They are to provide safety professionals with a broad base of information from which choices can be made in developing the matrix considered appropriate for their clients' needs.

The breadth of possibilities in drafting a risk assessment matrix is extensive. Matrices have been developed that display only one or a combination of several of the following injury or damage classes: employees, members of the public, facilities, equipment, product, operation downtime, and the environment.

For this primer, two-dimensional risk assessment matrices are discussed. They are displays of variations for two categories of terms: the *severity* of harm or damage that could result from a hazards-related incident or exposure, and the *probability* that the incident or exposure could occur. They also show the *risk levels* that derive from the various combinations of severity and probability.

A review of three-and four-dimensional risk assessment systems is given in Chapter 13, "Three and Four Dimensional Numerical Risk Scoring Systems".

2. **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.
3. **Identify the hazards.** A frame of thinking should be adopted that gets to the bases of causal factors, which are hazards. These questions would be asked: What are the aspects of technology or activity that produces risk? What are the characteristics of things or the actions or inactions of people that present a 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 similar systems.
   - Consider the potential for unwanted energy releases.
   - Take into account possible exposures to hazardous environments.
   - Review historical data: industry experience, incident investigation reports, OSHA and National Safety Council data, manufacturers' literature.
   - Brainstorm.

4. **Consider the failure modes.** Define the possible failure modes that would result in realization of the potentials of hazards. Ask: 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? How effective are the controls?
5. **Determine the frequency and duration of exposure.** For each harm or damage category selected for the analysis (people, property, business interruption, etc.), estimate the frequency and duration of exposure to the hazard. This is a very important part of this exercise. For example, in a workplace situation, ask: How often is a task performed, how long is the exposure period, and how many people are exposed? More judgments than one might realize will be made in this process.
6. **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 injuries or illnesses and their severity, and fatalities; the value of property or equipment damaged; the time for which productivity will be lost; and the extent of environmental damage. Historical data can be of value as a baseline but should not be treated as the primary or sole determinant. Judgment of knowledgeable and competent personnel should prevail.

   On a subjective basis, the goal is to decide on the worst credible consequences should an incident or exposure occur, not the worst conceivable consequence.

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

7. **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. As is the case when determining severity of consequences, historical data can be of value as a baseline but should not be the sole determinant. Judgment of knowledgeable and competent personnel, controls in place and their capability, and lessons learned with respect to similar systems should prevail.

   For the more complex hazardous situations, it should be considered a necessity that brainstorming sessions be held with knowledgeable people and that consensus be reached in determining occurrence probability.

   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 a product.
8. **Define the initial risk.** Conclude with a statement that addresses the probability of a hazard-related incident or exposure occurring, the expected severity of