

IMPROVING THE UNDERSTANDING OF PROCESS SAFETY MANAGEMENT

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Synopsis

Process Safety Management is an integral part of safety across the process industries and has been reinforced by requirements under legislation in the UK, Europe and the USA. Studies into existing practice, such as the Baker Panel, investigation which was initiated following the Texas City explosion, have highlighted the importance of staff at all levels having a sound understanding of the both the systems in use and the principals and science behind them.

The paper will review existing training in process safety and the thinking which has lead to the development of a new training course. 'Fundamentals of Process Safety' by the IChemE. The course, which is targeted at engineers, managers and supervisors at an early stage in their careers, is aimed at both improving the understanding of company systems as well as providing a foundation for more specialised training such as that provided by the IChemE and others.

It is hoped that the paper will provide an opportunity for a wider discussion on the course aims and its further development.

INTRODUCTION

Following the explosion at the Texas City refinery in 2005 which resulted in 15 deaths and 170 injuries, BP established an independent panel to review process safety at its US refinery operations, the Baker Panel. On completion of its review of US refinery operations the panel issued a comprehensive report. (ref. 1) This made ten recommendations, the majority of which cover corporate safety culture, process safety leadership, incorporation of process safety into management decision making and process safety management.

One of the recommendations is of particular interest to industry is:

Recommendation # 3:

Process Safety Knowledge and Expertise:

BP should devise and implement a system to ensure that its executive management, . . . and all refinery personnel including managers, supervisors and contractors possess an appropriate level of process knowledge and expertise.

It is clear that the requirement for a sound understanding of Process Safety Management (PSM) is not restricted to BP and is required at all levels throughout an organization. Managers, engineers and shift managers play a critical role in promulgating the standards established at board level as well as linking the principals of Process Safety to the technology of the process being developed, designed or operated. Process safety is dependant upon the activities of many people and it is vitally important that everyone involved has an understanding of how their own activities integrate with and are dependant upon the activities of others as well as each person's understanding of the potential consequences of failure.

This thinking has lead to the IChemE to develop a new training course 'Fundamentals of Process Safety'.

CURRENT TRAINING IN PROCESS SAFETY

What training is currently being provided in Process Safety?

UNDERGRADUATE TRAINING

A survey into process safety training was carried out by the author in 2005. The survey was sent to all Institution members under the age of 35 and the replies from 376 members graduating between 1991 and 2004 from 44 different Universities were analysed and reported at CHISA 2006 (ref 2 & 3).

Overall the survey showed that the majority of undergraduate courses in Chemical Engineering in the UK provide a broad coverage of process safety. (see Table 1) Over 80% of those responding to the survey reported that important topics such as HAZOP, Safety & Environmental Legislation, Hazard Identification, Risk Perception and Fire and Explosion were included in the syllabus of their degree course. Other topics such as Emergency Planning, Area Classification, Human Factors and Ergonomics, Safety Culture and Process Safety Management were less well covered being included in fewer than 53% of courses. These topics are still very important in the achievement of a high standard of process safety.

POST GRADUATE TRAINING

Whilst undergraduate training is important it needs to be reinforced and supplemented following graduation. The survey reported above questioned members on their post graduate training, Table 2 indicates the percentage of those responding to the survey who had received training in safety related topics following graduation.

By far the greatest proportion of the post graduate training was provided by employers (see Table 3).

What conclusions can we draw from these results? Clearly the majority of employers recognise their responsi-

Table 1.

Undergraduate training in safety	
Topic	% in syllabus
Inclusion in Design Project	93
HAZOP	92
Health & Environmental Legislation	91
Case Studies	91
Hazard Identification	88
Risk Perception	85
Fire & Explosion	84
Terminology	83
Mechanical Aspects	81
Inherent Safety	78
Design Standards	76
Cost Benefit Analysis	75
SHE Legislation	72
COSHH	71
Major Hazards (COMAH)	69
Toxics	68
Discharge & Dispersion	68
Protective Systems	62
Process Safety Management	53
Reliability	50
Permit to Work	50
Safety Culture	49
Logic Diagrams & QRA	48
Human Factors & Ergonomics	46
Ethics	39
Area Classification	34
Emergency Planning	34
FMEA	31

Table 2.

Topic	% receiving post graduate training, all sources
Personal Safety	83
Legal Requirements	70
HAZOP	68
COSHH (Control of Substances Hazardous to Health)	61
Management of Process Safety	58
Pressure Relief	52
Human Factors	52
COMAH (UK Major Hazards Legislation)	50
Area Classification	50
Fire Protection	45
Consequence Assessment	38
Logic diagrams/QRA	35
Static Hazards	35
LOPA (Layer of Protection Analysis)	31

bility to provide training in safety for their engineers. As expected the most frequently covered topic was personal safety, although bearing in mind the importance which the industry attaches to safety it is somewhat surprising that 17% did not report having had training in this topic.

The league table is similar to that produced for undergraduate training. Whilst the Management of Process Safety is slightly higher up the table than for undergraduate training, 58% versus 53%, it is still disappointing that 42% of those who responded had still not received any formal training in this topic. We can therefore conclude that despite the existing provisions a significant proportion of graduate chemical engineers will have had little or no formal training in some important aspects of Process Safety.

As noted by the survey the importance of providing training in Process Safety is recognized by many major companies. Examples of the training provided by two major companies are noted below.

Following the Texas City explosion BP has instituted a worldwide programme to ensure that managers, engineers, and supervisors have a sound understanding of the process safety. The training is based on a one week course which covers the principle elements of process safety with a strong emphasis on case studies and an understanding how accidents happen (similar to the IChemE course, see below). This is supplemented by specialised courses covering for example the safety aspects of project management and of operations management.

Shell has a well established course in Process Safety Management for its engineers. Whilst the objectives are similar to those of the course developed by the IChemE it does not include topics such as human factors and safety culture. There is however a more detailed appreciation of technical topics such as Pressure Relief and Risk Assessment. Shell corporate procedures require attendance on this course as a prerequisite to being able to approve modifications.

Table 3.

Training provider	% of training received
Employer	70%
College/University	11%
NEBOSH	4%
IChemE	4%
IOSH	3%
Other (external)	9%

SPECIALISED TRAINING

More specialised training is available at Sheffield University where a course in Process Safety, developed in collaboration with the Institution and the HSE, is available (ref 4). The course comprises nine modules, each of five days duration. The modules may be taken individually, as part of a Diploma or as an MSc in Process Safety. The course provides a sound grounding in the topic but is more likely to be suitable for those who will specialise in the process safety and it is unlikely that an engineer or manager who has other roles will attend this course.

TRAINING PROVIDED BY ICHEME

The Institution has a long tradition in the provision of training in Process Safety through its extensive range of Training Packages and Approved Courses. The courses currently provided include (ref 5).

- Applied HAZOP (3 days).
- HAZOP study leadership & management (3 days).
- HAZOP study for offshore oil & gas (4 days).
- HAZOP for team leaders & team members (4 days).
- Layer of protection analysis (LOPA) (2 days).
- Safety Instrumented systems according to IEC 6511 (2 days).
- Pressure relief (2 days).
- Human Factors (4×5 day modules).

NEED FOR A NEW COURSE IN PROCESS SAFETY

Whilst it is clear from the above that a number of different courses in process safety management are available there are still gaps which need to be filled. In particular none of the current courses provide a broad overview which will enable the young engineer or manager to appreciate how the individual elements of process safety need to be combined to deliver practical results and how his own work interacts with that of others. In addition it is unlikely that an engineer who does not plan to specialise in process safety will be able to attend more than one or two of the above courses. It was this thinking that led to the decision by the Institution to develop a new course '**Fundamentals of Process Safety**'.

Whilst aimed primarily at Chemical Engineers there was it was recognised during the development of the course that success in process safety requires input from many different disciplines, all of whom need to appreciate the importance of their contribution and how their work interacts with that of others.

COURSE DEVELOPMENT

Following support from the Institutions 'Safety Forum' the proposal to develop a new course was shared with the Health & Safety Executive who agreed on the need and offered technical support in course development. A working party of Institution members was then formed comprising,

- Mike Broadribb, BP,
- Ken Patterson, Yule Cato,

- Steve Yee, Ineos,
- Gary Pilkington, GSK,
- Ceri Petri, HSE
- Bob Skelton, Cambridge University
- Neil Atkinson, IChemE
- Robin Turney, Consultant (Chairman).

The working party was fortunate in securing the services of Ian Thorpe, until recently a safety adviser at Ciba, to develop course material.

Early on the course aims were agreed as:

To provide an understanding of the key principles of process safety and its management. At the end of the course delegates should achieve the following key learning outcomes:

- *Understand the consequences of poor process safety (human, environmental and business consequences)*
- *Be aware of and understand the key factors influencing the basis for process safety*
- *Understand the hazards associated with process plant and how the risks can be controlled.*
- *Understand the key process safety requirements at each stage in the life cycle of process plant from conceptual design through to operation, maintenance and modification.*
- *Understand the ways in which their work depends on the knowledge and expertise of others (i.e. interdependency and the need for overall organisational process safety management competence).*
- *Understand their own limitations and know how to acquire further knowledge and understanding of process safety management.*

Clearly with such a broad coverage there was no shortage of material to be included in the course. Whilst the material could easily fill a two or three week course the view was taken that a long course would limit the number of engineers able to attend. In addition the course is aimed to be a 'starter' likely to be followed by more detailed training in specific topics. For this reason the course is of one week duration. This has required a great deal of discipline in deciding just what to include, or more importantly what to leave out, and it is unlikely that adequate coverage of the topic would be possible in any shorter period.

Some consideration was given to the development of an on-line training course but this was not progressed. Factors which lead to this conclusion included the comments of the Baker panel, which was critical BP's over reliance on computer based training in the US. In addition it was decided that whilst on-line training can be effective for technical information it is unlikely to be effective in providing a full understanding of the consequences of poor process safety and in gaining a long term commitment, 'hearts and minds', to the topic, something which was considered of critical importance by the Working Party.

The course aims to provide a basic understanding of technical issues, including ways in which the engineers'

basic scientific and engineering training can be applied to process safety. However such understanding is by itself insufficient to ensure that the knowledge is applied. Following the approach developed by Trevor Kletz, the course includes detailed discussion of a number of case studies. These have been carefully selected to demonstrate the catastrophic consequences which can arise from failings in process safety, different failure mechanisms, the importance of multiple layers of defence, interdependence and the reliance on the contribution of many people in achieving a safe level of operations.

Consideration was initially given to the development of parallel courses for those involved in design and operations. However it was concluded that one course would be more effective in demonstrating interdependence, in addition many engineers move through a number of different roles, in both design and operations during their careers.

An outline of the course structure is given in Table 4.

The existing courses delivered by IChemE do not include any form of assessment. For this course the Working Party concluded that the topic was sufficiently important to require formal assessment. Currently this is an end of course exam of approximately one hour duration. Because process safety is essentially a practical topic it is also intended to support this by a 'back home' assignment. This is however proving more difficult to implement and is one of the areas requiring more work. Delegates who successfully complete the assessment will receive an IChemE certificate in the 'Fundamentals of Process Safety'.

PILOT COURSE

The pilot course was advertised in August 2008 and was very rapidly fully subscribed with the first course being run October. Delegates came from a variety of backgrounds including fine chemicals, oil & gas, insurance, design and environmental regulation. The majority of those attending the pilot course had more than 5 years experience either in industry or as a regulator, slightly more than the Working Party had in mind during the design of the course. The feedback was very encouraging with comments indicating that some 10–15% of the course could be improved, in some areas by simplifying the modules in others by making slight additions.

Some individual comments are given below.

"Before coming on the course I was not aware of how much process safety I already do in my day to day job."

"It is good to refresh basic information and fundamental information relating to Chemical Plant Safety."

"I suspect the audience was more experienced than expected. This course would have been excellent for me 5 years ago."

"Gives good overview, less of first two days, days 3.4 and 5 were very good."

Table 4.

Course Outline
Day 1
Importance of process safety management
Case study
Model for process safety management (including process safety framework, major accidents/accident causes, mechanisms for loss of containment, prevention and control measures, mitigation and emergency measures, process safety strategies) Introduction to hazards and risks
Day 2
Fire, explosion and toxic release – hazards, consequences and basic science
Hazard identification techniques Case study Risk assessment Reaction hazards and material compatibility
Day 3
Process design – including inherent safety, layer of protection, integrity of containment, protective systems, pressure relief, ATEX, occupied buildings
Case study
Operations – including procedures, safe systems of work, control of contractors, maintenance, asset integrity, operational readiness, Management of change – change of people, control systems, plant and process
Day 4
Human factors and safety culture, Safety management and continuous improvement, Safety leadership at all levels in the organization, Leading and lagging indicators, Learning from accidents and incidents, Legal framework
Mitigation and emergency measures, Start of multi-stage case study
Day 5
Multi-stage case study, Course summary, Individual action plans, Assessment

“Very good, excellent standards of presenters and insights.”

“Time keeping poor. Needs to be more disciplined, faster presentations.”

FUTURE DEVELOPMENT

The response to the pilot course has given the Institution confidence to plan further courses during 2009. In addition there have been enquiries for in-house courses as well as interest from overseas.

The course content has been designed to cover those elements of process safety which are common across a range of segments of the process industry. With the strong emphasis on case studies it is however very important that these are suitable for the target group and it is expected that additional case studies will be added as the course develops, for example for the offshore oil and gas sector.

One sector expected to grow significantly over the next few years is nuclear power and work is in hand to develop a version of the course specifically for the needs of this sector including the provision of suitable case studies.

As noted above engineers from a range of disciplines make important contributions to process safety and it is hoped that the Institution will be able to use its links with other institutions to promote the course. There is also

scope to improve linkage to the training currently being provided in industry.

It is confidently expected that the improved understanding provided by the course, it will assist industry in maintaining and improving Process Safety performance.

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