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Investigating new risk reduction and mitigation in the oil and gas industry

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A B S T R A C T

The complexity of the processes and the nature of volatile petroleum products urged the oil and gas industry to utilize various risk assessment techniques to identify potential failure modes that can interrupt operation processes. Consequently, government agencies and nonprofit professional societies guide the industry with regulatory guidelines, standards, and best recommended practices to oversee the operations management, assure safe working environment, and contain failures within tolerable limits. Yet, accidents due to electro-mechanical failures still occur and result in various consequences. Accordingly, critics have raised concerns about the petroleum industry's safety and risk mitigation credentials and question its ability to prevent future major accidents. Therefore, new risk assessment tools need to be introduced to provide decision makers and novice engineers with a diverse perception of potential risks. The aim of this paper is verify the application of Risk in Early Design (RED), a product risk assessment tool, in identifying potential failures in the oil and gas industry. Approximately thirty major accident underwent the RED analysis to verify the software's application to identify and rank potential failure modes.

1. Introduction

The complexity of the processes and the nature of volatile petroleum products urged the oil and gas industry to utilize various risk assessment techniques to identify potential failure modes that can interrupt operation processes. Consequently, government agencies and nonprofit professional societies guide the industry with regulatory guidelines, standards, and best recommended practices to oversee the operations management, assure safe working environment, and contain failures within tolerable limits. Yet, accidents due to electro-mechanical failures still occur and result in various consequences. Accordingly, critics have raised concerns about the petroleum industry's safety and risk mitigation credentials and question its ability to prevent future major accidents. Therefore, new risk assessment tools need to be introduced to provide decision makers and novice engineers with a diverse perception of potential risks. The aim of this paper is verify the application of Risk in Early Design (RED), a product risk assessment tool, in identifying potential failures in the oil and gas industry.

2. Impact of major accidents in the petroleum industry

The oil and gas industry has been criticized for accidents that resulted in catastrophes on different scales. The following lists some of these accidents; Deepwater Horizon drilling rig explosion and major oil spill in the Gulf of Mexico, Piper-alpha rig explosion in the North Sea, Kuwait's Mina al-Ahmadi refinery explosion, and Venezuela's Amuay refinery explosion (Anderson and LaBelle, 1994; Davies, 2010). The result of these accidents negatively impacted the oil and gas industry as well as the surrounding communities on different aspects.

Environmentally, the pollutants spread due to oil or its refined products contaminate both land and marine ecosystem (The Commonwealth Scientific and Industrial Research Organisation, 2013). The environmental damage includes underwater soils and reefs that are natural habitat to marine life (Ronza et al., 2009). Containing oil spill accidents requires the usage of chemical dispersant agent. Although they remedy pollution, using the chemicals causes toxicity regardless of their capability diluting the

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concentrated crude oil (Etkin, 1999).

Health has been impacted by major accidents in the oil and gas industry. The Bhopal gas leak disaster in 1984 killed more than 3800 in first few days of the accident as a result of inhaling methyl-isocyanate (MIC) gas (Sharma, 2002). Moreover, an estimate of "15,000 to 20,000 premature deaths reportedly occurring in the subsequent two decades" following the accident as "the Indian government reported that more than half a million people were exposed to the gas" (Broughton, 2005). The eight hundred burning oil wells in Kuwait due to sabotage during desert storm war resulted in an increase in lung cancer, reparatory, and skin diseases (Seacor, 1994). The pipe alpha tragedy claimed one hundred sixty seven lives due to a gas leak that resulted in an explosion; families and relatives of the lost crew member were psychologically impacted due to the loss of their loved ones (Kirchsteiger, 1999).

There are different financial losses due to an accident; operational profit and compensation and legal penalties are types financial impacts. Accidents can suspend the flow of operations causing a loss of production and downtime losses. Hence, postponing production operation results in decline in the company's marginal profit (Cohen, 1993). The tourism industry in the Gulf coast generates an average of $34 billion in revenues; the Deepwater Horizon oil spill resulted in contaminating the Gulf shores and resulted in a significant loss of $11 billion due to tourists avoiding those areas. In addition, Gulf shore business owners such as real estate, recreation, and fisheries, filed civil lawsuits, which BP could face $20 billion in legal penalties, to compensate for their losses (Perry, 2011).

Government agencies and nonprofit professional societies guide the industry with regulatory guidelines, standards, and best recommended practices to oversee the operations management, assure safe working environment, and contain failures within tolerable limits. Thus, The oil and gas industry utilizes different risk assessment tools to mitigation potential failures within tolerable limits.

3. Common Risk Assessment tools in the petroleum industry

The petroleum industry utilizes different risk mitigation methods to minimze operational failures. These strategies aim to mitigate potential electromechanical failures that can interrupt operations within its facilities. For example, Failure Mode and Effect Analysis (FMEA) examines the effect of potential failure modes to classify necessary phase alterations of the system to overcome failures (Stamatis, 2003; Altabbakh et al., 2013).

Fault Tree Analysis (FTA) surveys failures and contributing factors of breakdown in a system by applying diagrams and logic gates to indicate the relationship between failures and other events in the system (Hauptmanns, 2004; Altabbakh et al., 2013). This method identifies the probability for base event to occur; the corresponding event tree shows possible sequence of the triggered event (Zolotukhin and Gudmestad, 2002).

Event Tree Analysis (ETA) classifies and evaluates possible accident along with chain of events (Altabbakh et al., 2013). The method starts with an instigating event and continues to evaluate corresponding possible outcomes (Khan and Abbasi, 1998). ETA is a bottom up method where it starts with a triggered failure and progresses with the following consequences; it is considered as both qualitative and quantitative risk assessment technique (Mannan, 2004).

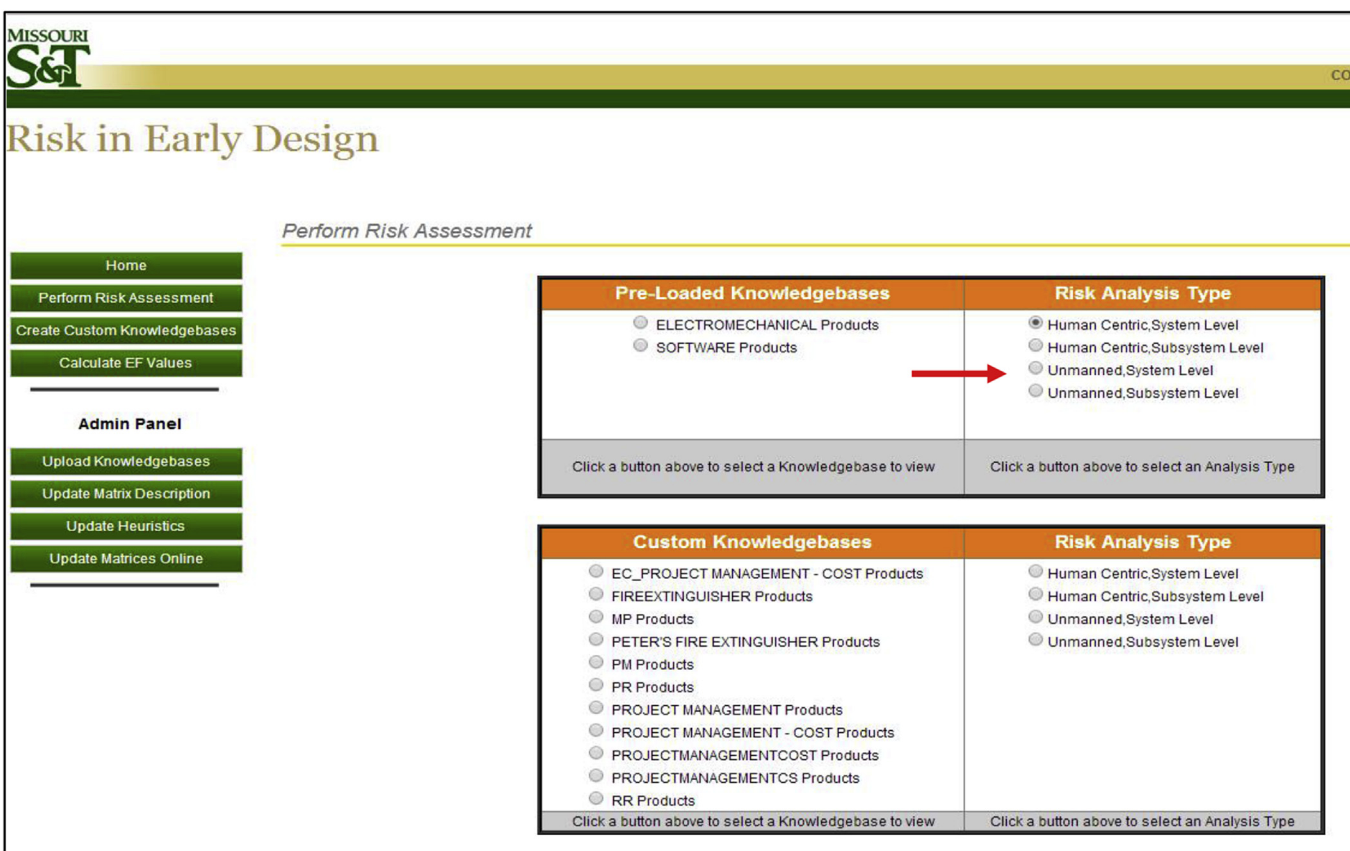

Fig. 1. Selecting the appropriate risk analysis type.