Journal of Loss Prevention in the Process Industries 44 (2016) 112–118

Contents lists available at ScienceDirect

Journal of Loss Prevention in the Process Industries

journal homepage: www.elsevier.com/locate/jlp

Perspectives on human factors in a shifting operational environment

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ARTICLE INFO

Article history:
Received 1 February 2016
Received in revised form
18 August 2016
Accepted 22 August 2016
Available online 29 August 2016

Keywords:
Human factors
Incident investigation
Leadership
Culture
Operational discipline
Automation & technology

ABSTRACT

A significant number of catastrophic incidents occur primarily due to human factors. Despite the use of advanced automation, the implementation of more sophisticated management systems and increased training, many organizations are still finding that their approaches to reducing incidents are failing. This paper looks at why addressing human factors in today's shifting operating environment is important to reduce incidents and shares insights in the following three key areas for incident prevention:

- The critical need to deepen incident investigations;
- Why technical solutions and automation may not be sufficient; and
- How expectations affect behaviour and the role of biases and preconceptions in human errors.

These factors are reviewed from the perspective of operational discipline, an expanded view of leadership and the power of interdependent culture. Whether applied to safety, reliability, quality or capital effectiveness, the insights provided in this white paper will help readers appreciate the opportunities to broaden, as well as deepen, their human factor perspectives to reduce their organization's risks and strengthen their performance at all levels.

This paper was prepared by the author in his personal capacity. The opinions expressed in this paper are the author's own and does not reflect the view of the organization in which he is currently employed.

1. Introduction

Despite the well intentioned efforts around incident investigation, stringent regulations, advanced process automation, safety management systems, and organizational work processes, incidents still happen and similar incidents continue to be repeated. Humans are fundamental to the success of any business and understanding their role and the factors that influence their decision-making are vital to prevent incidents and achieve excellence. But the individual alone is hardly ever solely responsible and the incident hardly ever isolated.

The key to prevention comes from gaining a comprehensive understanding of the root causes of individual incidents and addressing them holistically by considering their relation to other incidents - whether they are at the facility, site, business or within the wider operating environment of the organization and the industry. More often root causes are either not identified or incident causes from different incidents are not analysed to understand the prevalent and widespread organizational and human factors that lead to incidents.

2. Learning lessons – organizational and human factor contribution

Research has shown that human and organizational factors play a significant role in incidents across all industries. Despite the clear evidence and repetitive nature of the evidence, many industries are struggling to move forward.

An analysis of incidents in the Greek Petrochemical Industry from 1997 to 2003 (Konstandinidou et al., 2006) revealed that 73 percent of the incident causes were due to human factors (46 percent) and management/organizational (37 percent) related. Similar analysis of incidents in Korea (Kang, 1999) from 1988 to 1997 found that most accidents (46 percent) occurred primarily

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http://dx.doi.org/10.1016/j.jlp.2016.08.014
0950-4230/© 2016 Published by Elsevier Ltd.

due to operation errors, with causes rooted in human factors that included lack of maintenance and lack of a safety-conscious culture. Inclusion of design error and process defects contribution will yield a similar level of contribution as observed in the Greek Petrochemical industry incident analysis. In an effort to develop a working model that integrates human factors, safety management systems and wider organizational issues, Bellamy and Geyer (2007) analysed a sample of eight incidents between 1974 and 1997 using taxonomy of 850 factors. This revealed that 142 out of 400 factors highlighted across all incidents were found to be organizational and human factor elements and remaining elements were related to safety management systems and risk-control systems.

An analysis of 118 investigation reports related to loss of containment incidents in Dutch Seveso Sites from 2006 to 2010 showed that more than half of the operating barrier task failures were primarily due to rule-based and knowledge-based errors (Bellamy et al., 2013). Analysis of 330 incidents after 1961 involving domino effects showed that the most important causes of the domino accidents were mechanical failure, external events and human factors, increasing the human factor contribution from 24.6 percent to 35 percent when analysing the accidents that occurred in the 21st century (Hemmatian et al., 2014).

It is important to recognize that plants are designed, constructed, maintained by humans and not just operated by humans. Incident investigation reports categorize errors committed during the operation phase as human error more than those that resulted during the design, construction and maintenance phase. Hendershot (2006) highlighted design, construction and computer errors in his review of four case studies and emphasized the need to address human factors and consider error potential during the entire life cycle. The report analysing 183 major accidents (Okoh and Haugen, 2014) in the United States and Europe between 2000 and 2011 showed that 44 percent were related to maintenance. “Lack of barrier maintenance, deficient design, organization and resource management, and deficient planning/scheduling/fault diagnosis” were identified to be the most frequent causes in the active accident, latent accident and work process respectively. This clearly highlights the importance of addressing the human factors throughout the life cycle of a process (Okoh and Haugen, 2014). The report, *Analysis of Equipment Failures as Contributors to Chemical Process Accidents* (Kidam and Hurme, 2013), studied 549 accidents from the Japanese Failure Knowledge Database and found that human and organizational reasons were the most common accident contributors for storage tanks (33 percent), piping (18 percent) and heat transfer equipment (16 percent).

Spotlight on Overfilling Incidents.

Overfilling of vessels can occur in any process that handles liquid and is of primary concern when the liquids are hazardous with the potential to cause personnel, environmental, asset and business impact.

A study of 242 storage tank accidents in North America, Asia and Europe between 1960 and 2003 showed that 30 percent of the incidents were caused by operational and maintenance error and overfilling was identified as the most frequent type of incident in the operational error category. Among the 15 overfilling incidents reviewed, 13 cases led to fire and explosion (Chang and Lin, 2006). Mannan et al. (2007) reviewed four similar overfilling incidents that occurred before the Buncefield 2005 incident and concluded that the earlier overfilling incidents had not been investigated and thus did not identify any corrective actions or remedial measures, emphasizing the need to focus on leading indicators instead of lagging indicators. Knegtering and Pasman (2009) documented five gasoline tank overfilling incidents between 1977 and 1999 prior to the Buncefield incident highlighting the importance of organizational learning and the weak memory in the industry.

Waite (2013) highlighted 10 tank overfilling incidents between 1972 and 2009 with eight out of 10 incidents resulting in fatalities and one incident resulting in 43 injuries. Tank overfilling incidents have similarities with refinery incidents in which columns have been flooded resulting in loss of containment through the relief system. Waite highlighted the need to challenge and review the operator mental models and address them adequately during Process Hazard Analysis, with a special focus on human factors.

Hemmatian et al. (2014) also summarizes that overfilling is the most frequent type of incident in the operational error or human error category in incidents involving domino effects. Bellamy (2015) analysed 17 overfilling accidents from 1998 to 2009 in Dutch sites using the story builder tool. It showed that 12 of 17 accidents had the process deviation (pressure, temperature, flow) indication/detection as one of the failures that led to the accidents. Bellamy also determined the patterns of other common underlying failures for 10 of 12 incidents and demonstrated smaller severity and more frequent accidents can provide information about the direct and underlying causes of more catastrophic accidents by looking within the same hazard category such as overfilling, overpressure, etc. It is evident from the review of incidents that the human and organizational factors contributed significantly to the incidents. Analysis also showed that specific incidents such as overfilling were frequent and primarily due to failure in recognition, detection, diagnosis and response.

To address human factors holistically, it is essential to understand the contribution of human factors as a function of the type of equipment (piping, storage, heat transfer, separation equipment) involved, phase of operations (start-up, shut-down, normal, maintenance), type of activities (routine, non-routine), type of process (batch, semi-batch, continuous), type of incident (overpressure, overfilling), location of incidents (tank farms, process, utilities, warehouses) and level of human intervention.

3. Are current investigations deep enough?

What is evident from a review of reports is a long history of the significant role of human factors in incident causation and repetition of incidents within the same organization, industry or across industry.

Kletz (2002) highlighted that incident reports are superficial and often stop at the first evident cause or immediate causes or list human error as the cause without further investigation into ways to avoid hazards, the nature/classification of human error and the organizational and human factors that influenced the human error. Kletz (2006) showed the lack of identification of deeper causes and actions to avoid hazards in well-known incidents at Flixborough, Bhopal, Piper Alpha and many other lesser known incidents. Kletz emphasized the need to involve people