

RISK-BASED DECISION-MAKING GUIDELINES

Volume 2

Introduction to Risk-based Decision Making

Basic Principles

Chapter 3 — Principles of Risk Management

Chapter Contents

This chapter provides an overview of basic risk management principles that play a key role in the risk-based decision-making process. Major topics addressed in this chapter include:

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Risk Goals



1.0 Risk Goals

It is hard to control risks without knowing where to aim or how closely you have come to hitting the target. Therefore, the first step in managing risk involves establishing risk management goals.

All operations in an organization present some risk. To determine whether operations are adequately controlled, management must establish some risk acceptance criteria. The criteria usually take the form of a frequency level, a consequence severity, or a combination of these two, with an understanding that the criteria should not be exceeded. A possible system failure that violates these criteria usually results in recommendations to better control the risks.

Factors Affecting Risk Acceptance

Many factors influence our acceptance of risk:

- Familiarity
- Frequency
- Control
- Media attention
- Consequence
- Suddenness of consequence
- Personal versus societal
- Benefit
- Dread

2.0 Factors Affecting Risk Acceptance

In deciding how to manage risk, one key question is whether or not a risk is acceptable. Many factors affect our perception of acceptable risk. These include the following:

Familiarity — People are more comfortable and accepting of risk when they are personally familiar with the operation. For example, is a traveler more fearful of a bus accident or a plane crash? Which has the greater risk?

Frequency — Our belief in the frequency of an accident influences our risk acceptance. If we do not believe that the accident will happen, we are more likely to accept the risk.

Control — We accept more risk when we are personally in control, because we trust ourselves. For example, are you more afraid when you drive a car too fast or when you are the passenger in a speeding car?

Media attention — We fear problems that we are aware of and that we think are important and credible. Media coverage of issues increases our awareness of a problem and our belief in its credibility.

Consequence — We are not likely to accept risk for facilities that can have accidents with severe consequences. For example, an accident at a nuclear power plant could affect a large population. Therefore, we build very few such plants and we stringently regulate their safety. The risk related to coal-fired plants may be higher, but such plants are not as stringently regulated by the government.

Suddenness of consequence — The sooner we feel the impact of an event, the less likely we are to accept the risk. Would you risk your life to save your car from a carjacker? Would you risk your life by smoking cigarettes for 40 years?

Personal versus societal — We accept risk that affects only ourselves. We apply a higher standard to protect society.

Benefit — As the benefit we receive from an operation increases, we are more accepting of the risk. For example, driving a car is more risky than traveling by plane. Because of personal benefit, people are usually more accepting of driving than flying.

Dread — We have a strong fear or dread of risks whose severity we believe we cannot control. These risks are thought to be catastrophic, fatal, hard to prevent, inequitable, threatening to future generations, and involuntary. An example is the risk of cancer. People are fearful of anything that may cause cancer because of the nature of the disease, its treatment, and, in some cases, the low probability of recovery.

Issues of Acceptable Risk

- **There is no practical definition**
- **Its perception varies among industries**
- **It is very hazard specific**
- **Even government agencies are not consistent**
- **There are contemporary comparisons that can be made**

3.0 Issues of Acceptable Risk

With so many factors influencing our ideas about risk, it is nearly impossible for us to define “acceptable risk.” Many companies and the government have tried, but everyone has a different understanding of “acceptable risk.” For example, what risk is acceptable with the carcinogens benzene in gasoline and asbestos in public buildings? Even though defining acceptable risk is difficult, we should not give up on the idea. By setting a risk standard, organizations can more easily identify high-risk operations, can more appropriately allocate resources, and can measure the effectiveness of their risk reduction efforts.

The table on the next page is a summary of implied risk acceptance criteria from different government agencies for a variety of substances. Although the numbers listed are no longer valid, they show that acceptable risk is hard to determine.

Agency Interpretations of Significant Risk

Lifetime individual risks that agencies chose to regulate

Risk*	Substance (statute)
4×10^{-1}	Arsenic (OSHA)
2×10^{-1}	Ethylene dibromide (OSHA)
1×10^{-1}	Ethylene oxide (OSHA)
6×10^{-2}	Asbestos (OSHA)
3×10^{-2}	Arsenic from primary copper smelting (CAA)
2×10^{-2}	Coke oven emissions (CAA)
1×10^{-2}	Methylenedianiline (TSCA)
1×10^{-2}	Butadiene (TSCA)
1×10^{-2}	Uranium mines (CAA)
5×10^{-3}	Benzene from coke ovens (CAA)
2×10^{-3}	Benzene from fugitive emissions (CAA)
1×10^{-3}	Radionuclides from phosphate mines (CAA)
8×10^{-4}	Arsenic from glass manufacture (CAA)
8×10^{-4}	Radionuclides from DOE installations (CAA)
2×10^{-4}	Workers in coke ovens (OSHA)
1×10^{-4}	Radionuclides from NRC licensees (CAA)

*Probability of death given maximum regulated exposure

Risk Management Categories

S — Spread out

T — Transfer

A — Accept

A — Avoid

R — Reduce

4.0 Risk Management Categories

Risk can be managed in many different ways throughout the life cycle of the system. The following list describes the major categories of risk management strategies:

Spread out — Spread the loss exposure responsibility out among different entities, across operations, or across time

Transfer — Make others accept loss exposure responsibility

Accept — Live with the current loss exposure level or responsibility

Avoid — Cancel or delay the activity that involves the risk, or do not operate equipment that involves the risk

Reduce — Do something to reduce the accident potential

Category	Description	Example for a Possible Fishing Derby
S	Spread out	Ask local authorities to get involved in planning
T	Transfer	Make the applicants arrange safety patrols, emergency response
A	Accept	Do nothing
A	Avoid	Don't allow the derby
R	Reduce	Make the participants pass Coast Guard Auxiliary Boating Skills and Seamanship course

Accident Prevention Options

- Eliminate hazards
- Prevent initiating events (incidents)
- Add safeguards
- Make safeguards more reliable
- Reduce consequences
- Reduce effects

5.0 Accident Prevention Options

Accidents can be well controlled at any point in the chain of events producing the accident. The goal is to get the most for your money by doing the things that are most effective. The following sections describe each of the risk management options.

Eliminate hazards. Make processes inherently safer by eliminating hazards.

Examples:

- Eliminate energy sources:
 - pressure
 - heat
 - potential energy
 - kinetic energy, etc.
- Don't use hazardous materials and materials that can generate hazardous energy

Prevent initiating events (incidents). Reduce the likelihood of initiating events.

Examples:

- Eliminate error-likely situations that set people up for failure
- Perform inspections, tests, and preventive maintenance when needed
- Improve design ratings and factors of safety

Add safeguards. Provide multiple layers of safeguards, sometimes called layers of protection, in critical applications.

Examples:

- Add additional instrumentation, equipment, or safety interlocks, especially items with different design and operation
- Make the operators perform more surveillance and checks during operations

Make safeguards more reliable. Reduce the chance of safeguard failures.

Examples:

- Eliminate error-likely situations that set people up for failure
- Perform additional or more frequent inspections, tests, and preventive maintenance
- Improve design ratings and factors of safety
- Make sure that enough people are assigned to operations and maintenance departments

Reduce consequences. Make processes inherently safer by reducing the severity of consequences.

Examples:

- Reduce energy stored or generated as:
 - pressure
 - heat
 - potential energy
 - kinetic energy, etc.
- Keep only small inventories of hazardous materials and materials that can generate hazardous energy
- Use other, less hazardous, materials in place of more hazardous materials
- Provide shutdown and response systems to limit consequences. These include alarms and quick-shutoff valves.

Reduce effects. Protect people and other valuables from consequences.

Examples:

- Provide emergency response training
- Provide personal protective equipment
- Move people away from the danger zones
- Train the employees and community to find shelter in a safe place

Guidelines for choosing risk management options

We can measure how well our actions are working, or will work, to reduce risk. Three general measures of risk management success are shown in the table below.

Criterion	Description
Efficacy	How much of the risk will be eliminated or minimized by the proposed action?
Feasibility	Is the proposed action acceptable (legally, physically, politically, socially, technically, etc.)?
Efficiency	Is the proposed action cost-effective? In other words, is the cost of implementing the action low compared to the loss that could occur if no action were taken?

An effective risk management activity must strike a good balance among the three criteria in the above table.

