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QUANTITATIVE AND SEMIQUANTITATIVE RISK ASSESSMENT

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ABSTRACT
Semi-quantitative risk assessment requires strict labeling categories probability of hazard activation and impact to individual categories don´t overlap and were also exhausting; provides the same, but more accurate outputs in the form of a matrix and risk maps compared with qualitative analysis; has a similar utility in practice as a qualitative assessment. Semi-quantitative analysis may not differentiate properly between risks, particularly when either consequences or likelihood are extreme. PoF assessments usually require more detail and are therefore more resource intensive than CoF assessments. Therefore, some prefer to screen systems and groups of components on consequence of failure only.
Keywords: PoF assessments, CoF assessments, Risk assessment

1. SEMI-QUANTITATIVE ANALYSIS
Semi-quantitative analysis may not differentiate properly between risks, particularly when either consequences or likelihood are extreme.
In a sense, the examples given in the previous chapter are showing some characteristics of semiquantitative approach, whereas for the purpose of the analysis we will assume that semi-quantitative approach is an approach that combines simplifications, assumptions and expert judgment with the numerical methods used in purely quantitative approaches.

The objective is to produce a more expanded ranking scale than is usually achieved in qualitative analysis, not to suggest realistic values for risk such as is attempted in quantitative analysis. Since the value allocated to each description may not bear an accurate relationship to the actual magnitude of consequences or likelihood, the numbers should only be combined using a formula that recognizes the limitations of the kinds of scales used.

Care must be taken with the use of semi-quantitative analysis because the numbers chosen may not properly reflect relativities and this can lead to inconsistent, anomalous or inappropriate outcomes. [1]

1.1. Quantitative analysis
Quantitative analysis uses numerical values (rather than the descriptive scales used in qualitative and semiquantitative analysis) for both consequences and likelihood using data from a variety of sources.

The quality of the analysis depends on the accuracy and completeness of the numerical values and the validity of the models used. Consequences may be determined by modelling the outcomes of an event or set of events, or by extrapolation from experimental studies or past data.

Consequences may be expressed in terms of monetary, technical or human impact criteria, or any of the other criteria. In some cases, more than one numerical value is required to specify consequences for different times, places, groups or situations.

The current probability of failure and the PoF development over time should be assessed for all relevant damage mechanisms. The development of the PoF over time is an important parameter to consider when the maintenance/inspection strategies and intervals are determined later in the analysis. The probability of failure should also be linked to the appropriate end event in the bow tie model to ensure that each consequence is assigned the correct probability of failure. In addition the uncertainty in the PoF assessment should be determined.

For introducing the PoF according to RIMAP procedure, three different types of source can be used. One common reference source is taken from statistical analysis of historical data (H/S) on failures in comparable components. A second common source is based on forecasting or modelling (F/M) of the foreseen failure mode in the component considered.

1.2. Expert judgment

The third source is expert judgment (E/J), whereby human expertise is applied to extract the best estimate of PoF. The individual sources for overall PoF determination are combined. The elements from different kinds of sources can be modified according to factors related to source reliability and application [2]. The logic involves the following steps: To assess the failure scenarios the user may opt for two types of models:

- Data-based models considering uncertainties in material data, NDT results, geometry, loads, etc.
- Life models calculating the remaining life of a component based on the relevant damage mechanisms.

Several methods can be used when more than one failure scenario is considered (Monte-Carlo simulation, decision trees, fault-tree analysis, fuzzy rules). This approach allows combining of different levels and methods like expert judgment and probabilistic analysis consistently, also when applied for different or same components.

The proposed approach is comparable and consistent with previously established approaches, extending them in several aspects. The extension is done by considering applicability in different industries, first by implementing relations between components in a plant and damage mechanisms, and by associating and suggesting appropriate inspection methods depending on the damage type and assessing the reliability of selected inspection method. [3]

Determine CoF The health, safety, environmental and business consequences of failure (CoF) are assessed for the relevant degradation mechanisms. Other consequences, e.g., image loss or public disruption, may also be considered. There are many approaches for gathering data necessary the CoF analysis. Four typical sources of information can be used in the analysis of CoF:

1. Historical data
2. Forecast of future behaviour
3. Expert judgment
4. Modulation of behaviour

The detailed assessment for CoF for Health, Safety, and Environment & Business involves calculations based on material properties, internal energy and the presence of people. Before going into the flowchart, it is necessary to determine toxicity number and combustibility number, which are discussed in detail in literature.
The formula for these numbers are: Combustibility number,

$$Cf = Nm\left(1+ke\right)\times\left(1+k\vartheta+kv+kp+kq\right) \quad (1)$$

Toxicity number, $Ch = Nh\left(1 + k\vartheta + kv + kp + kc\right)$ (2)

where:
Nm - Flammability index, Nh - health index, ke - enclosure penalty, $k\vartheta$ - Temperature penalty, kv - vacuum penalty, kp - pressure penalty, kc - cold penalty, kq - quantity penalty

2. RISK ASSESSMENT

When the PoF and CoF have been assessed, the health, safety, environment, and business risks are to be determined. The results can be plotted in risk matrices for presentation and comparison. Separate matrices should be used for each risk type unless it is relevant to compare the risk types.

Note that the risk matrix presents the risk for a predefined time period. It is generally useful to rank the evaluated. components or items by risk level, because this will provide guidance on where to concentrate the inspection/maintenance effort and where such activities can be relaxed.

If risks are measured in monetary terms, the expected need for mitigation investment as well as savings by avoided inspection and maintenance become then apparent. [4]

Table 1. Example of decision / action criteria for various risk levels in risk matrix

Risk level	*Decision*
Low	*If no inspection and maintenance program plan exists, no detailed analysis is required*
Medium	*Check if it is possible to reduce the risk through inspection and maintenance at low cost.*
High	*Define required inspection and maintenance program to reduce risk*
Very high	*Define required inspection and maintenance program to reduce risk*

Process of semi-quantitative analysis is based on the description of each category level of probability, impact and seriousness. [5]

Individual perception of risk is very much dependent of risk exposure and social amplification of the risk perception. Risk events interact with individual psychological, social and other cultural factors in ways that either increase or decrease public perceptions of risk.

Behaviors of individuals and groups then generate secondary social or economic impacts while also increasing or decreasing the physical risk itself. Due to long exposure to risk, people tend to accept more risk, especially for the cases when the event linked to the risk has very low likelihood of appearance and no personal experience has been made with it.

Risk management approaches (general) includes terminate (Avoid or eliminate the loss exposure) and /or treat (risk and loss control activities) and/or tolerate (acceptable level of risk) and/or transfer. There are many ways to do risk management, what is important to understand different levels of details

3. CONCLUSION

General characteristic of semiquantitative analysis allows the comparison of different systems from the aspect of risk positions and risk positions of each subfields. Risk management approaches (general) includes terminate and /or treat (risk and loss control activities), tolerate and transfer. There are many ways to do risk management, what is important to understand different levels of details. Estimates are based on historical data of CoF for different failures. The data could be generic in databases, company statistics (from plant), benchmarks or recommended practices. For failures without historical data, similar failures are used for reference. Typical results from these tasks are: PoF value for the piece of equipment under consideration, CoF value for the piece of equipment under consideration and risk value or category.

4. REFERENCE

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