

Table 6 shows how the severity of harm or damage categories can be related to several types of adverse consequences and levels of harm or damage.

**TABLE 6 Relating Severity Categories to Kinds and Extent of Harm or Damage**

Category: Descriptive Word	People: Employees, Public	Facilities, Product or Equipment Loss	Operations Down Time	Environmental Damage
Catastrophic	Fatality	Exceeds \$3 M	Exceeds 6 Mos	Major event, requires more than 2 years for full recovery
Critical	Disabling injury or illness	500K to \$3 M	4 Wks to 6 Mos	Significant event, requires 1 to 2 years for full recovery
Marginal	Minor injury or illness	50K to 500K	2 days to 4 wks	Recovery time is less than 1 year
Negligible	Injury requires only first aid	Less than 50K	Less than 2 days	Minor damage, easily repaired, little time for recovery

**EXAMPLES OF RISK ASSESSMENT MATRICES**

Five examples of risk assessment matrices follow. First, an adaptation is shown in Table 7 of the “Mishap risk categories and mishap acceptance levels” as in the working draft of MIL-STD-882E, the *Department of Defense Standard Practice For System Safety*. A comment in Appendix A of 882E is pertinent here: “A mishap assessment matrix allows classification by mishap severity and mishap probability and assists in managing the decision-making to achieve the necessary risk elimination or reduction to an acceptable level.”

MIL-STD-882, first issued in 1969, is the grandfather of risk assessment matrices. All of the over 30 variations of matrices I have collected include the basics that came out of 882. They include event probability categories, severity of harm or damage ranges, and risk gradings.

This Second exhibit of a risk assessment matrix—Table 8—is a composite of matrices that include numerical values for probability and severity levels that are transposed into risk gradings. It is presented here for people who prefer to deal with numbers rather than qualitative indicators.

Take care, though—arriving at the values shown in this matrix is a qualitative exercise. And that is the case for all risk scoring systems that are not based on hard probability and severity numbers, which rarely are available.

**TABLE 7 Risk Assessment Matrix**

Occurrence Probability	Severity of Consequence			
	Catastrophic	Critical	Marginal	Negligible
Frequent	High	High	Serious	Medium
Probable	High	High	Serious	Medium
Occasional	High	Serious	Medium	Low
Remote	Serious	Medium	Medium	Low
Improbable	Medium	Medium	Medium	Low

**TABLE 8 Risk Assessment Matrix: Numerical Gradings**

Severity Levels and Values	Occurrence Probabilities and Values				
	Frequent (5)	Likely (4)	Occasional (3)	Seldom (2)	Unlikely (1)
Catastrophic (5)	25	20	15	10	5
Critical (4)	20	16	12	8	4
Marginal (3)	15	12	9	6	3
Negligible (2)	10	8	6	4	2
Insignificant (1)	5	4	3	2	1

Very high risk: 15 or greater. High risk: 9–14. Moderate risk: 4–8. Low risk: under 4.

The risk-scoring system in Table 9 appears in the American National Standard, Safety Requirements for Packaging Machinery and Packaging-Related Converting Machinery ANSI/PMMI B155.1-2006. It is shown here for two reasons. It is an indication of the validity of the concepts on which the risk assessment matrices in MIL-STD-882 are based and why so many developers of matrices use 882 as a reference. Although Table 9 is almost identical to the 882 version shown in Table 7, a slight difference exists: There is one variation for a risk severity category. As was said previously, people who develop risk assessment matrices work their own risk perceptions into them. And that is great. Table 10 shows a risk assessment matrix that combines types of severity categories and uses alpha risk gradings.

**TABLE 9 Risk-Scoring System: ANSI/PMMI B155.1-2006**

Probability Level	Severity Category			
	Catastrophic	Critical	Marginal	Negligible
Frequent	High	High	Serious	Medium
Probable	High	High	Serious	Medium
Occasional	High	Serious	Medium	Low
Remote	Serious	Medium	Medium	Low
Improbable	Medium	Medium	Low	Low

**TABLE 10 Risk Assessment Matrix**

Severity Categories	Frequency (likely to occur immediately or soon after)
<b>Catastrophic:</b> death, multiple injuries, severe property or environmental damage	E
<b>Critical:</b> serious injuries, significant property or environmental damage	E
<b>Marginal:</b> may cause minor injuries, financial loss, negative publicity	H
<b>Negligible:</b> minimum threat to persons or damage to property	M

E: Extremely High Risk. H: High Risk. M: Medium Risk.

Annex E in Z10 provides information and Prioritization section. Table 1 Annex E.

This author provided input on Howe, vice chairman of the Z10 A United Auto Workers International Kendall C. Crawford Associates as a Z10 committee member. Howe so that its definitions and language Crandall combined the separate risk levels I sent him into one matrix. example given in Annex E, it is

Crawford believed that my risk places on the bottom line of the He did not disagree with the other of this? Risk assessment is more largely a matter of judgment, peo

**TABLE 10 Risk Assessment Matrix: Alpha Risk Level Indicators**

Severity Categories	Probability That Something Will Go Wrong				
	Frequent (likely to occur immediately or soon: often)	Likely (quite likely to occur in time)	Occasional (may occur in time)	Seldom (not likely to occur, but possible)	Unlikely (unlikely to occur)
<b>Catastrophic:</b> death, multiple injuries, severe property or environmental damage	E	E	H	H	M
<b>Critical:</b> serious injuries, significant property or environmental damage	E	H	H	M	L
<b>Marginal:</b> may cause minor injuries, financial loss, negative publicity	H	M	M	L	L
<b>Negligible:</b> minimum threat to persons or damage to property	M	L	L	L	L

E: Extremely High Risk. H: High Risk. M: Moderate Risk. L: Low Risk.

Annex E in Z10 provides informative data concerning the standard's Assessment and Prioritization section. Table 11 is close to the risk assessment matrix shown in Annex E.

This author provided input on Annex E to the two people who drafted it: Jim Howe, vice chairman of the Z10 Accredited Standards Committee, representing the United Auto Workers International Union; and Kendall Crawford, who operates Kendall C. Crawford Associates and represented the American Petroleum Institute as a Z10 committee member. Howe and Crawford made revisions in what I provided so that its definitions and language were compatible with those of the standard itself. Crandall combined the separate risk assessment matrix and management decision levels I sent him into one matrix. Although the exhibit in Table 11 is close to the example given in Annex E, it is not an exact duplicate.

Crawford believed that my risk level categories were one step too high in two places on the bottom line of the matrix and he changed the matrix accordingly. He did not disagree with the other risk levels I suggested. What is the significance of this? Risk assessment is more art than science. Since establishing risk levels is largely a matter of judgment, people will come to different conclusions in a given

situation. Nevertheless, the ultimate goal needs to be kept in mind: satisfaction that the residual risk which exists after risk reduction measures are implemented is acceptable.

TABLE 11 Risk Assessment Matrix in Z10

Example of a Risk Assessment Matrix				
Likelihood of OCCURRENCE or EXPOSURE For selected Unit of Time or Activity	Severity of Injury or Illness Consequence and Remedial Action			
	CATASTROPHIC Death or permanent total disability	CRITICAL Disability in excess of 3 months	MARGINAL Minor injury, lost workday accident	NEGLIGIBLE First Aid or Minor Medical Treatment
Frequent Likely to Occur Repeatedly	HIGH Operation not permissible	HIGH Operation not permissible	SERIOUS High Priority Remedial action	MEDIUM Take Remedial action at appropriate time
Probable Likely to occur several times	HIGH Operation not permissible	HIGH Operation not permissible	SERIOUS High Priority Remedial action	MEDIUM Take Remedial action at appropriate time
Occasional Likely to occur sometime	HIGH Operation not permissible	SERIOUS High Priority Remedial action	MEDIUM Take Remedial action at appropriate time	LOW Risk Acceptable: Remedial Action Discretionary
Remote Not likely to occur	SERIOUS High Priority Remedial action	MEDIUM Take Remedial action at appropriate time	MEDIUM Take Remedial action at appropriate time	LOW Risk Acceptable: Remedial Action Discretionary
Improbable Very unlikely – may assume exposure will not happen	MEDIUM Take Remedial action at appropriate time	LOW Risk Acceptable: Remedial Action Discretionary	LOW Risk Acceptable: Remedial Action Discretionary	LOW Risk Acceptable: Remedial Action Discretionary

There are no restrictions or rules with respect to the terms used to establish qualitative risk levels. But a matrix, as a minimum, should illustrate probability and severity categories and risk gradings. Tables 7–11 show a general acceptance of a group of terms for incident probability and severity, and for risk categories. However, I repeat: Safety professionals should draft matrices with which they are comfortable. Since risk assessment matrices are valuable communication tools, the terms used in them must be agreed on and the education time necessary to achieve an understanding of them must be allocated.

**ON ACCEPTABLE RISK**

In Chapter 6, “Achieving Acceptable Risk Levels: The Operational Goal,” I wrote that as every element of Z10 is applied, the outcome would be the achievement of acceptable risk levels so that the risk of harm remains at a practicable minimum. I also said that the risk assessment matrices in this chapter and the discussion of risk categories here will help in determining acceptable and tolerable risk levels.

The concept of As Low as Reasonably Practicable (ALARP) is a valuable tool in determining acceptable risk levels. It was offered: On occasion, achieving a risk level that is as low as reasonably practicable will not be acceptable. Prior to providing a workable and sound definition of acceptable risk, the probability, severity, and economic consequences of the risk must be understood.

Acceptable risk is that risk for which the probability of exposure occurring and the severity of the consequences are reasonably practicable, and tolerable.

Thus far, this chapter has dealt with the ALARP concept, and applying the ALARP concept, the risk level may be defined as follows: ALARP may be defined as follows: the risk level is further lowered by an increment in risk until the resulting decrement of risk is acceptable.

**MANAGEMENT DECISION LEVELS**

Remedial action or acceptance levels permit intelligent decision making. The risk levels shown in Table 12 served as a guide, and I agreed on the entries to be included in Z10. Table 12 provides a general craft risk assessment matrices and the management actions to be taken. The exercise of creating and recommending the management decision levels and communicating about risks and recommended actions.

TABLE 12 Management Decision Levels

Risk Category	Recommended Management Action
High	Operational Discontinuation
Serious	Remedial Action
Medium	Remedial Action
Low	Risk Acceptable

In the discussion that follows, the management actions to be taken for each risk level. The Matrix given in Table 11 serves as a guide.

- An acceptable risk level is one that is as low as reasonably practicable.

The concept of As Low as Reasonably Practicable (ALARP) was recognized as a valuable tool in determining acceptable risk levels. However, a word of caution was offered: On occasion, achieving risk levels as low as reasonably practicable will not be acceptable. Prior to presenting the following definition, I said that a workable and sound definition of acceptable risk must encompass hazards, risks, probability, severity, and economics:

Acceptable risk is that risk for which the probability of a hazards-related incident or exposure occurring and the severity of harm or damage that may result are as low as reasonably practicable, and tolerable in the situation being considered.

Thus far, this chapter has dealt with hazards, risks, probability, and severity. In applying the ALARP concept, economics is brought into the decision making. ALARP may be defined as follows: ALARP is that level of risk which can be further lowered by an increment in resource expenditure that cannot be justified by the resulting decrement of risk.

## MANAGEMENT DECISION LEVELS

Remedial action or acceptance levels must be applied to the risk categories to permit intelligent decision making on the part of management. The remedial action levels shown in Table 12 served as the basis from which Ken Crawford, Jim Howe and I agreed on the entries to be made in the example of a risk assessment matrix included in Z10. Table 12 provides a basis for review and discussion. Others who craft risk assessment matrices may have other ideas about acceptable risk levels and the management actions to be taken in a given risk situation. Going through the exercise of creating and reaching agreement on a risk assessment matrix and the management decision levels adds to a safety professional's effectiveness in communicating about risks and obtaining consideration of the remedial actions recommended.

**TABLE 12 Management Decision Levels**

Risk Category	Remedial Action or Acceptance
High	Operation not permissible.
Serious	Remedial action to have high priority.
Medium	Remedial action to be taken within appropriate time.
Low	Risk is acceptable; remedial action discretionary.

In the discussion that follows of acceptable and tolerable risk levels and the management actions to be taken to achieve them, the Example of a Risk Assessment Matrix given in Table 11 serves as the foundation. Keep in mind that:

- An acceptable risk level must be tolerable in the situation being considered.