

Risk Assessment & Management

Objectives of this Section

- Introduce the concept of risk assessment and risk management and its role.
- To define the principle components of risk management.
- To outline advanced risk assessment methodologies for use in QRA's.
- To outline a practical risk assessment process.

Principals of Risk Management

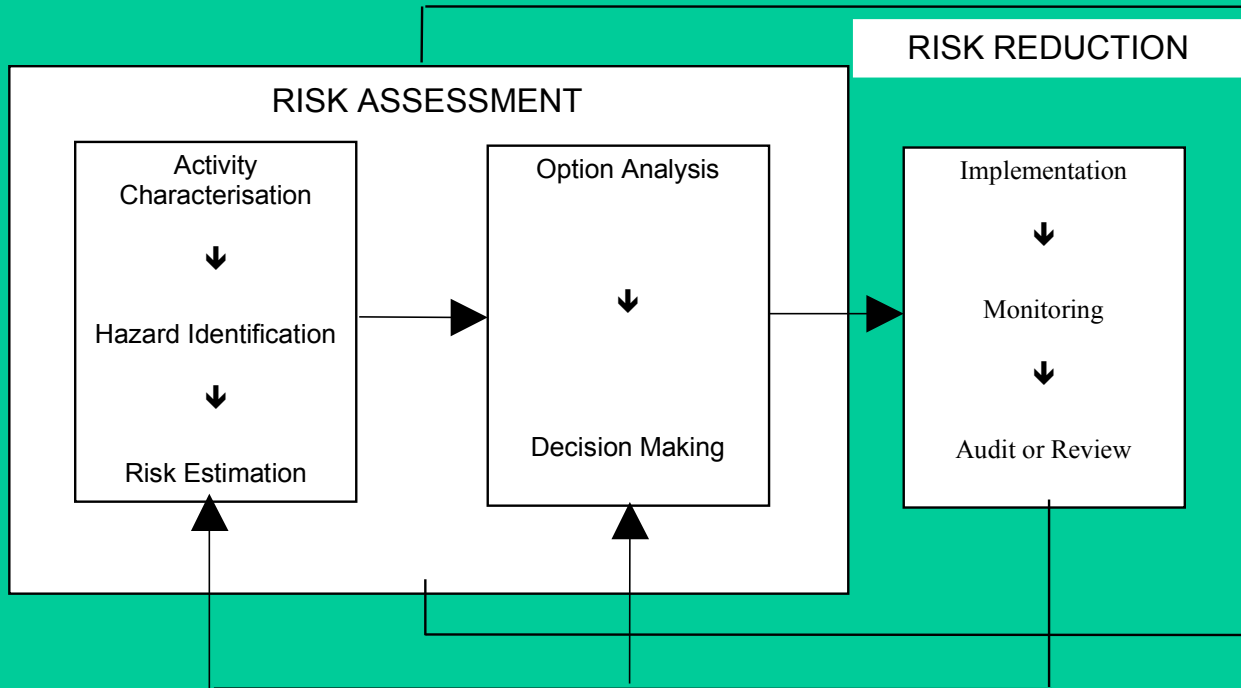
Risk management can be defined as:

The eradication or minimisation of the adverse affects of risks to which an organisation is exposed.

Stages in Risk Management

- Identifying the hazards.
- Evaluating the associated risks.
- Controlling the risks.

RISK MANAGEMENT



'Management Responsibility

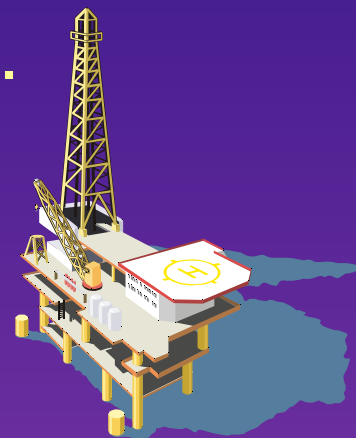
- *'Every Employer shall make a suitable and efficient assessment of:-*
 - a) *The risks to the health and safety of his employees to which they are exposed whilst they are at work.*
 - b) *The risks to the health and safety of persons not in his employment arising out of or in connection with the conduct by him or his undertaking;*
- *For the purpose of identifying the measures he needs to take to comply with the requirements and prohibitions imposed on him by or under the relevant statutory provisions.'*

Risk assessment can be a
*‘very straightforward process based on
judgement requiring no specialist skills or
complicated techniques.’*

This approach is commonly known as
qualitative or subjective risk assessment.

Major Hazards

- Major hazards associated with complex chemical or nuclear plants, may '*warrant the need of such techniques as Quantitative Risk Assessment*'.
- In Quantitative Risk Assessment (**QRA**) a numerical estimate is made of the probability that a defined harm will result from the occurrence of a particular event.



The Risk Management Process

Hazard Identification

Hazard :

The potential to cause harm. Harm including ill health and injury, damage to property, plant, products or the environment, production losses or increased liabilities.

Hazard Identification

- **Comparative Methods**. e.g. checklists and audits.
- **Fundamental Methods**: e.g. Deviation Analysis, Hazard and Operability Studies, Energy Analysis, Failure Modes & Effects Analysis.
- **Failure Logic**: e.g. Fault Trees, Event Trees & Cause- Consequence diagrams

Assessing the Risks

Risk:

The likelihood that a specified undesired event will occur due to the realisation of a hazard by, or during work activities or by the products and services created by work activities.

Assessing the Risks

Quantitative risk assessment

- Commonly used in the high technology industries
- QRA tends to deal with the avoidance of low probability events with serious consequences to the plant and the surrounding environment.

Assessing the Risks

Subjective risk assessment

- Qualitative risk assessment involves making a formal judgement on the consequence and probability using:

$$*Risk = Severity \times Likelihood*$$

Assessing the Risks

Example:

The likely effect of a hazard may for example be rated:

1. Major

Death or major injury or illness causing long term disability

2. Serious

Injuries or illness causing short-term disability

3. Slight

All other injuries or illnesses

Assessing the Risks

The likelihood of harm may be rated

1. High

Where it is certain that harm will occur

2. Medium

Where harm will often occur

3. Low

Where harm will seldom occur

Assessing the Risks

$$\begin{array}{c} \text{Risk} \\ = \\ \text{Severity of Harm} \\ \times \\ \text{Likelihood of occurrence} \end{array}$$

- This simple computation gives a risk value of between 1 and 9 enabling a rough and ready comparison of risks.
- In this case the lower the number, the greater the risk, and so prioritises the hazards so that control action can be targeted at higher risks.

Controlling Risk

- **Risk Avoidance** — This strategy involves a conscious decision on the part of the organisation to avoid completely a particular risk by discontinuing the operation producing the risk e.g. the replacing a hazardous chemical by one with less or no risk potential.
- **Risk Retention** — The risk is retained in the organisation where any consequent loss is financed by the company. There are two aspects to consider here, risk retention with knowledge and risk retention without knowledge.

Controlling Risk

- **Risk Transfer** — This refers to the legal assignment of the costs of certain potential losses from one party to another. The most common way is by insurance.
- **Risk Reduction** — Here the risks are systematically reduced through control measures, according to the hierarchy of risk control described in earlier sections.

ALARP

- Legislation requires employers to reduce risks to a level that is as low as is reasonably practicable (sometimes abbreviated as ALARP).
- To carry out a duty *so far as is reasonably practicable* means that the degree of risk in a particular activity or environment can be balanced against the time, trouble, cost and physical difficulty of taking measures to avoid the risk.

Advanced Risk Assessment Techniques

Quantitative Risk Assessment

- QRA is most commonly used in the process industries to quantify the risks of 'major hazards'.
- QRA used in the offshore oil and gas industries, the transport of hazardous materials, the protection of the environment, mass transportation (rail) and the nuclear industry.

Quantitative Risk Assessment (1)

- **Individual Risk** is defined as 'the frequency at which an individual may be expected to sustain a given level of harm from the realisation of specific hazards'.
- **Societal Risk**

Failure Modes and Effect Analysis

The system is divided into sub systems that can be handled effectively.

It involves:

- Identification of the component and parent system.
- Failure mode and cause of failure.
- Effect of the failure on the subsystem or system.
- Method of detection and diagnostic aids available.

Failure Modes and Effect Analysis

A typical format:

Component	Function	Failure Mode	Failure Rate	Failure Effect	Criticality	Detection Method	Preventative Measures
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Failure Modes and Effect Analysis

- For each component's functions, every conceivable mode of failure is identified and recorded.
- It is also common to rate the failure rate for each failure mode identified.
- The potential consequences for each failure must be identified along with its effects on other equipment, components within the rest of the system.
- It is then necessary to record preventative measures that are in place or may be introduced to correct the failure, reduce its failure rate or provide some adequate form of detection.

Hazard & Operability Studies

- Hazard and Operability Studies (HAZOP) have been used for many years as a formal means for the review of chemical process designs.
- A HAZOP study is a systematic search for hazards which are defined as deviations within these parameters that may have dangerous consequences.
- In the process industry, these deviations concern process parameters such as flow, temperature, pressure etc.



Hazard & Operability Studies



- HAZOP is a team approach, involving a team of people representing all different functions in a plant.
- They identify all the deviations by 'brain-storming' to a set of guide words which are applied to all parts of the system.

Hazard & Operability Studies

The process is as follows:

- The system is divided into suitable parts or sub-systems, which are then analysed one at a time.
- For each sub-system each parameter (flow, temperature, pressure, volume, viscosity etc.) that has an influence on it, is noted.
- Guidewords are applied to each parameter in each subsystem. The intention is to prompt creative discussion of deviations and possible consequences
- For each significant deviation, possible causes are identified.

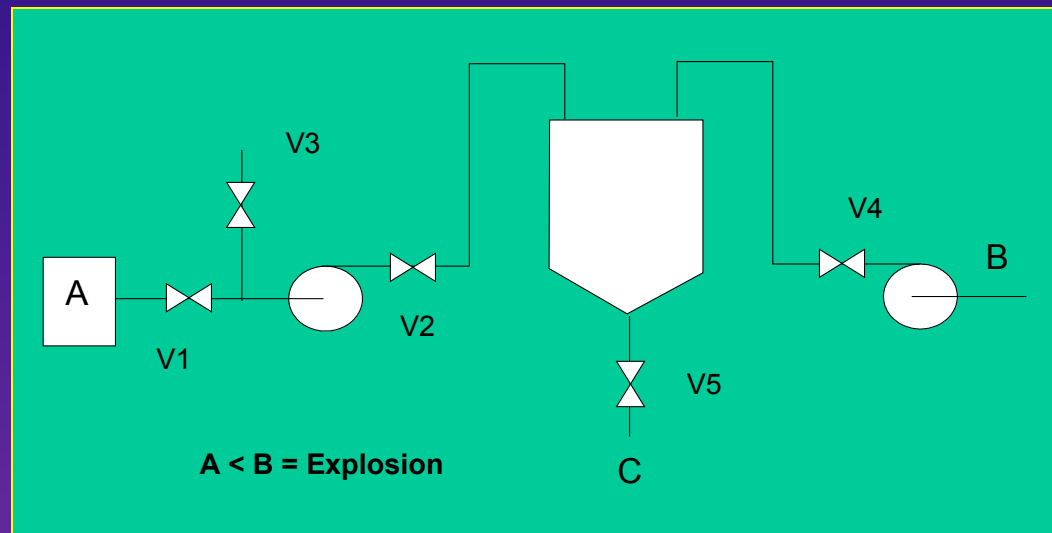
Hazard & Operability Studies

Guideword	Definitions
NO or NOT	No part of the design intent occurs, such as no flow in a pipeline due to blockage.
MORE or LESS	A quantitative increase or decrease of some parameter, such as flow, temperature etc.
AS WELL AS	All the design intentions are fulfilled and something happens in addition
PART OF	Only part of the design intention is fulfilled
REVERSE	The logical opposite of the design intention occurs
OTHER THAN	Something completely different than intended occurs

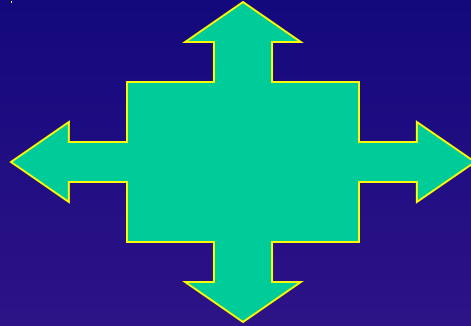
Hazard & Operability Studies

Example

- Consider the simple process diagram below. It represents a plant where substances A and B react with each other to form a new substance C. If there is more B than A there may be an explosion.



Fault Tree Analysis








- A fault tree is a diagram that displays the logical interrelationship between the basic causes of the hazard.
- Fault tree analysis can be simple or complex depending on the system in question. Complex analysis involves the use of Boolean algebra to represent various failure states.

Fault Tree Analysis

- The first stage is to select the hazard or top event that is to be analysed.
- The tree is structured so that the hazard appears at the top. It is then necessary to work downwards, firstly by identifying causes that directly contribute to this hazard.
- When all the causes and sub-causes have been identified, the next stage is to construct the fault tree.

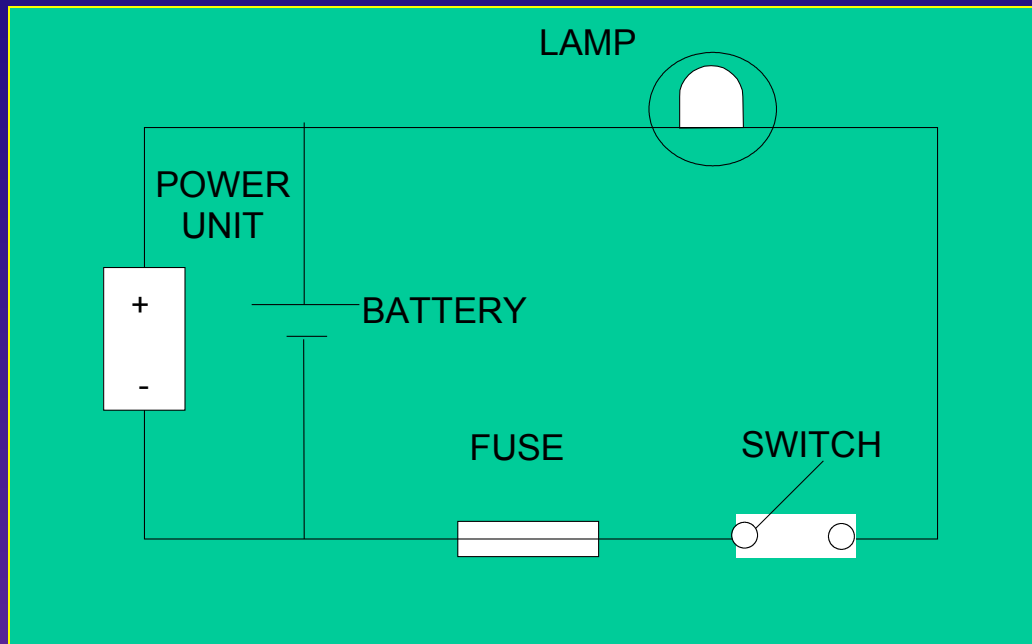
Fault Tree Analysis

Symbol	Designation	Function
	EVENT / CAUSE	Causes or events that can be developed further
	BASIC EVENT/CAUSE	Basic or Root Causes or events that cannot be developed further
	UNDEVELOPED EVENT/CAUSE	Causes are not developed due to lack of information or significance.
	AND gate	Output event occurs only if all input events occur
	OR gate	Output event occurs if any one of the input events occurs

Fault Tree Analysis

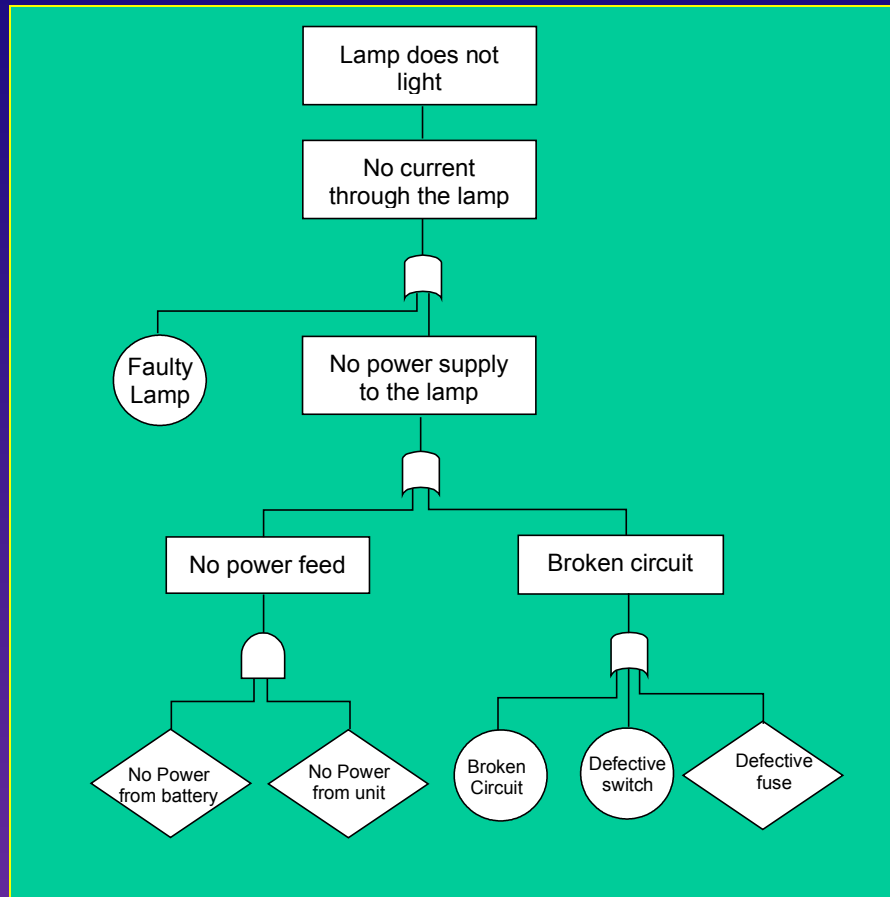
Example

- Consider the simple circuit diagram shown below:

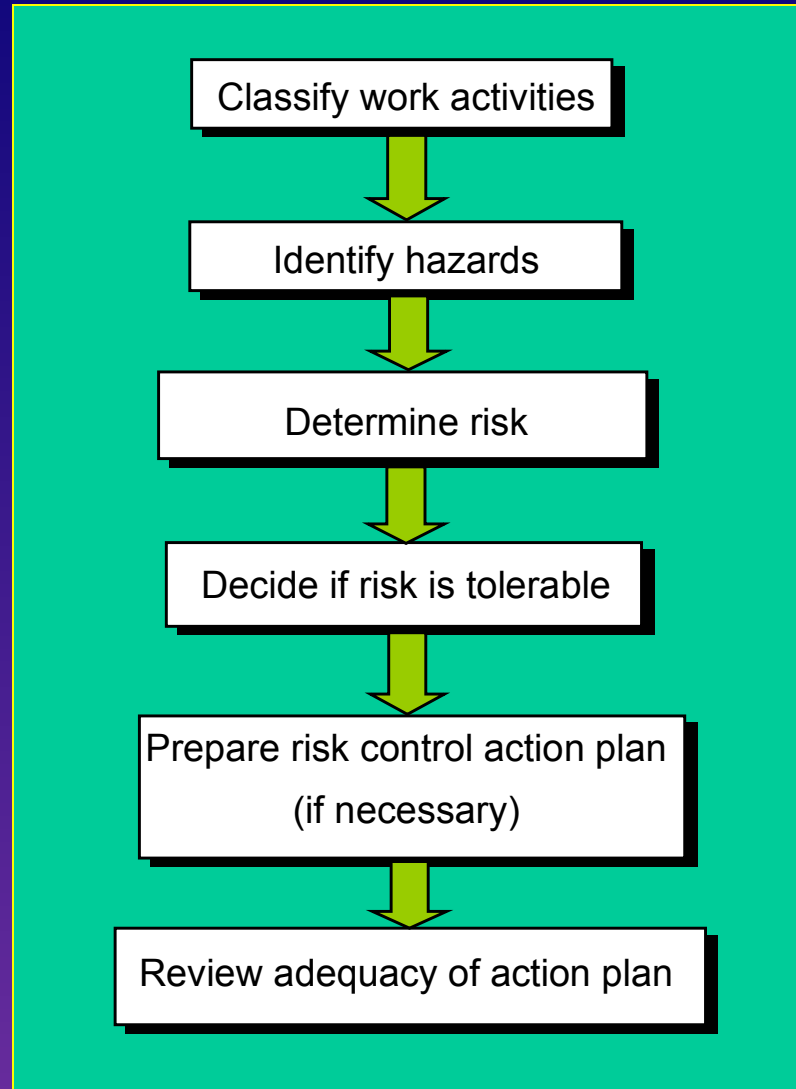


Fault Tree Analysis

- The corresponding fault tree for the above circuit, with the top event (or hazard) being the lamp not working is as follows:



Practical Risk Assessment



Classify Work Activities

Possible ways of classifying work activities include:

- Geographical areas within/outside the organisation's premises.
- Stages in the production process, or in the provision of a service.
- Planned and reactive work.
- Defined tasks (e.g. driving).

Identify Hazards

Broad categories of hazard

To help with the process of identifying hazards it is useful to categorise hazards in different ways, for example by topic, e.g.:

- Mechanical.
- Electrical.
- Radiation.
- Substances.
- Fire and explosion.

Hazards prompt-list

During work activities could the following hazards exist?

- *Slips/falls on the level.*
- *Falls of persons form heights.*
- *Falls of tools, materials, etc., from heights.*
- *Inadequate headroom.*
- *Hazards associated with manual lifting/handling of tools, materials, etc..*
- *Hazards from plant and machinery associated with assembly, commissioning, operation, maintenance, modification, repair and dismantling.*

Hazards prompt-list

- *Vehicle hazards, covering both site transport, and travel by road.*
- *Fire and explosion.*
- *Violence to staff.*
- *Substances that may be inhaled.*
- *Substances or agents that may damage the eye.*
- *Substances that may cause harm by coming into contact with, or being absorbed through, the skin.*
- *Substances that may cause harm by being ingested (i.e., entering the body via the mouth).*
- *Harmful energies (e.g., electricity, radiation, noise, vibration).*

Hazards prompt-list

- *Work-related upper limb disorders resulting from frequently repeated tasks.*
- *Inadequate thermal environment, e.g. too hot.*
- *Lighting levels.*
- *Slippery, uneven ground/surfaces.*
- *Inadequate guard rails or hand rails on stairs.*
- *Contractors' activities.*

Determine risk

The risk from the hazard should be determined by estimating the potential severity of harm and the likelihood that harm will occur.

Severity of harm

Information obtained about work activities is a vital input to risk assessment. When seeking to establish potential severity of harm, the following should also be considered:

- Part(s) of the body likely to be affected;
- Nature of the harm, ranging from slightly to extremely harmful:
 - 1) Slightly harmful, e.g.:
 - Superficial injuries; minor cuts and bruises; eye irritation from dust.
 - Nuisance and irritation (e.g. headaches); ill-health leading to temporary discomfort.

Severity of harm

- 2) Harmful, e.g.
 - Lacerations; burns; concussion; serious sprains; minor fractures.
 - Deafness; dermatitis; asthma; work related upper limb disorders; ill-health leading to permanent minor disability.
- 3) Extremely harmful, e.g.
 - Amputations; major fractures; poisonings; multiple injuries; fatal injuries.
 - Occupational cancer; other severely life shortening diseases; acute fatal diseases.

Likelihood of harm

When seeking to establish likelihood of harm the adequacy of control measures already implemented and complied with needs to be considered.

Issues considered:

- Number of personnel exposed.
- Frequency and duration of exposure to the hazard.
- Failure of services e.g. electricity and water.
- Failure of plant and machinery components and safety devices.
- Exposure to the elements.

Likelihood of harm

- Protection afforded by personal protective equipment and usage rate of personal protective equipment;
- Unsafe acts (unintended errors or intentional violations of procedures) by persons, for example, who:
 - 1) May not know what the hazards are.
 - 2) May not have the knowledge, physical capacity, or skills to do the work.
 - 3) Underestimate risks to which they are exposed.
 - 4) Underestimate the practicality and utility of safe working methods.

Decide if risk is tolerable

One simple method for estimating risk levels and for deciding whether risks are tolerable. Risks are classified according to their estimated likelihood and potential severity of harm.

	Slightly harmful	Harmful	Extremely harmful
Highly unlikely	TRIVIAL RISK	TOLERABLE RISK	MODERATE RISK
Unlikely	TOLERABLE RISK	MODERATE RISK	SUBSTANTIAL RISK
Likely	MODERATE RISK	SUBSTANTIAL RISK	INTOLERABLE RISK

Prepare risk control action plan

Risk categories shown form the basis for deciding whether improved controls are required and the timescale for action.

The outcome of a risk assessment should be an inventory of actions, in priority order, to devise, maintain or improve controls.

A simple risk-based control plan.

RISK LEVEL	ACTION AND TIMESCALE
TRIVIAL	No action is required and no documentary records need to be kept.
TOLERABLE	No additional controls are required. Consideration may be given to a more cost-effective solution or improvement that imposes no additional cost burden. Monitoring is required to ensure that the controls are maintained.
MODERATE	<p>Efforts should be made to reduce the risk, but the costs of prevention should be carefully measured and limited. Risk reduction measures should be implemented within a defined time period.</p> <p>Where the moderate risk is associated with extremely harmful consequences, further assessment may be necessary to establish more precisely the likelihood of harm as a basis for determining the need for improved control measures.</p>
SUBSTANTIAL	<p>Work should not be started until the risk has been reduced. Considerable resources may have to be allocated to reduce the risk.</p> <p>Where the risk involves work in progress, urgent action should be taken.</p>
INTOLERABLE	Work should not be started or continued until the risk has been reduced. If it is not possible to reduce risk even with unlimited resources, work has to remain prohibited.

Prepare risk control action plan

The action plan should be reviewed before implementation, typically by asking:

- Will the revised controls lead to tolerable risk levels?
- Are new hazards created?
- Has the most cost-effective solution been chosen?
- What do people affected think about the need for, and practicality of, the revised preventive measures?
- Will the revised controls be used in practice, and not ignored in the face of, for example, pressures to get the job done?

Changing Conditions and Revising

Risk assessment should be seen as a continuing process. Thus, the adequacy of control measures should be subject to continual review and revised if necessary.

Thanks

“The first step in the risk management process is to acknowledge the reality of risk. Denial is a common tactic that substitutes deliberate ignorance for thoughtful planning.”