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The energy source based job safety analysis and application in the project

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ABSTRACT

The hazard identification is one of the most significant issues of the safety management process. Conventional approaches to hazard identification in a job safety analysis (JSA) tend to failure of identifying all the potential hazards involved in a work and can lead to accidents. How to identify the hazards thoroughly has becoming a challenge. The energy source based job safety analysis (ESBJSA) method proposed in this paper, aimed to identify and assess all the potential hazards effectively by applying an analysis basis on energy sources. Through clarifying the energy sources in each sub step and identifying the corresponding potential hazards of each energy source respectively, the measures and solutions to eliminate or reduce the risks can be determined. The ESBJSA method was applied in an offshore construction and installation project, and the total recordable incident rate (TRIR) result was reduced 50% when compared with another similar project using conventional JSA method. Additionally, ESBJSA is a technique that can be fully applicable to many high risk construction and installation projects in shipyard.

1. Introduction

Identifying and assessing the hazards and risks is an essential step in safety management (Brown, 1976; Ophir et al., 2010). Job safety analysis (JSA) is currently one of the most important onsite risk management methodologies for high risk tasks using a simplified and structured team approach to identify hazards related to each step in a job or activity, and develops effective risk reducing measures to eliminate or minimizes the hazards.

Hazards identification is the first and critical step in a systematic JSA process (Bahr, 1997). However, conventional JSA methods lack effective tools to identify all potential hazards (Nai-Wen et al., 2014; Sijie et al., 2015), which results in inadequate risk control measures. An appropriate combination of techniques throughout the process of hazards identification becomes an objective need (Hillson, 2002). Recently, some improved methods are put forward. Ale et al. (2008) developed and tested a tool for accident analysis based on a storybuilder method which improves investigation and categorization of accidents. Nai-Wen et al. (2014) suggested an accident causation method based text classification to assist job hazard analysis. However, how to identify all the potential hazards systematically is still a challenge. In this paper, the methodology of energy source based job safety analysis (ESBJSA) is introduced, which correlates the potential hazards with ten categories energy sources, aiming to identify all potential hazards in each sub step and make preventative solutions effectively.

The structure of this paper is as follows: Firstly, literature reviews on risk assessment and risk management, project JSA application and energy source. Then, the proposed methodology for hazards identification, which contains three main sections and eleven sub steps, is introduced. Thirdly, two case studies are shown in constructing floating storage offloading (FSO) in northern China shipyard. Finally, the compared results between the two cases and related discussion are provided.

2. Literature review

2.1. Risk management and risk assessment

Risk is the likelihood of the hazard actually causing harm, and will depend on potential severity of the hazard, likelihood of harm occurring, and who might be affected by the undertaking tasks. Risk management is a system which aims to identify and quantify all risks to which the business or project is exposed so that a conscious decision can be taken on how to manage the risks (Flanagan and Norman, 1993; Chen, 2014). A systematic process of risk management is normally divided into: (1) risk identification and classification, (2) risk assessment, and (3) risk reduction (Brandsater, 2002; Duijne et al., 2008).

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Risk identification is the first step of risk management and it plays an important preliminary effort for taking preventive measures to risk reduction (Lee and Park, 1997; McCoy et al., 2006). Many researchers are trying to apply different methods to hazard identification, although many techniques are presented available to people for risk management (Susanne, 2013; Sijie et al., 2015; Rui et al., 2016). Risk assessment is an important process for organizations' safety, allowing them to demonstrate that hazards have been identified, existing risks to workers' health and safety have been assessed, and measures to reduce risks to a reasonably practicable level have been taken (CCPS, 2009; Fera and Macchiaroli, 2010). The federal Occupational Safety and Health Act (OSHA ACT of 1970) states that employers must furnish a place of employment free of recognized hazards that are causing or are likely to cause death or serious physical harm to employees. ANSI/AIHA Z10-2012 states that the organization shall establish and implement a process to set documented objectives, quantified where practicable, based on issues that offer the greatest opportunity for Occupational Health and Safety Management System improvement and risk reduction. Risk assessment has several objectives (Cooper et al., 2005):

- It gives an overview of the general level and pattern of risk facing the project.
- It focuses management attention on the high-risk items in the list.
- It helps to decide where action is needed immediately, and where action plans should be developed for future activities.
- It facilitates the allocation of resources to support management's action decisions.

2.2. JSA application in construction industry

The construction industry is dynamic and hazardous due to the diverse and complex nature of work tasks, trades and environment, as well as the temporary and transitory nature of construction work places and workforces (Kines, 2002). Therefore, the risk of occupational accidents in the construction industry is far greater than in a manufacturing based industry (Larsson and Field, 2002) Employers and the self-employed must identify the hazards involved with their work, assess the likelihood of any harm arising and decide on adequate precautions (Health and Safety in Construction, 2006). MHSWR (Management of Health and Safety and Safety at work Regulation, 1999) also requires all employers and self-employed to conduct suitable and sufficient assessments on all risks to health and safety of themselves, their employees whilst at work and all risks to non-employees arising out of or in connection with his undertaking for the purpose of identifying measures and prohibitions imposed upon him by health and safety law.

The JSA is an essential safety management tool in construction industry that, if used consistently, will build an inventory or portfolio of hazards and associated risk, provide an understanding of how things really get done in your workplace, and reduce the potential for undesired events as controls are implemented (Roughton and Crutchfield, 2007; Park, 2016). Hazard identification is in place to identify the hazards and potential risks for people, equipment and environment, which may arise from project activities, products and services, to reduce risk to as low as reasonably practicable (ALARP) (Risk Management – IEC/ISO 31010, 2011).

2.3. Energy source

Based on accident investigations and the absence of accidents, major accident theories have arisen to explain the causation of the accidents occurred and why some organizations do not encounter accidents. One of the most acknowledged theories which form the theoretical basis of our work is the energy and barrier perspective. Energy in people's life and production process is indispensable. In 1961, Gibson suggested that the accident resulted from an abnormal or undesirable energy release (Gibson, 1961; Haddon, 1980). The accidental release of a variety of energies is the direct cause of harm or accident. If accidental disclosure or release of energy which exceed the capacity of people sufferance comes into contact with the human body, the body will get hurt. Accidental release energy theory reveals the physical nature of the accident and provides a theoretical basis for people to design and adopt safety measures.

The energy source which is used in people's life can be divided into ten categories: gravity, motion, mechanical, electrical, pressure, temperature, chemical, biological, radiation and sound. These ten energy source categories cover all types of energy which are exposed to in our life. Up to now, very little studies have been conducted regarding energy sources analysis in a JSA process.

3. The proposed methodology

The proposed ESBJSA methodology is designed in three main sections and eleven sub steps in the Fig. 1. The planning phase decides what to do, the doing phase decides how to do and the checking and reviewing phase decides how it is doing and what can be improved.

3.1. Defining the job or task

Normally higher risk, non-routine and no written procedure tasks or jobs that have a history of incidents or near misses need the JSA (Job Hazard Analysis, 2002). Appropriate level of detail is important, but the identified task must not be too broad like "opening the gas plant", or too narrow like "turning on a switch". There are some examples of appropriate level such as "removing a pump for maintenance", "collecting an oil sample" and "loading pipe for transport". You can break a complex job into two or more JSAs sometimes.

3.2. Organizing the JSA team

The JSA must be undertaken by people who are performing the task. HSE members can help to facilitate the JSA team rather than being in charge of team alone.

3.3. Dividing the job into sub steps

One job can be divided into a series of sub steps which begin with "action" words like remove, open, weld, etc. According to the rules that not be too general or too detailed, the number of sub steps should ordinarily be no more than 10–12. But the correct sequence of job steps must be ensured.

3.4. Recognizing potential energy sources

The potential energy sources in each specific step will be recognized by applying the ten categories energy source mentioned. This step plays a critical role for the entire ESBJSA and makes a big difference from the conventional JSA method.

3.5. Identifying potential hazards

Potential hazards of each identified energy source among the ten categories will be identified from the perspective of safety,