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Actual safety performance of the Malaysian offshore oil platforms: Correlations between the leading and lagging indicators

Daniel Tang Kuok Ho, [a,*] Siti Zawiah M.D. Dawal, [b] Ezutah Udoncy Olugu [c]

[a] Department of Mechanical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia
[b] Department of Mechanical Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur, Malaysia
[c] Faculty of Engineering, Technology & Built Environment, UCSI University, Kuala Lumpur, Malaysia

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A B S T R A C T

Introduction: This study establishes the correlations between performance of a set of key safety factors and the actual lagging performance of oil platforms in Malaysia, hence the relevance of the key safety factors in evaluating and predicting the safety performance of oil and gas platforms. The key factors are crucial components of a safety performance evaluation framework and each key safety factor corresponds to a list of underlying safety indicators. *Method:* In this study, participating industrial practitioner rated the compliance status of each indicator using a numbering system adapted from the traffic light system, based on the actual performance of 10 oil platforms in Malaysia. Safety scores of the platforms were calculated based on the ratings and compared with the actual lagging performance of the platforms. Safety scores of two platforms were compared with the facility status reports' findings of the respective platforms. *Results:* The platforms studied generally had good performance. Total recordable incident rates of the platforms were found to show significant negative correlations with management and work engagement on safety, compliance score for number of incident and near misses, personal safety, and management of change. Lost time injury rates, however, correlated negatively with hazard identification and risk assessment. The safety scores generally agreed with findings of the facility status reports with substandard process containment found as a contributor of hydrocarbon leaks. *Conclusions:* This study proves the criterion validity of the safety performance evaluation framework and demonstrates its usability for benchmarking and continuous improvement of safety practices on the Malaysian offshore oil and gas platforms. *Practical applications:* This study reveals the applicability of the framework and the potential of extending safety reporting beyond the few conventional lagging safety performance indicators used. The study also highlights the synergy between correlating safety factors to streamline safety management on offshore platforms.

1. Introduction

Safety performance measurement of offshore oil and gas platforms in Malaysia is conventionally fragmented covering entities such as technical integrity, structural integrity, process safety, and occupational safety (Hassan & Abu Husain, 2013). There is a lack of integrative approach in the offshore platform safety performance measurement by combining the major safety and health entities using both leading and lagging indicators for proactive and reactive monitoring (Tang, Leiliabadi, Olugu, & Md Dawal, 2017). An integrative safety performance measurement provides indication of the "health" of an offshore oil and gas platform, which is crucial for timely actions or rectifications should the "health" status fall below satisfactory level.

Nonetheless, it is of interest to know how a safety performance measurement framework correlates with the actual performance. A safety performance measurement framework that is predictive of actual performance is desirable as it enables more effective accident prevention, hence death and injury reduction (Martinovich, 2013). Such framework relies on specific and relevant indicators measuring crucial safety facets of offshore oil and gas platforms, hence the overall "health" of the platform. Generally, a "healthy" safety system is one with high compliance to the safety performance targets or standards set. A healthy system is commonly associated with lower incident rates, be it fatality, injury, or near-miss (Shannon, Mayr, & Haines, 1997). Auditing the effectiveness of safety management is vital as higher accident rates are associated with higher safety management failings (Kawka & Kirchsteiger, 1999; Reason, 1997). Mearns, Whitaker, and Flin (2003) reported connection between certain safety climate scales as well as proficiency in some safety management practices, and official accident statistics. This highlights that different safety practices and aspects exert varying

* Corresponding author.
E-mail addresses: daniel.tang@curtin.edu.my, (D.T.K. Ho), sitizawiahmd@um.edu.my, (S.Z.M.D. Dawal), Olugu@ucsiuniversity.edu.my (E.U. Olugu).

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influence on incident occurrence. An understanding of the influence permits more effective safety management on the offshore installations.

Currently, there is no database in Malaysia to collect and share data on safety performance of offshore oil and gas platforms beyond the common parameters such as fatality and injury rates, as well as hydrocarbon leaks (Petronas, 2015). An integrative safety measurement that is well-accepted may set the path for performance benchmarking and information sharing. However, the success of performance benchmarking using the same sets of safety indicators depends on transparency in reporting and performance standards. Performance reporting has been collected on a voluntary basis (Petronas, 2015) and it could be difficult to impose performance reporting on all oil and gas companies in Malaysia due to challenges in data collection, hence cost consideration. In addition, target-setting for the performance indicators may present certain challenges as different platform operators have different priorities and levels of safety management (Podgorski, 2015).

According to the United States Transportation Research Board (2016), the offshore industry is fragmented with diverse workforce having different safety attitudes and practices. The industry consists of large and small companies differing in their commitment of resources for safety and safety culture. The complex relationship among operators, contractors, and subcontractors on offshore oil and gas installations complicate safety-related roles and responsibilities. This presents significant challenge for industry-wide goal-setting in the effort of performance benchmarking. This study examines the potential use of a set of safety factors for performance evaluation and reporting on offshore oil and gas platforms using a safety performance evaluation framework, without attempting to achieve industry-wide goal setting for safety performance. It also depicts the correlations between actual performance of leading and lagging safety factors.

2. Literature review

Safety performance measurement forms a crucial component of the safety management system. The safety management system is the fruition of systemic approach in safety, which can be linked to the concept of safety system or safety system engineering made popular by Bertalanffy (1971), Johnson (1980), and Hammer (1989) in the 1970s. Safety system integrates safety management techniques and perceives safety as comprising inter-related components whose respective performance contribute to the overall systemic performance. This approach does not single out any component as the sole determinant of safety (Hammer, 1989). The list of components in the system is subject to continuous review, with substitution and addition of components based on relevance, for instance focus was placed on technical personnel such as control room operators and maintenance works in the late 1970s (Bertalanffy, 1971) but shifted to other areas as knowledge related to safety advanced. The safety system is therefore a dynamic system that evolves and improves in light of new knowledge, technology, and experience.

In the mid-1980s, after the Chernobyl accident, focus was placed on safety culture due to several safety deficiency of the Chernobyl power plant such as ambiguous operating procedures, flawed designs, and safety features, breaching of safety rules by operating staff, lack of competence, and pressures to meet production goals (Hammer, 1989). Nonetheless, Rentch (1990) and Witt, Hellman, and Hilton (1994) pointed out that safety culture is not the entirety of safety system but, rather, an aspect of safety system and promulgated a more holistic view of safety management with safety being an emergent property subject to continuous improvement in lifecycle of an installation.

Safety management has been given multiple definitions. Gupta and Edwards (2002) defined safety management as “the management process to ensure that risks are reduced to a level as low as reasonably practicable via hazard identification, risk assessment and monitoring.” Cox and Tait (1991) interpreted it as “the process whereby informed decision are taken to meet safety criteria” while HSE (2013) construed it as an intervention mechanism to prevent accidents. From the definitions, safety management aims to reduce risks, meet safety criteria, and prevent accidents via management process adapted from business-like approach. Typical elements of a management system consist of policy setting, organizing, planning, and implementation, evaluation, and action for improvement (ILO, 2001).

Performance monitoring and measurement fits into the evaluation stage of a safety system where safety performance is continuously and systematically monitored, measured and recorded, and procedures of performance measurement is consistently reviewed (ILO, 2001). Reliable performance monitoring necessitates adoption of relevant safety indicators. Safety indicators have historically developed parallel to advancement of safety approach from lagging indicators such as fatalities and injuries rates, organizational indicators such as work arrangement, operational indicators, to resilience based indicators (Reiman & Pietikainen, 2012).

Safety indicators have also been categorized based on safety domains. On an offshore installation, the major safety domains encompass process and personal safety. Process safety stemmed from the occurrences of industrial major accidents (e.g., the Flixborough explosion [Kletz, 1999] and the Seveso disaster resulting in dioxin leakage). Process safety management, therefore, aims to prevent, minimize, and control industrial major accidents such as fires and explosions, which cause not only injuries and fatalities but property and environmental damage. Process safety is frequently equated to asset integrity and both terms have been used interchangeably (Lauder, 2012; Ratnayake, 2012). By definition, the latter covers the breadth of management of people, systems, processes, and resources to minimize operational risks of an asset to employees, the public, and the environment (Hassan & Khan, 2012). In practice, asset integrity management on an offshore facility closely resembles process safety focusing on the safety critical elements (SCEs), which form crucial barriers of a system to prevent accidents and escalation of the accidents once they occurred (Frens & Berg, 2014). The focus is placed on the hard barriers of a system such as piping and instrumentation as well as the corresponding design and operational parameter (Vinnem, 1998).

The KP3 Asset Integrity Program by the HSE UK initiated in 2008 tracked the progress of participant oil and gas companies in indicators related to maintenance and management of safety critical elements on offshore facilities. Participating companies adopted a set of SCEs recommended by the program and tracked compliance of the SCEs (HSE, 2008), usually via facility status reporting that captures the performances of the SCEs (Frens & Berg, 2014). For comparison and benchmarking, companies participating in the KP3 Asset Integrity Program report hydrocarbon releases, verification non-compliance, and safety-critical maintenance backlog to the HSE (HSE, 2009). HSE then tracked the asset integrity performance of the participating companies based on the few key indicators over a fixed duration.

Personal safety, on the other hand, emphasizes the health, safety, and wellbeing of individual employees via minimization of their exposure to occupational risks (ILO, 2001). In the offshore context, personal safety focuses on reducing workers' exposure to radiations, chemicals, noise, vibration, extreme temperatures, and ergonomic hazards via measures such as industrial hygiene monitoring, chemical health risk assessment, job safety analysis, medical surveillance, safety awareness program, and work arrangement to reduce fatigue and increase alertness (Venkataraman, 2008). Personal safety also looks into competence building and safety behavior promotion (Arezes & Miguel, 2008). The reporting of personal safety performance in terms of number of injuries or fatalities caused by slip and trip, falling from height, electrical exposure, struck-by, caught between and burns, and so forth (IOGP, 2016) is more common than process safety performance. Personal safety is also reported to a significantly larger extent than process safety in corporate safety reporting.

Though conventionally managed separately, process and personal safety are not mutually exclusive. Studies have pointed to their

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