The Hexagonal Safety Climate Structure:
– Proposing a new safety climate structure, and assessing its implications for the RNNP survey

Master's thesis

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Abstract

This master's thesis paper proposes a new dimensional structure for the safety climate construct. The basis for this structure is data collected in the period 2001 – 2013 by the Petroleum Safety Authority Norway through the RNNP survey. The data material is vast; a total of 51 803 respondents have participated in the survey, making it the largest safety climate assessment conducted in the Norwegian oil and gas industry. The proposed dimensional structure was obtained through a dynamic combination of explorative Principal Component Analysis in SPSS and a qualitative and theoretical based assessment of the strength and structure of the data driven dimensional structures. The result of this repetitive process is presented as a six dimensional safety climate structure consisting of 30 items, given the name "The Hexagonal Safety Climate Structure".

The proposed dimensional structure of this thesis fits well with the three-dimensional basis of the RNNP survey. The proposed structure provides a theoretically supported and good psychometric solution to the dimensional structure of the safety climate construct of the RNNP survey. It is recommended that the 22 safety related questions that are not part of the dimensional structure are revised or removed from the RNNP survey.

The assessment of safety climate and safety culture has major issues to overcome. No clear conceptual agreement exists, theoretical models are lacking and the validity of the measurement instruments is questionable. Until these issues are sorted, the use of surveys to measure safety climate will still have significant potential for improvement.

Keywords: safety climate, safety culture, principal component analysis, Norwegian continental shelf

Preface

Working on this master's thesis has been both interesting and challenging. Even though I have had more pleasant weekends than the ones spent at the reading room at the Department of Psychology during this spring, it was definitely worth it. The resulting paper is a product based on curiosity and determination, and I hope the reader finds it as interesting as I do.

I wish to thank my supervisors Fay Giæver and Eva Langvik for guidance, critique and a continuous stream of helpful input on the thesis, particularly during my final weeks of frantic writing. I would also like to thank Sverre Andreas Kvalheim at the NTNU Centre for Integrated Operations and Safetec for helping me navigate through the myriads of theoretical and technical possibilities that exist in the world of organizational safety and human factors, and for valuable input on this thesis throughout the process. A special thank you goes to the Petroleum Safety Authority Norway for allowing me to use their data in this thesis.

I would also like to thank my wonderful fiancée for overwhelming support and for believing in me. A special thanks also goes to my classmates, whom I have appreciated getting to know and working with during the master's program.

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Introduction

The first uncontrolled blowout on the Norwegian continental shelf [NCS] occurred on April 22nd 1977 on the Ekofisk B platform, and resulted in the worst oil spill in Norwegian history (Norwegian Oil and Gas Association [Norwegian Oil and Gas], 2010). The official inquiry of the incident concluded that human errors, such as faults in documentation and improper planning, were the major factor responsible for the blowout (Christou & Konstantinidou, 2012). Similarly, the causes of both the Piper Alpha explosion in 1988 and the Macondo blowout in 2010 were, amongst others, identified as a lack of communication, training, emergency preparedness and bad safety culture in the organizations (Christou & Konstantinidou, 2012).

There has not been a major accident on the NCS since 1985 (Vinnem, Hestad, Kvaløy, & Skogdalen, 2010). Regardless of this, work related accidents and deaths, and major accident precursors are still occurring in the industry (Petroleum Safety Authority Norway [PSA], 2013b). The amount of incidents have declined since the peak year of 2002, which might be explained partially by the fact that the oil and gas industry has been through major technical, organizational, economic and social changes since the beginning of oil drilling on the NCS in 1966.

Haukelid (1998; 2001) has divided the evolution of the Norwegian oil and gas industry into four major phases, starting with a phase where willingness to take risks, acceptance of injuries and hard work was part of the culture. This phase, lasting into the 1980s, is described as "Texas", and is characterized by poor communication between workers and a strict hierarchical organization (Haukelid, 1998). The phases of "Great Change" and "Great Systems" during the 1980s and 1990s saw an increased focus on "Norwegianizing" the culture and the control systems of the industry. New legislations were passed, and the use of safety management systems were introduced. Although these systems meant that a wide range of human, organizational and technical efforts were introduced, employees in the industry were reluctant to adopt the changes (Haukelid, 2001). Nevertheless, the safety culture in the industry was fairly good up until the end of the 1990s, and there was a shared realization that working and thinking in a safe manner was the best way to work. The current phase, called "the cultural solution", although beginning with a decline in safety and increase in cutbacks

and downsizing, is now characterized by a strong belief that a well-functioning safety culture is essential for all actors within the Norwegian oil and gas industry (Haukelid, 2001).

In order to investigate and monitor the safety on the offshore oil platforms on the NCS, the PSA initiated the trends in risk level in the petroleum activity [RNNP] project in 1999/2000. The purpose of the RNNP project was to measure the effect of Health, Safety and Environment [HSE] work in the industry, identify critical HSE areas and increase the understanding for potential accident causes and their significance for risk (Tharaldsen, Olsen, & Rundmo, 2008). As a part of this project, a survey for measurement of safety climate and risk was developed and is now administered biannually amongst workers on the NCS. The RNNP survey was developed by analyzing previous research on safety climate and culture, and by testing and reviewing other existing dimensions, scales and surveys on safety culture and climate (Tharaldsen et al., 2008). The RNNP survey is just one of many methods of data collection used by the PSA to assess the safety culture on the NCS. The PSA wishes to assess the safety culture of the industry, and a part of this assessment is done by using the RNNP survey as a method for assessing the safety climate on the NCS through the belief's and experiences of the employees. The distinction between these concepts is not necessarily apparent, which is one of the issues this thesis will discuss. Nevertheless, an improvement of the RNNP survey should improve the PSA's assessment of the safety culture on the NCS.

A study on the psychometric qualities (i.e. the dimensional structure, statistical strength and fit with theory) of the RNNP survey based on data from 2001 and 2003 resulted in a five dimensional safety climate structure containing 32 items (Tharaldsen et al., 2008). The study expected to confirm dimensions related to the Cooper (2000) model of reciprocal safety culture, which is the theoretical basis of the RNNP survey. These dimensions are: safety practices, individual safety skills and situational aspects relevant for safety behavior (Cooper, 2000; Tharaldsen et al., 2008). A three-dimension solution would be in complete accordance with the theoretical basis, but this was not found. Instead, a five-dimensional safety climate solution, which included Safety prioritization, Safety management and involvement, Safety versus production, Individual motivation and System comprehension dimensions, was proposed. These five dimensions were then re-allocated according to the theoretical model: The first dimension is related to safety practice, dimension two, three and four are somewhat related to situational aspects, and dimension five includes some aspects of individual safety skills (Tharaldsen et al., 2008).

A subsequent study that used RNNP data from 2005, by Høivik, Tharaldsen, Baste and Moen (2009), confirmed the dimensional structure proposed by Tharaldsen et al. (2008).

In addition to this, it proposed a sixth dimension named Competence, which brought the number of items up to 35 (Høivik et al., 2009). No discussion of the relation of the dimensional structure and the theoretical basis is offered, but it can be argued that the sixth dimension is related to individual safety skills. The overall evaluation of the dimensional structure is that it confirms the structure proposed by Tharaldsen et al. (2008) and that it fits well with the data (Høivik et al., 2009).

The total subjects of a sample and the ratio of subjects per item in an analysis have been shown to significantly improve the "goodness" of PCA (Osborne & Costello, 2004). Thus, the use of a larger sample, which also includes the data from 2001, 2003 and 2005, in this thesis should provide more psychometrical robust results, which in turn should provide a more theory-fitting dimensional structure.

Issues relating to the conceptualization, definition, assessment and validity of the safety climate and safety culture concepts are still not solved, even though these concepts have been in use for more than two decades (Cooper, 2001). These issues form the basis for this master thesis and the research question presented below. In order to better understand and measure the concept of safety climate, an extensive amount of data from the RNNP survey is used to present a new dimensional structure of the concept. The presented structure will be compared with Cooper's (2000) model of safety culture. Issues with the items not included in the structure will be discussed, along with theoretical issues tied to the concepts of safety climate and safety culture. The goal is to provide a more psychometrical suitable dimensional structure for the safety climate concept, as well as addressing some of the apparent issues related to the concept, and the consequences these issues might have for the RNNP survey.

Research Question

"What is a psychometric and theoretical sound way to measure safety climate?"

In this thesis, "psychometric sound way" is defined as providing a strong factor structure in accordance with existing recommended levels of reliability, factor loadings and communalities. "Theoretical sound way" is defined as a dimensional solution that fits well with the theoretical basis of the RNNP survey and the safety culture concept.

Outline of the thesis

The theoretical framework of the thesis will start by presenting definitions of safety climate and safety culture. A presentation of the theoretical basis for safety climate measurement will be followed by some of the recurring findings regarding the dimensional structure of safety climate. The theoretical basis of the RNNP survey and for measuring safety climate through surveys will mark the end of the theory section of the paper.

The method for data collection and some descriptive information about the data will be presented. This will be followed by a description of how factor analysis has been used in this thesis, and the criteria that are used. In the analysis chapter, the retained factor solution will be presented, as well as the contents and names of the proposed dimension.

The discussion will start with assessing the psychometrical quality of the proposed dimensional structure, primarily by comparing it with the structures of Tharaldsen et al. (2008), and Høivik et al. (2009). The theoretical fitness of the proposed structure will be assessed in light of the Cooper (2000) model of safety culture, which is the theoretical basis of the RNNP survey. The removed items, the RNNP survey length and recommendations for future use of the RNNP survey will be discussed, followed by a general discussion of some of the issues concerning the safety climate concept. The thesis will end with a conclusion and some recommendations for future investigation of the Hexagonal Safety Climate Structure.

Theoretical Framework

Many researchers have tried to define the concept of safety climate. In fact, there is not much of a consensus among researchers and academics within the organizational psychology field about what the concept constitutes. Many definitions can be found in the psychological literature; in just one review paper an astounding 18 definitions of either safety climate or safety culture are presented (Guldenmund, 2000). In order to fully understand the concepts of safety climate, it is necessary to describe two different – although somewhat similar – concepts: safety climate and safety culture. For clarification purposes, their relative position to each other and to other organizational aspects will also be presented.

Safety Climate or Safety Culture?

There appears to be some dispute in the psychological literature about the distinction between safety culture and safety climate. A definition of safety climate that does not relate to the concept of safety culture has yet to be discovered by this author. Because of this, a description of safety culture and its relation to safety climate will be presented.

Safety culture is understood as an enduring and relatively stable subcomponent of an organization's culture (Cox & Cheyne, 2000; Glendon & Stanton, 2000; Guldenmund, 2000; Mearns, Whitaker, & Flin, 2003; Tharaldsen et al., 2008; Vinnem, Hestad, Kvaløy, & Skogdalen, 2010). Safety climate, on the other hand, is understood as the manifestation of safety culture through the beliefs and experiences of the employees in an organization; it is either a subcomponent of safety culture (Mearns et al., 2003; Glendon & Stanton, 2000), or a reflection of the safety culture (Cox & Flin, 1998; Guldenmund, 2000).

Safety climate can be defined as the surfacing parts of a safety culture discerned from the employees' perceptions and attitudes of safety at any given time. It is operationalized by the use of psychometric surveys, which provide a snapshot of the state of the safety culture within an organization (Flin, Mearns, O'Connor, & Bryden, 2000).

The first time the term safety culture appeared in relation to high risk organizations and major accidents was in an International Atomic Energy Agency report from 1988 on the Chernobyl nuclear reactor meltdown (Booth & Lee, 1995; Cox & Flin, 1998; Tharaldsen et al., 2008). The nuclear industry was an early adopter of the term, which is reflected in the fact that the perhaps most widely accepted definition of safety culture is from the Advisory Committee for Safety in Nuclear Installations [ACSNI]: "The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management" (ACSNI, 1993, p. 23).

Guldenmund (2000) characterizes this definition as being the most explicit because it outlines most of the assumed characteristics of safety culture, while adopting a social psychology perspective (Cox & Flin, 1998). The safety culture definition quoted above will be used in this thesis.

The Theoretical Basis for Assessment with RNNP

When researchers want to study organizational culture in general or safety culture in particular, they should consider triangulation of research methodologies. Triangulation of methodologies is essentially a way of combining different methodological techniques (e.g. surveys, interviews and audits) in order to provide a multifaceted view of culture (Cooper, 2000). Triangulation should be of special importance for researchers which claim to study safety culture, because the use of surveys – which is the methodology behind the data in this thesis – is just one of many different methods of studying safety culture. The basis for this statement is a theoretical framework in which safety climate is viewed as a snapshot of the safety culture in an organization, and thus this provides one part of a total assessment of the safety culture (Cox & Flin, 1998; Guldenmund, 2000).

Based on the view of safety climate being a reflection, or manifestation, of safety culture, it is possible to use psychometric surveys to measure safety climate in order to capture a snapshot of the safety culture in an organization at the time of the assessment (Cox & Cheyne, 2000; Flin et al., 2000; Mearns et al., 2003; Vinnem et al., 2010). The RNNP survey is an example of the use of a survey to assess the safety climate at a given time. This assessment is one subcomponent of the overall assessment of the safety culture, while accident and injury data, and safety management system audits are some of the other subcomponents the PSA uses for assessment (PSA, 2013a). However, using the premise that safety climate reflects safety culture might not be theoretically sound enough, according to Cooper (2000). Basing the understanding and investigation of safety culture and safety climate on the ACSNI (1993) definition of safety culture constitutes an interactive relationship between psychological, behavioral and situational factors (Cooper, 2000):

> Individual and group values and attitudes refer to members' perceptions about, and attitudes towards, safety goals; patterns of behaviour refer to members' day-to-day goal-directed safety behaviour; and the style and proficiency of an organisation's health and safety programmes indirectly refer to the presence and quality of organisational safety systems to support goal-directed safety behaviour. (p. 118)

The main argument Cooper (2000) presents is that the safety culture of an organization does not exist in a vacuum; it affects, and is affected by, other processes and systems within an organization. The ACSNI (1993) definition has contributed to a narrow focus on solely using questionnaire surveys to measure safety climate as a surrogate measure of safety culture, and this has led to a loss of a more holistic and multi-faceted understanding of the concept of safety culture, according to Cooper (2000). The appropriate way of understanding safety culture should be through a model where safety culture is reflected in a dynamic reciprocal relationship between the employees' perceptions about, and attitudes towards, the operationalization of organizational goals, their daily goal-directed behavior, and the presence and quality of the organization's systems to support the goal-directed behavior. Building on the premise of a dynamic relationship, Cooper (2000) suggests a reciprocal model for safety culture based on Bandura's (1977; 1986) model of social learning theory and social cognitive theory.

Four arguments are provided for why the reciprocal model based on Bandura's (1977; 1986) theories is a suitable framework for analyzing and understanding safety culture: Cooper (2000) argues that a) the triangular composition of situational, behavioral and psychological elements of the model is a perfect match to the accident causation relationships found in several studies; b) the dynamic nature of the model is believed to suit the measurement of human and organizational systems that operate in dynamic environments, while at the same time accounting for the fact that each element may be influenced either simultaneously or not; c) the proposed model provides a triangulation method for multilevel analysis, by offering different analytical approaches to the different elements of the model; d) the proposed model provides a framework in which a holistic, multi-faceted nature of safety culture can be more fully examined (Cooper, 2000).

Figure 1 provides a visualization of Cooper's (2000) proposal for a reciprocal model for safety culture, which consist of subjective internal psychological factors assessed by safety climate questionnaires, observable safety-related behaviors assessed by checklists, and objective situational features assessed via safety management system inspections.

The model of reciprocal safety culture in Figure 1 does not offer any explanation to what the contents of each element are. While Figure 1 provides the theoretical basis and model for the RNNP survey, Figure 2, retrieved from Cooper (2002), provides an insight the expected dimensions that the PCA should present, in order to confirm that the analysis and the data matches the theoretical basis of the RNNP survey. The dimensions of Figure 2 are reflections of how Cooper (2002) conceptualizes the safety climate concept. In Figure 2, the

three reciprocal factors of safety climate is presented, and it is this model that forms the platform for which assessment of the theoretical fit of the dimensional structure of safety climate will be performed. It provides a deeper look into the safety climate construct of Figure 1, while at the same time offering a suggestion to which factors the safety climate construct of the RNNP survey should contain.

Cox and Cheyne (2000) support the idea that a multiple-perspective, holistic model of safety, with different approaches to assessment, is beneficial for the overall understanding of safety culture. Cooper's (2002) reciprocal model of the safety climate construct (Figure 2) will be regarded as the theoretical basis for the RNNP survey and assessment of safety climate, while the general model of safety culture (Figure 1) provides a framework for the development of the RNNP survey and the overall safety culture assessment through multiple measurement techniques (PSA, 2001; Tharaldsen et al., 2008).

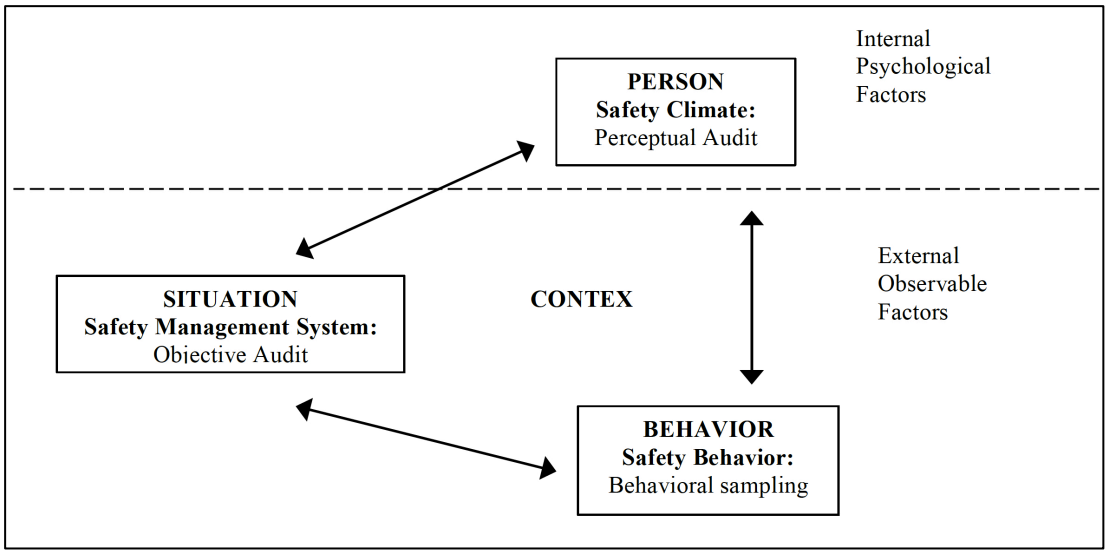

Figure 1, model of reciprocal safety culture (Cooper, 2000)

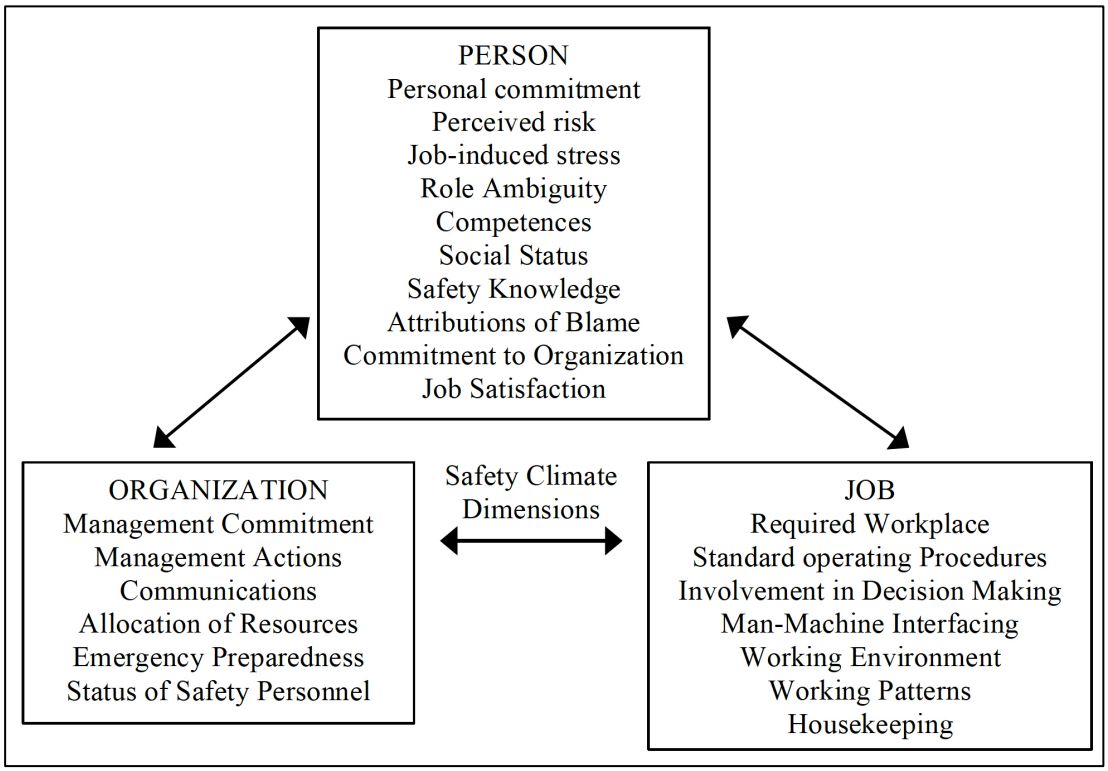

Figure 2, contents of the safety climate construct (Cooper, 2002)

Safety Climate Measurement

The main research method for measuring the safety climate of an organization is through questionnaires, which should be completed by sufficient employees to enable generalization and dimension reduction analysis; a sample size of more than 1000 is characterized as "excellent" when performing dimension reduction analysis (Glendon & Stanton, 2000; Osborne & Costello, 2004). Several tools for measurement of safety climate have been developed, both for the offshore oil industry and for other high-reliability industries such as the nuclear and aviation industry. Although these questionnaires differ in content and length, they are – in general – comprised of a series of items designed to measure participants' beliefs, values, perceptions and attitudes towards various statements which relate to specific dimensions thought to be important for safety (Mearns et al., 2003). The questionnaires are used to survey individuals within organizations, and scores are then often aggregated to a group or organizational level in order to provide insight into the overall safety climate (Cooper, 2000). The dimensional structure in the data is then used to give insight into correlations between dimensions and how the dimensions interact with other variables such as accident rates or amount of safety training given (Flin et al., 2000).

Dimensional Structure of Safety Climate

As we have seen in Figure 1, the theoretical basis for the safety climate construct in the RNNP survey is that it consists of subjective internal psychological factors. This premise enables assessment through questionnaires. By operationalizing safety climate as the manifestation of safety culture through the expressed attitudes and behaviors of employees, researchers have been able to develop several scales for which to measure safety climate (Mearns et al., 2003). Although safety climate has been characterized as multi-dimensional, the number of dimensions remains disputed (Guldenmund, 2000; Mearns et al., 2003; Tharaldsen et al., 2008). According to Guldenmund (2000), one of the issues regarding dimensionality is that researchers can name their dimensions as they see fit. This complicates comparative analyses. Most of the studies reviewed by Guldenmund (2000) were exploratory, which means that there is little cohesion between the number of dimensions and the names of these; the number of dimensions in the studies reviewed range from two to 16. These differences in the underlying dimensional structure may also reflect methodological differences, according to Tharaldsen et al. (2008).

Although the dimensional structure of safety climate is a disputed and unsettled issue, some of the recurring dimensional findings in several studies are related to management commitment to safety, supervisor competence, priority of safety over production, time

pressure and colleague involvement (Mearns et al., 2003; Tharaldsen et al., 2008). In a review paper on human factors in the offshore oil industry, Gordon (1998), found that management commitment to safety, safety training, open communication, environmental control and a positive safety promotion policy were factors which affected safety climate on an organizational level.

Method and Data

This thesis is not based on self-collected data. Instead it relies on previously collected data from the RNNP survey. A presentation of the design process of the RNNP survey, what the survey consists of and how it is administered will be given.

The PSA initiated the RNNP in 1999/2000 as a tool for measuring and illustrating the development in risk level on the NCS. The RNNP tool was developed in order to measure both personal risks amongst employees, as well as the risks for abrupt oil or gas spills on the NCS. The RNNP survey is conducted every other year, and the results are presented in annual reports (PSA, 2013a).

The RNNP began as a pilot project where the main objectives were to keep records of unwanted events, measure the effect of the safety work in the industry, focus on the industry's own follow-up of trends and analyses, contribute to identifying critical areas for the safety on the NCS, and to increase the insight on possible explanations of accidents. Furthermore, the pilot project intended to develop and test a model for analysis and assessments of the development of the risk level on the NCS (PSA, 2001).

Developing the RNNP Survey

The PSA decided that it was highly necessary to include both quantitative and qualitative analyses in order to assess the safety level in a broader way. Initially, it was decided to register and analyze quantitative data, which was supplemented with qualitative data of less measureable factors such as attitudes, culture and perceived risk. The qualitative data was collected through interviews, and the data was then used as a basis for the development of a survey (PSA, 2001). It was argued that this data triangulation would help increase the understanding of organizational, cultural and behavioral factors related to, or associated with, accidents in high-risk organizations (PSA, 2001).

Initially a total of 16 qualitative interviews were conducted with different key informants and actors within and surrounding the Norwegian oil and gas industry. Several of the informants agreed that an extensive survey should be conducted every other year – although it was also pointed out that such a survey was dependent on relevant and concrete survey questions and items (PSA, 2001).

Several problem areas were pointed out during the qualitative interviews, and one of these areas was the safety culture concept and the different ways of understanding what a "good" safety culture constituted. Based on this, the three main areas of interest for the quantitative survey were safety culture, perceived risk and safety attitudes amongst the respondents (PSA, 2001). The project group identified three main weaknesses within the

existing literature on the measurement of safety culture, perceived risk and safety attitudes. These were: the conceptual confusions of the dimensions and concepts of the surveys, the lack of focus on behavior, and the uncertainty of the predictive validity of the existing surveys (PSA, 2001). In an attempt to cope with these issues, it was decided to base the RNNP survey on the reciprocal safety culture model proposed by Cooper (2000).

The Structure of the RNNP Survey

Basing the theoretical foundation of the survey on social learning theory allowed for structuring the RNNP survey around four main focus areas; Behavior, Person, Situation and Risk Experiences (PSA, 2001). In addition to these areas, demographical and HSE item batteries were included in the survey. The survey is 10 pages long, consisting of 50 questions and a total of 111 items, as well as demographical items. A copy of the RNNP survey can be found in Appendix A, and the 52 items concerning safety climate can be found under question 29 in the survey. All of the safety climate items are statements (e.g. "Safety is my number one priority when I work") where the person answering them must indicate on a Likert scale whether they fully agree (1) or fully disagree (5) with each statement. McIver and Carmines (1981) states that a Likert scale should be composed of a fairly equal number of positive and negative items concerning the construct in question, and that the responses of these items should be calculated in a way that individuals with the most favorable responses have the highest scores, and vice versa. Consequently, the RNNP survey meets former requirement for Likert scales, but not the latter.

In accordance with Cooper's (2000) model for reciprocal safety culture, the RNNP consists of items concerning safety practices, individual safety skills and experience and situational aspects related to safety behavior. Safety practices are related to daily safety prioritization and risk communication, individual safety skills and experience are concerned with role clarity, competence and safety training, while the situational aspects are divided into factors that influences behavior and consequences of actions (Tharaldsen et al., 2008).

RNNP Participants

The questionnaire part of RNNP has been used to collect data biannually on the NCS since 2001, when a selection of employees on the NCS was included as participants (PSA, 2013c). In 2003 the questionnaire was administered to all offshore employees on the NCS, and since 2005 it has also been administered to onshore employees in the Norwegian oil and gas industry (PSA, 2013c). The data used in this thesis is from offshore employees only, after being filtered by the PSA upon request. The response rate on the questionnaire has been between 30 % and 55 % throughout the years since 2001 (PSA, 2013c).

The data provided from PSA consists of a total of 51803 respondents, in which 89,1 % are men and 9,1 % are women. 1,9 %, approximately 1000 respondents, have not provided information about their sex. Respondents are employees working in the oil and gas industry on the NCS. Professions vary in a wide range; chefs, electricians, health workers, engineers, welders, priests and helicopter pilots are just some of the professions represented in the data. The five largest groups of employees are process and management technicians, roustabout pushers, electricians, mechanics and engineers – representing approximately 16000 of the respondents. Almost 9 out of 10 (89 %) respondents are Norwegian, while Danish (3,4 %), British (2,8 %) and Swedish (2,5 %) respondents are the three largest foreign groups. More than 40 nationalities are represented in the data material.

Roughly 7 out of 10 (71,8 %) are classified as reporting that they work on a production unit, while 28,2 % are classified as working on a mobile installation. Only 3,7 % of respondents are temporarily employed, while the rest are permanent employees.

Factor Analysis – PCA

The main purpose of this study is to propose a new dimensional structure for safety climate, based on the data provided by the PSA. Because safety climate cannot be measured directly – it consists of many dimensions, or factors – one way of analyzing the underlying structure of the variables that are meant to measure safety climate is by using a factorial analysis technique to identify these underlying structures (Jolliffe, 2002, Schmitt, 2012). The central idea behind PCA is to reduce the dimensionality of a data set containing a large number of interrelated variables, while in the same time retaining as much of the variation in the data as possible (Jolliffe, 2002). Since this master's thesis paper is built upon data exploration – and because there is no need for generalization beyond the data itself – it was decided that initial exploratory factor analysis through principal component analysis [PCA] – followed by additional PC analyses – was the best factorial technique.

PCA is a statistical procedure for testing whether groups of items can be separated by linear combinations of dependent variables (Shlens, 2014). In PCA, the overall correlation matrix of variables is used to calculate the variates, and the total amount of variates that is calculated will always equal the number of variables in the data (Abdi & Williams, 2010). In a PCA, the variates are described by eigenvectors, which in turn is weighted by eigenvalues. The eigenvalues represent the importance of each variate, and the basic idea of PCA is to retain factors with large eigenvalues, and ignore factors with small eigenvalues (Abdi & Williams, 2010).

The process of deciding which factors to retain is called extraction, and this is either done by observing a scree plot or by retaining all factors with an eigenvalue larger than 1, or larger than 0,7 – depending on whether the scientist uses the Kaiser's criterion or recommendations made by Jolliffe (Beavers, Lounsbury, Richards, Huck, Skolits, & Esquivel, 2013). This thesis uses IBM SPSS to analyze the data, and the default setting in SPSS is to use Kaiser's criterion to extract factors (Field, 2013). Because of this, a combination of scree plots and subsequent analysis with a specified number of factors has been used to determine the appropriate number of factors.

According to Costello and Osborne (2005) a good rule of thumb for the minimum factor loading of an item is .32. Both previous studies provided dimensional structures where factor loadings were either barely above this threshold or very much below it (Tharaldsen et al., 2008; Høivik et al., 2009). Neither study reports any multifactorial loading of items, even though it is recommended that items loading at .32 or higher on two to more factors should be considered dropped (Costello & Osborne, 2005). Likewise, neither study confirmed a three-dimensional structure that was in complete accordance to Cooper's (2000) model – i.e. retaining a three-factor structure. In addition to this, the size of the data material is substantially larger in this thesis than in both studies.

Cronbach's α is the most widely used measure of reliability (Peterson & Kim, 2013). The measure was developed by Cronbach (1951) in order to express the internal consistency of a test or a scale as a number between zero and one. The internal consistency of items in a scale describes whether the items measure the same construct (Tavakol & Dennick, 2011). According to Cronbcach (1951), no factor analysis would be interpretable without an estimate of the reliability of the measurement. When performing a factor analysis, it is generally advised to report Cronbach's α for each of the retained factors. This is because Cronbach's α assumes that each item of a test measures the same trait on the same scale, and this assumption is violated when more than one factor is proposed for a concept – which leads to Cronbach's α underestimating the reliability of the test (Tavakol & Dennick, 2011). Different views of the acceptable value of Cronbach's α exist within the literature, but as a rule of thumb, Cronbach's α should be within .70 (Beavers et al., 2013; Peterson & Kim, 2013; Tavakol & Dennick, 2011).

Analysis

Initially, a total of 52 items were chosen for analysis. These items were chosen through a theoretical assessment, and because of their possible relevance for the concept of safety climate.

Analytical Process

The analysis began with an exploratory factor analysis, which resulted in an eight-factor solution that explained 47,5% of total variance. The solution was rotated by the use of the orthogonal rotation method varimax, and Kaiser's criterion of an eigenvalue > 1 was applied to determine the number of factors to retain. The resulting solution suggested that factor 1 and 2 should contain 18 and 12 items, respectively, while the remaining 22 items were fairly equally divided among the remaining six factors. This was expected, because PCA will aim to explain as much as the variance in the data as possible with as few factors as possible, as well as explaining as much as possible with the first factor(s) (Beavers et al., 2013; Field, 2013).

The exploratory factor analysis showed that factor 9 had an eigenvalue of .99, and therefore a forced nine-factor solution was tested. This increased the total explained variance to 49,4 %, but issues with multi-factorial and low loadings among several item, as well as theoretical issues with the retained factors meant that items had to be eliminated.

By using extracted communalities, factor loadings, theoretical assessments of proposed factor structures, and total explained variance as criteria, items were removed one by one and a new PCA was conducted after removal of each item. This process required precision and thorough assessments of the factor solutions. An overview of removed items and the reason for removal is presented, in order of removal, in Appendix B. Eventually, a PCA with 30 items, presented in Table 1, proposed a six-factor solution, which provided few items with loadings above .300 for more than one factor and sufficient factor loadings. The proposed solution in Table 1, obtained through PCA with orthogonal varimax rotation, explains 53,1 % of the total variance, while also meeting Kaiser's criterion for eigenvalues > 1.

Table 1

Factors and loadings, six factor solution

Items	Factor					
	1	2	3	4	5	6
1) My manager appreciates me pointing out matters of importance to HSE	.63				.41	
2) Being to preoccupied with HSE can be a disadvantage to your career	- .62					
3) My supervisor is committed to the HSE work on the facility	.61					
4) The company I work for takes HSE seriously	.60					
5) The management takes input from the safety delegates seriously	.58					.40
6) I would rather not discuss HSE with my immediate supervisor	- .57					
7) I can influence the HSE matters at my workplace	.57					
8) My colleagues are very committed to HSE	.44			.34		
9) I have easy access to procedures and instructions concerning my work		.75				
10) I think it is easy to find what I need in the governing documents (requirements and procedures)		.74				
11) The HSE procedures cover my work tasks		.63				
12) I always know who to report to in the organisation		.62				
13) I have access to the information necessary to make decisions which ensure the HSE aspect		.60				
14) The equipment I need to carry out my work safely is easily available		.45				
15) Dangerous situations arise because everyone does not speak the same language			.65			
16) There are often concurrent work operations which lead to dangerous situations			.63			
17) Deficient maintenance has caused poorer safety			.62			
18) Different procedures and routines at different facilities may pose a threat to safety			.61			
19) Lack of cooperation between operators and contractors often lead to dangerous situations			.60			
20) Reports about accidents or dangerous situations are often “embellished”	-.41		.53			
21) I report any dangerous situations I see				.72		
22) Safety is my number one priority when I work				.70		
23) I ask my colleagues to stop work which I believe is performed in an unsafe manner				.66		
24) I stop work if I believe that it may be dangerous for me or others to continue				.48	.37	
25) I sometimes breach safety rules in order to get a job quickly done				-.44		
26) My colleagues will stop me if I work unsafely				.39	.47	
27) I have been given adequate safety training					.74	
28) I have been given adequate working environment training					.72	
29) I have the necessary competence to perform my job in a safe manner						.82
30) I am thoroughly familiar with the HSE procedures						.74

Note. Items translated from Norwegian by the PSA

Dimensional Structure

Before naming the dimensions of the six-factor solution, decisions regarding the placement of items #1, #5, #8, #20, #24 and #26 had to be made. These items were placed either with the factor they loaded most towards, or with the factor which overall theme was most appropriate. Items #1, #5 and #8 were placed with factor 1, item #20 was placed with factor 3 and item #24 was placed with factor 4 because of their loadings with these factors. In the case of item #26, placed with factor 4, the factor loading criteria was discarded as main criteria in favor of a theoretically more robust factor 4.

Supportive safety culture. Dimension 1, comprising of eight items reflecting a supportive culture of safety among the leadership, colleagues and in a personal sense (e.g. "The management takes input from the safety delegates seriously"), was given the name Supportive safety culture. Items #2 and #6 show a negative loading, which is explained by their inverted wording. Because the statements are answered with a Likert scale where 1 indicates fully agreeing and 5 indicates fully disagreeing, it should be expected that scores on these two items are closer to 5 while scores on the remaining six items are closer to 1 – or vice versa. In order to test the reliability, items #2 and #6 were reversed, and the resulting Cronbach's α was .82, which is above acceptable level of .70 (Beavers et al., 2013).

Procedures and guidelines. Dimension 2, containing six items reflecting employees experience with, and access to, safety procedures and HSE documents (e.g. "I have easy access to procedures and instructions concerning my work"), was named Procedures and guidelines. Cronbach's α was .82, the same as with dimension 1.

Absence of hazards. Dimension 3 consists of negatively worded statements. In order to simplify interpretation and comparison with the other dimension, the items in this dimension was reversed. Due to reversing the items, the dimension was given the name Absence of hazards. The six items of this dimension are concerned with organizational and day-to-day issues that have a negative effect on the safety of employees and/or the workplace (e.g. "There are often concurrent work operations which lead to dangerous situations"), which means that scoring low on this dimension indicate an absence of hazards. Cronbach's α was .73, somewhat lower than dimension 1 and 3, but still acceptable.

Safe behavior. Dimension 4, also comprising of six items, reflects respondents willingness to overrule work operations and report safety issues, and their belief that colleagues will do the same (e.g. "I stop work if I believe that it may be dangerous for me or others to continue"). The dimension was named Safe behavior, and it contains one item (#25), which is negatively phrased. This item loads negatively on the dimension, which is expected.

The reliability of the dimension is .69, barely below the recommended level of .70 (Beavers et al., 2013).

Training and Competence. Dimension 5, named Training, consists of two items regarding personnel training in safety and in working environment. It has a Cronbach's α of .76. Dimension 6, consisting of two dimensions regarding perceived personal competence, was named Competence, and has a Cronbach's α of .69. Table 2 provides an overview of the mean score, standard deviation and variance of the dimensions.

Table 2

Self reported assessment of safety climate, 2001 - 2003

Safety climate dimensions			
Dimension label	Mean	Standard deviation	Variance
1. Supportive safety culture	2.31	.39	.16
2. Procedures and guidelines	1.96	.72	.52
3. Absence of hazards (REV)	2.64	.82	.67
4. Safe behavior	1.85	.37	.14
5. Training	1.72	.77	.59
6. Competence	1.47	.65	.43

The mean of the six proposed dimensions is relatively low, ranging from 1.47 to 2.64. These dimensions are comprised of items, which – if scored low – indicate a positive safety culture. The third dimension, Absence of hazards, represents negative organizational or day-to-day issues, but because it is reversed a low mean score will represent a positive employee rating of the prevalence of hazards. This seems counter intuitive, but it is a product of the scoring of the responses of the items, where a high number will indicate a disagreement with the statement of the item.

Discussion

The research question in focus was: What is a psychometric and theoretical sound way to measure safety climate? In order to answer this, exploratory factor analysis and principal component analysis was used to reveal the underlying dimensional structure of the safety climate data from the RNNP survey. The theoretical basis for the concepts of safety culture and safety climate has been presented. Through theoretical and analytical assessment, items were removed gradually. The result is a six-dimensional structure containing 30 items with strong reliability and factor loadings above recommended levels.

In order to assess how psychometrically sound the proposed structure is, the discussion will start by comparing the proposed dimensional structure with previous psychometric studies of the RNNP survey and their proposed dimensional structure. Furthermore, the model of reciprocal safety culture proposed by Cooper (2000) will be compared with the six-dimensional structure of this thesis, in order to assess how theoretically sound the proposed structure is. The removed items (Appendix B), the length of the RNNP survey, the use of surveys for assessing safety culture and climate, and recommendations regarding future use of the survey will be discussed. Some essential issues with the theoretical basis for the RNNP survey will be addressed, followed by a conclusion where implications for future research on the safety climate concept will be presented.

The main research method for measuring the safety climate of an organization is through questionnaires, and samples of more than 500 is considered "good" when conducting factor analysis (Glendon & Stanton, 2000). Several tools for measurement of safety climate have been developed, both for the offshore oil industry and for other high-reliability industries such as the nuclear and aviation industry. Although safety culture and safety climate have been in focus in high-risk organizations in general, and the NCS in particular, for more than two decades (Haukelid, 2001), no unified dimensional structure of safety climate exists and the exact number of dimensions that make up safety climate remains in dispute (Guldenmund, 2000; Mearns et al., 2003; Tharaldsen et al., 2008). Some of the recurring dimensions from previous research are management commitment to safety, priority of safety over production, colleague involvement and open communication (Gordon, 1998; Mearns et al., 2003; Tharaldsen et al., 2008).

Psychometric properties of the Dimensional Structure

Tharaldsen et al. (2008) performed a psychometric study of the RNNP survey based on data from 2001 and 2003. A subsequent study by Høivik et al. (2009) confirmed, and developed, the dimensional structure proposed by Tharaldsen et al. (2008) by using data from

2005. Even though these two studies propose a fairly similar dimensional structure, they will be discussed separately. This is because they have used different data, and in such present some different results when it comes to factor loadings and reliability. The proposed dimensional structure, named The Hexagonal Safety Climate Structure, differs substantially from the dimensional structure proposed by Tharaldsen et al. (2008) and Høivik et al. (2009) in terms of reliability, size of the dimensions and factorial loadings.

Unfortunately, because the item contents of the dimensions differ, a direct comparison of dimensions will not make sense. Instead, the comparison will focus on clarifying the differences between the proposed dimensions of this thesis and the dimensions that are most similar in the Tharaldsen et al. (2008) and Høivik et al. (2009) studies, and an attempt to clarify the differences will be made. The comparison will use the proposed dimensions of this thesis as a reference.

Supportive safety culture. Dimension 1 of the Hexagonal Safety Climate Structure shares six of its items with the Safety management and involvement dimension of Tharaldsen et al. (2008) and Høivik et al. (2009). Item #1 in Table 1 is missing from the dimensional structure of Tharaldsen et al. (2008) and Høivik et al. (2009). The reason for why this particular item is missing is unknown, but it is likely that it was removed because of psychometric or theoretical reasons. Furthermore, items #4 and #7 - #11 in the Safety management and involvement dimension of Tharaldsen et al. (2008) and Høivik et al (2009) were removed from the analysis in this thesis because of extracted communalities below .40 (items #7 and #9) and multifactorial loadings above, or close to, .32 (items #4, #8, #10 and #11). This is in accordance with the recommendations that items which load either below .32 on a factor, or which loads .32 or higher on two or more factors should be considered dropped from the analysis (Costello & Osborne, 2005; Gaskin & Happell, 2014. More accurate factor solutions are achieved with communalities above .41, thus items with communalities less than .40 should be considered dropped (Gaskin & Happell, 2014). At the same time, items #1, #5 and #8 of the Supportive safety culture dimension have multifactorial loadings above .32 (Table 1). This might indicate that the proposed dimension is unsuited for the data, or that the items are poorly written. All three items concerned might have been removed, but because the sample size of the data is vastly larger than in the previous studies, it was decided to keep them.

Tharaldsen et al. (2008) and Høivik et al. (2009) did not report whether items had multifactorial loadings or not. Nevertheless, it is not unlikely that the items included in the Safety management and involvement dimension of the aforementioned studies in fact do

show multifactorial loadings and/or have low communalities, because these were the reasons for dropping them in the analysis in this thesis. The essence of the Safety management and involvement dimension, management's prioritization of safety and employees' feelings regarding involvement and influence (Tharaldsen et al., 2008), is equal to the essence of the Supportive safety culture dimension proposed in this thesis.

Furthermore, the reliability of the dimensions is fairly equal: Tharaldsen et al. (2008) reported Cronbach's α of .85 in data from 2001 and 2003, Høivik et al. (2009) reported Cronbach's α of .84, and Cronbach's α of dimension 1 in this thesis is .82. This suggests that the reliability of the dimensions is equally good. But, as Field (2013) writes, when the number of items in a factor increases, the α of the factor will increase. This means that a high α might reflect a large number of items, and not an internal consistent factor. This is exemplified by Cortina (1993), which shows that a scale with α = .80 will have an average item correlation of .57 if it contains three items, but average item correlation drops to .28 when the scale contains 10 items. In conclusion, the reliability, potential multifactorial loadings and communality of the items in the Tharaldsen et al. (2008) and Høivik et al. (2009) dimension Safety management and involvement can be questioned. The proposed dimension 1 of this thesis conserve the essence of the aforementioned dimension, and in the same time maintains a high reliability with fewer items. It does however include three items with multifactorial loadings above .32. In spite of this, the totality of arguments in favor of the proposed dimension 1 of this thesis suggest it is a better dimension than the corresponding dimension in the studies of Tharaldsen et al. (2008) and Høivik et al. (2009).

Procedures and guidelines. The second dimension of the Hexagonal Safety Climate Structure shares three items with the System comprehension dimension of the Tharaldsen et al. (2008) and Høivik et al. (2009) studies. In the Tharaldsen et al. (2008) study, the dimension contains four items, while in the Høivik et al. (2009) study it contains three items. None of the items in either of the abovementioned dimensions include items with multifactorial loadings, and all of the items appear to load sufficiently on their dimensions.

Item #13 and #14 in Table 1 are not included in the proposed dimensional structure of either Tharaldsen et al. (2008) or Høivik et al. (2009). The reason behind this is unknown, since neither demonstrates low communalities or low, or multifactorial, loadings in the proposed dimensional structure of this thesis. The reliability of the proposed dimension of this thesis differs quite a lot from the reliability reported by Tharaldsen et al. (2008) and Høivik et al (2009). Cronbach's α is .82 for the proposed dimension, while Tharaldsen et al. (2009) reports Cronbach's α of .67 for both 2001 and 2003 data, and Høivik et al. (2009) reports

Cronbach's α of .65. The opposite of what was discussed for dimension 1 may be happening with dimension 2: Due to the fact that dimension 2 of this thesis has six items, its reliability might be inflated in a way that does not happen with the corresponding dimension of the Tharaldsen et al. (2008) and Høivik et al. (2009) studies.

The essence of the proposed dimension 2 in this thesis is the same as the essence of the System comprehension dimension. The intention of both dimensions is to measure employees' experience with and understanding of safety related procedures and documents. It is not necessarily straightforward defining which of the dimensions fits better to the data provided, although the proposed dimension does contain more items related to safety procedures than the corresponding dimension in the Tharaldsen et al. (2008) and Høivik et al. (2009) studies.

Absence of hazards. The proposed dimension 3 of this thesis corresponds to the Safety versus production dimension of Tharaldsen et al. (2008) and Høivik et al. (2009). Item #2 of the Safety versus production dimension has been removed from the analysis in this thesis because of multifactorial loadings. At the time of removal, it had a loading of -.47, .39 and .35 on three different factors, and its strongest loading was on the factor that eventually became the Supportive safety culture dimension of this thesis. The sum of these issues led to it being removed.

Item #20 in Table 1, "Reports about accidents or dangerous situations are often "embellished"", loads towards both factor one (-.41) and factor three (.53) in the factor solution. This indicates that the item could have been dropped from the analysis (Costello & Osborne, 2005), although its theoretical importance was deemed more important, partially because the reliability of the dimension would have dropped from Cronbach's α = .73 to Cronbach's α = .68 if the item was removed. Removing the item would have seen the reliability dropping below the levels of Tharaldsen et al. (2008) and Høivik et al. (2009), which reported Cronbach's α of .70 for 2001 data, .73 for 2003 data and .74 for 2005 data. However, this particular item is also part of the Safety versus production dimension of Tharaldsen et al. (2008) and Høivik et al. (2009), which supports the decision of keeping the item.

As was the case with dimension 2, the essence of this dimension is equal to the Safety versus production dimension of Tharaldsen et al. (2008) and Høivik et al. (2009). They all have in common that they reflect framework conditions and day-to-day issues that have a negative effect on the safety of employees and/or the organization. The proposed dimension of this thesis contains three items (#15, #18 and #19) that are not part of the dimensional

structure of Tharaldsen et al. (2008) and Høivik et al. (2009). The reason behind not including these is unknown, although it can be speculated that these items did not have sufficient factor loading, or they might have shown multifactorial loadings in the previous studies. In the case of this thesis, the items in question show loadings of .65, .63 and .60, respectively, which is considered as strong loadings (Costello & Osborne, 2005).

Safe behavior. The proposed dimension 4, consisting of items #21 - #26 in Table 1, can be compared with the Individual motivation dimension of Tharaldsen et al. (2008) and Høivik et al. (2009). They do differ to some extent, mainly because item #25 and #26 of Table 1 is not part of the corresponding dimension of Tharaldsen et al. (2008) and Høivik et al. (2009). Item #25 is part of the Tharaldsen et al. (2008) and Høivik et al. (2009) dimension named Safety prioritization, while item #26 has been removed in their studies. It is likely that item #26 was removed because of multifactorial loading, since this is the case in the factor solution of this master thesis. The item has a loading of -.39 on factor four and .47 on factor 5. The item was placed in dimension four because of its theoretical meaning and because it fitted better there than in dimension five. The item "I use personal protective equipment", which is part of the Individual motivation dimension of Tharaldsen et al. (2008) and Høivik et al. (2009) was removed from the RNNP survey before data collection in 2013 (PSA, 2013a), thus it was not part of the analysis in this thesis.

Item #24 in Table 1 is multifactorial; it has loadings of .48 on factor four and .37 on factor five. This is higher than recommended by Costello and Osborne (2005), but it was decided to keep the item and incorporate it into dimension four because of its relevance for the dimension. The item loading is much higher in the analysis of this thesis than in the Høivik et al. (2009) study (.28) – but not very much different from the Tharaldsen et al. (2008) study, where loadings of .44 and .39 was reported from the 2001 and 2003 data, respectively.

The reliability of the proposed dimension, measured by a Cronbach's α of .69, is close to the reported reliability of both Tharaldsen et al. (2008) and Høivik et al. (2009), which is .67, .67 and .68 for the data from 2001, 2003 and 2005, respectively. Because the Safe behavior dimension proposed in this thesis contains six items, and the corresponding dimensions in previous studies contain five, it can be argued that the proposed dimension is not a better measure than the existing dimension of previous studies – due to the fact that an increase in items will inflate the reliability of a factor (Field, 2013).

Training. This dimension consists of items #28 and #29 in Table 1. It has no direct correspondence with any of the dimensions of the Tharaldsen et al. (2008) study, but it does

correspond to the Competence dimension of the Høivik et al. (2009) study. The Competence dimension proposed by Høivik et al. (2009) has a lower reliability (Cronbach's α = .72) than the Training dimension of this thesis (Cronbach's α = .76), as well as lower factor loadings for the two items in question. Høivik et al. (2009) report factor loadings of .61 and .53, while the factor loadings of the items in the Training dimension are .74 and .71.

Competence. This dimension consists of items #29 and #30, and has a Cronbach's α of .69. It does not correspond to any of the dimensions in the Tharaldsen et al. (2008) or Høivik et al. (2009) studies.

When viewed in total, it appears that dimension one and two are, psychometrically and theoretically, more fitting for the data than their corresponding dimensions in the Tharaldsen et al. (2008) and Høivik et al. (2009) studies. Dimension three and four might not be more psychometrically fitting, but in a theoretical light it is possible to say that they are better because they include more items regarding the overall concept they are said to reflect, while at the same time maintaining the psychometric strength. It is harder to determine whether dimension five and six fits better to the data. On one hand, dimension five is more psychometrically fitting, both in terms of reliability and factor loadings. On the other hand, neither one corresponds particularly well to any of the dimensions in the Tharaldsen et al. (2008) or Høivik et al. (2009) studies. At the same time, dimensions containing less than three items are generally regarded as both weak and unstable (Costello and Osborne, 2005), which disfavors dimension five and six. An attempt at counteracting this was made by measuring the Cronbach's α of a combined dimension five and six, which resulted in Cronbach's α of .75. If the four items of these two dimensions were forced together through a fixed five-factor solution, they would have loadings of .69 (#27), .66 (#28), .66 (#29) and .61 (#30). A solution could have been to use a forced five-factor solution, although this would have affected the other factor loadings in a negative way, as well as reducing the explained variance of the solution to 49,6 %.

The proposed structure is equally, though most likely more psychometrically fit for measuring the safety climate dimensional structure than the previous structures proposed by Tharaldsen et al. (2008) and Høivik et al. (2009). It is most likely more psychometrically fit, due to the fact that it proposes a more even distribution of items across dimensions, it shows strong factor loadings and reliability across the dimensions and it explains more than 53 % of the variance in the data. Even though the proposed solution contains six items with multifactorial loadings, this is less than what is believed to be the case with the solutions of

Tharaldsen et al. (2008) and Høivik et al. (2009), which includes 10 items that have showed multifactorial loadings in the analysis of this thesis.

Cooper's Reciprocal Model of Safety Culture

The reciprocal model of safety culture proposed by Cooper (2000) provides the framework for the RNNP survey (Tharaldsen et al., 2008; PSA, 2001). The main focus of Cooper (2000) is that the links between personal, behavioral and situational aspects of safety needs to be empirically investigated because these links are reciprocal. When developing the RNNP survey, it was important that the final instrument contained items that addressed safety practices, individual safety skills and experience, and situational aspects relevant for safety behavior (Tharaldsen et al., 2008). In spite of basing the RNNP survey on a theoretical model that contained three dimensions, a three-dimensional solution in accordance with the model was not found (Tharaldsen et al., 2008).

Cooper (2000) is concerned with defining an outcome measure of safety culture, because this might aid in determining whether an organization has a "good" or a "bad" safety culture. Cooper uses the ACSNI definition of safety culture as a basis, and stresses the importance of conceptualizing the "product" of the definition. Cooper (2000, p. 115) suggests defining the product as "That observable degree of effort with which all organisational (sic) members direct their attention and actions towards improving safety on a daily basis". This definition of the product provides a tangible outcome measure which is possible to measure – for instance through surveys.

When determining whether the proposed dimensional structure of this thesis fits Cooper's model of safety culture, one has to compare the concepts of the proposed dimensions with the elements of the model. First of all, a three-dimensional structure was not obtained, which is consistent with Tharaldsen et al. (2008) and Høivik et al. (2009). Figure 2 provides an overview of the proposed contents of each element of the safety climate construct. As seen in Figure 2, the content of the three elements of safety climate is quite broad. This is practical when assessing the fit of a dimensional structure, but it also highlights the theoretical and empirical complexity of the safety climate concept. It is hard to imagine a dimensional structure of safety climate that would not fit within the reciprocal model of safety culture, simply because the elements of safety climate are so universal.

Regardless of this, an assessment of the fit of the Hexagonal Safety Climate Structure with Cooper's reciprocal model of safety climate (2002) should be made. The following is considered as appropriate: It is proposed that Dimension 1 "Supportive safety culture" fits with the Organization construct (Figure 2). Dimension 2 "Procedures and guidelines" fits

within the Job construct. Dimension 3 "Absence of hazards" fits within both the Organization and the Job construct, although it seems to be more in compliance with the Job construct. Dimension 4 "Safe behavior", Dimension 5 "Training" and Dimension 6 "Competence" fit with the Person construct of Figure 2. The assessment shows that the proposed dimensional structure of this thesis fits well with the theoretical basis of the RNNP survey. Although, one might question whether it is an issue that the Organization construct of safety climate seems to be less represented than the Person and Job constructs in the proposed dimensional structure. It is important to note that the items of the proposed "Supportive safety culture" dimension covers most of the topics mentioned by Cooper (2002) in the Organization construct of safety climate. This, in combination with other safety assessment methods used by the PSA, indicates that the construct is sufficiently represented by the dimensional structure presented in this thesis.

Another issue that is relevant is the fact that the proposed dimensional structure does not contain a specific dimension focusing on communication. Yet, four of the six dimensions contain items that are related to, or directly concerned with, communication. Communication permeates the dimensional structure, which points to communication being essential both for employee participation, management commitment to safety and employee responsibility to take action. This is true also for the dimensional structure proposed by both Tharaldsen et al. (2008) and Høivik et al. (2009).

The Removed Items

A total of 22 of the 52 items of the RNNP survey that appears to relate to safety climate, were removed (Appendix B) from analysis during the PCA. This was either due to psychometric issues such as low communality or multifactorial loadings, or due to theoretical assessments related to the "fit" of the item within the factor solution. In the case of the Tharaldsen et al. (2008) and Høivik et al. (2009) studies, 20 and 17 items, respectively, where removed from the dimensional structure.

Although many items were removed, this does not mean that the items in question are unimportant for measuring the safety climate amongst employees in the Norwegian oil and gas industry. Tharaldsen et al. (2008) do not discuss the implication of removing items from the analysis, and Høivik et al. (2009) appear to have chosen only the 35 items of the RNNP survey that was relevant for their study. Most, if not all, of the removed items in Appendix B should provide important information regarding employee perception of the safety climate. The items are concerned with areas such as attitudes towards safety, management commitment to safety, organizational safety measures and emergency preparedness. All of

these areas have been found to be important parts of safety climate in earlier studies (Gordon, 1998; Mearns et al., 2003; Tharaldsen et al., 2008), and a decision of whether to remove or keep some of the items from the RNNP survey must be done with great caution.

According to the PSA (2013a), the RNNP survey consists of 111 questions, plus demographic questions. This raises an issue of whether deterioration of the motivation of participants can affect the data obtained. Herzog and Bachman (1981) found that people tend to respond in a more stereotypical way in later parts of a long survey – but the effect is not necessarily big enough to affect the data in any substantial way. Cole, McCormick and Gonyea (2012) found that straight lining – i.e. selecting the same response option for a continuous set of items – increased over the length of surveys, and that the behavior is more frequent among males. This is an issue that should concern the PSA, particularly because the overwhelming majority of respondents of the RNNP survey are male, and that the length of the survey is substantial. These issues might be avoided by reducing the number of questions in the RNNP survey.

Another issue for concern is that certain items, particularly #6, #11, #17, #18 and #19 of Appendix B, seem to be either double-barreled or ambiguously worded. An example of these issues can be seen in item #19 "I do not participate actively in HSE meetings". This item forces the respondent to define "participate actively", which is a subjective and undefined measure. It is difficult to determine what "actively" means, and as such it is impossible to extract any useful information from the data of this item. A rephrasing of the item into "I am reluctant to speak my mind in HSE meetings" or "HSE meetings do not interest me" might be a better choice, if the point is to investigate the respondents view towards the importance of HSE meetings or if a culture of conformity exists in the workplace.

As far as this author is aware, no qualitative assessment of the safety climate related items of the RNNP survey has been conducted since the survey was developed in 1999/2000. Although the PSA reports that the RNNP survey has been subject to improvements over the years (PSA, 2013a), this is only exemplified by the necessity of adding items when new topics are made current. With the psychometric, theoretical and conceptual issues in mind, it might be time to refurbish the RNNP survey and re-evaluate the purpose of assessing safety climate in the NCS by the use of quantitative measurement techniques such as surveys.

Theoretical Issues of the Safety Climate Concept

According to Cooper (2000), one issue with safety climate measurement is that many of the studies that have measured safety climate have combined attitudinal, behavioral, affective and descriptive constructs within the same measure. This may provide larger

correlations than if these constructs were measured with different measurement techniques (e.g. safety climate scores and accident frequencies), and this in turn might explain why different factor structures emerge from different research groups (Cooper, 2000).

The fact that Cooper (2002) provides such a broad theoretical content of the three dimensions of safety climate points towards a larger issue within the field of safety climate and safety culture. Several scientists have pointed out that the concepts lack clarity when it comes to definitions, conceptualizations and possibly even validity (Cooper, 2000; Cox & Cheyne, 2000; Cox & Flin, 1998; Guldenmund, 2000; Mearns et al., 2003). These issues should be the main focus of scientists within the field, because as long as the content and definition of the concepts and how they relate to each other remain a topic of discussion and disagreement, there really is no point in trying to measure safety climate and safety culture through quantitative methods, as far as this author sees it.

Researchers within the organizational psychology field should, as a minimum, clarify the differences between the concepts of safety climate and safety culture. According to Antonsen (2009), the predominant way of measuring safety culture is through survey-based assessment – but because of the lack of clarity and agreement of the differences, or similarities, of safety culture and safety climate, it is not even clear whether the label "climate" or "culture" is more appropriate for certain studies (Antonsen, 2009).

Issues of the predictability of survey-based assessments of the safety culture within an organization is brought forward by Antonsen (2009), which compared the safety culture results of a survey conducted on the Snorre Alpha platform with qualitative investigations of a blowout incident on the same platform a year later. Antonsen (2009) found that there was a considerable gap between the safety culture assessment of the survey and the depiction of the safety culture through the post-accident investigation. Where the survey results depicted that safety was highly prioritized and risk assessments were carried out at all times, the investigation found that safety was discarded in favor of meeting production targets and that risk assessments were lacking (Antonsen, 2009). Furthermore, the survey indicated that communication was working well and that rules and procedures were complied with, but the investigation found that the communication climate was weak, that procedures were often breached and that a culture of non-compliance was dominant (Antonsen, 2009). This should be an eye opener to the major issues related to the measurement and assessment of safety culture and safety climate in high-risk industries.

The safety climate construct, and its connection with safety culture, is of great importance for understanding how industries such as the oil and gas industry can achieve as

few accidents and injuries as possible. Nevertheless, conceptual, psychometric and theoretical obstacles must be addressed if the safety climate construct shall remain useful for scientific investigation of employee's perception of safety. The use of surveys to measure employee perception seems to be associated with low generalizability and issues with validity. These are basic methodological essentials that should make scientists question how they present findings of safety climate, and how safety climate can be measured in a more purposeful way. Perhaps the use of qualitative methods, such as interviews and focus group discussions might provide a more holistic picture of the safety climate of an organization. After all, the employee's perceptions of their safety are what should be in focus, if the point is to reduce the risk of accidents in the organization.

Conclusion

The goal of this thesis has been to answer the research question "What is a psychometric and theoretical sound way to measure safety climate?" through assessing the proposed dimensional structure obtained from analysis in light of the theoretical basis of the RNNP survey. This thesis has proposed a new dimensional structure, consisting of 30 items, for the concept of safety climate, based on exploratory principal component analysis of 52 safety climate items of the RNNP survey. Principal components analysis shows that the proposed dimensional structure provides stronger factor scores, communalities and reliability than the dimensional structures of Tharaldsen et al. (2008) and Høivik et al. (2009). Furthermore, the proposed dimensional structure does fit with the theoretical basis of the RNNP survey, although the theoretical model defines safety climate in such a broad way that it is difficult to imagine any structure that would not fit. 22 of the 52 items where removed, either because of theoretical or psychometrical issues.

This underlines that the safety climate and safety culture concepts still have significant potential for improvement: There is no unified definition or conceptualization of these concepts, and they appear to have low validity when measured through survey-based methodologies. These issues were seen as critical during the development of the RNNP survey (PSA, 2001), and it seems that they have yet to be solved. Improving these issues should be prioritized in future research within the field.

The items of the RNNP survey give valuable information about the employees' perception of the safety on their workplace. A thorough revising of the items' wording should be conducted, in order to assure that no ambiguity is present and to strengthen the quality of the survey. The Hexagonal Safety Climate Structure suggested in this thesis provides a promising starting point for further development and improvement of the RNNP survey and the safety climate concept. Future research should focus on testing the dimensional structure against external and objective outcome variables such as accident and injury rates. Other essential measures of the strength of the dimensional model are the fit and congruence, as well as the concurrent and predictive validity. In light of the current state of the safety climate concept, it is essential that these measures are objects of future testing of the model.

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Appendix A
The RNNP survey, english version

1 **Sex**

☐ Male ☐ Female

2 **Age**

☐ 20 years or younger ☐ 21-24 years ☐ 25-30 years ☐ 31-40 years
☐ 41-50 years ☐ 51-60 years ☐ 61 years or older

3 **Nationality**

☐ Norwegian ☐ British ☐ Swedish ☐ Danish ☐ Other

4 **If you replied "other", please specify. Use capital letters.**

5 **Which sort of education do you have?**

☐ Apprentice ☐ Unskilled ☐ University ☐ Upper secondary school (no trade certificate)
☐ Skilled with one trade certificate ☐ Skilled with more than one trade certificate ☐ Trade-specific certificate(s)

6 **If you replied "trade-specific certificate(s)": which ones? Please use capital letters.**

7 **Approx. how much of your working hours during the last year have been spent...**

	None at all	1 - 24 per cent	25 - 49 per cent	50 - 74 per cent	75 - 100 per cent
offshore	☐	☐	☐	☐	☐
in oil/gas-related activities on land	☐	☐	☐	☐	☐
in other work/education	☐	☐	☐	☐	☐

8 **How long have you worked offshore?**

☐ 0 - 3 months ☐ 4 months - 1 year ☐ 2 - 5 years
☐ 6 - 10 years ☐ 11 - 19 years ☐ 20 years or more

9 **Which company are you employed in? Please use capital letters.**

10 **Do you have permanent or temporary employment?**

☐ Permanent ☐ Temporary

11 **What is your position title? Please use capital letters.**

12 **How long have you been employed in your present position?**

☐ 0 - 3 months ☐ 4 months - 1 year ☐ 2 - 5 years
☐ 6 - 10 years ☐ 11 - 19 years ☐ 20 years or more

13 **In what area do you work? If you work within several areas, select the one most appropriate for your position.**

☐ Process ☐ Drilling ☐ Well service ☐ Catering ☐ Construction/ modification
☐ Maintenance ☐ Crane/deck ☐ Administration ☐ Other

14 **If you replied "other", please specify. Use capital letters.**

15 **Do you have management responsibilities?**

☐ No ☐ Yes, with personnel responsibility ☐ Yes, without personnel responsibility

16 **Do you work in permanent offshore rotation?**

☐ Yes ☐ No

17 **What is your current shift arrangement?**

☐ Permanent day shift ☐ Permanent night shift ☐ Fixed shift (14 nights/14 days every second tour) ☐ Swing shift with 7 nights first, then 7 days
☐ Swing shift with 7 days first, then 7 nights ☐ Staggered hours ☐ Shift arrangements vary

18 **What is the name of the installation where you are currently working?**

19 **Do you work permanently on this installation?**

☐ Yes, every tour ☐ Yes, mostly ☐ No, it varies

20 **During a typical work period, how often do you travel by helicopter between your place of work and your accommodation ("shuttling" to other accommodation offshore or commuting onshore for hotel accommodation)?**

☐ Always/nearly always ☐ A few times during the period ☐ Never/almost never ☐ Varies much from period to period

21 **Have you been assigned any emergency preparedness functions?**

☐ Yes ☐ No

22 **If yes, tick the boxes for your assigned emergency preparedness function(s).**

☐ Lifeboat coxswain ☐ Fire team ☐ Man-over-board boat (MOB boat) ☐ First aid
☐ Helicopter landing officer (HLO) ☐ Rescue leader ☐ Emergency team leader ☐ Other

23 **If you replied "other", please specify. Use capital letters.**

24 **Do you currently hold the office of...**

	Yes	No
Employee representative?	☐	☐
Safety delegate?	☐	☐
Member of working environment committee?	☐	☐

25 **Have you done the mandatory 40-hour basic course for safety delegates and members of working environment committees?**

❑ Yes ❑ No

26 **During last year, have you experienced reorganisations that affect the way you plan and/or carry out your work on the facility?**

❑ I have experienced reorganisations with significant consequences

❑ I have experienced reorganisations with moderate consequences

❑ I have experienced reorganisations without significant consequences for my work

❑ I have not experienced reorganisation

27 **During the last year, has your workplace been subjected to workforce reductions or redundancies?**

❑ Yes ❑ No

28 **During the last year, have you experienced changes in your work situation as a result of land and offshore being more closely connected through modern information technology?**

(for instance integrated operations, moving work tasks to land, remote control, remote support, remote monitoring or similar)

❑ Yes ❑ No

29 **Below are some statements of importance to health, working environment and safety (HSE). Some statements only apply to working environment or safety. Based on your experiences from your workplace, indicate to what degree you agree with the various statements by placing an X in one box for each statement. If you find a statement irrelevant, leave the box unchecked**

	Fully agree	Partially agree	Neither agree nor disagree	Partially disagree	Fully disagree
Risk-filled operations are always carefully planned before they are begun	❑	❑	❑	❑	❑
At times, I am pressured to work in ways that threaten safety	❑	❑	❑	❑	❑
My lack of knowledge of new technology may sometimes increase accident risk	❑	❑	❑	❑	❑
There is enough manning to properly safeguard HSE	❑	❑	❑	❑	❑
I have the necessary competence to perform my job in a safe manner	❑	❑	❑	❑	❑
I am thoroughly familiar with the HSE procedures	❑	❑	❑	❑	❑
The management takes input from the safety delegates seriously	❑	❑	❑	❑	❑
My workplace is often messy	❑	❑	❑	❑	❑
I feel uncomfortable pointing out breaches of safety rules and procedures	❑	❑	❑	❑	❑
The work permit (WP) system is always adhered to	❑	❑	❑	❑	❑

	Fully agree	Partially agree	Neither agree nor disagree	Partially disagree	Fully disagree
I can influence HSE matters at my workplace	❑	❑	❑	❑	❑
I sometimes breach safety rules in order to get a job quickly done	❑	❑	❑	❑	❑
In practice, production takes priority over HSE	❑	❑	❑	❑	❑
Information about undesirable incidents is used efficiently to prevent recurrences	❑	❑	❑	❑	❑
I use mandatory personal protection equipment	❑	❑	❑	❑	❑
I do not participate actively in HSE meetings	❑	❑	❑	❑	❑
Being too preoccupied with HSE can be a disadvantage to your career	❑	❑	❑	❑	❑
Communication between me and my colleagues often fail in a way that may lead to dangerous situations	❑	❑	❑	❑	❑
The HSE laws and regulations are not good enough	❑	❑	❑	❑	❑
I would rather not discuss HSE with my immediate supervisor	❑	❑	❑	❑	❑
Deficient maintenance has caused poorer safety	❑	❑	❑	❑	❑
I stop work if I believe that it may be dangerous for me or others to continue	❑	❑	❑	❑	❑
My manager appreciates me pointing out matters of importance to HSE	❑	❑	❑	❑	❑
I have been given adequate safety training	❑	❑	❑	❑	❑
I have been given adequate working environment training	❑	❑	❑	❑	❑
My colleagues will stop me if I work unsafely	❑	❑	❑	❑	❑
I doubt that I will be able to perform my emergency preparedness tasks in case of an emergency	❑	❑	❑	❑	❑
There are often concurrent work operations which lead to dangerous situations	❑	❑	❑	❑	❑
The accident preparedness is good	❑	❑	❑	❑	❑
Reports about accidents or dangerous situations are often "embellished"	❑	❑	❑	❑	❑
I ask my colleagues to stop work which I believe is performed in an unsafe manner	❑	❑	❑	❑	❑
The company I work for takes HSE seriously	❑	❑	❑	❑	❑

	Fully agree	Partially agree	Neither agree nor disagree	Partially disagree	Fully disagree
Lack of cooperation between operators and contractors often lead to dangerous situations	❑	❑	❑	❑	❑
I report any dangerous situations I see	❑	❑	❑	❑	❑
Safety is my number one priority when I work	❑	❑	❑	❑	❑
My supervisor is committed to the HSE work on the facility	❑	❑	❑	❑	❑
It is easy to tell the nurse/company health service about complaints and illnesses that might be work-related	❑	❑	❑	❑	❑
My colleagues are very committed to HSE	❑	❑	❑	❑	❑
I am unsure about my role in the emergency preparedness organisation	❑	❑	❑	❑	❑
The safety delegates do a good job	❑	❑	❑	❑	❑
I think it is easy to find what I need in the governing documents (requirements and procedures)	❑	❑	❑	❑	❑
I always know who to report to in the organisation	❑	❑	❑	❑	❑
The HSE procedures cover my work tasks	❑	❑	❑	❑	❑
Different procedures and routines at different facilities may pose a threat to safety	❑	❑	❑	❑	❑
I feel sufficiently rested when I am at work	❑	❑	❑	❑	❑
The equipment I need to carry out my work safely is easily available	❑	❑	❑	❑	❑
I have easy access to procedures and instructions concerning my work	❑	❑	❑	❑	❑
Increased cooperation between a facility and land through IT systems has led to less safe operations	❑	❑	❑	❑	❑
I feel a group pressure which affects HSE assessments	❑	❑	❑	❑	❑
I have access to the information necessary to make decisions which ensure the HSE aspect	❑	❑	❑	❑	❑
Dangerous situations arise because everyone does not speak the same language	❑	❑	❑	❑	❑
I experience a pressure not to report personal injuries or other incidents which may "mess up the statistics"	❑	❑	❑	❑	❑
I know which chemicals I may be exposed to	❑	❑	❑	❑	❑
I have been informed of the risks of the chemicals I work with	❑	❑	❑	❑	❑
I have been informed of the risks associated with noise	❑	❑	❑	❑	❑
There have been dangerous situations because people have been under the influence of alcohol or drugs at work	❑	❑	❑	❑	❑

30 **Perceived risk: Below is a list of some hazard and accident situations which may occur on the petroleum facilities. Please state how much of a hazard you feel the different situations constitute to you. Place an X in one box for each situation.**

	Very slight hazard (1)	(2)	(3)	(4)	(5)	Very great hazard (6)
Helicopter accident	❑	❑	❑	❑	❑	❑
Gas leak	❑	❑	❑	❑	❑	❑
Fire	❑	❑	❑	❑	❑	❑
Explosion	❑	❑	❑	❑	❑	❑
Blowout	❑	❑	❑	❑	❑	❑
Emissions/discharge of toxic gases/substances/chemicals	❑	❑	❑	❑	❑	❑
Radioactive sources	❑	❑	❑	❑	❑	❑
Collisions with ships/vessels/floating objects	❑	❑	❑	❑	❑	❑
Sabotage/acts of terror	❑	❑	❑	❑	❑	❑
Collapse of the installation's load-bearing structures or loss of buoyancy	❑	❑	❑	❑	❑	❑
Serious work accidents	❑	❑	❑	❑	❑	❑
Falling objects	❑	❑	❑	❑	❑	❑
IT systems failure	❑	❑	❑	❑	❑	❑

31 **Below is a list of some matters concerning free periods offshore. Indicate how often you are inconvenienced by these issues by marking one box for each question with an "X".**

	Very rarely or never	Quite rarely	Sometimes	Quite often	Very often or always
Is there disturbing noise in the public rooms in the accommodation quarters?	❑	❑	❑	❑	❑
Is there disturbing noise in your cabin?	❑	❑	❑	❑	❑
Do you find the indoor climate poor in the public areas of the accommodation quarters?	❑	❑	❑	❑	❑
Do you find the indoor climate poor in your cabin?	❑	❑	❑	❑	❑
Are the accommodation quarters clean and tidy?	❑	❑	❑	❑	❑

32 **Indicate how satisfied or dissatisfied you are with the different matters. Mark with an "X"**

	Very satisfied	Satisfied	Neither satisfied nor dissatisfied	Dissatisfied	Very dissatisfied
Quality of food and drink	❑	❑	❑	❑	❑
Cabin conditions	❑	❑	❑	❑	❑
Exercise opportunities	❑	❑	❑	❑	❑
Other recreational opportunities	❑	❑	❑	❑	❑
Comfort during helicopter transport	❑	❑	❑	❑	❑

33 **Below is a list of some questions concerning your work situation. Indicate your experience of the various issues by ticking one box for each question.**

	Very rarely or never	Quite rarely	Sometimes	Quite often	Very often or always
Are you exposed to noise levels so high that you have to stand close to people and shout to be heard, or have to use headsets?	❑	❑	❑	❑	❑
Are you exposed to vibrations to your hands or arms from machines or tools?	❑	❑	❑	❑	❑
Do you work in cold areas exposed to the weather?	❑	❑	❑	❑	❑
Do you work under unsatisfactory indoor conditions?	❑	❑	❑	❑	❑
Do you experience difficulties seeing what you are doing due to insufficient, weak or blinding lighting?	❑	❑	❑	❑	❑
Is your skin exposed to e.g. oil, drilling mud, detergents or other chemicals?	❑	❑	❑	❑	❑
Can you smell chemicals or clearly see smoke or dust in the air?	❑	❑	❑	❑	❑
Do you do heavy lifting?	❑	❑	❑	❑	❑
Do you have to twist or bend your upper body when lifting?	❑	❑	❑	❑	❑
Do you do repetitive and monotonous movements?	❑	❑	❑	❑	❑
Are your hands at or above shoulder height when working?	❑	❑	❑	❑	❑
Do you work in a squatting position or on your knees?	❑	❑	❑	❑	❑
Is your work static sitting with little possibility of variation?	❑	❑	❑	❑	❑
Is it necessary to work very fast?	❑	❑	❑	❑	❑
Do you find the shift arrangement a strain?	❑	❑	❑	❑	❑
Do you work so much overtime that it is a strain?	❑	❑	❑	❑	❑
Do you get sufficient rest/recreation between workdays?	❑	❑	❑	❑	❑
Do you get sufficient rest/recreation between work periods?	❑	❑	❑	❑	❑
Is your workplace well adapted to the work tasks you perform?	❑	❑	❑	❑	❑
Does your work require so much attention that you find it a strain?	❑	❑	❑	❑	❑
Is your work challenging in a positive way?	❑	❑	❑	❑	❑
Does your immediate supervisor value your work results?	❑	❑	❑	❑	❑

	Very rarely or never	Quite rarely	Sometimes	Quite often	Very often or always
Can you set your own work speed?	❑	❑	❑	❑	❑
Can you influence decisions which are important to your work?	❑	❑	❑	❑	❑
Can you influence the way you perform your work?	❑	❑	❑	❑	❑
Do your colleagues help and support you in your work, if you need it?	❑	❑	❑	❑	❑
Does your immediate supervisor help and support you in your work, if you need it?	❑	❑	❑	❑	❑
Do you feel that the cooperation climate in your work unit is encouraging and supportive?	❑	❑	❑	❑	❑
Do you have so many tasks that it becomes hard to concentrate on each one?	❑	❑	❑	❑	❑
Does your immediate supervisor give you feedback on your work performance?	❑	❑	❑	❑	❑
Do you have the necessary access to IT-/computer systems?	❑	❑	❑	❑	❑
Do you get necessary training in the use of new IT systems?	❑	❑	❑	❑	❑
Do the IT systems you use provide the necessary support in the performance of your work tasks?	❑	❑	❑	❑	❑

34 **Do you feel sure that you will have a job as good as the one you have now in two years' time?**

❑ Very sure ❑ Quite sure ❑ Somewhat sure ❑ Quite unsure ❑ Very unsure

35 **Over the last six months, have you been subjected to repeated bullying and harassment at your workplace?**

❑ Yes ❑ No

36 **If yes, by whom? Feel free to place an X in more than one box.**

❑ Colleagues ❑ Supervisor(s) ❑ Subordinates ❑ Others at the facility

37 **Indicate how often you feel the various statements apply to you by marking one box per statement with an "X".**

	Very often or always	Quite often	Sometimes	Quite rarely	Very rarely or never
I sleep well when offshore	❑	❑	❑	❑	❑
I sleep well the last few nights before going offshore	❑	❑	❑	❑	❑
I sleep well the first few nights after an offshore tour	❑	❑	❑	❑	❑
I have a problem with noise when sleeping offshore	❑	❑	❑	❑	❑
I must share cabins with others when I sleep	❑	❑	❑	❑	❑

38 **How many hours**

	Hours
... were you awake before going on your first shift?	☐☐
...overtime did you work on your last tour?	☐☐

39 **How many days did you spend offshore on your last tour?**

☐☐

40 **Have you worked more than 16 hours during the course of a 24-hour period one or more times during the last year?**

☐ Yes ☐ No

41 **During your last offshore tour, were you woken up in your free time to do a work task?**

☐ Yes ☐ No

42 **Do you normally have one or more additional jobs when you are on land between offshore tours?**

☐ Yes ☐ No

HEALTH

43 **Have you been absent from work because you have been ill during the last year?**

☐ No ☐ Yes, 1-14 days ☐ Yes, more than 14 days

The next question should only be answered if you answered "yes" to the last question. If you answered "no", proceed to question 45.

44 **Do you believe that your last sick leave period was fully or partly caused by your work situation?**

☐ Yes ☐ No

45 **Have you been injured in a work accident while at the facility during the last year?**

☐ Yes ☐ No

46 **If yes, was the injury reported to your supervisor or nurse/ company health service?**

☐ Yes ☐ No

47 **If so: How was the injury classified?**

☐ First aid ☐ Medical treatment ☐ Alternative work
☐ Lost time injury ☐ Serious lost time injury

48 **Working capacity**

	Very good	Quite good	Moderate	Quite poor	Very poor
How do you evaluate your own work capacity with respect to the physical demands at work?	☐	☐	☐	☐	☐
How do you evaluate your own work capacity with respect to the psychological demands at work?	☐	☐	☐	☐	☐

49 Over the last three months, have you been troubled by any of the following:

	Not troubled	A little troubled	Quite troubled	Very troubled	Mark ("X") here if you feel that your symptoms are fully or partially caused by your work situation
Reduced hearing	❑	❑	❑	❑	❑
Ringing in the ears	❑	❑	❑	❑	❑
Headache	❑	❑	❑	❑	❑
Neck/shoulder/arm pain	❑	❑	❑	❑	❑
Back pain	❑	❑	❑	❑	❑
Knee/hip pain	❑	❑	❑	❑	❑
Eye problems	❑	❑	❑	❑	❑
Skin complaints (eczema, rash)	❑	❑	❑	❑	❑
White fingers	❑	❑	❑	❑	❑
Allergic reactions/hypersensitivity	❑	❑	❑	❑	❑
Stomach/bowel problems	❑	❑	❑	❑	❑
Respiratory problems	❑	❑	❑	❑	❑
Cardiovascular problems	❑	❑	❑	❑	❑
Psychological problems (anxiety, depression, sadness, unease)	❑	❑	❑	❑	❑

50 How would you generally describe your health?

❑ Very good ❑ Good ❑ Neither good nor poor ❑ Poor ❑ Very poor

51 We have now asked all our questions. If you have opinions or comments to the topics raised in this form or in your answers, you can write them here. Please use capital letters.

Appendix B

Removed items and reason for removal

Removed items and reason for removal

Items	Reason for removal
1) There have been dangerous situations because people have been under the influence of alcohol or drugs at work	Multi-factorial loading, extracted communality < .35
2) My workplace is often messy	Theoretical assessment, extracted communality < .35
3) The safety delegates do a good job	Multi-factorial loading, extracted communality < .35
4) The HSE laws and regulations are not good enough	Multi-factorial loading, extracted communality < .35
5) I feel sufficiently rested when I am at work	Multi-factorial loadings
6) Communication between me and my colleagues often fail in a way that may lead to dangerous situations	Ambiguous formulation, theoretical assessment
7) Risk-filled work operations are always carefully planned before they are begun	Multi-factorial loadings
8) It is easy to tell the nurse/company health service about complaints and illnesses that might be work-related	Multi-factorial loadings, theoretical assessment
9) I experience a pressure to not report personal injuries or other incidents which may "mess up the statistics"	Multi-factorial loadings
10) The accident preparedness is good	Multifactorial loadings
11) The work permit (WP) system is always adhered to	Multifactorial loadings
12) In practice, production takes priority over HSE	Multifactorial loadings
13) I feel uncomfortable pointing out breaches of safety rules and procedures	Multifactorial loadings, extracted communality < .36
14) Information about undesirable incidents is used efficiently to prevent recurrences	Theoretical assessment, extracted communality < .36
15) I feel a group pressure which affects HSE assessments	Multifactorial loadings, theoretical assessment
16) There is enough manning to properly safeguard HSE	Multifactorial loadings
17) My lack of knowledge of new technology may sometimes increase accident risk	Multifactorial loadings
18) At times, I am pressured to work in ways that threaten safety	Multifactorial loadings, extracted communality < .40
19) I do not participate actively in HSE meetings	Multifactorial loadings, ambiguous formulation
20) I am unsure about my role in the emergency preparedness organisation	Multifactorial loadings, theoretical assessment
21) I doubt that I will be able to perform my emergency preparedness tasks in case of an emergency	Multifactorial loadings, theoretical assessment
22) Increased cooperation between a facility and land through IT systems has led to less safe operations	Extracted communality < .30, theoretical assessment

Note. Items translated from Norwegian by the PSA