Process Safety Competency - effective approaches to creating and judging competency on process safety

Revonda Tew, Senior Engineer; Gerald Burch, Senior Engineer;
and William Bridges, Senior Engineer
Process Improvement Institute, Inc. (PII)
1321 Waterside Lane
Knoxville, TN 37922
Phone: (865) 675-3458
Fax: (865) 622-6800
e-mail: rtew@piii.com
e-mail: gburch@piii.com
e-mail: wbridges@piii.com

Prepared for Presentation at
10th Global Congress on Process Safety
New Orleans, LA
March 30 - April 2, 2014

Keywords: process safety competency, process safety management, incident investigation, root cause analysis, near miss reporting, process hazard analysis, human factors, leadership, accountability, employee participation

ABSTRACT

Process safety is a deep topic and requires the involvement of nearly ALL staff at a site. But, how do you make sure your staff are up to the task? And how do you judge the competency of subcontractors or third party experts? This paper describes the basics of building competencies in each aspect of process safety, including those tasks that require expert levels of competencies. It shows how different companies plan for the progression to levels of competencies and the typical requirements to reach a new level. One focus of the paper is that competency cannot be "specified" (at least not completely). Competency must instead be judged by those who are already competent in that skill or role.

Background

The increasingly complex and technical demands of process safety management (PSM) have placed a large demand on existing resources across the process industries. Success requires the utilization, involvement, and full support of nearly ALL staff at a site. Success also demands that a substantial portion of staff be competent and capable of contributing.

Unfortunately, the process safety competencies required for people to become fully involved are not easy to achieve quickly. New engineering graduates may have academic exposure to safety engineering principles and critical thinking skills, but they generally lack specific training on process safety fundamentals, though that is changing in man engineering curriculum. More importantly, new graduated always lack the practical experience required to make sound risk management judgments and they lack the skill required for many tasks in PSM, such as leading process hazard analyses (PHAs).

Similarly, operators and mechanics may have the practical, hands-on experience required, but they often lack the technical skills necessary to perform some of the skill-based tasks that fall to them, and they may also lack the analytical background to evaluate and manage risk effectively.

The challenge facing nearly all companies today is how to identify, develop, nurture, and maintain competent individuals across the organization with the right combination of natural abilities, experience, education, and training.

Developing, Measuring, and Maintaining Individual Competency

Competency is the skill or ability to do something well enough to meet a standard. An individual gains competency through the combination of natural abilities, general education, experience, and specific skill/task training (classroom and hands-on), as should in Figure 1.

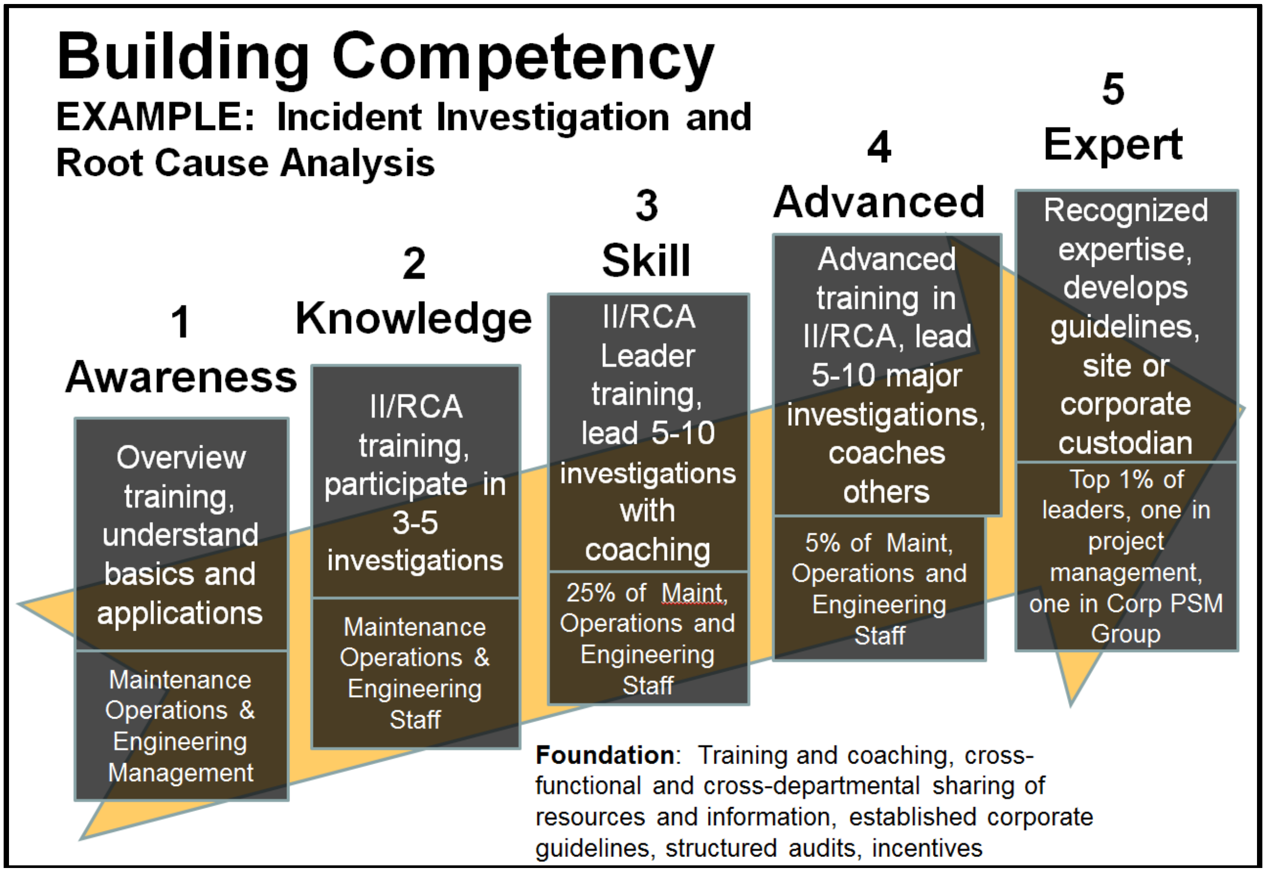
Some of these components, such as education or experience (knowledge), can be measured directly and minimum standards established. However, evaluation of the competency level requires demonstration of the ability and judgment by others who are already competent. How can someone who NOT an expert judge the competency of someone in a new skill or activity?

Figure 1: The Make-Up of Competency in an Individual
© Process Improvement Institute, Inc. (2013)

Progressive competency levels are achieved over time by participation in specific activities and achievement of specific milestones. Increasing levels of expertise are mastered and maintained through training and mentoring others, cross-functional and cross-departmental sharing of resources and information, stewardship of organizational guidelines and standards, and external engagement with other experts in sharing and developing new knowledge.

Figure 2 shows how this progression applies to building competency in incident investigation / root cause analysis (II/RCA). Two case studies (actual examples from two company) using the model below is provided after the figure.

Figure 2: Building Competencies for II/RCA Leadership



Case Study: Building Competencies in II/RCA at AMOCO Oil Offshore Business Unit

The ratio of near loss incidents to loss incidents reported is a critical leading indicator of process safety performance. Near loss incidents provide an opportunity to learn about and correct management system weaknesses before losses are incurred. The desired ratio is 50 to 100 reports of near loss incidents for every loss incident incurred.

In 1996, Amoco Oil's offshore business unit on Louisiana (about 650 workers and other staff) determined that an increase in near loss reporting was desired to improve their process safety performance. They had historically reported less than 2 near loss incidents per loss incident incurred. First they educated superintendents and managers in how to get near misses reported, including how to create and maintain a blame free environment. This change in management approach included having workers lead all investigations to reduce the fear caused by investigations led by bosses. This changed worked great and the near miss report jumped from the prior ratio to about 80 in one month! (Near miss reporting increased from about 20 a month to about 900 a month, in one month of implementation.)

The only way to manage the huge increase in incident investigations was to develop additional resources to participate in and lead investigations. With help from staff now at PII, AMOCO trained about 60 staff (~10% of the work force in that business unit) in the incident investigation and root cause analysis leadership. The training included examples from within AMOCO to add realism and pertinence. Some coaching of new leaders also occurred via phone and e-mail. Then about 9 months later, Refresher training was provided for the 60 leaders, using incidents that they had investigated; this training help make mid-course corrections to the approach/techniques used by the newly trained leaders.

These in-house staff carried on the training for many years thereafter. This case study illustrates progression of the II/RCA leaders from the Knowledge level through the Advanced Level (and perhaps Expert Level).

Case Study: Building Competencies in II/RCA at A Large Pharmaceutical Company

As mentioned earlier, the desired ratio of number of near misses reported to number of actual loss should be 50 to 100 in a company with excellent management systems for process safety. This also extends to quality, reliability, and productivity.

In 1997, the pharmaceutical company (with more than 50,000 workers and staff world-wide) determined that an increase in near loss reporting was desired to improve their process safety performance. They combined all incident databases (there had been 5 different ones) into one database covering reliability, quality, safety, process safety, productivity, and environmental protection. Then, they developed a customized training course (with help from staff now at PII) and trained 7 internal staff of the fundamentals taught in this course; these 7 had been identified as future trainers and they began applying the new methods/approach right away. About a year later, the future trainers appeared expert enough in the methods (as judged by a expert investigator now at PII) and training of 10% of the site staff began across all of the company. Originally, the site staff was trained by the expert at PII, but gradually, the 7 Lilly instructors began to gain skill and confidence in teaching this topic. After about 20 courses in the USA and UK, the training was turned over entirely to the 7 internal trainers.

These changes worked great and the near miss report jumped from the prior ratio to about 105 (the highest ratio we have ever measured).

This case study illustrates progression of the II/RCA leaders from the Knowledge level through the Advanced and Expert Levels.

Developing and Maintaining Organizational Competency

An organization gains competency through the identification and development of the requisite **Skills**, but skills alone are not sufficient. Organizational competency also requires that **Information** is developed and shared, that a learning **Culture** (supportive, nurturing, and encouraging) is maintained to ensure that the skills are developed and applied in an effective manner, and that **Performance Measures** are monitored to continuously evaluate performance and reevaluate organizational needs.

Figure 3: The Make-Up of Competency for an Organization
© Process Improvement Institute, Inc. (2013)

Step 1: Skills – What are the organization's needs?

Understanding the organization's process safety skill requirements is the first building block of developing competency across the organization. What are the organization's needs?

A gap analysis is essential to develop these skill requirements. Begin by identifying the organization's current strengths and weaknesses in process safety. What is going well and should be maintained? What improvements are necessary and how will those be achieved? Then, establish organizational goals and objectives for maintaining and improving process safety performance.

Once process safety goals and objectives have been established, it is possible identify what skills, individual competency levels, and resources are needed to successfully meet those objectives.

Comparing the available inventory of resources with the organization's needs identifies those gaps which must be filled.

> *Example: An organization has determined that it is underreporting "near misses" by a factor of 10. Leaders are confident that increased reporting and investigation of near loss incidents will identify and resolve management system weaknesses (root causes) common to both near loss incidents and loss incidents. By eliminating these common causes the risk of incurring losses will be decreased. However, increasing the number of incidents reported by a factor of 10 will also increase the number of investigations which must be performed. Managing this increased workload requires that additional resources (shift operators and mechanics) be trained to lead effective and efficient investigations as quickly as possible after the incident occurs. Involving workers has the added benefit of increasing process safety awareness, employee engagement, and ownership of the proposed resolutions. To achieve this goal, the management of the company needs to become proficient in process safety management and especially become expert in reducing the barriers to near miss report (the biggest barrier being fear of blame for the mistakes that led to the near miss or accident).*
>
> *This change requires awareness training and then knowledge by management; skill and advanced training by 10-15% of the workers, and expert level for the workers assigned to be the chief investigators (gatekeepers of quality). This progression was followed at Amoco Oil and Eli Lilly mentioned earlier, but has also been implemented in dozens of other companies world-wide.*

Table 1 is one example of a "process safety skills" inventory for an organization; this one is for II/RCA only; the table which identifies resources required and training/skills needed.

Table 1: Typcial Competencies needed for II/RCA across an Organization

Training need	Group				
	Upper management	Supervisors	Engineers/Operators/ Maintenance Staff (general)	Staff leading investigation of complex events	Staff leading investigation of low complexity events
Incident/problem reporting definitions and procedure/forms	Yes	Yes	Yes	Yes	Yes
Objectives of II/RCA, Near miss reporting, Gathering data (including interviewing of peers)	**Proficiency**	**Proficiency**	**Proficiency**	**Proficiency**	**Proficiency**
Analysis techniques (CFC, FTA, Root Cause Charting)	Awareness	Awareness	Awareness	**Proficiency**	**Moderate proficiency**
Investigation follow-through requirements	Their responsibilities, including measuring performance of II	Their responsibilities	Their responsibilities	Their responsibilities	Their responsibilities
Communicating analysis results and resolutions	Yes	Yes	Yes	Yes	Yes
Trending Techniques	Awareness	Awareness	Awareness	Detailed	Awareness
Typical length of course segment	3 hours	3 hours	3 hours	3 to 5 days	1½ to 2 days
Typical number of personnel at an operating facility	All	All	All	3 per site of 100 total operations and maintenance staff	15 per site of 100 total operations and maintenance staff

Similar inventory tables can and should be developed for each aspect of process safety engineering:

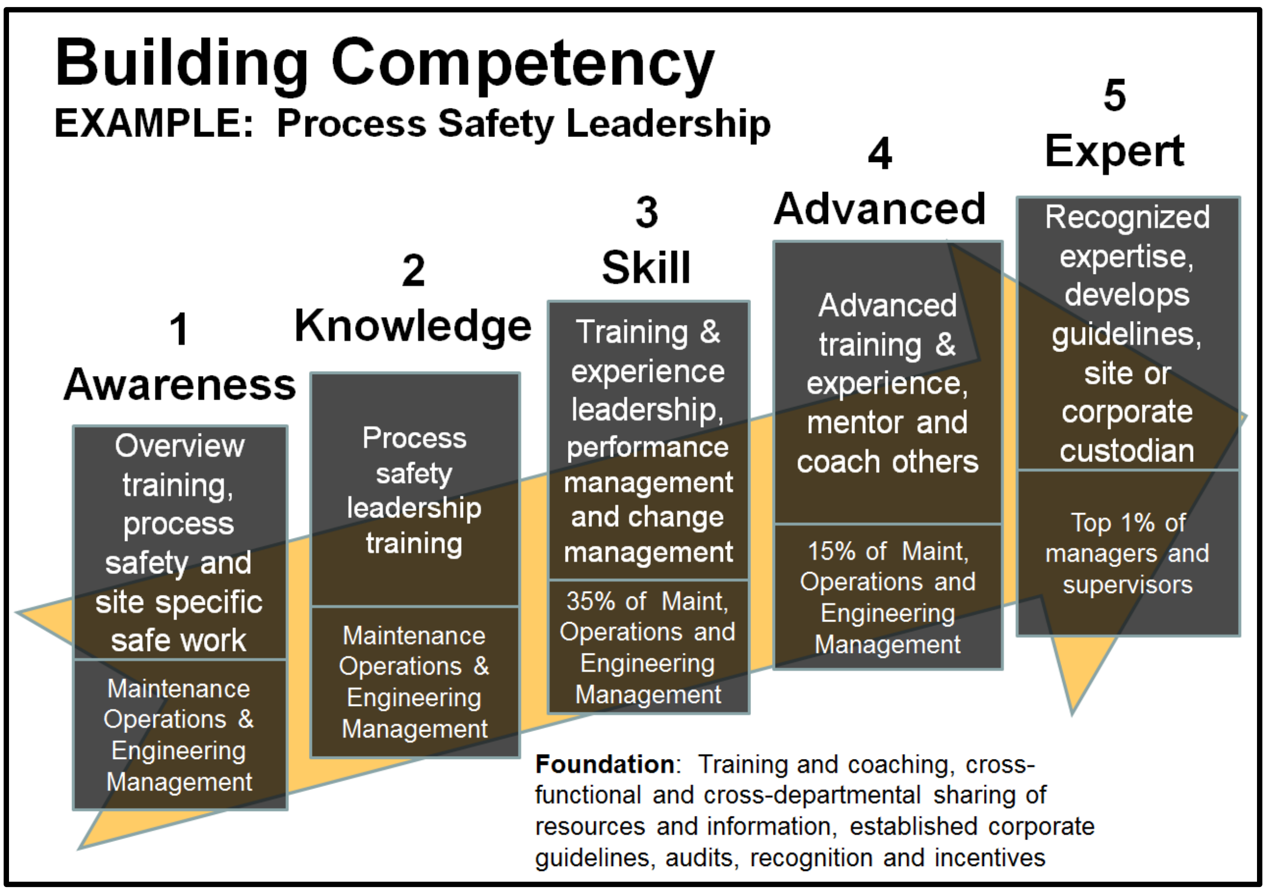
- Relief valve sizing
- Safety instrumented systems
- Corrosion engineering
- Selecting the right materials of construction
- Etc.

and each activity/skill within process safety management

- Investigators
- PHA
- Auditing
- Procedure Writing
- Etc.

Just like with specific skills such as II/RCA and relief valve sizing, company leadership also needs to have a set of knowledge, and selected leadership may need to also advance to skill, advanced, and expert levels as should in Figure 4 below.

Figure 4: Building Competencies for Process Safety Leadership



Step 2: Identify Candidates

After the organization has identified the inventory of process safety skills and resources needed, it must now determine how those needs will be met. Some organizations may decide to develop a relationship with external service providers for much of the process safety engineering expertise required and even for some of the process safety skills. Others may decide to develop this expertise internally, relying on external support only until internal resources can be developed (it is hoped that this is the approach all companies adopt). There are many factors outside the scope of this paper that must weigh into this decision for each organization. For instance, it is not practical or wise to have someone other than plant workers develop operating procedures and maintenance procedures; having outsiders develop these may produce well written documents, but the content will not be as accurate and the language and jargon will be somewhat different if outsiders download the information from the heads of workers and write the procedures. And, there is a practical necessity to have shift staff trained on how to perform root cause analyses of near misses, if the plant gets 100 near misses reported per loss event.

Regardless, it is important to maintain a healthy mix of internal participation to ensure ownership and consideration of specific process technology issues and external engagement to ensure continuous learning and best practice standards.

If internal resources will be used, then it is important to continually look for and identify good candidates early in the process for further development as advanced and expert resources. Awareness and knowledge training provide ideal opportunities to begin this process.

For formal training, ensure all sessions include interactive workshops and other small group activities designed to apply the skills being taught. Have the instructors observe and evaluate participants based on their interest level, their natural ability to grasp and apply the skill, and their interaction with others as participant and leader. Ideal candidates will quickly grasp the technical aspects of a skill, learn to apply them in an appropriate way, serve as a positive role model for others, gravitate to leadership roles within the group, and gently begin to encourage, coach, and teach others who may not grasp the concepts as quickly.

At this stage, it is important to keep an open mind about the possibilities that lie within each individual. At the risk of reinforcing stereotypes, engineers sometimes bring technical knowledge and critical thinking skills, but sometimes lack the communication skills and personal empathy needed to become a good teacher. Operators may bring the practical knowledge and credibility necessary to be a good facilitator, but sometimes lack the detail orientation and education necessary to conduct a thorough analysis. People bring a wide variety of education, experience, abilities, and biases to the table. Your competency development job is to build on their strengths and fill their gaps.

Step 3: Culture - Develop Career Paths and Opportunities

Incorporate the process safety skills inventory and competency requirements (Table 1 was an example of one of about 20 such inventories necessary) into the normal career progression for all roles. When considering individuals for advancement or promotion, give consideration to the development and demonstration of process safety competencies appropriate to the role. For example, incident investigation, management of change, and operating procedures are important within the operations ranks. Management of change, mechanical integrity, and writing of maintenance procedures are important for the progression of mechanics. Process technology and hazard evaluation are important for the progression of process engineers. In each discipline, establish the minimum competencies required to progress to the next level. Reward those who exceed the minimum requirements with additional learning opportunities, special projects, coaching assignments, individual recognition, and promotions. With higher levels of progression, should come higher compensation as well.

It is often desirable to develop a formal career path for engineers which includes advancement and demonstration of process safety competency. Table 2 is an example of a technical professional career progression path for a key competency identified by the organization. In this example, competence levels are described for the skill "Pressure Relief Device Adequacy Assurance." which is one of elements of "Process Safety Risk Assessment." A complementary skill of "relief valve design" is necessary for "process safety engineering."

> ***Example:*** *A process engineer has shown aptitude and expressed interest in advancement in process safety. Work with this engineer's manager to build a developmental plan which incorporates process safety competency developmental goals. Identify learning opportunities such as an advanced class in inherently safe process considerations, participation/leadership of a process hazard analysis, an opportunity to lead a complex incident investigation, or a mentoring assignment to coach and develop others in leading human factor audits.*

Step 4 – Build individual competency

Individuals build competency through their natural abilities, education, training, and experience. Formal training classes provide the basic awareness and knowledge necessary, but advanced skills require application and hands-on experience in real-world applications. Mentors who have already demonstrated advanced skills should be assigned to each new learner to provide guidance, feedback, encouragement and support. This assignment is important to the mentor as well since real expertise is developed by coaching and teaching others. Experts gain and enhance their competence by acting as stewards over the discipline, developing standards and guidance documents, overseeing coaches and trainers, and interacting with experts outside the organization to continuously learn, improve, and create new knowledge.

Some organizations reward Experts at the same compensation level as vice presidents of the company because they recognize the potential vulnerability and loss of investment in losing Experts.

Table 2: Example of a Generic Skill Progression Path (courtesy of PETRONAS)

	Competence Level / Technology	Awareness	Knowledge	Skill	Advanced	Expert
		DISCIPLINE COMPETENCE MATRIX				
		Competence Level Descriptors				
1	**Pressure Relief Device Adequacy Assurance**					
			Awareness +	Knowledge +	Skill +	Advanced +
1.1	This technology is concerned with the skills required to ensure safety in the design of processes and plants through avoidance of over or under pressure.	Aware of the different types of pressure relief devices.	Able differentiate and identify the application of different type of pressure relief devices.	Able to select suitable type of pressure relief device for specific application. Able to identify type of pressure relief device at site. Understand the terms associated with ensuring reliability of pressure relief devices such as "failure to danger", pop test, pre-pop test, bench test and Trevi test.	Able to interpret the pressure relief device datasheet. Able to train other on the selection of suitable pressure relief devices for a specific application. Able to elaborate on the terms associated with ensuring reliability of pressure relief devices and conduct site verification.	Acts as an internal consultant on all aspects of pressure relief issues (selection, design and installation); stays current on relief valve literature. Able to advise the plants on ensuring reliability of pressure relief devices to prevent Loss of Containment (LoC).
1.2	This includes specification of equipment design pressure, fundamental understanding of the causes of over/under pressure, development of overall relief philosophy and detailed specification of hardware and systems to protect the process.	Aware of causes of over and under pressure in plant operation and design. Understands importance of safe disposal of vented material.	Has received formal training and able to describe common causes of over and under pressure in plant operation and design. Aware of the key codes and international standards for pressure system design requirements (e.g. API 520, API RP 521 and DIERS).	Able to identify relief case for specific relief system. Able to identify the necessary information and performing pressure relief device sizing calculation. Understand and apply of the key codes and international standards for pressure system design requirements.	Able to review pressure relief device sizing calculations and provide assurance to stake holder. Interpret the outcome of pressure relief device sizing calculation and recommend suitable corrective measures, as required.	Train and coach others to carry out calculations for pressure relief device sizing.
1.3	This technology describes the ability to calculate the provision for pressure/vacuum relief as ultimate protection to prevent loss of containment.	Aware of the general configuration and different type of flare header design.	Able to describe the function of the various components of flare system. Understand the calculation used for flare network analysis and aware of suitable tools/software for the calculation.	Detailed understanding of flare systems and its adequacy inclusive of pressure drop across the system and potential for backpressure.	Perform flare header calculations to determine adequacy for design relief case.	Train and coach others to carry out calculations to determine adequacy of flare header system.
1.4	Ability to calculate the loading on flare header during design relief case; to ensure adequate capacity and minimize back pressure.	Aware of the general configuration and different type of flare header design.	Able to describe the function of the various components of flare system. Understand the calculation used for flare network analysis and aware of suitable tools/software for the calculation.	Detailed understanding of flare systems and its adequacy inclusive of pressure drop across the system and potential for backpressure.	Perform flare header calculations to determine adequacy for design relief case.	Train and coach others to carry out calculations to determine adequacy of flare header system

The list below shows how this process works for building competence in Incident Investigation and Root Cause Analysis:

> ***Level 1 (Awareness)*** *- attend a 1-2 day classroom training covering human factors, data collection, causal factor charting, and root cause categories.*
>
> ***Level 2 (Knowledge)*** *- attend a 3-4 day classroom training which reviews the basics and then includes advanced investigation topics such as conducting interviews, collecting, organizing and analyzing more complex data, and teaches fault tree analysis in an investigation setting. Practice workshops are followed by participating in 3-5 investigations led by others.*
>
> ***Level 3 (Skill)*** *- lead 5-10 investigations of low to moderate complexity (99% of the incidents at a facility will typically fall into this category) with the active support and oversight of a coach. Additional training on human factors, procedures, mechanical integrity, and hazard evaluation may also be required.*
>
> ***Level 4 (Advanced)*** *- coach Level 3 investigators and lead 5-10 major, more complex investigations. Participate in or lead investigations at other sites to gain the experience and practice needed (typically, fewer than 1% of the incidents at a facility are major).*
>
> ***Level 5 (Expert)*** *- serve as the site or corporate steward, developing policies, procedures, and guidelines for conducting investigations and analyzing incidents. Monitor and analyze organizational performance, evaluate effectiveness, identify and implement improvements. Interact with other experts outside the facility through involvement in corporate teams, industry groups, site visitations, and other opportunities to expand and grow their skills.*

Step 5 – Maintain Proficiency and Extend Skills

Organizations maintain and extend process safety competency by providing a supportive culture, making information available, and evaluating performance.

A supportive process safety culture begins with management's understanding, commitment, and unwavering support of process safety management as a critical risk management tool. Resources are made available, priorities are clearly established, and key performance indicators are monitored and discussed to ensure that process safety related activities are completed. A supportive process safety culture also values and recognizes its expertise. Process safety stewards are visible, engaged, and available. They maintain up-to-date training materials and searchable databases, teach and attend training classes, and maintain high visibility by pushing information out to the organization on relevant achievements, results, findings, and future plans. They ensure that everyone understands the important role of process safety management in preventing serious incidents and injuries.

Step 6 - Measure and evaluate results, reevaluate needs

A strong set of leading and lagging metrics is essential to measuring and monitoring performance. Most of the metrics associated with process safety competency are activity based, such as the following examples:

- Ratio of near misses report to number of accidents that occur
- Training sessions completed
- Achievement of specific competency goals
- Timely completion of investigations or all causal factors and root causes
- Timely completion of high quality MOCs
- Timely completion of high quality PHAs
- Timely completion of compliance and best practice audits
- Timely closure of recommendations and action items
- Timely completion of and good results from human factors audits
- Procedure quality and accuracy audits

Periodically, it is also important to review and reevaluate the organization's process safety goals and objectives to determine how things are going. Are these still relevant and are they being achieved? Are the identified competency needs being met and have new needs become apparent?

Ensure that the process safety plans and strategies are completely aligned with the organization's overall goals. If not, determine why and adjust accordingly to remain a relevant and contributing part of the organization's success.

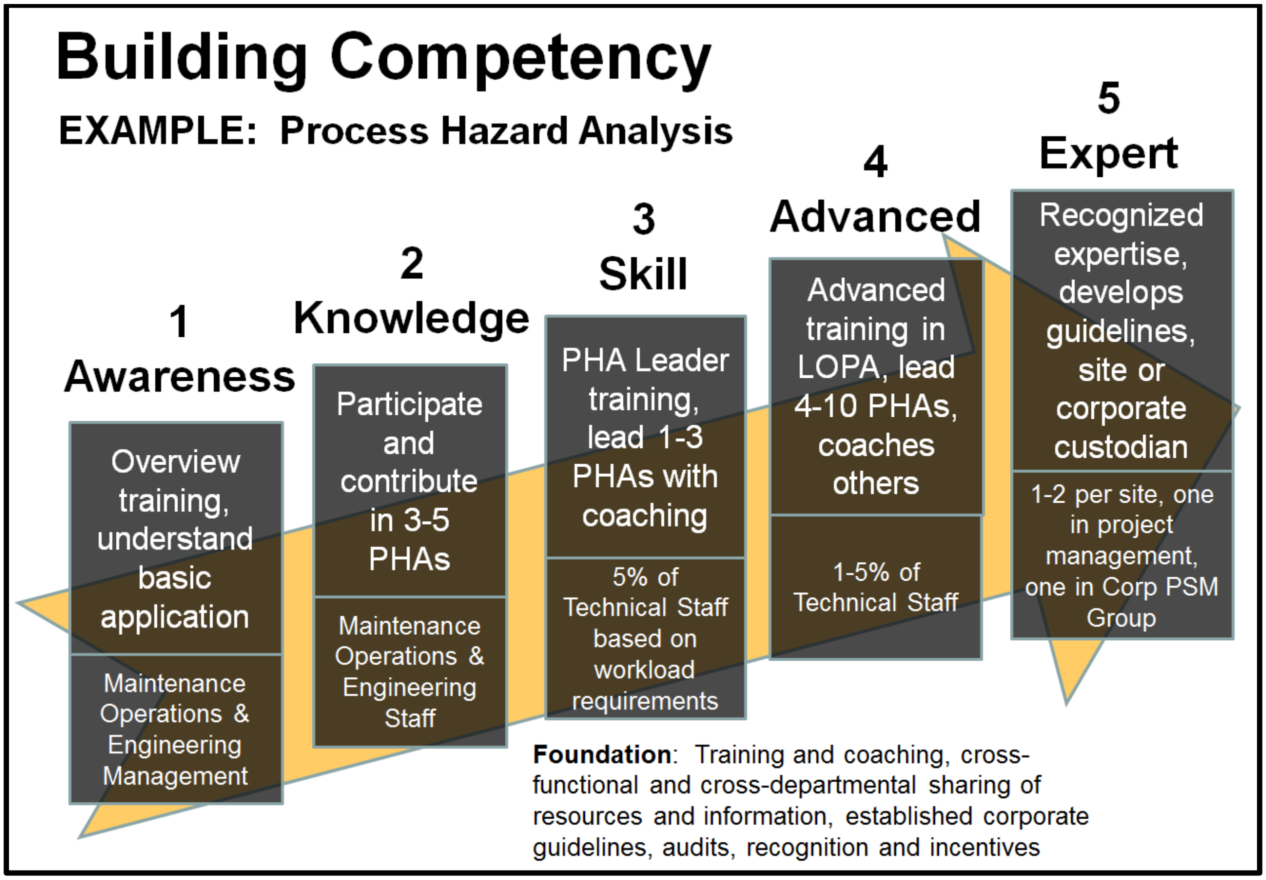
Additional Case Studies – Results Achieved

PHA Leaders at UNITED (SABIC affiliate). *This petrochemical site (ethylene, polyethylene, alpha-olefin) of about 600 employees determined that 4 PHA Leaders are needed for this size and nature of complex to handle PHAs and Revalidations and large MOC risk reviews.*

- *Experts (PII, in this case) trained 15 process engineers to the knowledge level in leading and scribing PHAs (5 days)*
- *The PII instructor then chose the 8 best candidates, and coached them for 2 weeks while they led and scribed 3 different PHAs (re-do of existing units; initial PHAs were poor)*
- *Training and coaching included all methods (HAZOP, What-If, Checklist, FMEA) with analysis of continuous mode, along with procedure modes for startup and shutdown*
- *During the PHA report-writing phase, PII coached, reviewed, and edited the draft PHA/HAZOP reports, with the UNITED leaders/scribes finishing*
- *By the end of the process, PII certified 4 leaders and 3 scribes*
- *These leader/scribes completed the PHAs of all modes of operation for all 4 plants and for utilities*

- *In the 5 years since, the leaders have been backfilled as a couple were promoted to superintendent*
- *Certified leaders/scribes have ensured that each PHA and each large MOC risk review was performed well*
- *See Figure 5 below for the overall competency progression for PHA*

Figure 5: Building Competencies for Process Hazard Analysis

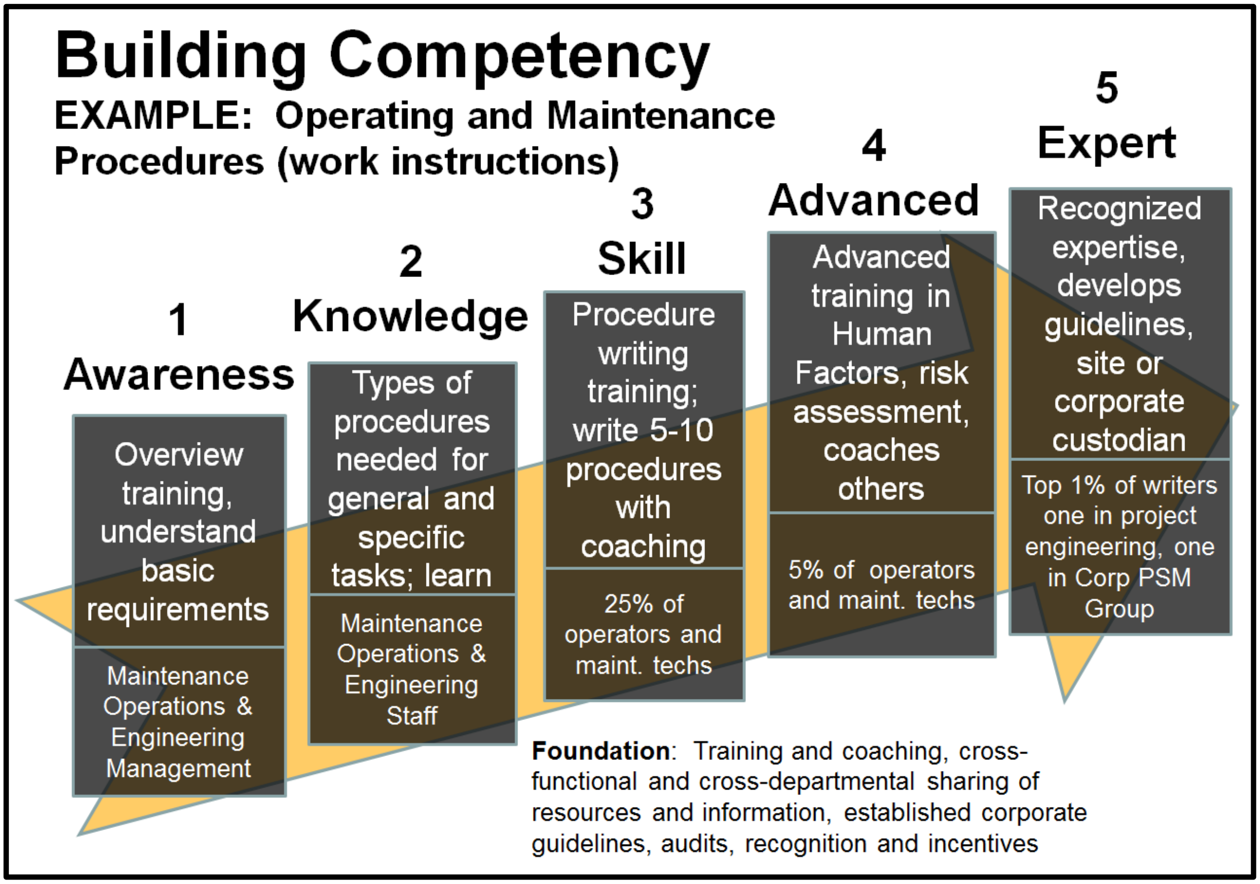


Operating Procedures Writers at a Medium Size pharmaceutical site with about 250 operatora: *The site identified deficiencies in their operating procedures as a root cause of a high percentage of incidents. They developed procedure writing guidelines and trained 3 engineers, 45 operators and 10 mechanics in the procedure writing process. Now, subject matter experts (SMEs; operators and maintenance technicians) write and review the procedures, and evaluate accuracy, completeness, and clarity. The clarity is judged versus the best practices for controlling human errors in written procedures. Technical resources (engineers, etc.) continue to provide editorial comments, but SMEs are the owners of their procedures. This took less than 50% of the effort originally estimated. PII provided the initial training and coaching:*

- *2 days of classroom training by experts in procedure writing and human factors, for 3 sessions to train the 58 folks listed above (6 training days total)*

- *3 days of hands-on coaching by experts for each group, where pairs of graduates wrote procedures from walk-downs in the field. This was followed by an additional 5 days of coaching onsite about one month later. Total of 14 days of courses and hands-on coaching at the site*
- *2 days of coaching by experts from a distance (by e-mail and telephone)*
- *3 days assistance by experts on development of management system for writing procedures and management of changes to procedures*
- *See Figure 6 below for the overall competency progression for writing procedures*

Figure 6: Building Competencies for Procedure (work instruction) Writing



© Process Improvement Institute, Inc. (2013)

Full Set of Process Safety Competencies for Operators at a Refinery. *This refinery on the West Coast of the USA, has about 800 employees. Management established a very strong process safety culture early (20+ years ago, under Arco) and maintained consistent vision since then. There has been continual investment in empowering workers to take the lead on writing procedures, incident investigations, near miss reporting, and change management; with no compromise on budgets for critical competencies and activities.*

- *One operator per unit was identified, trained, and assigned responsibility for PSM unit leadership on a day-to-day basis including coordination of the MOC process, risk* *reviews for MOCs, incident investigations, procedure updates, human factors evaluations, etc. This assignment rotates every two years.*

- *PII provided skill training and coaching on all topics for these unit leaders in MOC, mini-PHA of procedure changes, procedure writing and analysis (what-if and 2 guide-words), and deep training on human factors.*
- *New workers immediately begin building competencies in process safety.*
- *Workers help train each other to "fix" a procedure or task instruction rather than "oh, let's not follow that because the steps are not correct in it"*
- *There is a thorough risk review of all hazards and tasks*
- *The organization scores high on process safety competencies and process safety culture on surveys (they had the highest scores across all of BP USA on Process Safety Culture during the Baker Panel surveys)*
- *Their process safety performance in the past 15 years is best in class*

CONCLUSIONS

Competencies can be achieved and maintained at chemical process plants and companies. Organizations need to recognize their gaps in competencies first; this first step is a major failure of many companies, even the largest and oldest, because for some process safety needs, the organization does not know how to judge competencies. An organization needs to have existing experts in order to have the coaches/mentors available to build the missing process safety competencies; for the short-term, this may require a company to contract in the experts. Building competencies requires sustaining staff in a role long enough to build competency; and the organization must get a few of these competent staff to reach Advanced and Expert levels. Eventually, competency levels can be self-sustaining; this is possible if the organization recognizes the importance of sustaining competencies and rewards those with very high level of competency accordingly.

ACRONYMS USED

AIChE – American Institute of Chemical Engineers
CCPS – Center for Chemical Process Safety (of AIChE)
CFR – Code of Federal Regulations
GCPS -- Global Congress of Process safety
HAZOP – Hazard and Operability; as in HAZOP Analysis or HAZOP Study
II/RCA – Incident Investigation / Root Cause Analysis
LOPA – Layer of Protection Analysis
MOC – Management of Change
PHA – Process Hazard Analysis
PSM – Process Safety Management
RAGAGEP – Recognized and Generally Accepted Good Engineering Practice
RCA – Root Cause Analysis
US EPA – United States Environmental Protection Agency
US OSHA – United States Department of Labor, Occupational Safety and Health Administation

REFERENCES

1. Bridges, W., *Gains in Getting Near Misses Reported (Updated)*, 8th GCPS, AIChE, 2012.
2. Williams, T. and Bridges, W., *Effective Procedure Writing – A Two-Part Series (Part 1: Reducing Risk of Worker Errors; Part 2: Addressing Process Safety Management Requirements for Operating Procedures),* Chemical Engineering Progress, 1997.
3. Excerpts on Learning Objectives and Competency Requirements from various PII Training Manuals.