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Exploring relationships between organizational factors and hydrocarbon leaks on offshore platform

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ABSTRACT

In general, it is important to understand drivers of safety performance. The issue of hydrocarbon leaks on offshore platforms is one of the most important safety performance indicators based on risk related to major accidents. In this study, a longitudinal design was used to investigate the relationships between work climate and hydrocarbon leaks from a broader organizational perspective. Confirmatory factor analyses tested on a sample of offshore workers ($N = 3320$), supported the validity of the Scandinavian Work Climate Instrument (SWCI). Complementary results also supported the measurement model. Pearson's correlations indicated significant associations between work climate dimensions and hydrocarbon leaks occurring in the post survey period. All correlations were negative, supporting the proposed hypothesis. Generally, the results supported the assumption and model that guided the overall investigation. Specifically, work climate was associated with safety performance. The findings indicated that several work climate factors could function as leading indicators, implying that the work climate approach has been underestimated in safety research. Correlations with hydrocarbon leaks indicate that the organizational factors explored in this study can predict different levels of leaks. This suggests that the work climate approach used in this study represents an important contribution to achieving a holistic understanding of safety performance. Future research should replicate the study design in other settings and investigate the possibility of exploring relationships with other types of safety performance indicators using SWCI.

1. Introduction

Hydrocarbon leaks are one of the major risks on offshore platforms producing oil and gas. They are often caused by failures related to human and operational factors (Haugen et al., 2011; Sklet, 2006; Vinnem et al., 2007). Identifying and measuring such factors is therefore of high priority within the oil and gas industry; the assumption being that regular monitoring of these factors makes it possible to implement mitigating actions before barriers fail and evolve into accidents.

In safety research, safety climate and safety culture have been emphasized since the 1980s. However, the existing research might have overlooked the Scandinavian approach to safety that emphasizes work environment aspects, for instance, as expressed in the legal regulation of the Petroleum industry in Norway. One could argue that safety research does not consider sufficiently broader spectra of organizational factors that might influence the accidents. Typically, safety researches include variables with a safety-specific focus, for example, safety motivation, safety leadership, safety involvement, and safety communication (e.g. Guldenmund, 2000; Zohar, 1980). However, this emphasis overlooks other factors related to work climate in general, such as participatory leadership, competence, workers' participation or individual development. In this study, we claim that more general work climate factors influence safety levels in addition to more specific safety dimensions commonly covered in safety research.

In the current study, the level of work climate factors is expected to influence the level of hydrocarbon leaks. Work climate factors will be identified using a holistic model developed by Olsen (2011) to predict organizational performance. This model reflects a holistic approach, using indicators at different organizational levels. The setting for the study will be offshore platforms on the Norwegian Continental Shelf (NCS).

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The goal of this study is to explore different organizational safety performance indicators that can be used to explain the large differences in the level and frequency of hydrocarbon leaks. In order to be able to reach the overall ambition, the following sub goals are defined: (1) develop a longitudinal methodological design to explain the level of hydrocarbon leaks on offshore platforms, (2) validate work climate factors that can be used to predict/explain hydrocarbon leaks, and (3) correlate work climate factors with sequent/posterior hydrocarbon leaks. Additionally, an assumption that different levels of hydrocarbon leaks are correlated will be explored.

1.1. Hydrocarbon leaks

In the Norwegian offshore petroleum industry, hydrocarbon leaks increase the risk of major accidents. On average, 23.3 hydrocarbon leaks above 0.1 kg/s where registered between 1996 and 2011 on the Norwegian Continental Shelf (Bergh et al., 2014; PSA, 2012). While recent years have seen a reduction in the number of hydrocarbon leaks, maintaining this momentum and achieving further improvements requires continuous developments and refinements of indicator models (Bergh et al., 2014). As Kongsvik et al. (2011) stated, "... it is of specific interest in safety research and safety management to develop indicators that can support proactive action and reveal underlying factors or early stages of development of accidents" (p. 405).

In terms of hydrocarbon leak causations, studies have shown that a large portion of these leaks occur in connection with maintenance work (PSA, 2012) and manual interventions in the process system (Haugen et al., 2011; Vinnem et al., 2007). It has also been found that failures during the preparation for carrying out maintenance tasks is the main contributor to hydrocarbon leak risk (Vinnem, 2012). Overall, these findings suggest the importance of exploring underlying factors related to the organization, design, and management of work (psychosocial risk factors). This connection is supported by Bergh et al.'s (2014) finding that higher psychological risk scores are associated with a greater number of hydrocarbon leaks. In a similar approach, Kongsvik et al. (2011) found that the safety climate indicator explained more of the variance in hydrocarbon leaks compared to technical indicators (such as installation age, weight and number of leakage sources). Consistent with the safety climate indicator, Vinnem et al. (2010) found that the safety climate explained up to one-fifth of the hydrocarbon leak variation.

Investigations of major accidents in the offshore oil and gas industry, including hydrocarbon leaks with a catastrophic potential, frequently show that these accidents could have been prevented if early warnings about the relevant risk elements had been revealed and tackled appropriately (Skogdalen et al., 2010, 2011). In other words, by identifying and addressing risk elements, the likelihood of hydrocarbon leaks with major environmental or high fatality potential can be reduced (Bergh et al., 2014). The aim of this study was therefore to explore the possibility of explaining different levels of hydrocarbon leaks based on organizational factors (reflecting our holistic modeling approach); more specifically, the work climate was used to represent the organizational perspective. This led to the following hypotheses:

Hypothesis 1. Work climate scores will correlate negatively with hydrocarbon leaks.

1.2. Connecting the organizational perspective to safety theories

Several safety theories emphasize the relevance of exploring safety performance from an organizational perspective. Accordingly, we decided to select a representative sample of these theories, as presented in the following section.

Weick and Sutcliffe (2001) developed the mindfulness concept as a response to their concern about a particular organizational vulnerability, which they called "dealing with the unexpected." These were events or problems at a strategic (decisional) or operational (practical) level that "occur either when something that we expected to happen fails to happen or something that we did not expect to happen does happen" (p. 2). To address the organizational vulnerability of unexpected events, they examined organizations with low rate of accidents despite working under high pressure and trying conditions (so-called high reliability organizations [HROs]), and they attempted to understand how these types of organizations are able to remain more resilient and reliable compared to non-HRO organizations. Weick and Sutcliffe (2001) identified one important organizational safety mechanism or principle, specifically, the ability to be mindful, which could account for the difference between these organizations at both managerial and operational levels. At its core, mindfulness implies ways of thinking and organizing that have a higher likelihood of revealing unexpected events. One specific aspect of the concept is the preoccupation with even the smallest failure, where every signal or symptom of failure is treated as having potential severe or catastrophic (worst-case scenario) consequences for the system as a whole.

Related to our focus on hydrocarbon leaks, even the smallest leaks can indicate larger system failures and thus they should be given high priority in terms of understanding their nature and causations.

Another safety theory is Snook's (2000) causal map model, which developed in response to the accidental downing of two Black Hawk helicopters by two F-15s over northern Iraq in 1994, suggesting that this incident was the result of a combination of individual and organizational factors. Specifically, because global procedures were perceived to be static and impractical, local adaptations of rules and procedures occurred both at an individual level (pilots of the Black Hawk helicopters and F-15s) and at an organizational level (practices within the control central). According to Snook, local practices were gradually detached from written procedures (the identified concept). Finally, the complex interactions among locally adapted practices of several actors, at both an individual and organizational level, contributed to the incident. Similar to Snook's (2000) concept, Vaughan (1996) viewed the Challenger Space Shuttle accident as a culmination of individual, organizational, political, and economic factors that shaped the NASA's practices over time. Specifically, NASA developed a tendency to normalize technical irregularities and deviations (individual and organizational aspects). The organization also was affected by a culture that prioritized continued launching of the space shuttle above thorough risk analyses (individual and organizational aspects). In addition, the organization struggled for continued support and resources from Congress and publicity (political and economic aspects). According to Vaughan (1996), the accident was a result of complex interactions among all of these aspects.

While the smallest hydrocarbon leaks may not interact with other factors in ways that can lead to catastrophic incidents, it is important for the organization to prevent large detachments between local adaptions and global rules and procedures as well as prevent normalization of irregularities and deviations. It follows that an organization's disregard for smaller leaks – due to local adaptions and normalization of such incidents – can be interpreted as an expression or signal of general weakness in safety vigilance with associated potential for larger system failures.