17th International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2013, Istanbul, Turkey, 10-11 September 2013

RISK MANAGEMENT IN INDUSTRY & RELEVANT PROPERTIES OF THE HAZARDOUS SUBSTANCES

Emina S Dzindo, Jasmina V Lozanovic Sajic
Innovation Center of Faculty of Mechanical Engineering, University of Belgrade,
Kraljice Marije 16, 11120 Belgrade 35
Republic of Serbia

ABSTRACT
Risk management is the act or practice of controlling risk. This process includes identifying and tracking risk areas, developing risk mitigation plans as part of risk handling, monitoring risks and performing risk assessments to determine how risks have changed.
Keywords: Risk management, Hazard, Dangerous Toxic Load, Frequency Categories

1. PRESSURE VESSELS

Risk management provides a clear and structured approach to identifying risks. Having a clear understanding of all risks allows an organization to measure and prioritize them and take the appropriate actions to reduce losses. Risk management has other benefits for an organization, including: Saving resources: Time, assets, income, property and people are all valuable resources that can be saved if fewer claims occur; Protecting the reputation and public image of the organization; Preventing or reducing legal liability and increasing the stability of operations; Protecting people from harm; Protecting the environment; Enhancing the ability to prepare for various circumstances; Reducing liabilities. The risk judgment should come with an answer whether we are happy or not with it; however let us consider three possible practical answers and their meanings:

a) The actual risk level is not really low, and we are excited/upset at the level that we shall do something in practical terms, thus investing something into additional safety measures (being technical, organizational, or whatever) in order to possibly reduce the risks to a level as described under "a.".

b) Now we came to the complicated case where both risk level is above the set criteria and investment in risk reduction measure(s) are just too high. If the risk level is not as high as being intolerable, then if ethical issue is not of a concern and we are willing to take risks.

If the issues apply, or the risks are high and risk reduction is not possible/practical/economical, then we are facing a potential radical decision, possibly to eliminate risk source. Given that hazards arising at installations may not be self-evident, a range of techniques have been developed in order to identify such hazards. The main aim of these hazard identification techniques is that all possible hazards are identified and none are overlooked. This may be facilitated by the use of more than one method or technique.

2. RELEVANT PROPERTIES OF THE HAZARDOUS SUBSTANCES

The real question is why substances can provide damage or harm? The answer is that this is due to their dangerous properties, being of - generally speaking: explosion (violent energy release): physical, and/or chemical, fire (reaction with oxygen), toxicity (impact to the biological cell)

The related classification of the hazardous substances is usually done according to the provisions of applicable directive 67/548/EEC.

2.1. Hazard identification methods and tools

The methods require members of the review team to be knowledgeable and experienced in relation to the processes and activities. It involves breaking the site down into different areas or processes. The operations and activities within each of these areas/processes are defined and reviewed for potential major-accident hazards. Only those areas or processes considered to have the potential to generate a major-accident, i.e. areas where hazardous materials are used or stored, are reviewed. A good hazard identification methodology is systematic and ensures that all parts of the system, all steps, all activities and all materials are reviewed. The main output from the hazard identification stage is a list of potential hazards.

For the purpose of any hazard identification process the extensive, in-depth experience of personnel, particularly Process Managers, engineers, chemists and operators should be availed of. A team based approach is the most suitable method to help reduce subjectivity and to increase scope and experience.

There are many recognized techniques for hazard identification. *Checklists* consist of a series of prompts, often of a general nature, which aim to identify hazards by providing a stimulus or focus for the assessors. They are essentially a simple method of applying the experience of others to a process design or operation to ensure that the elements addressed in the checklist are not overlooked. *HAZOP* studies are primarily used to identify potential hazards and operability issues at the design or modification stage. The HAZOP process is essentially a team exercise which involves examining the design intent using guidewords and potential deviations. The teams generally consist of 6-8 people including an experienced leader and those involved in the design and operation of the process to be studied. Detailed engineering process and instrumentation drawings (P&IDs) of the process are required for the review. The design should be well advanced but still adaptable enough to allow changes which are highlighted during the review. The basic technique for carrying out a HAZOP is detailed in a Chemical Industries Association publication. *What If?* This hazard identification method involves asking a series of questions starting with What if This method is generally used at design stage and requires an experienced team to review the entire design by asking appropriate questions. These questions can be guided through the use of a checklist which supplements the experience of the team members. The answers to the questions may reveal hazards that require elimination or protection. This technique is a brainstorming approach which is best performed by a group of people who are familiar with the equipment or similar equipment. It is however, less structured and comprehensive than a HAZOP and more dependent on the experience of the review team. *FMEA* is an analytical technique which involves the examination of potential failure modes or malfunctions of a process unit. It addresses both the causes and the effect. It is generally applied to electronic, electrical or mechanical systems and equipment. The FMEA team reviews the system to identify potential failure modes for each component and the potential consequences. The starting point is usually a block diagram which shows components within the system. *Hazard indices* give a quantitative indication of the potential for a hazard to arise. They are used to most effect at the early design stage of a new plant. Indices can be used to rank various components of processes on the basis of associated hazards such as fire, explosion and toxic releases. They allow for the prioritization of hazards on the basis of consequences and the selection of potential accident scenarios for further elaboration.

3. mDANGEROUS TOXIC LOAD (DTL)

The UK Health & Safety Executive (HSE) calculates Dangerous Toxic Loads (DTL) for the purpose of giving advice regarding land use planning. The DTL, which is normally quoted in ppm (parts per million), is equivalent to a lethal dose for 1-5% (LD1-5) of the population. DTL data are currently not available for all substances. DTL data are supplied in the form of two constants, A and N. The DTL depends on the exposure time for the scenario. Assuming duration of exposure in the event of a release, i.e. the Emergency Response Plan is implemented in this time, equivalent ppm levels can be calculated for each material. An exposure time of 30 minutes is recommended by the Committee for the Prevention of Disasters. To calculate DTL for a substance the following equation is used:

$$DTL_t = \left[\frac{A}{t}\right]^{1/N} \quad (1)$$

where time, t, is in minutes. For example, for chlorine: $A=1{,}08x10^5$ N=2

Therefore, the DTL30 for chlorine is calculated as: $DTL_{30} = \left[\frac{1.08 \cdot 10^5}{30}\right]^{1/2} = 60\ ppm$

3.1. Probit approach

The conceptual problem with the use of the reference concentrations and exposure time is that all the individuals exposed are not sensitive in the same way. The extent of the damage (e.g., fatalities) upon the exposure (dose, related to both the concentration in the ambient media and exposure time) is related to response curve, usually far from linear curve/line. In order to convert the dose response curve to a straight line a probit variable (Y) is introduced and equation from General equation used to describe substances is:

$$P - \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Y-5} \exp\left(-\frac{u^2}{2}\right) \mathrm{d}u \qquad (2)$$

where Y - probit, a, b, n – constants for substance, C – concentration in ppm by volume, tc – exposure time in minutes.

$$P = 50\left[1 + \frac{Y+5}{Y-5} erf\left(\frac{|Y-5|}{\sqrt{2\pi}}\right)\right] \qquad (3)$$

Conversation from probit to probability is done by tabulated values or graphically. General equation used to describe substances is:

$$Y = a + bx \cdot \ln(C^{\mathrm{n}} \cdot t_{\mathrm{c}}) \qquad (4)$$

Constants are usually reported in the literature. This approach allows the general assessment of the consequences for any substance, concentration, exposure level in probabilistic terms.

4. FIRE AND EXPLOSION CONSEQUENCES

Explosions can arise from exothermic chemical reactions of gaseous fuel-air mixtures or from mixtures of dust of fuel droplets with air. Such mixtures are used in tehnical combustion plants, furnaces, combustion chambers and motors. In addition, there are exotermic compounds which can explode without the presence of an oxidant in the gas phase. In practice, any substance or combination of substance which can undergo (sufficiently) exothermic ractions can, under the appropiate conditions, cause an explosion. [2]

For all fire scenarios, the principal parameter of interest is thermal radiation (kW/m2). Once calculated, the thermal radiation levels can be used to determine the potential effects by reference to published sources. The distances to the following thermal radiation levels are usually determined for each scenario modelled: 37,5 kW/m2, sufficient to cause damage to process equipment, 12,5 kW/m2, minimum energy required for piloted ignition of wood, melting plastic tubing, etc, 4,5 kW/m2 sufficient to cause pain to personnel if unable to reach cover within 20 seconds, however, blistering of skin (first degree burns) is unlikely. Explosion modelling estimates the overpressure at given spatial position. The potential damage caused by the overpressure can be assessed using published data for referencing purposes such as those provided in which provides reference levels for evaluating the blast effects on humans.

The maximum overpressure observed from a completely unconfined vapor cloud explosion is typically 1 bar. However, significantly higher pressures may be observed from a confined or semi-confined vapor cloud explosion. Secondary impacts of an explosion which may injure people, such as to being knocked over/displaced, flying debris/fragments or building collapse, also need to be considered. However, these can not be accurately modeled.

5. CONCLUSION

Risk is the probability and severity of loss from exposure to the hazard. The assessment step is the application of quantitative or qualitative measures to determine the level of risk associated with a specific hazard. This process defines the probability and severity of an undesirable event that could result from the hazard.

Risk is a measure of a project's inability to achieve system life cycle objectives. It comprises two components: the probability of failing to achieve particular system life cycle objectives, and the consequences of failing to achieve those objectives.

Fire and explosion consequences reduction can be achieved in many ways, like fire prevention, fire detection, emergency shutdown, passive protection, active systems, and salvage. As every facility works in its own special environment, it is important to develop the optimum, cost effective incident consequence reduction strategy taking into account local conditions, the plant's criticality and an incident's potential effect on life safety, the environment, asset value, continued operations and company image.

6. REFERENCES

[1] Asseal, J.M.: „Fires, explosions and Toxic Gas Dispersions“, Handbook, 2009

[2] Casal, J.: “Evalution of the Effects and Consequences of Major Accidents in Industrial Plants” Vol.8, UK, 2008

[3] Hattwig, M., Henrikus S.: “Handbook of Explosion Prevention and Protection”, Germany, 2004.

[4] MHIDAS: Mayor Hazard Incident Data Service, OHS-ROM, Reference Manual, April 2001

[5] Directive 89/391/EEC

[6] Directive 1999/92/EC