EFCE Working Party on Loss Prevention and Safety Promotion in the Process Industries

or in brief

WP on Loss Prevention

H.J. Pasman, chairman going, G.Suter, chairman coming

Introduction / history

When in the late sixties the development and expansion of the process industry in various West-European countries had resulted in frequent incidents with explosions, fires and dispersion of toxics, national efforts of chemical engineers were initiated to exchange knowledge and expertise. In 1971 the Institution of Chemical Engineers organised an international conference on Loss Prevention and Safe Operation of chemical plants, which generated such enthusiasm to try to improve the situation that an international working group was formed with firm backing by the Institution. This was the start of the present Working Party under the umbrella of the European Federation which started to organise a series of triennial symposia of which the last, the eleventh has taken place in Prague in June 2004. Although always improvements are to be pursued, the last few symposia have been praised for their papers of high quality and new ideas. The attendance is rather stable at 400-500, although there are shifts in affiliation and origin of the attendees. Over the years the fraction of attendees from industry decreased in favour of the number of university professors, students and consultants. The last symposium was attended by participants of more than 40 countries, with relatively large participation from Japan and Eastern European countries.

Developments in the field and state of the art

The analysis of major accidents, the so called case histories was and still is a subject that draws much interest. The often complex cause-consequence relationships in which hazardous materials get released or start to react stimulate the thinking and the unravelling of the intricate chemical and physical phenomena is sharpening the mind. Much can be learned. However it proved not so easy to keep the knowledge living, since at the time there were no data banks and few concepts and methods to condense experience into.

Already at the first international symposium in Delft, the Netherlands in 1974 the merits of “risk analysis” were put forward and a discussion group tried to create some order in the flood of new terms. The day after this symposium the vapour cloud explosion of the Nypro plant in Flixborough, U.K., which over the years became one of the most extensive investigated accidents, proved once again how urgent the study of safety issues was at the time.

The Working Party has spent in the first years quite some effort to discuss the accident statistics, since it appeared that the incident rates in the American industry were an order of magnitude lower than in Europe. Beside doubt whether the statistical basis was equal, there was the question what are we doing wrong. The issue of the comparability was more or less cleared when rates could be compared of a same company with subsidiaries in Europe and the U.S. Differences appeared to be real.

To improve safety work had to be done on many fronts. More systematic studies were initiated. The Working Party undertook study groups on Risk Analysis and Human Factor.

The hazard and risk analysis methodology was described, the terms defined and the directions for further development of methods and data collections determined. In the early eighties the Commission of the European Community started to sponsor industrial safety research. The vapour cloud explosion phenomenon and the transportation of volatile, flammable materials along water ways where at certain locations nuclear power plants were built, triggered this. Together with national funding the research developed rapidly and various national research organisations started to co-operate on gas dispersion, vapour cloud explosion and reactor run-away.
At the same time in the industry materials and components applied in the process installations improved drastically in technical sense. Leakage of pumps and flanges, rupture of pipes and tanks reduced. Built-in safety features and reserve capacity improved reliability. Also practices were established, which helped to identify possible mishaps. Known methods coming into use were the Dow Chemical company Fire & Explosion index and the Hazard and Operability analysis (HAZOP), introduced by engineers in ICI. These methods were picked up quickly by many companies and engineering contractors. Although these methods have their advantages they also have limitations in that the first can miss an important detail and the second is very labour intensive. So many new methods and extensions have been proposed since.
The public outcry and reaction to the accidents became stronger over time. In the early eighties national legislations were reinforced and on European level the Seveso directive after the reactor run-away and dioxin dispersion incident at Seveso, Italy in 1976 was issued. Notification of major hazard installations and formal reporting of accidents implemented. Licensing of operations required detailed studies.
The importance of the Human Factor and organisation to improve the safety level became acknowledged. Written work procedures and behavioural improvement steps were introduced. It took however till the next major catastrophe in Europe the Piper Alpha off shore platform disaster in 1988, that the crucial attitude of top management with respect to safety, health and environmental protection became widely recognised. Also following the developments in the United States in the years after safety management systems were introduced. This further diminished incident rates as shown in the Figures 3, 4 and 5.

In Brussels in March 1992 on an initiative of the Working Party the European Process Safety Centre (EPSC) was founded in good consultation with CEFIC and with moral and secretarial support of EFCE and IChemE. Also here the U.S. situation has been an example, where in 1985 after the Bhopal disaster and a similar near miss in West Virginia, the Senate urged the American Institute of Chemical Engineers to found the Center for Chemical Process Safety (CCPS). In both centres many guidelines and initiatives to tackle actual problems were developed, the Technical Steering Committee being the central body of expertise. EPSC became also a centre of industrial technical expertise to assist the law makers of the European Union to come with adequate regulation. This was just in time for the Seveso II Directive, the gas and dust explosion safety regulation: ATEX 100a setting requirements for safe equipment in explosive atmospheres and ATEX 118a for the protection of workers, and the Pressure Equipment Directive.

The last few years as a further measure of protection and risk reduction highly reliable controls are installed (in the 1971 symposium already mentioned as High Integrity Protective Systems). These now called Emergency Shut Down systems or Safety Instrumented Systems got much attention via a new standard IEC 61511 which is risk based and is prescribing certified Safety Integrity Levels or SILs depending on the risks involved. In connection the Layer of Protection analysis method came into use.

So, looking back the community succeeded in getting better control over the risks of the operations. Attention shifted from explaining after the fact how the accident had occurred via designing and implementing protective measures towards prevention by inherent safer features and rethinking the processes. These trends do not hold only for safety, health and environmental protection, but of course also for product quality, energy management and process operability. In the following some further aspects will be highlighted.

Fig.1: Vapour cloud explosion debris in a refinery in 1968.

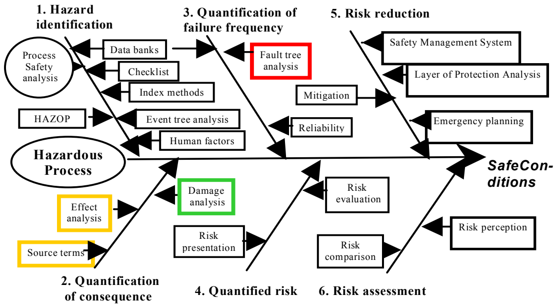

Fig.2: *Steps and tools in a risk assessment process.*

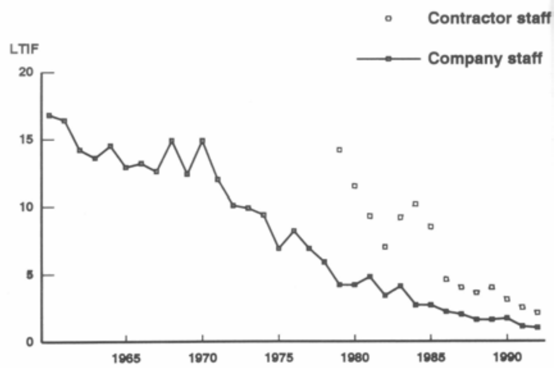

Fig.3: *Decay of Lost Time Injury Frequency (LTIF = per 10^6 hours worked); the trend is typical and further continued in the 90-ties. Just before 1980 outsourcing starts.*

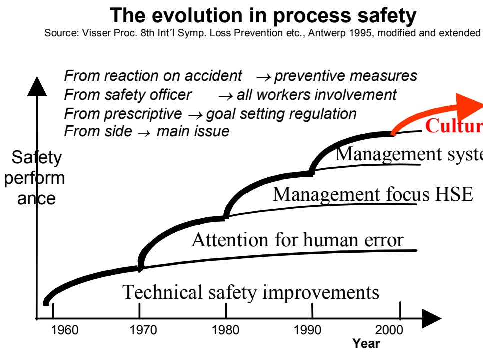

Fig.4: *Improvement in safety level and the major contributing factors (Source Fig.3 and 4: J.P.Visser, 8th Symp LP, Antwerp 1995).*

Elements of Safety Management Systems:

1. Leadership and commitment
2. Policy and strategy objectives
3. Organisational responsibilities
4. Standards and Documentation
5. Hazards investigation
6. Planning and procedures
7. Monitoring and corrective action
8. Audits and feed back
9. Management review

Fig.5: *Main elements of a safety management system. (There exists a variation in numbers and terms.) Essential is a permanent impro-vement cycle on operational, tactical and strategic level as in Quality management (ISO 9001).*

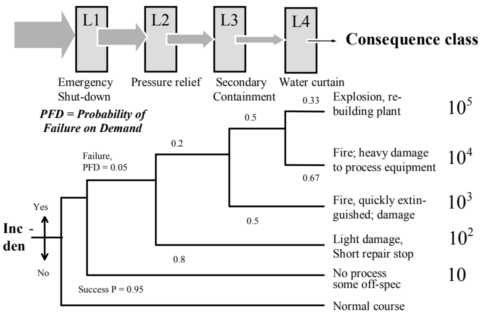

Fig.6: *A Layer of Protection effectiveness tree, with the initiating event and the subsequent independent functioning layers in case of a critical event with their probability of failure on demand and damage consequence end points in k€.*

Future needs and perspectives

When evaluating the results of the conference last June several conclusions can be drawn[1].

1. Much is shown in analytical methods, but too few methods, techniques and technology are presented to prevent and to rule out accidents. In fact the loop from experience back to design has not been closed sufficiently. The adagium to go for inherent safer design, as it has been first called for by Prof. Trevor Kletz[2], has resulted in projects but their application is lacking. A principal difficulty is that design is a creative process and one has to be aware of the potential risks introduced in the conceptual process design. Information on hazardous properties of materials and hazard mechanism should be instantaneously available in a user-friendly manner. No information system is available yet that can cope with the complexities as occurring in practice. In more general terms know-how and know-what transfer are points requiring attention.
2. Few methods help to make plant operation safer. There is improvement in methods on risk analysis and assessment. An EU sponsored project, ARAMIS, is promising in the sense that it on one hand is deepening and nuance-ing the analysis and on the other simplifies the results by producing a standardised scenario generating method and three index numbers on risk severity (consequence potential), prevention management effectiveness, and environment vulnerability. The scenario identification applies the so called bow-tie model with the fault tree on the left, event tree on the right and the critical event in the centre. Barriers in the tree branches indicate safety measures either technical or organisational. Management effectiveness appears via the failure rates of the barriers. Geographical information systems are used for mapping risk contours and vulnerable areas. These methods will be in use for Land Use Planning and are in use already in some countries to fulfil the Seveso 2 Directive requirements for licensing plant in view of public safety, but their use for making the operation safer is limited. Methods to identify systematically possible incident precursors in a running process and to analyse the installation and operation top down on risk reducing measures would help. It was also noticed that very little information has been presented on fire safety.
3. The economic side of safety is coming higher on the agenda. This relates to the changing business environment, the question of further investment in protective measures and pressures of downsizing staff, change of ownership of adjacent complexes with the possibility of domino effects etc. It will need attention in the future. It will certainly require further thinking about ethics and risk tolerability.
4. New is too the larger attention for security aspects in view of recent terrorist attacks. Most measures will be organisational.
5. In testing of hazardous properties and consequence modelling still much progress can be made. Present test methods are becoming well standardised but the interpretation of the results for predicting hazards in practical situations is still very underdeveloped. The triad of theory, test, and simulation should help. Computer simulation as e.g. computational fluid dynamics is becoming more of practical use with the steady growth of computer power. On the other hand the translation of results of these sophisticated methods into practical engineering rules should get much more emphasis. Close-in dispersion and semi-confined gas explosion modelling are high on the hit list of desirables.
6. Emergency response planning is making use of scenarios and results of risk analysis, but so far had to suffer from lack of sufficiently detailed models to be able to plan emergency operations with a high degree of reality sense and also to be able to support decision making in actual saving operations.

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[1] We include here the comments made by Director EPSC, Mr. Richard Gowland, formerly Dow Chemical Company, in the evaluation of the 11th Symposium LP.

[2] T.A.Kletz, The Origins and History of Loss Prevention, Trans IChemE, Vol 77, Part B, May 1999, 109-116.

7. Human factor, organisational aspects and culture change will require further future attention. Leadership, team building, behaviour modification and improvement of safety culture are items to discuss and to find handles to measure performance. Like more recent studies (NASA Challenger accident) already the data in Fig.3 show how outsourcing can negatively influence safety, when management has not given it additional attention and it is not well incorporated in the culture. Another aspect is that lack of implementation of inherent safety has to do too with imaginary borders in thinking processes of organisational “stove pipes” in design, operation and maintenance. As an alternative to human limitation the line of further automation and remote plant control will be followed including reliability centred maintenance and risk based inspection, given further evolution in information technology.
8. Inherent safety means too that the fundamentals of self-reactivity, thermal stability, corrosion processes, or in general molecular “aggressiveness” should be better understood. The interaction of chemistry and physics is often complex. With the thinking in multi-scales: molecular, meso-scale (nano/micro) and macro-scale progress can be made, since the tools become available to build with computer simulation from the small to the large scale. Molecular engineering can via thermodynamics and kinetic modelling and subsequently in computational fluid dynamic models result in safer, more efficient and cleaner processes.