Difficulties in the Evaluation of Process Risks: A Critical Analysis

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Summary

Risk assessment in the industrial sector, especially in the processing of dangerous chemical substances, addresses a high complexity; however, despite efforts to understand and control these risks, their materialization is difficult to predict and control. Growing awareness of these risks has driven demand for identification and assessment methodologies, such as HAZOP and WHAT IF.

This article explores the history of the concept of risk, from its origins in the Renaissance to its evolution in the modern era, and how the definition has been shaped by various fields and legislation. Currently, risk assessment faces challenges due to confusion in the definition and application of terms.

The difficulty in risk assessment is due to inadequate application of the concepts and components of the assessment, as well as incorrect interpretation of risks. The "defences-in-depth" barrier-based approach is presented as a strategy to identify and manage risks by implementing multiple barriers.

Finally, it is concluded that a correct interpretation and application of the concepts of risk and barriers is crucial to improve organizational security and efficiency, avoiding the false sense of security and focusing efforts on the most significant risks.

1 Introduction

Over the years, people in the industrial sector, and particularly the hazardous chemical processing sector, have strived to improve understanding of the risks to which they are exposed, however, the materialization of These risks that result in important consequences for organizations are events that are difficult to understand, predict and control.

In a Latin American context and surely similar at a global level, given the increasing awareness of the exposure of organizations to these risks with devastating consequences, the high demand for the application of methodologies for identifying danger scenarios and evaluating risks for processing is evident of dangerous chemical substances, as in all industrial sectors such as electric generation and transmission companies, commercial aviation, maritime and land transportation, banks and general construction.

In this effort to understand the risk exposed by organizations, it is widely covered by the application of techniques and methodologies for the identification of hazard scenarios, such as HAZOP, WHAT IF, Check List, among others, which are often complemented by a qualitative risk assessment that tends to be somewhat confusing.

With the development of methodologies for the identification of hazard scenarios, supported by information on the process and/or activities to be analyzed and the guidance or moderation of consultants knowledgeable in hazard identification techniques, it is possible to list a large number of scenarios of interest (scenarios that have adverse consequences for the organization), however, a large number of scenarios tend to be less valued due to various factors that are usually related to low perceptions of the potential consequences and/or conceptualization errors of risk reduction, or the application of barriers or safeguards associated with said scenarios.

This article/paper aims to provide tools to the reader that allow them to understand, more easily, the concepts with which they can assess the dangerous scenarios identified by the previously mentioned techniques and in this way ensure that the resulting hierarchical classification, after their identification, is truly corresponding to its current condition and potential for damage and in this way can generate a systematic and standardized evaluation at the corporate level and in accordance with risk management strategies.

2 History and origin of risk

Risk is a modern concept of humanity that, as a result of the maturation of the definition of probability and its laws, inspired by the passion and surely the addiction to games of chance, took shape since the Renaissance. Only after the introduction by Fibonacci (Leonardo Pisano) of the Hindu-Arabic numeration to the Western world, there were efficient tools to begin the understanding of the laws of probability and subsequently reach approximations of the definition of the risk. Before this inclusion of the current numbering, counting and doing calculations with letters was extremely difficult.

On the other hand, a mental barrier that prevented expanding the theories and laws of probability, already evident in games of chance, are medieval superstitions, however, with the passing of the years and Renaissance curiosity, the pleasures of gambling inspired several intellectuals and outstanding personalities of the time who founded the foundations of the concept of risk, based on experimentation with the results of games of chance and understanding the random results, sequences finally predictable with some certainty were revealed.

In the 17th century, different demographic variables began to be documented and analyzed that would later be the source of information for the development of life insurance policies. At the same time, Edward Lloyd's café, opened in London in 1687, was the meeting place for the great merchants of Europe, where the growing spirit of gambling, supported by high merchant shipping prosperity, would promote the insurance industry thanks to a dedicated record of the different activities and trade routes that were documented in this café.

Finally, reason has managed to overcome in our days the dependence on the traditions and superstitions of the past for decision making, which are made with a better understanding of risk. This real understanding of risk is what invites us to deepen our understanding and for this it is essential to understand its origin.

Therefore, we have some references to the word “risk”:

- From the Italian *riscare*, which means to dare.
- From the Latin *resecum,* which means “that which cuts”.
- From the Arabic *rizk*, it comes from the personal name “Rizq” which means “subsistence, provision”.
- From the Greek *rhiza*, meaning “dangers of sailing on a reef”.
- From Old Spanish *resegue*, which means “to dry out, to cut”.

All these and some other references contributed to the origin of the term “risk” that is widely used today. In the 18th century, during the industrial revolution, the scientific method was widely disseminated, and risk situations were transferred to man, probability and decision factors gained importance and were now evident when analyzing machinery accidents.

In the 19th and 20th centuries, the concept of risk is widely used and leveraged by stock market operations with the idea of calculation and probability of loss and gain, thus allowing it to be known and applied in different instances depending on the interests to be applied, such as the impacts of natural events or commercial, transportation or industrial activities on human beings.

Today, the interest in understanding different events that can affect the interests of people or organizations covers various fields of science, technology, medicine, sociology, economics, jurisprudence, among others, so the concept of risk can be seen and interpreted in different ways.

Given all these sections of the history of risk and its etymological references, it is appropriate to limit ourselves to the existing definitions and guide an adequate interpretation of risk to our interests. Therefore, the Royal Academy of the Spanish Language in its 22nd edition of the dictionary published in 2001 defines risk as “contingency or proximity of damage” which, complemented with the definition of

"contingency" of the same RAE, would result in "Possibility that damage may or may not occur."

On the other hand, ISO 31000 in its 2018 version indicates that risk is the "effect of uncertainty on objectives", for this definition, which tries to be as broad as possible to cover the greatest number of viewers/stakeholders in the application of the guide in organizations, there are three notes, the first refers to the concept of effect, which corresponds to a deviation from what was planned, the second note refers to the objectives that may have different aspects and categories and the third note refers to the fact that risk can be expressed in different terms such as sources of potential events, their consequences and their probabilities.

Colombian legislation in Law 1523 of 2012, by which it adopts a national risk management policy, defines "Disaster Risk" as "potential damage or losses that may arise due to dangerous physical events of natural origin". Another definition of risk applied is given to us by OSHA (Occupational Safety and Health Administration) corresponding to workers in the United States, where it says that risk "is the product of danger and exposure".

Other definitions of Risk:

- An estimate of the probability that a hazard-related incident or exposure will occur and the severity of harm that could result (ANSI/ASSE Z590.3-2011).
- An estimate of the combination of the probability that a hazardous event or exposure will occur and the severity of the injury or illness that may be caused by the event or exposure (ANSI/AIHA/ASSE Z10-2012).
- A combination of the probability that harm will occur and the severity of that harm (ANSI B11.0-2015; ANSI B11.TR3-2000).
- A combination of the probability that an injury or health damage will occur and the severity of the injury or health damage that results from a hazard (2015 NFPA 70E).
- A combination of the severity of the mishap and the probability of its occurrence (MIL-STD-882E-2012).
- The combination of the expected frequency (event in the year) and the consequences (effects/event) of a single accident or a group of accidents [8].

In conclusion, the aspect of the history and origin of the risk allows us to confirm the difficulty associated with this simple word, since with it is intended to supplant the existential problems of man that were previously dealt with widely and sufficiently by the divinities of humanity. Nowadays we are aware of our free will and that the results of our actions will have consequences, for this reason our modern "oracle" will be supported by the quality of understanding of the risk that we want to manage.

3 Difficulties in risk assessment

Starting from the thesis that has been presented about the diffuse origin of the word and confusing definition of risk, it is understandable that its application in evaluation has difficulties. Likewise, the large number of risk definitions that, in essence, may coincide, semantically appear different or are susceptible to different interpretations, which easily leads to errors in the application of risk assessments.

While it is true, I have focused a lot on understanding the definition of risk, but I have already begun to comment on risk assessment, therefore, it is necessary to expand the definition of this activity. Risk assessment is also a confusing concept; even security professionals use this term incorrectly. From English we have the term "risk assessment" which the ISO 73:2009 guide establishes as having three (3) components:

- "Risk identifications"[1]: which corresponds to finding, recognizing and recording dangers.
- "Risk analysis": compression of the consequences, existing probabilities and controls.
- "Risk evaluations": comparisons of risk levels and considering additional controls.

The ISO 73:2009 guide makes a distinction between the terms "Assessment" and "Evaluation" which, again, can confuse its purpose. Although in English, they are terms with very similar meanings, their translation into Spanish presents the same situation. Some translations of this differentiation between the terms "Assessment" and "Evaluation" could be "Appreciation" and "Evaluación" or "Valoración" and "Evaluación". In ISO3100:2018 second edition, which corresponds to an official translation, an adjustment is made in what corresponds to "Assessment" which is recognized as "Evaluación" and "Evaluation" by "Valoración".

With this clarity, it is worth clarifying that the difficulty that is intended to be clarified in this article then corresponds to the "Risk Assessment" and clarify the three (3) elements that compose it, identification, analysis and assessment.

With the conceptualization of the applied terminology already clarified and a oriented approach, we can conclude that an application of the risk concept focused on safety in industrial sectors would result in a value, commonly, qualitative and possibly quantitative, of the product of the consequences (measured in severity or seriousness) of the potential results of an unwanted event and the estimated probability or likelihood (Likelihood) that the unwanted event will occur in a unit of time or in a specific activity. Therefore, risk assessment is the attempt to predict, for adequate decision making, the worst event that could reasonably occur as a result of the danger and the operation and probability of its occurrence, taking into account that its understanding requires then application of the three (3) components of risk assessment, identification, analysis and assessment.

[1] The concept risk identification is used by ISO guidelines and standards, however, in process safety the appropriate term is hazard identification.

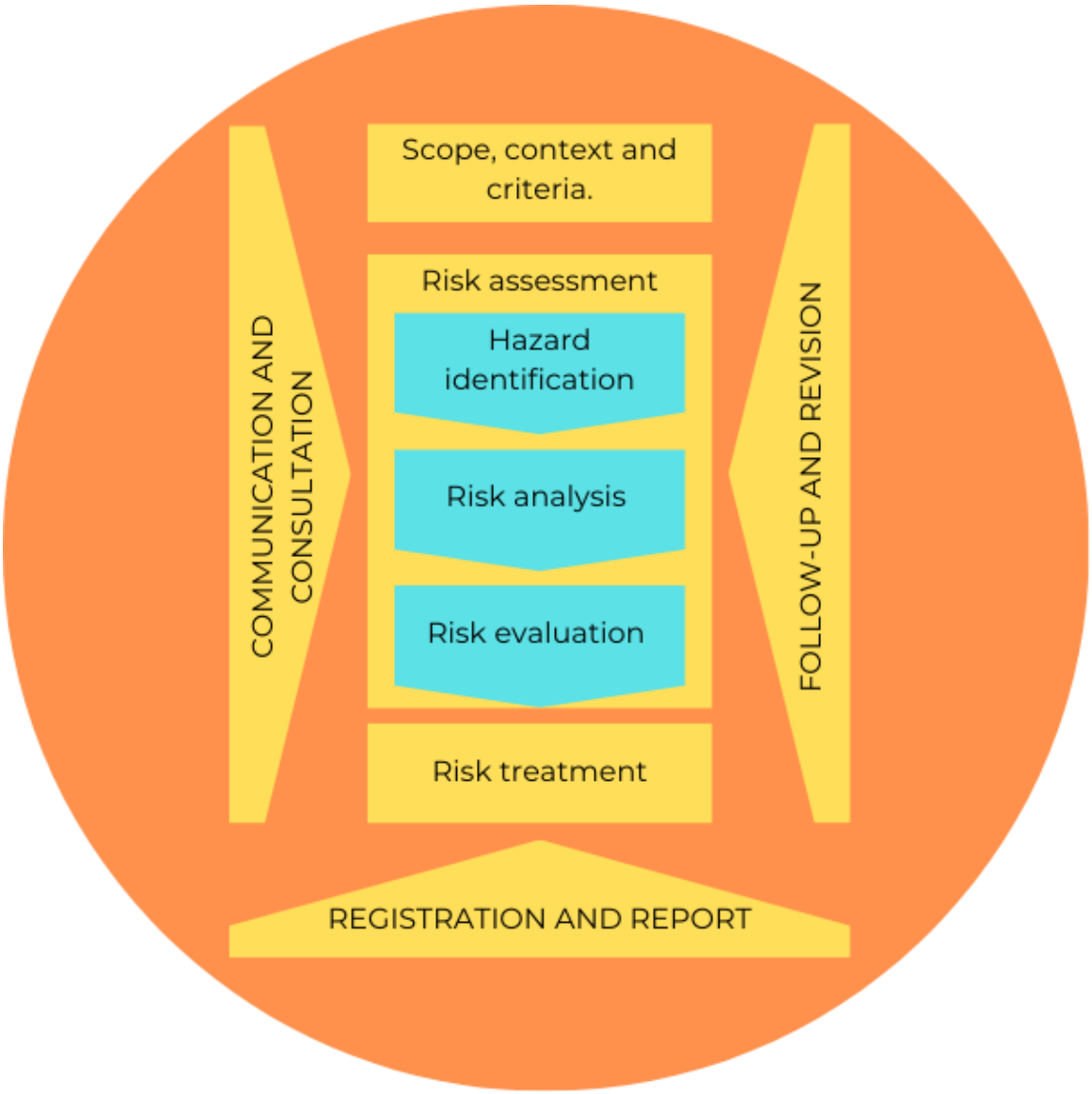

Figure 1. Risk Management Process Scheme [6]

This systematic structure of evaluating risks is very vulnerable to failure, the reasons why these processes commonly fail are late applications of the evaluations, incomplete applications of the components and/or incorrect perceptions of risk. Late applications of risk assessments are directly related to a weak risk management policy of the organization, since they do not ensure the ideal spaces or times for their application, so the results of said assessments imply conditions that are difficult to implement or high costs for risk reduction.

On the other hand, an incomplete application of the three (3) components of risk assessment will probably result in an incorrect perception of risk and even erroneous concepts of the different considerations that we have discussed in this article will also affect this perception of risk. These correspond to the other two (2) reasons why we may have difficulties in risk assessment.

In order to attack this vulnerability in the risk assessment process, it is essential to start from the essential concepts of scope, context and criteria with which the risk assessment will be applied. It is essential to keep in mind that risk assessment is an interpretation of the possible decisions that can be made during the operation or activity that is the objective of the analysis and now we are using our modern “oracle” to play to predict the future, however, this “ oracle” is built on concepts and criteria for its interpretation, if we use its conception inappropriately the results we will have will be inadequate for our management.

From this analysis it is confirmed that before considering the application of any risk analysis methodology it is crucial to be clear about the reasons why you want to apply said analysis, the conditions of how I am going to analyze the process or activity to be analyzed, what I hope to do with the results and of course the qualification criteria or risk quantification.

With the risk assessment carried out in the different risk identification and analysis methodologies, the aim is to determine, effectively, the hierarchical classification of risks that allows me to determine the events that have tolerable conditions, tolerable with the possibility of further reducing the risk in a practical way (ALARP) and not tolerable.

When the concepts of risk and risk assessment have been adequately defined and interpreted, the next level of difficulty in risk management arises and lies mainly in the effective practice of determining risks and effective management for their control and reduction.

According to the risk management process outline [6], once the risk assessment components have been applied, the risk treatment proceeds. The treatment of systematic risk corresponds to the activity with the greatest difficulty of application in organizations, since efforts are usually centralized in the identification of dangerous events with immediate attention to the finding, but which is difficult to interpret well and is usually addressed with an action in the short term.

As the years passed and after the occurrence of industrial accidents of great impact and relevance at a global level, mainly associated with complex processes and the handling of dangerous chemical substances, an approach to risk assessment emerged based on the determination of multiple layers. protection or barriers that prevent the occurrence of unwanted events and/or minimize their impact in the event that said unwanted events occur. This is the concept of thinking based on barriers or defenses in depth.

4 Defining risk with a “defences-in-depth” barrier-based thinking approach

From the experience of investigations of large industrial accidents around the world, it has been possible to conclude as a unique and certain fact that the defenses must have been violated or avoided. Identifying how these failures can occur is the first step in understanding the processes common to all organizational accidents [5].

Based on the concept that for the accident to occur, barriers have been violated or avoided, it makes sense to study the situations, commonly called scenarios, where unwanted events may occur and determine the quantity and quality of defenses/barriers available so that this event does not occur or is possibly less severe.

This concept sounds quite logical and simple, however, it implies careful discipline in the identification of scenarios, which have the potential to generate accidents, considered of interest to an organization, again the concept of Scope, Context and Criterion enters, and identifying if the study scenario has the necessary barriers to avoid the events of interest or mitigate the consequences, this determination of the sufficiency or deficiency of barriers is a great challenge, since again the vulnerability to failing to define the risk is presented, since by basic mathematical definition, it is the product of a consequence times the probability of its occurrence.

Therefore, all this prelude to the history and origins of risk, definitions of risk and risk assessment and the concept of defense in depth to be able to ask this question, how do I define the consequence and its probability to determine whether the barriers are sufficient or not?

The strategy for the proper application of these principles demands a great challenge for the people who are directly related to the execution of the process or activity subject to carrying out a risk assessment, since it starts from the definition of premises or restrictions for the application of the analysis.

Because it is based on the principle that the barriers are responsible for avoiding and/or mitigating the unwanted consequences of the processes and activities analyzed, what is first done in the risk assessment, in this case in the identification component, is define scenarios where, based on human error or a failure of an element of the system, an unwanted event identified of interest in the criteria defined for the study may occur, considering that the barriers associated with this process or activity are not available.

It is common to receive criticism, complaints about the approach, calling it illogical or unrealistic, where the low perception of the danger to which one is exposed by the people who live with the process or activity, finally manifest frustration because in their experience some scenarios it has not happened to them or they do not believe it could happen, however, as I indicated at the beginning of this chapter, the only common fact in all industrial accident investigations is that there is a failure and/or one or several barriers are violated.

Therefore, in order to identify the latent or potential consequences associated with a scenario that, based on a failure, terms used in the studies of event trees (ETA) and LOPA as an initiating event, triggers a sequence of events that, by not considering the existence of barriers or considering their failure results in the objective severity of the first factor of the risk formula (qualitative or quantitative).

Por tanto, para poder identificar las consecuencias latentes o potenciales asociadas a un escenario que, a partir de una falla, términos utilizados en los estudios de árboles de eventos

(ETA) y LOPA como evento iniciador, desencadena una secuencia de eventos que, al no considerar la existencias de las barreras o considerar el fracaso de estas, resulta en la severidad objetivo del primer factor de la formula (cualitativa o cuantitativa) del riesgo.

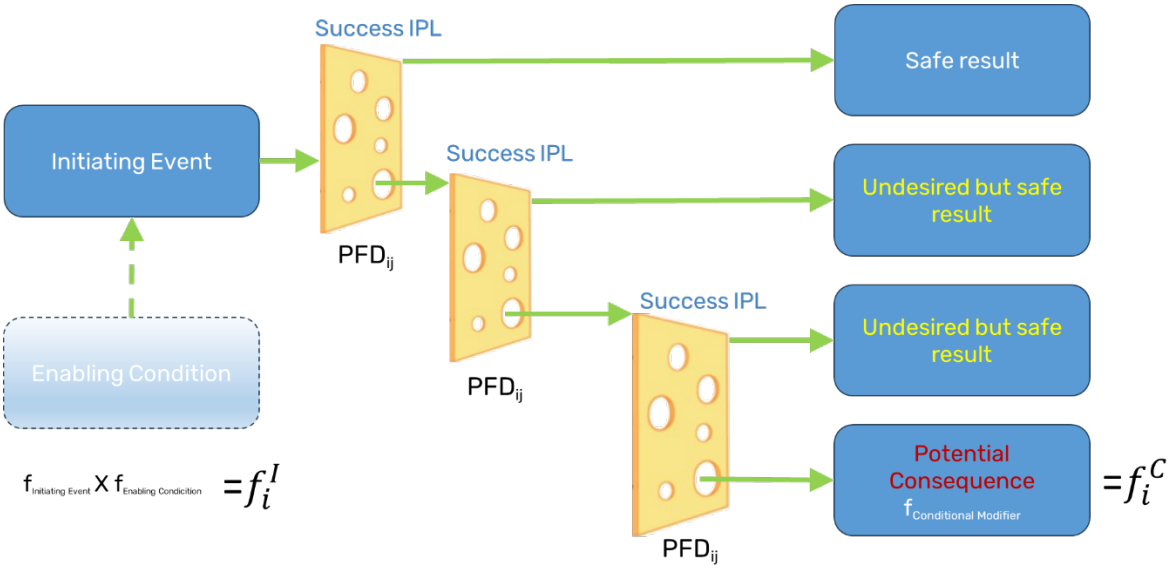

Figure 2. Event Tree Diagram [6]

In studies to identify dangerous scenarios, known as PHA (for its acronym in English "Process Hazard Analysis"), where it is common to apply methodologies such as HAZOP (preferred par excellence and exclusive for the hazardous chemical substance processing industry), What If, Security Reviews, Checklists, Relative Ranking, among other applicable methodologies, this latent consequence or potential of interest is usually defined, however, only 50% of the risk formula is being obtained. The other 50% of the risk formula is associated with the frequency with which this latent or potential consequence may occur and the team in charge of risk assessment faces another challenge.

If to determine the latent or potential consequence, I did not take into account the barriers, to determine the probability that this consequence will occur, we must again challenge the personnel of the related operation or activity. If we consider that to reach that latent consequence, we did not consider the barriers, then the probability of that latent or potential consequence is the probability with which this initiating event occurs.

With the combination of this latent or potential consequence, with the frequency of the initiating event, the potential risk of the analyzed scenario is obtained. The way in which the barriers act on this potential risk is by reducing the probability that the latent or potential consequence materializes, even if the barriers are mitigation of the consequence, by reducing its impact, they will be reducing the probability that it will materialize the latent consequence. This risk value considering the barriers associated with the scenario is called mitigated or current risk. This mitigated or current risk is intended to reveal the current risk situation of the studied scenario, so the quality and quantity of available barriers will affect the result of this analysis, and this mitigated or current risk is directly related to the latent or potential one.

Normally, in the assessment of risks and when the need to reduce a mitigated or current risk is seen, recommendations are generated to increase barriers or improve the performance of existing ones. The risk that is calculated from the future implementation of these recommendations is known as projected risk.

There are different terminologies for the aforementioned risks, however, all of these result from the application of the concepts of risk, risk assessment and defense in depth.

5 Conclusions

Understand the definition of the different terms and the relevant contextualization within the framework of risk assessment, contemplating a scope and a clear definition of risk criteria that in their organizational evolution will allow the development of more efficient elements and facilitate decision-making for investment and risk that will result in more secure and economically viable organizations.

An inadequate interpretation of the concepts of latent, potential or inherent risks of an organization can generate a false expectation of security, underestimating critical, sensitive and important scenarios, which will expose the organization to less desirable events. The proper interpretation of James Reason's Swiss cheese metaphor and its correct application will allow us to focus risk reduction efforts on the scenarios that really have the possibility of generating the greatest losses to organizations.

By performing risk reduction through the mitigation barrier function, reducing severity and not probability of occurrence, we are diverting the concept of risk reduction expressed in the metaphor of Swiss cheese, since in the conception of the model, which allows this barrier is to reduce the probability that the potential consequence will occur, mitigating the impact of the event.

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