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Integrating major accidents hazard into occupational risk assessment: An index approach

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ABSTRACT

Major Accident Hazard (MAH) and Occupational Safety and Health (OSH) are two separated topics in both industrial practice and legislation; recently, interest is increasing toward an integrated risk assessment mainly forced by the tendency to a more efficient safety management system. The present study proposes a semi-quantitative approach to integrate MAH in OSH risk assessment. The two risk types are characterized by opposite features: the OSH analysis is usually task-based and focused on job profiles, while the MAH analysis is space-based and focused on plant characteristics. The basic idea of the proposed approach is to merge spatial information and job profile features in order to improve OSH assessment; thus, a risk index derived by the recent standard ISO 12100 (2010) has been adapted. In detail, the proposed index combines exposure times of each worker at each plant unit – derived from the OSH analysis – with damage areas derived from MAH analysis allowing a quantitative assessment of the MAH risk level for each individual job profile. The model has been tested in a large petrochemical plant; several hypotheses have been developed in order to validate the model. Results have showed the potentiality of the proposed approach in providing a common and coherent representation of both MAH and OSH risks, according to job profiles and plant units.

1. Introduction

Occupational Safety and Health (OSH) and Major Accident Hazard (MAH) are two major concerns in chemical process industry. These two risks have been traditionally analyzed in a separate way in industrial practice as well as in the legislation. Safety managers have to provide risk assessment documents to two different authorities: one for OSH duties and one for MAH duties; these two documents should not be conflicting even if any explicit requirement about their consistency and harmonization is forced by the legislation. In industrial practice, MAH scenarios are very roughly evaluated in the OSH assessment and vice versa. Recently, the increasing attention toward integrated safety management systems is forcing firms to manage all risk sources – i.e. quality, environment, security and safety – in a more integrated view, aiming to improve firm efficiency by allocating not redundant resources. This issue is also confirmed by legislators and/or local authorities which are facing to plan more integrated control activities. This integration becomes critical for larger establishments – such as refineries and petrochemical plants – due to the high number of exposed workers and the intrinsic plant complexity. The contribution of MAH events to the overall risk level cannot be neglected in OSH analysis even though likelihoods are lower than a typical "occupational" accident.

By a theoretical point of view, the two risk types are characterized by opposite features. First of all, the accuracy is higher in MAH than in OSH analysis: Quantitative Risk Analysis (QRA) models are widespread in MAH sector: well-recognized industrial practices have defined "de-facto" standards (EC, 2005; TNO, 2005). More qualitative approaches (i.e. based on risk matrix) are widely applied in OSH analysis as safety experts in OHS analysis have to deeply evaluate the nature and the context of events as an underestimation could happen in such a case (Korvers & Sonnemans, 2008; Woodruff, 2005). Furthermore, the risk assessment process in OSH is heavily based on the task analysis: each job profile is classified based on its estimated risk exposure time. On the other hand, the analysis in the MAH sector focuses on plant area, as it is space-based and, consequently, it does not directly depend on the specific job profile.

Thus, where OSHs and MAHs could interact, data and results already estimated in mandatory OSH and MAH safety documents require an effective integration: the aim of the present study is to overcome the gap between these two different approaches and to

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develop a common guideline to integrate them effectively. Few theoretical recent papers faced with the application of QRA for OSH analysis (Ale et al., 2008; Aneziris, Papazoglou, & Doudakmani, 2010). The present paper focuses on a different perspective: the goal is to develop a fast but effective OSH risk assessment method suitable to include risks due to MAH scenarios. The trade-off between the conflicting requirements – i.e. simplicity and accuracy – is essential to provide a suitable tool for safety managers. The use of quantitative indicators could represent an effective solution for assessing integrated different risk types (Duijm, Fievez, Gerbec, Hauptmanns, & Konstandinidou, 2008; Mitchison & Papadakis, 1999). Thus, a semi-quantitative index approach for effectively integrating MAH in OSH analysis at process establishments is proposed: the aim is to provide a unified metric for assessing hazard elements and safety measures, suitable for both occupational accidents, chemical and environmental exposures, and accidental losses. This tool could be applied by safety managers to assess the actual risk level for each job profile by integrating data about MAH scenarios in OSH analysis.

The approach has been tested in a large chemical plant in order to point out potential benefits. The paper is organized as follows: in Section 2 goal and objectives are presented, in Section 3 the method is discussed, in Section 4 the application to the case study and the obtained results are discussed. A discussion on potentials and limits of the proposed methods are also proposed.

2. Scope and objectives

Traditionally, the focus in MAH analysis is on accident consequences both for people and the environment; thus, QRA models are heavily based on reliability assessment of process equipment even if human performances are also evaluated as a risk source. Results characterizing MAH assessment are usually expressed as damage areas: these data are reported in the Safety Report (SR) for MAH analysis. On the other hand, the OSH assessment is usually neglected in the MAH analysis due to its intrinsic lower consequences: with a reverse logic, the OSH analysis usually neglects MAHs due to their lower probability. Furthermore, according to the EU legislation, Safety Report is supervised by public control bodies, whilst a higher freedom degree is left for the OSH Risk Assessment; the OSH analysis developed by the company for each job profile is described in the Risk Assessment Document (RAD) which is compulsory for the OSH legislation.

An integrated assessment begins critical for large chemical facilities where workers are simultaneously exposed to both types of risks. It has to be noted that MAH installations are very complex production systems also for OSH analysis as there are many different hazards, posed by both equipment and materials. The number of different job profiles is usually high due to a complex work organization. Thus, traditional exposure–damage approach is valuable for discriminating effects on each different job profile, but an exhaustive treatment for a large plant could require a high resource effort. The purpose of the study is to define a fast but effective tool based on a semi-quantitative index for integrating risk analysis required by the OSH legislation with data derived from MAH analysis: the rationale is depicted in Fig. 1. Data required for the proposed model application could be derived directly from safety documents (i.e. the SR and the RAD developed by the company): these two documents represent main sources of information required for developing the proposed index approach.

The proposed approach is based on a semi-quantitative risk index: index methods have been popular in process industries since the Seventies, when they have been introduced to deal with major accidents; in the course of time, several studies have proposed applications of risk index approaches embracing additional factors in an innovative way. Koller, Fischer, and Hungerbühler (2000) described an application of index methods to deal with process inherent safety; Chen and Yang (2004) proposed an index method in order to improve prevention activities in process design phase. Tugnoli, Khan, Amyotte, and Cozzani (2008a, 2008b) applied index method in order to prevent in the process design phase risks specifically derived from plant layout; Gnoni, Lettera, and Bragatto (2012) proposed a multi-criteria index method to support effective assessment about potential knock-on effects at small sized chemical plants. These methods are also widespread in the OSH field: Hassim and Edwards (2006) and Hassim and Hurme (2010) proposed indexes for supporting effective OSH analysis at workplace. Papadakis and Chalkidou (2008) described an index method for quantifying the occupational risk of a worker based on an exposure–damage approach: an application in a depot of dangerous materials was analyzed. This brief literature review has pointed out the wide range of potential application of index methods: thus, this approach has been an inspiring model for proposing an easy but effective tool to harmonize OSH evaluation and MAH assessment. Main reasons supporting this option are described as follows:

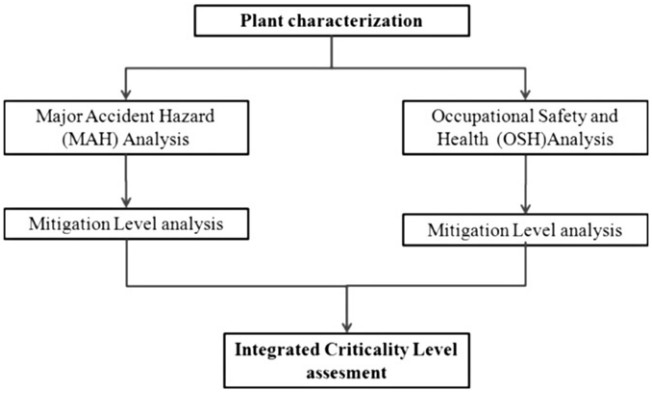

Fig. 1. The proposed approach scheme.

- Index methods are usually simple and fast to calculate, easy to understand and suitable to quickly support safety managers in their decision making process about safety management (Gupta, Khemani, & Mannan, 2003; Leong & Shariff, 2009; Maiti, 2010). Their inherent compressibility could support a fast communication also for an unskilled audience;
- indexes can be estimated on the basis of information and data already available in regulatory documents developed by the company, such as SRs and RADs. Thus, their application does not require high additional efforts.

Thus, a semi-quantitative index is detailed in the next section aiming to integrate in a fast but effective way MAH analysis into OSH assessment: the proposed index method will represent the criticality level characterizing each job profile (i.e. each worker) during its shift at Seveso plants.

3. Method

3.1. The approach

The basic idea derives from the risk definition proposed by a recent updated standard, i.e. the ISO 12100 (2010), which has been derived from a generalization of ISO 14121 (2007). This standard defines basic principles of risk assessment and risk reduction for machinery aiming to help designers in achieving safety of such an equipment: risk (R) definition is proposed in equation (1):