human limitations to capture and understand the entire problematic in a process environment are also recognised as a contributing element. Too many disciplines are involved and it is often not feasible for one individual to study, become experienced and master all different fields of expertise.

With respect to the training, recognition or validation of expertise, little has been prescribed in either different European countries or elsewhere.

However, this lack of a framework for process safety competence makes it difficult to map the knowledge and expertise of individuals.

Several commercial organisations have recognised this gap and attempt to fill it by providing courses and issuing certificates that have the intention to show to third parties that the individual concerned is indeed a “competent expert”. However, the level of competence of these same organisations can be questioned in turn, simply because there is no independent and generally accepted framework available that is recognised not only by the authorities, but also by end-users to verify and demonstrate this competence. Therefore, there is a clear need for such a framework that can be used to identify and demonstrate the competence at individual as well as at organisational level.

On 17 November 2008 several safety professionals from leading companies in the process industry gathered at the University of Leuven, Belgium, to discuss this issue. Very quickly, it became apparent that the problem was more complex than either of the companies had envisaged before. Therefore it was decided to organise a series of meetings to identify first the complexity of the problem and secondly to take a first step to allow progression in the establishment of a tool. The aim of the team was

clear and simple: “To improve technical / industrial safety of industrial process installations by harnessing and mapping the competence that surely exists and to provide a sound basis for further improvement of safety of the individuals working in this sector”. A first series of meetings resulted in a range of competence areas drafted (partially inspired by the CCPS publication “Guidelines for Risk Based Process Safety” [3]) at the beginning of 2010, which has been further elaborated and refined afterwards.

The team has provided a basis for a mapping tool that can allow organisations and individuals to measure and demonstrate their abilities in different fields of expertise. The work has, due to its complexity, not completely finished, but a global overview of the Process Competence Matrix has been prepared with the 18 identified competence domains. The team recognises that what is now available in this tool is a consensus that is based only on the information provided by the individuals and the organisations that have contributed. It is therefore important that organisations who would like to apply this, understand the limitations of this tool. At present, it is up to the industrial users to judge what part of this information can be used to improve technical safety in their particular situation. Some potential usage is explained below.

A (safety) engineering education programme can use this information to assess its programmes for coverage. A government can view this information as a valuable feedback from the industry. A way to analyse in what areas of expertise progress can be made to improve in the future. It can be used to map and recognise, the competency of people who contribute, not only in their own organisation but also in other organisations or in the industry as a whole, in the area of process safety improvements.

There is a need for recognition of technical safety experts of whom the competence is assured independently in a more structured way. This need is recognised by several industrial experts in the Benelux who have, with this effort, made a first step on a path forward.

Also other organisations are concerned with mapping safety competences, and this matrix was inspiring for some recent special sessions at conferences [4].

The challenge today is to evaluate what part of this information can be useful to make a next step in becoming a successful organisation in terms of major accident prevention.

2 THE PSE COMPETENCE MATRIX

In the Process Safety Expertise (PSE) competence matrix, the necessary competences for a function with process safety tasks or responsibilities have been enumerated and grouped into 18 different *areas of knowledge and expertise* (hereafter called **competence domains**). Each of the domains is further developed into *sub-domains*, indicating the topics related to process safety that can be relevant for an organisation.

Inspiration for these domains has partially been found in the CCPS-publication “Risk Based Process Safety” [3].

For each of the 18 competence domains an assessment can be made on the *level* of expertise. These levels are indicated on a 5-grade scale (1 to 5, from basic knowledge to expert).

First the 5 different levels are explained in generic terms. Then, the 18 different areas of knowledge and expertise are elaborated. Together they form a matrix that allows organisations to map their expertise on process safety with respect to a desired situation and allows them to identify gaps.

2.1 Levels

The levels are indicated on a 5-grade scale, and they take into account the knowledge (education) as well as the practical experience (abilities) of the person that fulfils the process safety function.

- Level 1: has basic knowledge. The person has a basic knowledge in the specific sub-domain, and has limited practical experience. She/He knows the principles but is only able to apply them in rather straightforward situations.
- Level 2: sees links. The person masters the principles in the sub-domain, and has gained some practical experiences, such that she/he is able to apply the knowledge to related domains.
- Level 3: steers. The person has obtained sufficient knowledge and experience from similar cases that she/he is able to steer a team for similar situations.
- Level 4: challenges and coaches. The person has much knowledge and experience from different cases that she/he is able to challenge and coach a team, also in different situations than her/his previous experience.
- Level 5: is expert. The person is internationally recognised as a reference person for the sub-domain and has influence on the standards or best practices for the sub-domain.

2.2 Areas of expertise and knowledge

The areas of expertise and knowledge comprise 18 domains, which are further divided into sub-domains. These domains and sub-domains are the main entries into the two-dimensional PSE-matrix.

- *Background & Competence*: this domain focuses on 4 elements: 1) engineering education, 2) generic knowledge domains such as project management and organisational aspects, 3) relevant technical knowledge domains (chemistry, mechanical, construction, …) and 4) generic competences such as communication and leadership skills.
- *Knowledge of Legal Framework*: this domain focuses on the knowledge and expertise with relevant European frameworks (Seveso [1, 2], ATEX (explosive atmospheres directive [5]), PED (pressure equipment directive), etc.)
- *Technical Standards and Codes of Best Practices*: this domain focuses on the knowledge and expertise with relevant technical standards and best practice guides. Examples include inherent safe design, equipment design, safety instrumented systems [6], etc.
- *Hazard Identification and Risk Analysis*: this domain focuses on the knowledge and expertise with relevant specific hazard identification and risk analysis techniques. Some techniques are applied in other sectors such as nuclear engineering as well [7].
- *Process Knowledge Management*: this domain focuses on the knowledge and expertise with knowledge management related to process safety: information management, learning modules, etc.

- *Incident Investigation & Learning from Events*: this domain focuses on the knowledge and expertise for investigating incidents and learning from such events in order to adapt processes and organisations.
- *Asset Integrity & Reliability*: this domain focuses on the technical competences related to the integrity and reliability of assets, such as equipment selection, pressure vessels, fire systems, electrical systems, structures, etc.
- *Operational Readiness*: this domain focuses on the knowledge and expertise for process safety experts related to the operational readiness, and reviews.
- *Culture of Excellence*: this domain focuses on the knowledge and expertise for a process safety expert related to the human factors and errors, as well as behavioural aspects and ways to deal with them.
- *Emergency Response Management*: this domain focuses on the knowledge and expertise for managing emergency responses, both topical (fire, explosion, releases), as organisational (procedures, policies, plans, etc.)
- *Fire & Explosion Prevention and Mitigation Measures*: this domain focuses on the technical competences related to fire and explosion prevention and mitigation: techniques, systems and site aspects.
- *Management of Change*: this domain focuses on the knowledge and expertise for a process safety expert to deal with all kind of changes during the lifecycle of an operating unit.
- *Standard Operating Procedures & Safe Work Practices*: this domain focuses on the knowledge and expertise for process safety experts for the different operational phases (start-up, normal, emergency conditions, maintenance, etc.).
- *Training & Performance Assurance*: this domain focuses on the knowledge and expertise required to train employees on safety aspects, as well as to assure performance according to the requirements.
- *Contractor Management*: this domain focuses on the knowledge and expertise for a process safety expert to deal with contractors, and to ensure that they adhere to the relevant practices.
- *Process Safety Measurement & Metrics*: this domain focuses on the knowledge and expertise for a process safety expert to quantify process safety: models, indicators and their applications.
- *Process Safety Auditing*: this domain focuses on the knowledge and expertise for a process safety expert to audit process safety systems. All phases are relevant: pre-auditing, auditing, post-auditing.
- *Commitment to Process Safety*: this domain focuses on the knowledge and expertise for a process safety expert to bring the safety culture and the commitment into the organisation.

2.3 Using the PSE-competence matrix

Figure 1 provides an example of some sub-domains (rows) in one of the knowledge areas (sheet). The columns indicate the requirements to reach a certain level.

The use of the PSE-matrix consists of filling values indicating the level of expertise for a particular sub-domain. (For instance, process safety engineer X has obtained level 3 (“steers”) for the sub-domain Technical knowledge domains/Chemistry within the area ‘Background and Competence’).

Such matrix can be completed at the level of an organisation, a company or for an individual. There is no need to complete the entire matrix, as some entries or areas

might be irrelevant in a particular context. It is clear that the specifics of a certain company or process need to be taken into account, and that no generic 'process safety expert' can be defined.

Neither can a required level be defined in a universal way: it should not be the ambition for an individual or organisation to strive for reaching the expert level 5 in all sub-domains for all areas. (On the contrary, being a specialist in a single domain implies having only more generic knowledge in other domains).

By using colours and vertical lines, the desired value ('set point') as well as the present values ('actual value') can be indicated. Numbers can indicate the amount of persons able to fill the function. This is illustrated in Figure 2, where an organisation requires for a particular domain that 4 persons are able to perform at level 1, 2 at level 2 and 1 at level 3; in the organisation there are 3 persons, whose level for that sub-domain is 4, 2, 1 respectively. That organisation needs to look for one more person at level 1 for that sub-domain.

Key Subject		1 BASIC KNOWLEDGE	2 SEES LINKS	3 STEER	4 CHALLENGE AND COACH	5 EXPERT
Engineering education	*Formal education*	highschool level	professional bachelor	master in industrial engineering	master in engineering sciences	specific master programs
	Education by experience	starter				many years and many projects
Generic knowledge domains	*Project management and life cycle management*	has basic knowledge	is able to actively contribute and to apply knowledge to similar cases	is able to steer discussions and to apply knowledge to similar cases	is able to apply to dissimilar cases and to coach others	contributes to the state of the art and is externally considered as expert
	Economic aspects	has basic knowledge	is able to actively contribute and to apply knowledge to similar cases	is able to steer discussions and to apply knowledge to similar cases	is able to apply to dissimilar cases and to coach others	contributes to the state of the art and is externally considered as expert
	Juridical aspects	has basic knowledge	is able to actively contribute and to apply knowledge to similar cases	is able to steer discussions and to apply knowledge to similar cases	is able to apply to dissimilar cases and to coach others	contributes to the state of the art and is externally considered as expert
	Organisational aspects	has basic knowledge	is able to actively contribute and to apply knowledge to similar cases	is able to steer discussions and to apply knowledge to similar cases	is able to apply to dissimilar cases and to coach others	contributes to the state of the art and is externally considered as expert
Technical knowledge domains	*Chemistry*	has basic knowledge	is able to actively contribute and to apply knowledge to similar cases	is able to steer discussions and to apply knowledge to similar cases	is able to apply to dissimilar cases and to coach others	contributes to the state of the art and is externally considered as expert
	Mechanical	has basic knowledge	is able to actively contribute and to apply knowledge to similar cases	is able to steer discussions and to apply knowledge to similar cases	is able to apply to dissimilar cases and to coach others	contributes to the state of the art and is externally considered as expert
	Electrotechnical	has basic knowledge	is able to actively contribute and to apply knowledge	is able to steer discussions and to apply knowledge to	is able to apply to dissimilar cases and to coach	contributes to the state of the art and is externally considered as

Figure 1: excerpt of sub-domains within area 'Background and Competence'

Key Subject		1 BASIC KNOWLEDGE	2 SEES LINKS	3 STEER	4 CHALLENGE AND COACH	5 EXPERT
Generic knowledge domains	*Project management and life cycle management*	has basic knowledge	is able to actively contribute and to apply knowledge to similar cases	is able to steer discussions and to apply knowledge to similar cases	is able to apply to dissimilar cases and to coach others	contributes to the state of the art and is externally considered as expert
	organisation	4	2	1		
	person X					
	person Y					
	person Z					

Figure 2: mapping competences into the PSE-competence matrix

3 POSSIBLE APPLICATIONS OF THE COMPETENCE MATRIX

The developed PSE-competence matrix is useful in at least the following different kind of applications.

- For *competence analysis in organisations*: organisations are able to identify the level of process safety expertise that is available within a certain organisation, or on a certain unit, or at a particular plant, etc., by indicating the present values ('set points') for the different sub-domains in the relevant areas, taking the knowledge and experience of different teams into account.
- For *competence gap analysis in organisations*: organisations are able to identify the required level of process safety expertise that is necessary within a certain organisation, or on a certain unit, or at a particular plant, etc. ('*set point'*, or *desired value*.) Besides, based on the competences that are already available within an organisation (*actual* or *present values*), they can identify competence gaps. The differences between the desired and present values may indicate the training potential for the existing workforce, or external competences that need to be hired. As such it identifies the gaps in competences related to process safety expertise within an organisation.
- For *positioning of individual persons* within the process safety expertise: the PSE-competence matrix allows a multifaceted view on the different competence of an individual, based on experience and education. Internally, such people can be better positioned within an organisational context. External 'self-claimed' process safety experts can be assessed or compared in a more objective way.
- Generically, the divisions Human Resources of the companies can use such matrix for personal development plans of their employees, companies can use it to challenge or benchmark each other, and academics to conceptualise and structure discussions with respect to process safety expertise.
- Finally, educational institutes may use this matrix to evaluate safety engineering programmes against the required professional competences.

4 RELATED WORK AND FUTURE STEPS

This PSE-competence matrix is being applied in several companies to indicate its real-world value, and to result in improvement suggestions. Initial feedback is quite

positive, though it requires a rather broad general knowledge of the person using the tool for assessing peoples competences.

It is the objective that this PSE-matrix be taken up by companies to identify the process safety expertise, by institutes to identify training programmes, by academics and professional organisations to harmonise discussions, etc.

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