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Accident prevention approach throughout process design life cycle

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ABSTRACT

The accident rate in the chemical process industry (CPI) has not been decreasing although majority of accident causes have been identified and could have been prevented by using existing knowledge. These recurring accidents show that the existing knowledge has not been used effectively. In this paper, accident knowledge learned from earlier accident analyses are utilized to predict the common design errors during chemical plant design. An accident prevention approach throughout process design life cycle is proposed for a safer design consideration where designers are guided to identify common design errors, accident contributors and critical points to look for. The accident prevention approach has been applied to analyze the BP Texas City Refinery Explosion and Fire tragedy.

Keywords: Accidents; Errors; Process design life cycle; Plant design; Loss prevention; Learning from accident

1. Introduction

Current analyses have shown that the accident rate in the chemical process industry (CPI) is increasing in most regions. In the USA, a study showed an increase of the accident rate in the country based on 2623 accident cases that were reported between 1994 and 2009 (Prem et al., 2010). Many major accidents were also reported in Asia, especially in China (He et al., 2011). However, the number of accidents in Europe as reported to MARS database was slightly decreasing from 1996 to 2004, after a significant increase from 1960s to 1990s (Niemitz, 2010). These fluctuating trend shows that the current safety practices are insufficient to prevent accidents in the CPI globally although significant safety achievements have been made in the CPI over the years.

The aim of this paper is to explore why accidents are still happening in the CPI and propose several safety improvements throughout the process design lifecycle.

2. Loss prevention in the CPI

Accident contributors can be broadly classified as human, management, technical and design, and external factors. In layers of protection (LOP) for preventing accidents, the inner layer is the inherently safer design (ISD). This premier strategy avoids and controls hazards at sources through design changes. Meanwhile, add-on layers are mainly installed to further reduce the likelihood and consequences of accidents by using either passive or active-engineered protective systems. Passive-engineered systems such as dikes and blast walls are static and do not perform any active operations. In contrast, the active-engineered systems utilize safety devices that respond to process changes. Examples of these active-engineered systems are process controls, alarm systems, and process relief valves. The outer layer of this LOP is the procedural strategy. This strategy focuses on organizational and human control measures such as establishing work instructions, safety culture and use of personal protective equipment. Commonly, this procedural strategy is preferred by the CPI although the approach is less reliable as compared to the inherently safer and add-on strategies (Amyotee et al., 2011; CCPS, 1998).

The general approach to manage CPI process risks in hierarchical order is summarized in Fig. 1. The main risk reduction strategy is to eliminate and reduce hazards by

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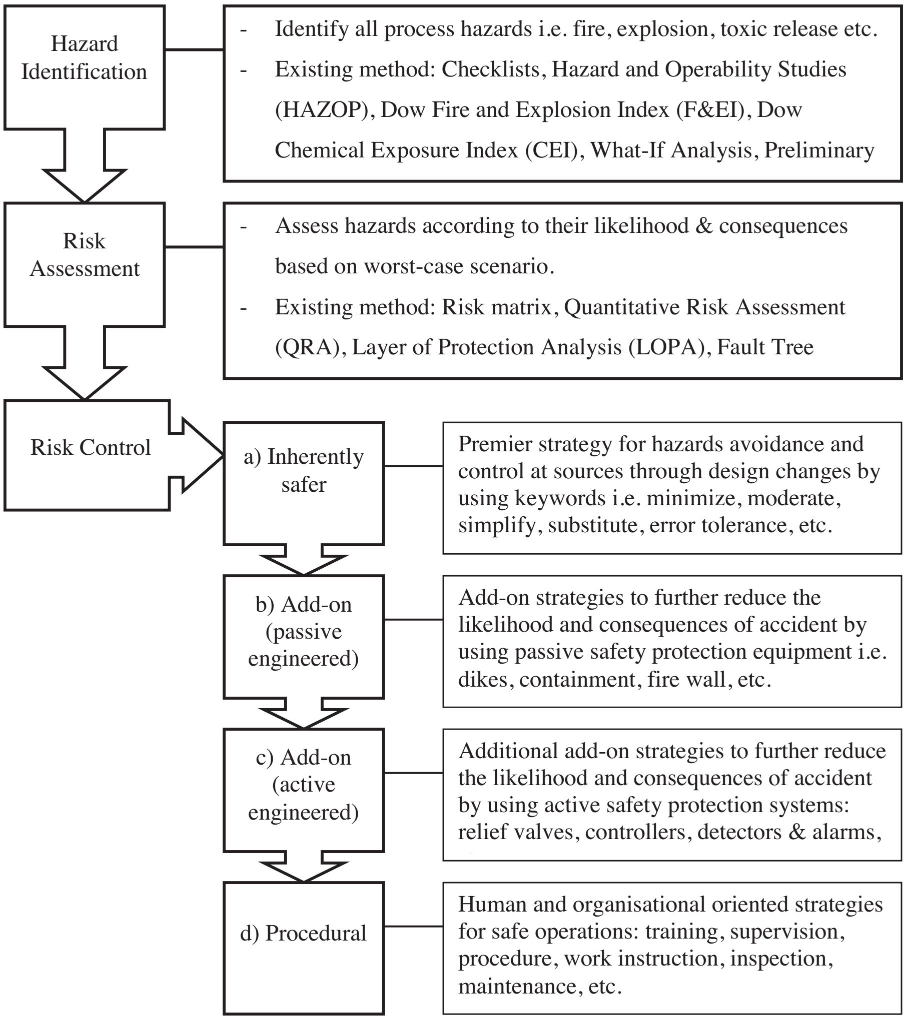

Fig. 1 – The design approach of risk management in the CPI.

inherently safer principles. The remaining risk is controlled by add-on engineered safety systems and procedural means. Nevertheless, the opportunity to adhere inherently safer principles decreases throughout the CPI lifecycle. The best time to implement ISD is during research and development, and preliminary engineering phases since the decisions are still conceptual and fundamental (Hurme and Rahman, 2005).

3. Current issues in loss prevention

The inability to reduce accident rate is usually related to physical changes of chemical process industry and the global economy. The potential accident contributors are discussed in the following and their identified corrective actions for better accident prevention are also included.

3.1. *Changes in industry*

The increasing global population and continuous improvement in living standards are forcing the CPI to produce new chemicals and build even larger chemical facilities around the world especially in locations with limited process industry experience and loose regulations. Simultaneously, the complexity of the process plants has increased due to extensive heat and mass integration. Thus, the plant operation becomes more demanding with multiple unit operation interactions.

The changing world economy and tight competition are prompting restructuring and cost-cutting measures. Major restructuring may affect the safety knowledge within the organization due to outsourcing and increasing workload. At the same time, the aging plants need periodical and systematic inspection and maintenance. These cost savings can cause insufficient maintenance, loss of qualified personnel, inadequate training of the freshmen and ultimately compromised safety cultures, as depicted in the Bhopal tragedy (Chouhan, 2005) and BP Texas City refinery explosion accident (CSB, 2007).

3.2. *Lack of learning and poor dissemination of accident information*

As the organizations are potentially losing their safety knowledge and experience, the CPI is also incapable to learn from past accidents. Most of the accidents are very similar to the past events and could be avoided by using the formerly available data (Kletz, 1993). The current implementation of process learning cycle is not sufficient to prevent accidents because of poor quality of reports, lack of analysis, poor dissemination of knowledge, and insufficient use of accident data (Kletz, 2009; Lindberg et al., 2010). As a result, the recent design safety methods do not utilize knowledge from past accidents and facilitate safety learning. For example, instead of utilizing accident information, Hazard and Operability Studies (HAZOP) method is often used as a final check for design. However,