Risk Management Program

(RMP)

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Rev.2

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1. INTRODUCTION

Murphy, in one of his "laws", declares that *"if something can go wrong, it will. What's more, it will go wrong in the worst possible way, at the worst possible time and in a way that causes the greatest possible damage."*

This statement becomes particularly important when dealing with activities involving dangerous materials (explosive, flammable, nuclear, infectious, carcinogenic, etc.) or adverse working conditions (confined spaces, high/low temperatures, high/low pressures, high noise, presence of ionizing radiation, etc.).

Since all events – natural or not – have the chance of occurring differently than we expect, it is extremely important to be prepared to take the necessary precautions to avoid the occurrence of such an unwanted event or take the necessary actions to minimize its consequences, after it has occurred.

2. THE RISK

The word "RISK" and the word "HAZARD" are often used interchangeably, although they are distinct terms.

> ***HAZARD*** *is a condition inherent to the agent that has the potential to cause damage to people, the environment or property.*
>
> ***RISK*** *involves the probability that exposure to a particular hazard will cause a negative consequence. Thus, if there is no exposure to danger, there is no risk.*

Many countries demand that the companies in general have a risk management program for their activities. For example, in Brazil, the Regulatory Standard NR-01 establishes that companies must manage their risks through a Risk Management Plan – RMP, which involves, among other measures, the identification of all hazards and risks involved in operational processes and the implementation of preventive measures to eliminate or reduce the identified operational risks.

It is expected that after a thorough work of identifying all hazards and risks, the companies will have a long list of unwanted events – then, a second step of the RMP preparation process comes into play, which is the quantification of the identified risks, so that mitigating actions can be prioritized. Another important part of the RMP are the actions to be taken in the event of an accident.

The RMP **does not prevent accidents**, but it shows that the company is aware of its risks and that they are at acceptable levels.

3. CAUTION WITH "NOVELTIES"

In the Risk Management area there is a huge diversity of literature and established techniques related to risk analysis that can be used as tools to assist senior management in fulfilling their responsibilities in relation to the security of their facilities.

However, with frequency, such already established techniques are revised and relaunched in the market under a different name – as if they were new – whereas in reality they are already known traditional techniques, disguised with a new fancy name.

Therefore, it is recommended to be very cautious when acquiring "new products" related to industrial safety analysis, since the tools already available today are more than sufficient to prepare an excellent MRP.

Among the countless analysis techniques available, there are those that can be used in the design of a project/installation to identify and quantify its potential risks, to those that can be used to analyse unwanted events occurring in installations already in operation.

The next items presented in this document bring each stage of preparing a MRP and show some of the tools available on the market that can be used in each of these stages.

4. PREPARING THE RMP

Based on experiences (positive and negative) collected over many years by renowned companies in the industrial market, it is recommended that the MRP be prepared according to the following steps:

a. Identification of unwanted events

b. Categorization / Quantification of the events

c. Analysis of existing safeguards

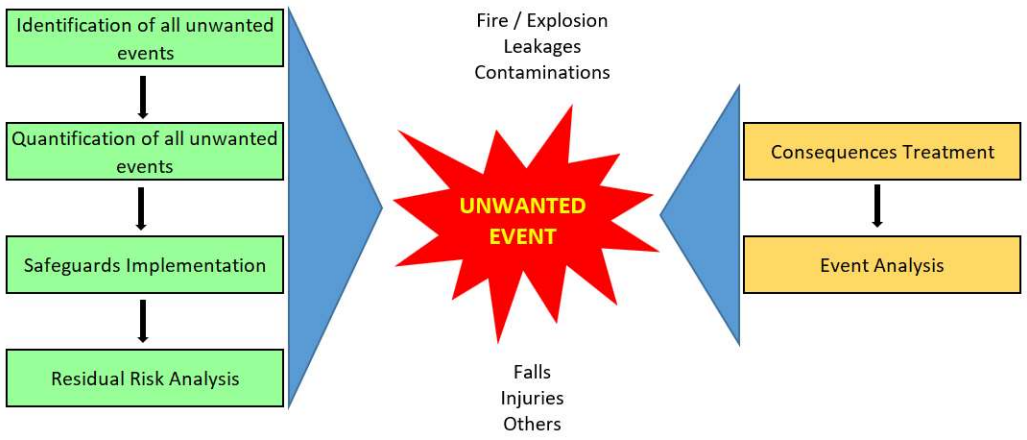
d. Analysis of residual risks

e. Mitigation of the consequences of an event that occurred

f. Analysis of the event that occurred, followed by a very detailed report

For each of the above steps, there are a series of techniques and tools that can be used to help understand each event and generate recommendations to increase the safety of the industrial installation as a whole. These techniques/tools are not mutually exclusive, i.e., they can/should be used together to provide the best result in terms of operational security analysis.

Visually, the RMP can be represented as in the figure shown below. This type of graphical representation, where a certain unwanted event is defined and its causes and preventive controls are presented on the left side and its consequences and mitigating controls on the right side goes by various names, including “Bowtie”, “Line of Fire”, Reason Model”, “Cause & Effect” and “Swiss Cheese Model”.



4.1 – IDENTIFICATION OF UNWANTED EVENTS

In order for a company to manage its risks and avoid unwanted events, it is necessary to know/identify these risks and events.

It is important at this stage to involve people who understand the process from an operational point of view, the dangerousness of the materials involved in relation to their handling, storage and transport, the machinery involved, etc. At this stage, a series of techniques and tools can be used for this purpose, among which the following stand out:

- Brainstorming
- CHAZOP (Control Hazard & Operability Study)
- FERA (Fire & Explosion Risk Assessment)
- FISH (Fire, Impact, Static & Heat)
- FTA (Fault Tree Analysis)
- Hazard Study 1
- HAZID (Hazard Identification)
- HAZOP (Hazard & Operability Study)
- HIRAC (Hazard Identification & Risk Assessment Control)
- HRA (High Risk Analysis)

4.2 – RISK QUANTIFICATION

Once the risks and unwanted events have been identified, it is necessary to evaluate the importance of each identified item so that an order of priority can be given in the treatment of these items, as it is impossible to treat all of them at once. Once quantified, work begins on the most relevant items.

This categorization and quantification of unwanted events can be done through several tools, among which the following stand out:

- DFEMEA (Design Failure Mode & Effect Analysis)
- FMEA (Failure Mode & Effect Analysis)
- FMECA (Failure Mode, Effects & Criticality Analysis)
- FMEDA (Failure Mode, Effects & Diagnostic Analysis)
- GUT Matrix
- Hazard Study 2
- HRN (Hazard Rate Number)
- Monte Carlo Analysis
- PFEMEA (Process Failure Mode & Effect Analysis)
- QRA (Quantitative Risk Assessment)
- Risk Matrix

Many of these tools enable a quantitative assessment of the consequences of a given event in terms of number of fatalities, environmental impacts, financial impacts, impacts on the company's image, damage to company facilities, etc.

4.3 – SAFEGUARDS EVALUATION

Once the companies have the list of priority risks and events to be analysed, they proceed to verify the existing conditions and safeguards that can eliminate or reduce these risks/events.

Each of the existing safeguards or those to be implemented must be evaluated and the impact of each of these safeguards on reducing the risk being analysed must be quantified.

Among the various items that can be considered safeguards and that can be analysed from the point of view of reducing the risk under analysis, the following stand out:

- ALARP Analysis
- Area Classification
- BOS (Basis of Safety)
- Emergency Drills Frequency
- Hazard Study 4 & 5
- Instrumentation level available
- Job Cycle Checks
- LOPA (Layers of Protection)
- Maintenance program (equipment & instrument)
- Operational Check-lists
- Permit To Work
- Quality of all Operational Procedures
- Safety Audit Frequency
- Site Security Plan
- Tool Box Talking Frequency
- Working environment conditions
- Work force training level

4.4 – RESIDUAL RISK ANALYSIS

This is one the most important items on the Risk Management Program.

Since there is no process that is 100% free of some kind of hazard and risk, we must accept that even after all control measures are taken to reduce the risks of a determined operation, some residual risk will always remain.

One could consider that the elimination of the risk it is just a matter of the amount of investment directed to safety. Although there is a direct correlation between safety and investment, we must consider that a massive and/or disproportional investment in safety can disrupt the competitiveness of the company in the market.

Therefore, at the end of the safeguard evaluation stage, a point must be reached where the residual risks are considered acceptable, in accordance with the criteria defined by the company's senior management or by legal requirements.

IMPORTANT: Few risks remain immutable over time and therefore all the identified risks must be constantly monitored and reevaluated to ensure that the existing or implemented safeguards remain adequate and effective and the residual risks remain acceptable.

The items discussed so far refer to the situations BEFORE the occurrence of an unwanted event. Experience shows that no matter how complete the safeguards measures are, there is always the possibility of an unwanted event (accident) happening and, as a rule, involving the simultaneous failure of more than one individual safeguard.

4.5 – DEALING WITH THE CONSEQUENCES

This step deals with the actions that must be taken AFTER an unwanted event has occurred.

The identification of the consequences of an unwanted event is done in the risk categorization and quantification stage. For each predicted consequence, there must be an appropriate action to minimize the effects of the undesired event. Topics that can help mitigate the consequences of an unwanted event include:

o Analysis of safety distances

o Availability of appropriate firefighting equipment

o Crisis Management Plan

o Emergency Plan (covering the most likely scenarios)

o Presence of a well-trained Fire Brigade

o Workforce training

A well-designed Emergency Plan typically contains items related to:

o Activation of external support (firefighters, ambulance, etc.)

o Definition of escape routes

o Definition of responsibilities during the emergency

o Definition of alarm types

o Description of the mitigating actions for each identified event

o How to deal with the press and external bodies

4.6 – EVENT ANALYSIS & REPORT

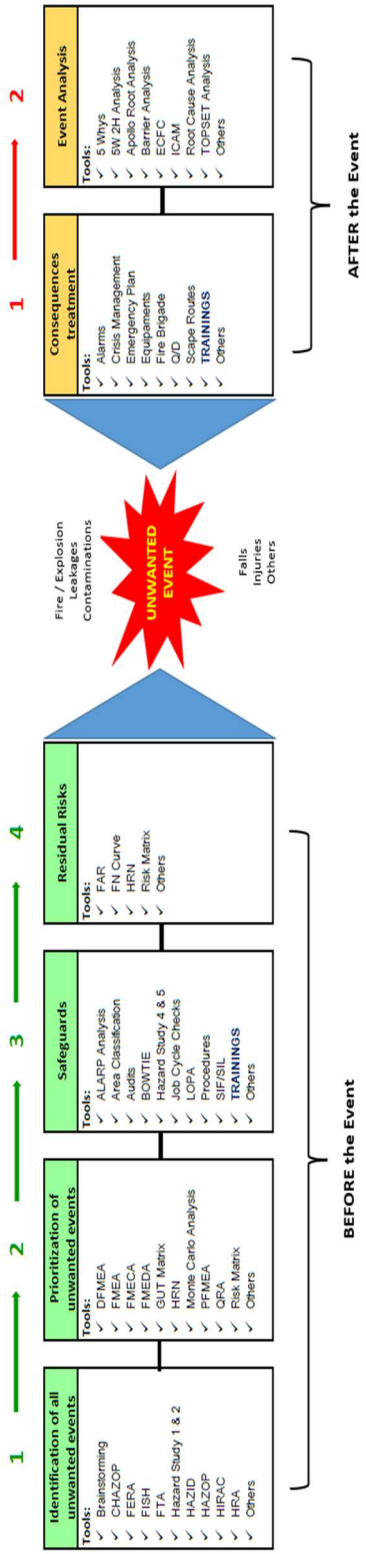
Once the emergency or unwanted event has ceased, it is necessary to bring together a team of experts to prepare an investigation report into the incident or even to prepare the relevant documentation for external bodies that may be involved in the event.

It is necessary to prepare a detailed description of what happened, highlighting all the points where there was any failure of existing protection measures (personnel, instrumentation, equipment, procedures, etc.) to allow the elaboration of recommendations to be implemented to avoid re-occurrence of the event.

Among the more than 20 tools that can be used to investigate an event/accident, we can highlight:

- 5 “Whys”
- 5W 2H Analysis
- Apollo Root Analysis
- Barrier Analysis (Safeguards Analysis)
- ECFC (Events and Causal Factors Charting)
- ICAM (Incident Cause Analysis Method)
- Root Cause Analysis
- TOPSET Analysis

RMP RESUME:


1
2
3
4
Identification of all unwanted events
Tools:
Brainstorming
CHAZOP
FERA
FISH
FTA
Hazard Study 1 & 2
HAZID
HAZOP
HIRAC
HRA
Others
Prioritization of unwanted events
Tools:
DFMEA
FMEA
FMECA
FMEDA
GUT Matrix
HRN
Monte Carlo Analysis
PFMEA
QRA
Risk Matrix
Others
Safeguards
Tools:
ALARP Analysis
Area Classification
Audits
BOWTIE
Hazard Study 4 & 5
Job Cycle Checks
LOPA
Procedures
SIF/SIL
TRAININGS
Others
Residual Risks
Tools:
FAR
FN Curve
HRN
Risk Matrix
Others
BEFORE the Event
Fire / Explosion
Leakages
Contaminations
UNWANTED EVENT
Falls
Injuries
Others
1
2
Consequences treatment
Tools:
Alarms
Crisis Management
Emergency Plan
Equipaments
Fire Brigade
Q/D
Scape Routes
TRAININGS
Others
Event Analysis
Tools:
5 Whys
5W 2H Analysis
Apollo Root Analysis
Barrier Analysis
ECFC
ICAM
Root Cause Analysis
TOPSET Analysis
Others
AFTER the Event

5. THE HUMAN ERROR

Most of the time when an unwanted event/accident occurs, the human factor is involved. The analysis of human behaviour, especially under stressful conditions (emergency situation, productivity pressure, incompatible work environment, etc.) is a topic to be taken into consideration when identifying the risks of the installation or process being analysed, as well as in relation to the actions to be taken immediately after an accident to minimize its consequences. Several tools are available for the qualitative and quantitative assessment of human error and its consequences, like the following ones:

- ASEP (Accident Sequence Evaluation Program)
- CREAM (Cognitive Reliability & Error Analysis Method)
- HEA (Human Error Analysis)
- HEART (Human Error Analysis & Reduction Technique)
- HRA (Human Reliability Analysis)
- PSF (Performance Shaping Factors)
- SHARP (Systematic Human Action Reliability Procedure)
- TECHR (Technique for Early Consideration for Human Reliability)
- THERP (Technique for Human Error Rate Prediction)

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