What Is "Risk"

Risk is defined as the probability that a substance or situation will produce harm under specified conditions. Risk is a combination of two factors:

- The **probability** that an adverse event will occur;
- The **consequences** of the adverse event.

Risk encompasses impacts on public health and on the environment, and arises from exposure and hazard. Risk does not exist if exposure to a harmful substance or situation does not or will not occur. Hazard is determined by whether a particular substance or situation has the potential to cause harmful effects.

MAKING A HAZARD ANALYSIS AND RISK ASSESSMENT

For many hazards and the risks that derive from them, knowledge gained by safety practitioners through education and experience will lead to proper conclusions on how to attain an acceptable risk level without bringing teams of people together for discussion. For more complex situations, it is vital to seek the counsel of experienced personnel who are close to the work or process. Reaching group consensus is a highly desirable goal. Sometimes, for what a safety professional considers obvious, achieving consensus is still desirable so that buy-in is obtained for the actions to be taken. A general guide follows on how to make a hazard analysis and how to extend the process into a risk assessment.

Whatever the simplicity or complexity of the hazard/risk situation, and whatever analysis method is used, the following thought and action process is applicable.

A Hazard Analysis and Risk Assessment Guide

1. *Establish the Analysis Parameters.* Select a manageable task, system, process, or product to be analyzed; establish its boundaries and operating phase (standard operation, maintenance, startup); and define its interface with other tasks or systems, if appropriate. Determine the scope of the analysis in terms of what can be harmed or damaged: people (the public, employees); property; equipment: productivity; the environment.

2. *Identify the Hazards.* A frame of thinking should be adopted that gets to the bases of causal factors, which are hazards. These questions should be asked: What are the aspects of technology or activity that produce risk? What are the characteristics of things or the actions or inactions of people that present the potential for harm. Depending on the complexity of the hazardous situation, some or all of the following may apply:

- Use intuitive engineering and operational sense. This is paramount throughout.
- Examine system specifications and expectations.

- Review codes, regulations, and consensus standards.
- Interview current or intended system users or operators.
- Consult checklists.
- Review studies from other similar systems.
- Consider the potential for unwanted energy releases
- Take into account possible exposures to hazardous environments.
- Review the historical data: industry experience, incident investigation reports, OSHA and National Safety Council data, manufacturer's literature.
- Brainstorm.

3. *Consider the Failure Modes.* Define the possible failure modes that would result in the realization of the potentials of hazards. What circumstances can arise that would result in the occurrence of an undesirable event? What controls are in place that mitigate against the occurrence of such an event or exposure?

4. *Determine the Frequency and Duration of Exposure.* For each harm or damage category selected for the scope of the analysis (people, property, business interruption, etc.), estimate the frequency and duration of exposure to the hazard. This is a very important part of the exercise. For instance, in a workplace situation, ask how often a task is performed, how long the exposure period is, and how many people are exposed.

5. *Assess the Severity of Consequences.* The purpose is to determine the magnitude of harm or damage that could result. Informed speculations are made to establish the consequences of an incident or exposure: the number of injuries or illnesses and their severity, and fatalities; the value of property or equipment damaged; the time during which productivity will be lost; and the extent of environmental damage. Historical data can be of great value as a baseline. On a subjective basis, the goal is to decide on the worst credible consequences should an incident occur, not the worst conceivable consequence.

When the severity of the outcome of a hazards-related incident or exposure is determined, a hazard analysis has been completed.

6. *Determine Occurrence Probability.* Extending the hazard analysis into a risk assessment requires the one additional step of estimating the likelihood, the probability, of a hazardous event or exposure occurring. Unless empirical data are available, and that would be a rarity, the process of selecting incident or exposure probability is subjective. For the more complex hazardous situation, brainstorming with knowledgable people is necessary. To be meaningful, probability has to be related to an interval base of some sort, such as a unit of time or activity, events, units produced, or the life cycle of a facility, equipment, process, or product.

7. *Define the Risk.* Conclude with a statement that addresses the probability of a hazards-related incident or exposure occurring, the expected severity of adverse results, and a risk category (e.g., high, serious, moderate, or low). Using a risk assessment matrix for that purpose assists one in communicating on the risk level.

8. *Rank Risks in Priority Order.* A risk-ranking system should be adopted so that priorities can be established. Since the risk assessment exercise is subjective, the risk-ranking system would also be subjective. Prioritizing risks gives management the knowledge needed on the potentials risks have for harm or damage so that intelligent resource allocations can be made for their elimination or reduction.

9. *Develop Remediation Proposals.* When the results of the risk assessment indicate that risk elimination or reduction measures are to be taken, alternate proposals for the design and operational changes necessary to achieve an acceptable risk level would be recommended. In their order of effectiveness, the actions as shown in Chapter 12, "Hierarchy of Controls: The Safety Decision Hierarchy," would be the basis on which remedial proposals are made. For each proposal, the remediation cost would be determined and an estimate of its effectiveness in achieving risk reduction given. Risk elimination or reduction methods would then be selected and implemented.

10. *Follow Up on Actions Taken.* Although a hazard analysis and a risk assessment result from applying the steps in the preceding outline, good management requires that the remaining steps in "The Safety Decision Hierarchy" be taken: Measure the effectiveness of the actions taken; determine that the residual risk is acceptable or unacceptable; and start over if the risk is unacceptable. Follow-up activity would determine that the:

- Problem was resolved, only partially resolved, or not resolved.
- Actions taken did or did not create new hazards.

If new hazards are introduced, the risk is to be re-evaluated and other countermeasures proposed.

RESIDUAL RISK

Residual risk is defined as the risk remaining after preventive measures have been taken. No matter how effective the preventive actions, there will always be residual risk if an activity continues. Attaining zero risk is not possible. If the residual risk is not acceptable, the action outline set forth in the foregoing hazard analysis and risk assessment process would be applied again.

RISK ASSESSMENT MATRICES

A risk assessment matrix provides a method to categorize combinations of probability and severity, thus establishing risk levels. A matrix helps in communicating with decision makers and influencing their decisions on risks and the actions to be taken to ameliorate them. Also, risk assessment matrices can be used to compare and prioritize risks, and to effectively allocate mitigation resources.