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Integrated Method for Evaluation of Environmental and Occupational Risks, Proposed Revision

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Abstract

The main goal of this article is to present a modified version of the Integrated Method for Evaluation of Environmental and Occupational Risks. The method was tested using a panel of experts. A similar scale of five points is proposed for all parameters, in order to improve the usability. Preliminary tests yielded a consensus rate of 92% among the experts. Although further studies to improve the reproducibility and reliability of the method is required, the use is extremely promising

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1. Introduction

Occupational safety and health is a legal obligation in many countries articulating issues focusing on the prevention of work-related accidents and occupational diseases. It also contributes to the promotion of a safe and healthy work environment condition, being a key element for the success of enterprises [1]. Studies confirm that the more productive companies have better levels of occupational health and safety compared to companies with poor working conditions [2]. In short, the good working conditions are identified as being contributing aspects/factors to

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a good performance of business economy. In this context, risk assessment is a management tool rather than a legal imposition. It allows, through its results and subsequent comparison with reference standards, to establish the degree of acceptability of the risks supporting the subsequent decision process. It is therefore fundamental to have consensual methods that allow a reliable evaluation, independently of the criteria and the perception of the evaluator himself [3, 4].

Quality management system (QMS) are global tools that can enhances the quality of the products and services provided by organizations. The integration of these systems, particularly in the areas of quality, environment and safety, can foster the emergence of positive synergies. The most usual reference standards that exist for these three areas (ISO 9001, ISO 14001 and OHSAS 18001) provide a common basis for a set of procedures that can be implemented in an integrated way. One of these procedures involves the identification of the processes, which form a solid basis for a quality analysis. Companies also use these same processes, quite often, as a base element for hazards identification.

In 2009, Antunes and co-authors [5] presented a new method for hazards identification and risk evaluation supported on the processes previously identified to meet the requirements of the standards. In the original version, the methodological approach was focused on both environment and occupational risks. It comprises the following steps: i) Identification of environmental and occupational hazards; ii) Assessment of environmental and occupational risks; iii) Hierarchizing environmental and occupational impacts; iv) Analysis of the options for minimization or control the impacts; v) Implementation and evaluation of the adequacy of the control plan [6, 7]

The method appeared to have been abandoned for several years until Bessa and co-authors. [8] presented an application of this same method in the process of opening a trench, evaluated by a 15 experts' panel. In this work, each of the experts assessed the 38 risks identified in the process by three different methods: (1) the method proposed by Antunes [5] (2) the method proposed in Spanish Standard NTP 330 [9] and (3) the method proposed by Fine [10]. The value of 75% of identical assessments was defined as the minimum consensus value among the experts. The results were surprising. With this criterion, within the evaluated risks, 32% obtained consensus using the method proposed by Fine, with the method proposed in the NTP 330 the consensus reached 55% and in the method proposed by Antunes 92% of the risks presented a consensual evaluation.

These results led to new research work around this method, particularly in occupational field. The developed work allowed improving the original architecture in order to guarantee the reproducibility of the results obtained by different and independent panels of experts. Thus, the objective of this work is to present the new base architecture of the method.

2. Methodological Approach

2.1. General approach

The developed methodology follows the *Processes Approach* principles [11] considered in ISO 9001: 2015 [12]. This approach is one of the main foundations of successful enterprise management practices. According to this approach, the activities of the organization are described with detail, identifying the inputs, the procedures and outputs of each process. It is important that the design of each unit operation that constitute the process be carried out by a multidisciplinary team, which should contain experienced technicians with know-how in several key production areas such as the ones concerning environment management, safety management, maintenance and process in order to ensure the achievement of the most complete knowledge of the system.

The methodology considers four types of elements: 1) macro-process, i.e., association of several processes that have a certain affinity with each other; 2) process, i.e., association of several activities that are interrelated; 3) activity, i.e., association of tasks that are developed with a certain order, which objective is to achieve the expected results of this activity; 4) task, i.e., basic element of the system.

All the production processes should be considered, as well as all the support processes that are necessary for the correct functioning of the production processes. At the end of the analysis of each process, there should be a list with the respective inputs and outputs. Depending on the nature of the process, it may be sufficient to study the process as a whole or to study, separately, one or more activities, or even, each one of the tasks of that activity. The detail degree will depend only on the organization´s needs [5].

2.2. Characterization of the process' inputs and outputs

Once the operative range and the working procedure is known, the components that are related to environmental and occupational factors should be identified. For example: i) Identification of the materials used, their chemical reactions potential and physical factors; ii) Identification of the machinery and equipment used; iii) Identification of the energy resources used; iv) Identification of the working conditions; v) Identification of the factors related to the involvement of the operation; vi) Identification of the procedures inherent to protection from existing environmental impacts; vii) Identification of the procedures inherent to protection from existing risks; viii) Identification of potential failures of prevention equipment and systems [13, 14].

The proposed methodology imposes as a start, the definition of the unit operations under study and their characterization. In addition, every one of the components of each unit operation should be detailed in sub-components in order to assess their impact into two forms: a unique way and in conjunction with the other identified impacts. Thus, for each "input", one has to specify the source process and for each "output" one has to specify the process/activity/unit operation where it will be treated as an "input". So, in relation to the outputs, they will constitute an input to another process and so on. Therefore, all outputs of a process must have a corresponding input in the next process. This technique ensures the inexistence of improperly treated elements along the procedure.

Typically, the following operations are considered: start-up or preparation, production, stopping and extraordinary/emergency operations. For each operation/sub-operation it will be necessary to identify the following aspects/factors: materials used (as "input"), processes and reactions, machines and equipment used and produced materials (as “output”).

2.3. Identification of aspects/factors and impacts

Based on the results obtained in the previous stage of processes characterization, the aspects/factors that may cause environmental and/or occupational impacts should be identified and characterized according to their nature, namely, whether they are beneficial or adverse according to the type of action of the impact.

In the environmental component, the impacts resulting from each of the aspects/factors, such as: atmosphere, surface and groundwater, soil, vegetation, fauna, energy reserves, human action, morphology and landscape, installations and properties, among others, must be identified.

In the occupational component, the working conditions must be analysed in order to identify the aspects/factors that can be translated into risks (negative impacts). As examples, risk of falling (people and objects over people), risk of land collapsing, risk of injuries caused by hypothermia or hyperthermia, electrical contacts, poisoning, intoxication, radiation explosion and fire, tools and machine operation, risk of visual fatigue, among many others may be considered. The results of the above described analysis should then be compiled into a table containing: process identification and sub-process/operation; Identified factor; Factor characterization; Operation conditions (Normal, Periodical, Accidental – Table 1); Type of impact (environmental or occupational); Characterization of Impact and Applicable operating conditions. Table 1 presents a way to synthesize this information as well as the evaluation component.

2.4 Parameters for assessing impacts

The assessment of the impact significance and the consequent Risk Index (RI) will take into account three aspects/factors: 1) the severity of the impacts, splited into: a) quantification of the aspect/factor combined with the level of danger and b) extension of the impact; 2) the probability of occurrence, splited into: a) exposure/frequency of occurrence of the aspect, b) performance of prevention and control systems and c) costs and technical complexity of prevention/correction of the aspect.

In this context, the impacts that arise from aspects/factors with high probability of occurrence conjugated with a high severity and that are associated to measures of prevention and correction of a low-cost aspect will have a high index of significance.

2.5. Criteria for assessing impacts

Depending on the type of impact, environmental or occupational, an evaluation criteria should be considered. The score of the Risk Index (RI) is obtained by multiplying the score of each of the parameters.

$$RI = S \times E \times EF \times PC \times C \quad (1)$$

where S is the Severity; E is the extension of the impact; EF is the exposure/frequency of aspect occurrence; PC is the performance of both prevention and control systems; C are both the costs and the technical complexity of the aspect prevention/correction measures. In this new proposal, all parameters have a 5 levels scale.

Once the characterization phase is completed, the information regarding the aspects/factors in table 1 should be summarized. After this, a prioritization of the impacts as a function of their RI should be conducted. This hierarchical procedure aims to facilitate the identification of the aspects/factors in which it becomes more urgent to intervene in order to minimize its effects. The continuity of the process consists in the definition of actions to be implemented, in the nomination the responsible for the action and the setting of deadlines for their implementation in order to reduce RI. It should be noted that for the definition of actions to be implemented, it is convenient to determine the impacts that they will have on the calculated risk index. For example, the implications of exchanging a chemical process for another alternative can be evaluated by taking into account the severity associated with the substances used by each one. After the implementation of the actions, it will be necessary to evaluate their effectiveness and re-calculate the RI value. The "live" nature of this methodology makes it possible to carry out a continuous evaluation of the RI and thus maintain not only a record of the improvements introduced in the processes but also a list of the most relevant situations in terms of risk.

3. Conclusions

Although ISO 9001, ISO 14001 and OHSAS 18001 standards have a common structure, it is usual that planning and control components are treated separately. This methodology can be considered as an approach to the integration of Quality, Environment and Safety Management Systems. This integrated approach of the Environmental and Occupational risks, using the organizational process diagrams outlined in the Quality Management System, has a number of advantages. Among them, one can highlight the importance of the results that include a qualitative component that allows to identify recommendations and a quantitative component that allows to assess the main consequences.

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