



Factors affecting safety of processes in the Malaysian oil and gas industry



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ABSTRACT

In Malaysia, oil and gas industry is a major contributor to the economy. Offshore plants pose a number of operational hazards. It is important to monitor the operational hazards by using relevant safety indicators for proactive prevention of accidents in the plants. This research aims to identify the most pertinent safety indicators for offshore oil and gas plants. The study is conducted using a questionnaire consisting of safety indicators for offshore operation identified from literature review and consultation with industrial experts. The respondents were required to rate the importance of indicators and the probability of incidents occurring due to failure to observe the indicators. The study shows that emergency management, start-ups and shut down system as well as documentation have the highest importance in safety performance of offshore operation. Incidents or errors are more likely to occur if indicators with higher importance are not observed. The study contributes to understanding and development of the most pertinent health and safety indicators for offshore oil and gas plants. Further study can investigate relation of the indicators to the actual safety performance of offshore oil and gas plants.

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1. Introduction

Indicators have an important role in accident prevention. They provide timely detection of undesirable incidents which enable prevention to be initiated. Indicators are operational variables that capture the conditions of a wider aspect. They are widely used in the oil and gas sectors to monitor safety performance. The reason that safety monitoring receives much attention in the oil and gas sector is because the activities associated with oil and gas extraction and processing are generally regarded as high risk and prompts continuous monitoring. The most common safety indicator used across multiple industries including on the offshore oil and gas installations is the number of injuries and fatalities (Hopkins, 2009).

There is a danger with over-reliance of generic safety indicators. Incidents are culmination of risks that often go unheeded due to defective monitoring mechanism (HSE, 2006). Esso Longford gas explosion and BP's Texas City accident are instances where fatality and injury rates were given considerably more attention than process safety indicators, causing the failure to keep track of crucial deviations of process-related parameters. Similarly, zero lost-

time injury (LTI) at Longford created the wrong perception that major hazards at the facility were well managed, leading to oversight of obvious process hazards (Øien et al., 2011).

Therefore, indicators should be developed by considering and understanding the risk factors leading to an incident, in relation to the processes and systems of a facility as well as the major risks it faces and the control already established (CCPS, 2011). In other words, effective safety performance indicators should ideally be based on good understanding of the process, the risks and the critical 'barriers' (Reason, 1997). In the Malaysian Oil and Gas Industry, safety indicators used to monitor offshore processes are derived largely from generic safety indicators published by the American Petroleum Institute (API) and the International Association of Oil and Gas Producers (IOGP). A wide range of safety indicators measuring different functional areas have been proposed by multiple safety institutions across different nations (HSE, 2006; OECD, 2008; API, 2010; CCPS, 2011; OGP, 2013). However, it would be counterproductive to adopt the safety indicators without paying attention to their significance and relevance, which in turn are associated with specific experiences of a company and requirements of the public authorities. Regulators often demand indicators which can demonstrate immediate practical application of results (Swuste et al., 2016).

To make sense of the large amount of data generated from offshore installation management system, studies have been conducted to identify key indicators providing an overview of safety

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performance. Hopkins (2009) proposed numerous key indicators for this purpose which included safety critical backlogs, temporary repairs, levels of deferred maintenance and percent maintenance not completed on time. Increasing studies to identify safety indicators (Sklet, 2006; Hopkins, 2009; Reiman and Pietikainen, 2012; Bhandari and Azevedo, 2013) contribute significantly to the pool of indicators. However, there is a lack of study to link the indicators to the Malaysian oil and gas experience and to identify the indicators that are most pertinent and meaningful to the offshore oil and gas installations in Malaysia. A search through established online scientific databases revealed virtually no results related to identification of indicators for offshore processes in Malaysia, and the closest matches were studies related to sustainable production (Vijayalakshmi et al., 2013).

With Malaysia holding the fourth-highest oil reserves and the third-highest natural gas reserve in the Asia-Pacific region, the oil, gas and energy sector contributes to about 20 percent of Malaysia's GDP (Malaysia Investment Development Authority, 2015). A well-developed safety system fitted to the unique field characteristics and the processes involved are paramount to the Malaysian offshore oil and gas installations. The installations are generally regarded as high-risk with workers exposed to challenging work environment (Jensen and Laursen, 2014). This study marks an important endeavor to identify safety indicators most relevant to the offshore oil and gas processes in Malaysia by tapping into the experiences of safety personnel in the Malaysian oil and gas sector.

2. Literature review

2.1. Lagging and leading indicators

Indicators used to measure safety performance are generally classified as lagging and leading. Lagging indicators measure number of incidents, injuries and damages beyond a certain level of seriousness. Leading indicators, on the other hand, provide indications of deviation from the ideal situation by assessing inputs to safety (CCPS, 2011) and are typified by indicators measuring mechanical integrity, action items follow-ups as well as training and competence (Reiman and Pietikainen, 2012).

Changes in a system are usually gradual and would only manifest over a long time. Such changes may not be observable on a day-to-day basis. Indicators enable data to be collected over time and trends to be identified (Vinnem, 1998). This facilitates continuous evaluation of a safety management system and allows timely corrective actions (HSE, 2006). Leading and lagging indicators are frequently used in combination nowadays and the HSE coins the term 'dual assurance' for such practice (HSE, 2006). Both categories of indicators are complimentary. Disagreement in the results of leading and lagging indicators imply that either the critical control measures are not adequately identified or risk control system is ineffective. To enable more effective safety performance monitoring, composite indicators combining both lagging and leading key indicators have been increasingly used. Baker (2007) recommended the adoption of a single key composite indicator encompassing number of fires, explosions, loss-of-containment incidents and process-related injuries. Hassan and Khan (2012) developed a composite asset integrity indicator which integrates mechanical, operational and personnel aspects via aggregation method.

In short, indicators for performance measurement should be relevant and meaningful to enable effective decision-making, motivate corrective actions and predict future performance (Hale, 2009). In developing safety indicators, it is worthwhile to ensure that the indicators are unambiguous, not easily manipulated, com-

patible to normal operational activities, validated and linkable to underlying cause of an incident (IAEA, 1999).

2.2. Safety indicators for oil and gas sector

In the oil and gas sector, numerous lagging indicators such as the number of fatalities, fatal accident, incident rates, total recordable injury rate and lost time injury frequency have been used in the reporting of safety performance (OGP, 2013). While the numbers of incidents and near misses serve as important safety indication of offshore oil and gas installation, it has limited role in demonstrating the current safety level of a facility and revealing the underlying systemic failure. BP's over-reliance on lagging indicators diverted their attention from faulty process safety conditions at its Texas City plant (Baker, 2007). Subsequently, attention has been given to proactive safety monitoring by gauging efforts and preventive measures committed to safety management and accident prevention. Leading indicators have been increasingly adopted by the oil and gas sector in addition to lagging indicators in examining the integrity of safety barriers, hence the needs of reinforcing safety barriers and planning corrective actions to safety systems (Reiman and Pietikainen, 2012).

Safety barriers form an integral of the physical, technical or operational systems (Sklet, 2006). Effective evaluation of safety requires multiple data which prompts the use of a combination of indicators generally important to an industry (Reiman and Pietikainen, 2012). Identification of crucial safety factors is important in selection of the most pertinent indicators or metrics for evaluation of a system's safety (Øien et al., 2011) and is subject to continual improvement. Development of safety indicators can be traced back to the Frigg Safety Case in 1995 during which safety indicators were established based on HSE regulations, sensitivity analyses via quantitative risk assessment (QRA) and subjective evaluations of critical safety factors (Vinnem, 1998). The indicators were technical-oriented and covered aspects such as leak frequency, hot work control, and automatic gas and fire detection.

QRA was later used in a different project to develop risk-monitoring indicators. As QRA was normally conducted on design process to assess the impacts of major modifications, it was assumed to capture the most significant risk-contributing factors. In fact, QRA was favored by researchers promulgating quantitative tools and yielded indicators addressing occupational and environmental risks as well as material assets integrity (Øien and Sklet, 1999).

Subsequent 'Risk Indicator Project' conducted for a fixed offshore installation called Statjord A, yielded indicators for process accidents and blow out (Øien and Sklet, 1999). Organizational risk factors such as training/competence and work force engagement were later included (Øien, 2001). The sequel "Risk Level Project" yielded indicators addressing major accident risks, occupational accidents, diving accidents, working environment factors as well as other "Defined Situations of Hazard and Accident" (DSHA). DSHA includes hydrocarbon leaks, well kick, fire/explosion in other areas and vessel on collision course (Petroleum Safety Authority Norway, 2009). These indicators are event-based (Vinnem et al., 2006).

In addition to the abovementioned approaches, the resilience-based approach is worth mentioning. It is based on the concept of resilience as starting point in indicators development. Resilience-based approach identifies attributes of a resilient organization in development of early warning indicators (Størseth et al., 2009). The indicators address top management commitment in safety matters, flexibility of work system designs in coping with hazards, the learning culture particularly learning from incidents and routine work as well as awareness of system status (Wreathall, 2006). As the indicators encourage proactive safety

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