The Use of a Ranking Matrix and Recommendation Prioritization System For Process Hazard Analysis Studies

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Abstract

OSHA regulations for Process Safety Management (PSM)[1] and EPA regulations addressing risk management programs (RMP) for chemical accidental release prevention[2] require industry to identify and analyze potential process hazards. This effort, known as the Process Hazard Analysis (PHA) element of the PSM and RMP standards, involves the use of qualitative hazard identification or analysis techniques acceptable to OSHA or EPA.

While making these assessments, two issues arise; how to judge acceptable risk and how to decide on appropriate risk reduction measures where necessary. Neither regulation defines a model for making risk management decisions. In the absence of formal, sanctioned risk management criteria, it is recommended that companies adopt a standard, defensible ranking scheme to provide a common basis for decision-making. This should be based on the company's defined safety goals. This paper discusses an approach, common to many companies, that qualitatively ranks the risk of identified scenarios. This paper also discusses the possible problems of using various ranking schemes and risk criteria.

I. Elements of PSM Regulations

A PSM program is comprised of various elements, or program components, each of which must be implemented and integrated with the others to manage process risk. As the underlying basis of all program elements is to manage the hazards of chemical processes, the PHA element is often referred to as the foundation of the PSM program. A sound, high quality PHA effort is imperative to making sound risk management decisions.

II. Performance-Oriented Objective

The fundamental principle followed during the development of the regulation was that it should be performance-based. No specific requirements or guidance are given on safety controls or design features. Instead, a safety management model was prescribed offering only very general guidelines. In general, OSHA only demands that industry has an appropriate and effective PSM program in place at the facilities that handle specific highly hazardous chemicals, and that the program comply with all fourteen elements of the standard. The OSHA regulation represents a very practical approach to risk management, where it is assumed that management will take prudent measures to reduce risk to an acceptable level given awareness and analysis of the hazards. "Acceptable" risk is not explicitly demanded or defined, although it is assumed that a PSM program will ensure that the likelihood of any catastrophic accident will be sufficiently low.

Sources of acceptable risk criteria exist, if only by inference or example alone. For example, these include:

- Any related local, state, or federal laws, standards or regulations
- Specific directives given by the local, state, or federal regulator
- Industry guidelines on safety, and "standard" industry practice

III. The Need for a Ranking System

While industry has always had programs to address process safety, a comprehensive PSM program represents a major change from the traditional practices of many companies. PSM requires that process risks be managed in a more formalized, systematic, and explicit manner. A major management challenge of the PSM regulations is the increased accountability for process safety within this new regulatory environment. This accountability inherently requires employers to determine and justify acceptable risk, and make more formal risk management decisions, including the decision to determine the need to make safety improvements.

One of the most significant challenges is the determination of "acceptable" risk. None of the currently enacted regulations give specific guidance or risk criteria for risk decision-making; the burden is on the employer. Once risk scenarios have been documented, employers are faced with a number of recommendations for addressing them. OSHA holds employers accountable for addressing each recommendation in a timely manner and for resolving what could be very complex and expensive risk decisions. This challenge combined with the sheer number of recommendations is often overwhelmingly difficult to manage.

A formal risk ranking and recommendation prioritization system is often used during PHA studies to offer management a way to organize team recommendations and process safety hazards. Assignment of ranking and priorities provide management with additional information from the PHA team on their perception of the importance of hazards and of the subsequent recommendations, and on the order in which the recommendations should be addressed. If used properly, a ranking captures the opinions of the team members regarding the likelihood and consequences of each recognized hazard scenario.

Ultimately, these are management decisions; the priorities identified should only be considered suggestions. Recommendations are commonly made by the team without extensive engineering study during the PHA meeting. Furthermore, the team is not always aware of all of the issues facing management, such as resource allocation under competing objectives, or future operating plans.

IV. Typical Risk Ranking/Prioritization System

In the absence of risk criteria, either approved by an appropriate agency or industry standards, employers have been using risk ranking systems. A matrix-based system with three to five levels of likelihood and severity is commonly used. Figures 1 provides an example of such a scheme.

The ranking system is an inclusive selection process; i.e., if any of the criteria on the higher level of severity or likelihood is met, then the criteria for that level is met. Most ranking systems place the highest priority on the likelihood of fatality or serious injury to workers and/or the public. Consideration of direct property damage, environmental damage, and business interruption can also be included. In addition, some company's ranking systems include quality issues such as efficiency of the process or interruption to customer supply, all issues outside the scope of PSM.

The matrix resulting from the combination of the various levels of severity and likelihood is then given a ranking which corresponds to the risk of each individual scenario. This, again, is up to the employer to define. For the matrix shown in Figure 2, five levels of risk are defined. The combinations which result in an equivalent risk are given the same risk ranking. The levels chosen for the matrix are an indicator of the employer's risk tolerance. These values can vary greatly from one company to another. Any system that is used should have a 'sensibility check', where each combination of severity and likelihood and resulting risk ranking represents a conclusion that is sensible and in line with management's philosophy.

Some employers have then set a priority system based solely on the resulting ranking. For example, they have set a priority such as shown in Figure 3.

Alternatively, other ways of ranking recommendations and setting priorities do exist. AIChE guidelines for hazard evaluation techniques list practical categories for dividing lists of safety improvements[3] and suggests additional decision-making approaches[4]. In general, the decisions are a function of:

- The severity and likelihood of the hazard or operability problem (risk ranking);
- Feasibility of making the change;
- Effectiveness of the recommendation;

- The stability of the recognized hazard; and
- Importance of the recommendation (the number and reliability of other safeguards available for managing the hazard scenario).

Other factors, which should be considered but are given less priority, are cost, ease of completion, scheduling issues, and public or worker perception of the risk or of the value of a safeguard. Management needs to weigh these factors when determining the follow-up schedule.

Priorities are also based on such factors as whether the recommendation is to provide further study, to investigate alternatives, or to install an engineered change. Further analysis should be given a higher priority, because there may still be some doubt about the hazard or there may be a need to confirm the necessity for additional safeguards. Investigating alternatives may be of high, medium, or low priority, based on the adequacy of existing safeguards.

Whatever risk ranking system is used, it has two key advantages over using PSM methodologies without them: it differentiates relative risks to facilitate decision-making and improves the consistency and basis of decisions.

V. Conclusions

It is recommended that companies adopt a standard, defensible ranking scheme to allow for a common basis for decision-making. This scheme should be based on the company's defined safety goals. Ranking systems assist in streamlining the decision-making process, and in making better decisions from a more defined basis.

Industry trade associations could provide industry with more guidelines for making risk management decisions, including such potential areas as: guidelines on credible hazards, qualitative and quantitative acceptable risk criteria, a standard risk ranking protocol for use during hazard identification, and better examples of acceptable risk management practices. Ultimately, though, this guidance may only educate risk analysts and not provide a true standard, since it is best left to industry to develop their own risk management systems.

Figure 1 - Typical Risk Ranking/Prioritization System

Example Severity Definitions		
Ranking	**Safety and Health Consequences**	**Environmental and Quality Consequences**
1 - Very high	- Fatality - Public fatalities - Extensive property damage	- Major environmental damage - Extended downtime (more than xx days) - Customer Downtime (customer dramatically impacted)
2 - High	- Lost Time Injury - Public injuries or public impact - Significant property damage	- Environmental permit violation - Downtime (x to xx days)
3 - Medium	- Minor Injury - Moderate property damage - Moderate environmental impacts	- Downtime (x to xx hours) - Off spec product
4 - Low	- No worker injuries - Minor property damage - Minor environmental impacts	- Downtime (< x hours) - Quality variation
5 - Very Low	- No worker injuries - No property damage	- No environmental impacts - Recoverable operational problem

Example Likelihood Definitions	
1 - Very high	Possible to occur frequently (1/year)
2 - High	Possible to occur occasionally (1/5 years)
3 - Medium	Possible to occur under unusual circumstances (1/15 years)
4 - Low	Possible to occur over the lifetime of the plant (1/30 years)
5 - Very Low	Could occur however not likely over plant life (1/100 years)

Figure 2 - Risk Ranking Matrix

INCREASING LIKELIHOOD ←

INCREASING SEVERITY ↑

	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	7	8
3	3	6	7	8	9
4	4	7	8	9	10
5	5	8	9	10	10

Figure 3 - Management Decision-Making Rules for PHAs

Ranking Levels	Description	Action Required
1-2	Very High	Must be mitigated with engineering and administrative controls before operation starts or is continued
3-4	High	Must be mitigated by engineering controls within xx time
5-6	Medium	Must be mitigated by administrative controls within xx time
7-8	Low	Mitigation is optional depending on cost-benefit
9-10	Very Low	No mitigation required

References Cited

1. "Process Safety Management of Highly Hazardous Chemicals," Code of Federal Regulations, Title 29 - Labor, Section 1910.119.

2. "Accidental Release Prevention Provisions," Code of Federal Regulations, Title 40 - Protection of the Environment, Part 68.

3. American Institute of Chemical Engineers, "Guidelines for Hazard Evaluation Procedures, 2nd Edition", American Institute of Chemical Engineers, New York (1992).

4. American Institute of Chemical Engineers, "Tools for Making Acute Risk Decisions," American Institute of Chemical Engineers, New York (1995).