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# Safety compliance and safety climate: A repeated cross-sectional study in the oil and gas industry

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ABSTRACT

*Introduction:* Violations of safety rules and procedures are commonly identified as a causal factor in accidents in the oil and gas industry. Extensive knowledge on effective management practices related to improved compliance with safety procedures is therefore needed. Previous studies of the causal relationship between safety climate and safety compliance demonstrate that the propensity to act in accordance with prevailing rules and procedures is influenced to a large degree by workers' safety climate. Commonly, the climate measures employed differ from one study to another and identical measures of safety climate are seldom tested repeatedly over extended periods of time. This research gap is addressed in the present study. *Method:* The study is based on a survey conducted four times among sharp-end workers of the Norwegian oil and gas industry (N = 31,350). This is done by performing multiple tests (regression analysis) over a period of 7 years of the causal relationship between safety climate and safety compliance. The safety climate measure employed is identical across the 7-year period. *Conclusions:* Taking all periods together, the employed safety climate model explained roughly 27% of the variance in safety compliance. The causal relationship was found to be stable across the period, thereby increasing the reliability and the predictive validity of the factor structure. The safety climate factor that had the most powerful effect on safety compliance was work pressure. *Practical applications:* The factor structure employed shows high predictive validity and should therefore be relevant to organizations seeking to improve safety in the petroleum sector. The findings should also be relevant to other high-hazard industries where safety rules and procedures constitute a central part of the approach to managing safety.



## 1. Introduction

The oil and gas industry, onshore as well as offshore, contains a characteristic convergence of several hazardous elements that have the potential for both occupational accidents and major disasters. Hydrocarbon leakages, falling objects, fires, explosions, blowouts and hydrogen sulfide emissions are all examples of such elements. Thus, ever since the initial phase of the petroleum activity, consideration has been given to accident prevention (Sutton, 2012).

Within the Norwegian oil and gas industry, to which the present study gives its attention, the sum of such preventive measures has reduced the risk level substantially (Ryggvik, 2003). As a result of this, the number of high potential events, serious personal injuries, and lives lost due to accidents has decreased considerably during the last two to three decades (PSA, 2012a).[1] However, events with catastrophic potential still happen. These are seldom or never caused by one single causal factor. Rather, a multitude of organizational, behavioral and technical factors contribute to such incidents. However, some causal factors occur more frequently than others. According to annual analyses of incident data performed by the International Association of Oil & Gas Producers (OGP), one of the most common causal factors of fatal incidents and high potential events in the oil and gas industry is violations of safety procedures (OGP, 2011, 2012, 2013, 2014; Walker, Poore, & Eales, 2012).

The fact that violations of safety procedures are a frequently occurring causal factor is not a new finding. Analyses and investigations of high-profile oil and gas accidents, such as the Piper Alpha disaster in 1988 (Paté-Cornell, 1993), the Texas City refinery explosion in 2005 (Hopkins, 2008) and the Montara blowout in 2010 (Hayes, 2012a), all identify a lack of compliance with rules and procedures as a contributing cause in accident scenarios. This is also the case within the Norwegian oil and gas industry, where investigations of both occupational accidents and high potential events repeatedly identify violations of safety procedures as a causal factor (e.g. Austnes-Underhaug et al., 2011; PSA, 2013, 2015a, 2015b; Schiefloe et al., 2005).

The significance of safety violations as an important causal factor in accidents is not only valid within the oil and gas industry, but is a frequent finding in accident investigations and analyses across different

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industries (e.g. Hopkins, 2011; Lenné, Salmon, Liu, & Trotter, 2012). This has led to a considerable amount of research aimed at identifying the reasons for non-compliant acts. In recent years, however, and similarly to this paper, researchers have been more focused on identifying conditions that promote safety compliance rather than on simply identifying violation-provoking conditions. The factor that has probably gained most research attention is that of safety climate (e.g., Agnew, Flin, & Mearns, 2013; Barbaranelli, Petitta, & Probst, 2015; Cavazza & Serpe, 2009; DeJoy, Schaffer, Wilson, Vandenberg, & Butts, 2004; Liu et al., 2015; Sinclair, Martin, & Sears, 2010). Safety climate can be defined as a set of perceptions that employees share regarding the priority of safety in their organization, and it is the preferred term when psychometric questionnaire surveys are employed to uncover such perceptions (Flin, Mearns, O'Connor, & Bryden, 2000; Zohar, 1980, 2010). In spite of some variation regarding the strength of the causal relationships, safety climate studies indicate that a positive safety climate promotes safety-compliant behavior (for review studies see, for example, Alper & Karsh, 2009; Clarke, 2006). This finding is important, because it demonstrates that compliance with safety procedures is not a result of mere chance and individual differences, but rather that it is highly influenced by manageable contextual factors. A challenge with these studies, however, is that identical measures of safety climate are seldom tested repeatedly over extended periods of time. Hence, the stability of the identified causal relationships between safety climate and safety compliance has not been subject to testing (Yule & Flin, 2007).

Safety within the oil and gas industry is highly regulated, and virtually all work operations are governed by rules and procedures. Thus, a high level of safety presupposes a high level of compliance (Bryden, 2002). Extensive knowledge on effective management practices related to improved compliance with safety procedures is therefore needed. However, studies of the causal relationship between safety climate and safety compliance within the oil and gas industry have the same challenges as those within other industries (Mearns, Whitaker, & Flin, 2003). Hence, the stability of the causal relationship is not properly confirmed, and there is no agreement regarding which safety climate factors are most important in influencing workers' compliance with safety procedures.

Based on a repeated cross-sectional survey, administered four times within a period of 7 years, among front-line workers within the Norwegian oil and gas industry, the aim of the present study is to perform multiple tests of the causal relationship between safety climate and safety compliance. This allows for repeated testing of a theoretical model that is held constant over a prolonged time span, thereby increasing the reliability and the predictive validity of the factor structure. This is believed to be important for at least two reasons. Firstly, it can contribute to the theoretical development of safety climate and safety compliance research, where repeated tests of causal relationships are lacking. Secondly, improved empirically based knowledge on the antecedents of safety-compliant behavior should be particularly relevant to the oil and gas industry and other industries where formal procedures constitute a vital part of the system of safety barriers.

## 2. Theoretical background

According to Griffin and Neal's (2000) safety performance framework, the term 'safety compliance' constitutes one of two aspects of the more overarching term 'safety behavior.' The other aspect is safety participation. Safety participation refers to the type of voluntary behavior that employees engage in to improve safety, such as helping colleagues, raising safety concerns and making suggestions to improve safety. Safety compliance, on the other hand, refers to core safety tasks that have to be carried out by individuals to maintain safety at work. Hence, safety compliance is often defined, in line with Neal et al. (2000: 101), as behavior that 'involves adhering to safety procedures and carrying out work in a safe manner.' In the present paper, however, safety compliance is understood as being narrower and consistent with Masia and Pienaar (2011), who define the term as 'the extent to which employees adhere to safety standards, procedures, legal obligations and requirements.'

As regards possible antecedents of safety compliant behavior within the oil and gas industry, several organizational factors have been studied. These include leadership involvement (Dahl & Olsen, 2013), workload (Rundmo, Hestad, & Ulleberg, 1998), employee involvement (Antonsen, Almklov, & Fenstad, 2008), pressure for production (Mearns, Flin, Gordon, & Fleming, 2001), and rule clarity and comprehensibility (Dahl, Fenstad, & Kongsvik, 2013). A similarity between most of these studies and studies that focus on safety climate as a possible precursor of compliance is that the explanatory factors are constructed on the basis of workers' perceptions of the subject. Another similarity is that these perceptions are uncovered by psychometric questionnaire studies.

As already described, safety climate can be defined as a set of perceptions that employees share regarding the priority of safety in their organization (Zohar, 1980). Hence, safety climate measures are multifaceted and cover a broad range of employee perceptions of the priority of safety within the organization. Basically, safety climate occurs as individual perceptions, but in aggregated form they represent the generalized group perceptions of the organization's priority of safety (Payne, Bergman, Rodríguez, Beus, & Henning, 2010). According to Zohar (2010), it is these perceptions that form the frame of reference for employees about what sort of behavior is expected, supported, and rewarded. Thus, employee behavior will tend to align with these perceived expectations.

Numerous safety climate structures exist within the safety research literature. The factor structure employed in this study is based on the most common features of the safety climate construct, as identified by Flin et al. (2000). In their review study, Flin et al. examined the thematic basis of 18 questionnaire scales used to assess safety climate and 50% of the scales were from studies in the energy/petrochemical sector. This makes Flin et al.'s study particularly relevant as a starting point for the present study. The most common features measured in safety climate surveys were found to be (a) safety competence, (b) safety systems, (c) management/supervision, (d) work pressure, and (e) risk. As regards risk, some researchers have chosen to include this dimension as a part of the safety climate construct (e.g., Cooper & Phillips, 2004), while others use risk as an outcome variable where risk is operationalized as risk-related behavior (e.g., Rundmo et al., 1998). In the present study, the risk dimension is used as an outcome variable, represented by safety compliance, whereas the four other features of the safety climate construct are treated as independent variables. The assumed relationship between these four features of the safety climate construct and safety compliance will be presented in more detail in the following.

### 2.1. Safety competence

According to Flin et al. (2000), competence appeared in one-third of the reviewed safety climate scales. The essence of competence was found to be the perceived general level of qualifications, skills, and knowledge, along with associated aspects such as training, selection and competence standards and assessment. Previous research that has focused on safety knowledge and safety training, as aspects of the competence concept, indicates that there is a positive causal relationship between safety competence and safety compliance. For example, in a study of the manufacturing industry, Kwon and Kim (2013) found that the level of safety knowledge was significantly related to safety compliance. Similar findings were obtained among retail employees by Sinclair et al. (2010). Studies have also demonstrated a positive relationship between safety training and safety compliance, for example in the passenger ferry industry (Lu & Yang, 2011), the chemical industry (Vinodkumar & Bhasi, 2010) and in container terminal operations