Health, Safety and Environment Culture in the Petroleum Industry in Norway

Dordi Høivik

Dissertation for the degree philosophiae doctor (PhD)

University of Bergen, Norway

2009

TABLE OF CONTENTS

SCIENTIFIC ENVIRONMENTS

- Dordi Høivik, Bente E. Moen, Valborg Baste; The Research group for Occupational and Environmental Medicine, Department of Public Health and Primary Health Care, Research group of Occupational and Environmental Medicine, University of Bergen, Norway

- Knut Haukelid; Centre for Technology, Innovation and Culture, University of Oslo, Norway

- Einar Brandsdal; Human Relation, StatoilHydro ASA, Norway

- Kathryn J. Mearns; Industrial Psychology Research Centre, School of Psychology, University of Aberdeen, Scotland, United Kingdom

- Jorunn E. Tharaldsen; International Research Institute of Stavanger (IRIS), Norway

- Rolf Bye, Trond Kongsvik, Marie Opheim, Roald Bovim; Studio Apertura, Norwegian University of Science and Technology, Trondheim, Norway

- Thor Inge Throndsen, Signy Midtbø Riisnes, Aud Nistov, Solveig Engen; HSE in StatoilHydro ASA, Norway

This study was carried out during the period 2003-2008.

ACKNOWLEDGEMENTS

The study could not have been completed without the assistance of many people to whom I would like to express my gratitude. I would like to express my thanks to my main supervisor, Bente E. Moen, for all support and advice during the study. With her knowledge of occupational health and her wise and dauntless way of fighting for the prevention of work-related diseases and safe workplaces she has been to great inspiration to me. Thank you, Bente. I would furthermore like to thank Knut Haukelid, who introduced me to the anthropological culture concept. I am very grateful to Valborg Baste's advices and help with the statistics and I am thankful for the discussions with and help from Einar Brandsdal, Kathryn J. Mearns and Jorunn E. Tharaldsen. In addition, Rolf Bye, Marie Opheim, Roald Bovim and Trond Kongsvik at Studio Apertura, University of Trondheim, were good discussion partners at the beginning of the study when the "HSE culture umbrella" was developed.

This study would never have been completed without the Research and Development Program "Human factors and HSE culture" in Statoil ASA that initiated and supported this project. As project manager I was allowed to spend time to further analyze the findings in Statoil ASA, and later StatoilHydro ASA, and to publish the results in International Journals. Signy Midtbø Riisnes, former vice president health and working environment, and Thor Inge Throndsen, chief engineer technical working environment in StatoilHydro ASA, initiated the research program and have been my discussion and supporting partners. During the study I have been supported by managers and colleagues, who have all made it possible for me to carry out my studies in combination with my other tasks in Statoil ASA and later StatoilHydro ASA. I want to thank Marianne Kvadsheim, Jakob Nærheim, Solveig Engen, Aud Nistov, Siri Slåstad and Gunnar Breivik for believing that I would complete this project and that the results would be important to the company and the industry. Thanks also to colleagues in the health and working environment network in the company.

I want to thank everyone at the Research group of Occupational and Environmental Medicine, Department of Public Health and Primary Health Care at the University of Bergen for the special, inspiring and fun working environment in the department; I will miss you all. A special thanks to my friends Tone Morken and Rønnaug Torsteinsen; they have been great support and discussion partners during the whole study period.

I think Ragnar, my husband, is the one who will be the happiest for seeing this project to an end. He has been alone during the weekends and afternoons for many years while I have been at the University. I could never have had a more supporting husband. My children, Eirik and Kari, have followed the study progress together with my parents and parents-in-law. They have been supportive in all possible ways.

The project was connected to the program Health, Safety and Environment in the Petroleum Industry in Norway, supported by the Research Council of Norway.

Bergen, 10th January, 2009

Dordi Høivik

ABBREVIATIONS AND DEFINITIONS

ABBREVIATIONS

DFU	Defined hazard and accident situations
HSE	Health, Safety and Environment
NCS	Norwegian Continental Shelf
NPD	The Norwegian Petroleum Directorate
NORSCI	Norwegian Offshore Risk and Safety Climate Inventory
PSA	The Petroleum Safety Authority
UK	United Kingdom
RNNS	The project ”Trends in risk level” [Utvikling i RisikoNivå - Norsk Sokkel]

DEFINITIONS

Injury	An injury is a bodily injury caused by an accident. The injury must be caused by a sudden, external stress or load that is greater than can be expected in the ordinary performance of work. Recordable injuries in this study include fatalities and lost-time injuries involving substitute work and health care
Lagging indicator	Performance measures that represent the consequences of actions previously taken
Leading indicator	A measure to provide early feedback on performance
Serious incidents	All undesirable incidents that have or could have caused (conditions and near misses) injury, damage or loss categorized as having a degree of seriousness of level 1 or 2 on a 5 level scale where 1 is most serious
Sickness absence	Days of absence from work with a medical certificate from a doctor or an absence reported by the employee (self-reporting)
Undesirable incidents	All undesirable incidents that have or could have caused (conditions and near misses) injury, damage or loss categorized as having a degree of seriousness of levels 1–5 on a five-level scale

SUMMARY

This thesis is based on four studies of aspects of health, safety and environment (HSE) culture in the petroleum industry in Norway.

Oil and gas production is currently Norway's largest industry, with both offshore and onshore operations. HSE issues, focusing on reducing risks to people, facilities and the environment, are important in this industry. The main objective of this study was to gain more knowledge about factors that affect the HSE in the Norwegian petroleum industry and to discuss how these factors might be part of the concept "HSE culture". It has been of special interest to gain more knowledge of organisational and working environment factors that affect health and safety in the petroleum industry.

Aims of the studies

The aim of study I, was to gain more knowledge of the various ways the health, safety and environment culture concept was understood and defined among employees with and without leadership responsibility.

The aims of study II, was to investigate the possible associations between working conditions and the registered health and safety results.

The aim of study III, was to compare working environment among onshore and offshore employees.

The aim of study IV, was to analyse whether company belonging or local working environment is the most important factor for safety climate in the offshore petroleum industry.

Material and methods

A combination of qualitative and quantitative methods has been chosen and the data have been gathered from several sources. In paper I we analysed interviews from 31 workers in one petroleum company using individual semi-structured interviews in order to explore work-related issues which could explain aspects of HSE culture. The same company's annual surveys of self-reported working environment were analysed

in Paper II and III. In Paper II a longitudinal design of both self-reported data and data from a company register were used, including items on working onshore or offshore, department, age, gender, perception of nearest manager, confidence in management, HSE behaviour, competence, collaboration and procedures. We also analysed health and safety performance; sickness absence, recordable injuries, serious incidents and undesirable incidents. Paper III was a longitudinal study design from 2003 to 2005 performed with data from employees from offshore and onshore plants. We included the same items from the self-reporting working environment survey as in paper II. Paper IV was a cross-sectional study including 4479 employees in 2005. The data came from the Petroleum Safety Authorities project "Trends in Risk Levels". The five largest companies on the Norwegian continental shelf were analysed, using factors relevant for safety and working environment.

In this thesis we have studied six factors that might be a part of HSE culture: Management, behaviour, competence, collaboration, procedures and the physical environment. Paper I includes all the factors. The other studies are partly based upon the first study, looking at some of these factors in more detail or from another angle.

Results

In study I, we found that the "HSE culture" concept was used in three ways. The most common was descriptive, but also a causal way and a systematic way were applied. Managers and employees differed little in the use of the concept. Management, behaviour, competence, collaboration, procedures and the physical environment were found to be important for the HSE culture and the relationship between them was illustrated as an HSE culture umbrella.

In study II, we found that cconfidence in management was negatively associated with recordable injuries. Offshore workers reported lower scores for working condition factors than onshore workers.

In study III we found that onshore petroleum workers were generally more satisfied with all organisational and working environment factors than offshore employees, especially on items concerning management and procedures.

In study IV we found that the installation (local working environment) explained more than company belonging within the safety climate dimensions ”Safety prioritisation”, ”Safety versus production”, “Individual motivation”, ”System comprehension” and ”Competence”. Contractor employees answered more positively on the health and safety dimensions than operator employees did.

Conclusions

This study has shown that “HSE culture” is a concept with several meanings, and management, behaviour, competence, procedures, collaboration and physical conditions are factors of importance. Company working and organisational survey might be used as indicators of risk of injuries. Management style and trust in the manager are important factors for personal injuries.

Onshore workers were more satisfied with all organisational and working environment factors. Differences in management style and resources, type of shift work and living conditions might be important in explaining the differences. Local HSE work on the offshore installations and the HSE work by the company have importance for the HSE culture in the petroleum industry.

LIST OF PUBLICATIONS

The thesis is based on the following papers referred to in the text by their Roman numerals:

Paper I Høivik, D., Moen B.E., Mearns, K., Haukelid, K. (2008): An explorative study of health, safety and environment culture in a Norwegian petroleum company. Accepted for publication in Safety Science, online 30th December.

Paper II Høivik, D., Baste, V., Brandsdal, E., Moen, B.E. (2007): Associations between self-reported working conditions and registered health and safety results. J Occ Env Med 49(2):139-147.

Paper III Høivik, D., Brandsdal, E., Moen B.E. (2008): Nearest management is important for health and safety. A longitudinal study of perceived working conditions in offshore and onshore petroleum industry. Maritime Medicine Journal 8(1):38-55.

Paper IV Høivik, D., Tharaldsen, J.E., Baste, V., Moen B.E.: What is most important for safety climate; the company belonging or the local working environment? - A study from the Norwegian offshore industry. Submitted.

1 INTRODUCTION

The title of this thesis may seem very broad, and I have not studied all aspects of "Health, safety and environment (HSE) culture". The topic that has been of special interest to me is gaining more knowledge of organisational and working environment factors that affect health and safety in the petroleum industry, in relation to the concept "HSE culture". This chapter presents the background of the study, including an overview of the Petroleum industry in Norway and a literature review of the research field of HSE culture.

1.1 The petroleum industry in Norway

In December 1969 a significant oil field was discovered on Norway's Continental Shelf (NCS). Since then, a large-scale industry has emerged and oil and gas production is currently Norway's largest industry, accounting for 24% of the country's value creation (Ministry of Petroleum and Energy, 2008). There are 52 Norwegian oil-producing fields. The largest oil field is Ekofisk, Norway's first oil field, where oil extraction started in 1971. Despite nearly 40 years of operation on the NCS, only around one third of the total expected resources on the NCS have been produced. The oil production is decreasing, but because of increasing gas production, total petroleum production is estimated to increase in the coming years. The exploitation of natural gas on the NCS started in 1977, and there has been a steady growth in production since then. Natural gas production makes up 41.9 per cent of the total petroleum production. Today there are 43 Norwegian gas producing fields (Statistic Norway, 2007). Of the remaining petroleum resources on the NCS almost 60 % is expected to be natural gas.

Activities in Norway's petroleum industry include both onshore and offshore operations. The petroleum industry can be divided into upstream and downstream segments. "Upstream" here refers to exploration, extraction and production of crude oil and natural gas. This activity is on the NCS and is called "the Norwegian offshore petroleum industry". According to Statistics Norway 2008, the upstream oil and gas

industry employed around 32 000 people in 2006, including 18 500 offshore employees in the sector "Extraction of oil and natural gas" and 13 500 employees in the sector "Service activities incidental to oil and gas extraction". Both Norwegian and international oil companies are responsible for the actual conduct of petroleum activities on the NCS, also called "operation companies". "Downstream" refers to refinery operations, distribution and retail of petroleum fractions.

Figure 1 Offshore platform, production ship and onshore processing plant (Photo: StatoilHydro).

1.1.1 Offshore and onshore working conditions

The oil installations related to the petroleum operations on the Norwegian continental shelf are located 40 to 185 miles from the coast. The crews are transported by helicopter to the offshore installations and the working period is normally 14 continuous days with 12-hour shifts, day or night, followed by a 4-week off period at home, the "2-4 "schedule.

The offshore working environment may involve several occupational hazards that can be stressful (Parkes, 1998; Gardner, 2003; Mearns et al., 2001; Chen, 2005). Psychosocial stress related to working and living conditions has been described (Lauridsen, 1990; Rundmo, 1992; Rundmo et al., 1995; Parkes, 1999; 2003) as well as physical stressors in indoor environments in the living quarters at offshore installations (Eide et al.,. 1992a; 1992b) and job stress (Ulleberg and Rundmo, 1997; Rundmo et al.,. 1998). A high prevalence of work-related musculoskeletal disorders (Morken et al., 2007) and occupational hearing loss (Morken et al., 2005) have been described among some groups of workers. Possible exposure to oil mist and oil vapour during

offshore drilling (Eide, 1990; Steinsvåg et al., 2006; 2007) has been measured. A large study was conducted in 1979–1984 on the working environment, health and safety of workers on Mobil's Statfjord A platform (Hellesøy, 1985). The study described and evaluated organisational, social and physical working environment. In the United Kingdom, Mearns et al. (1998; 2001; 2003) have indicated that social and organisational factors are associated with health and safety. One study has compared workers' perception of safety and working environment factors in Norway and the United Kingdom (Mearns et al., 2004).

The workers in the petroleum industry are either operator employees in an operating company or contractor employees employed in one of the many contractor/supplier firms working for an operating company. The operating companies are managing the day-to-day activities of the production. The contractor category contains employees from many different contractor companies providing services within drilling and well-services, maintenance and catering. Operator and contractor employees are working side by side and collaborate both on the offshore installations and on the onshore plants in the different job categories.

Figure 2 Working environment in the offshore and onshore petroleum industry (Photo: StatoilHydro).

In the production area several professions are needed for a large oil and gas production plant, such as processing operators, industrial and automatic control mechanics, electricians, instrument technicians, logistic personnel, painters, insulators and crane operators. In the drilling area we find drilling crews such as drillers, drill floor crew, mud engineers and well-service crew. We also find job categories like administrative personnel, service workers and cooks working in the living quarters at offshore installations. The shift work requires manning with three crews. This entails that many

employees offshore have to report to more than one manager. The managers have the same 2–4 work schedule, but the crew alternates on different days and may not be replaced at the same time. In addition, most managers work day shifts only. About 60% of the total number of offshore employees work day shift, 30% night and day shifts every second work period and 10% have other day and night schedules, such as two periods with day shifts and one period with night shifts.

The same operator company may have employees both on offshore installations and on onshore process plants. Administration personnel are located onshore, together with specialists and suppliers who support the offshore installations and the onshore process plants. At onshore plants employees may have similar education and tasks as the offshore employees. The production workers at onshore process sites normally work 8-hour shifts, and follow a rotation schedule. The mid-level managers or nearest manager follow the same shift schedule as the workers. Most employees live near the process plant and return to their homes after work every day.

Few studies have compared offshore and onshore workers, and the ones that have been carried out have been restricted to mental health (Banks et al., 1980), shift work and perceived working environment and health (Parkes, 1998; 2003) and shift work and sleep patterns (Parkes, 2002). Other working environment factors important to health and safety, such as the perception of the manager, competence collaboration and confidence, have not previously been compared onshore and offshore.

1.1.2 High risks and high focus on HSE

Health, safety and environment (HSE) has been an important issue since the offshore production and drilling operations started. The Norwegian Petroleum Directorate (NPD) was established in 1972, and later (2004) divided into Norwegian Petroleum Directorate and the Petroleum Safety Authority Norway (PSA). PSA is a regulatory authority for technical and operational safety as well as for working environment. Its task is to stipulate premises and follow-up to ensure that the participants in petroleum activities maintain high standards of health, environment, safety and emergency

preparedness. The first safety regulations were implemented in 1976. Since 2004 PSA has had the regulatory responsibility for both offshore and land-based plants in Norway.

The Working Environment Act of 1977 regulated both the physical and the psychosocial working environment. In 1992 a new regulation on health and safety management came into force in Norway: the Internal Control Regulation. This was further developed to become the Systematic Health, Environmental and Safety Activities in Enterprises (Ministry of labour and social inclusion, 1997) and a systematic follow-up of the working environment was implemented in the offshore petroleum industry regulations in 1995.

The Norwegian Working Environment Act requires that the employer and the employees co-operate within collaborative structures and provide opportunities for both parties to meet and consult on relevant occupational health and working environment matters. Internal control regulations are combining a top-down and a bottom-up approach to the organisation of health and safety activities at workplaces (Karlsen and Lindoe, 2006). The internal control regime is supposed to be effectuated as part of the line organisation. In Norway, everyone at his/her level has a particular responsibility to improve and safeguard the occupational health and safety quality of the workplace. However, the employer has the overall responsibility and seeks support both from the professional staff and from the participants in the organisation, the safety committee, the safety representatives and the occupational health and safety experts of the company (Hovden et al., 2008).

Health, safety and environment were seen as separate issues in the seventies and early eighties. Technological challenges and safety challenges were the main topics in this area for the offshore petroleum industry. The period was characterised by many serious occupational accidents and some catastrophes. The most serious ones were the Alexander L. Kielland breakdown in 1980, where 123 people got killed, and the Bravo blow-out in 1977 (Ryggvik and Smith-Solbakken, 1997).

Systematic work on health and working environment was strengthened in the offshore petroleum industry during the eighties and nineties. Topics of concern were, among others, ergonomics and human factors, chemical hazards, stress and technical working environment regulations. The occupational health service for the offshore population was developed; at the early stages securing health examinations, treatment and prevention.

The concepts “health, safety and environment” became more integrated during the nineties, as could also be discerned in the regulations from the Authorities. The working environment came more into focus during these years in the offshore and onshore petroleum industry in Norway.

An occupational health and working environment service is important and mandatory in the petroleum companies. Most companies have employed professionals with relevant expertise within physical, chemical, ergonomic and organisational working environment conditions, as well as acquired knowledge concerning possible effects on health, safety and productivity. On Norwegian offshore installations the occupational health service also takes care of injured and sick personnel.

The Norwegian Board of Health Supervision (Norwegian name: Statens helsetilsyn) is an independent supervision authority, with responsibility for general supervision of health, health care personnel and social services. They set premises for the offshore health service and follow up that offshore health services are run in accordance with acceptable professional standards. All installations are covered by a search and rescue service (SAR).

Offshore workers are required to pass a mandatory medical examination. Regular programs for monitoring health related to relevant work-related risks are offered to the employees. If work-related diseases and disorders, or risks of such, are suspected, the manager will implement actions and track these, supported by health and working

environment personnel. Health promotion work and preventive health and working environment programmes are important for many of these companies. When planning new workplaces high standards are set for the working environment, and evaluation of health risks and identifying measures to remove or reduce risks are important areas in new projects.

Today emission to sea and possible climate changes due to pollution of the air are environmental issues which are of importance for the petroleum industry. During drilling activities polluted rock material (drill cuttings) and drilling chemicals may be discharged, and during production produced water contaminated with oil and production chemicals might be discharged as well. A great deal of energy is needed for the production phase, and this may be produced using gas or diesel generators which emit greenhouse gases and gases that can result in the formation of ground-level ozone or cause acidification when they reach land. In addition, shuttle tankers and supply ships used to transport oil and gas and equipment also generate water and air pollution and may also have a negative impact on fauna, animals and birds.

Norway intends to be a front-runner within technology, environment and climate, and several research programs and activities related to the petroleum industry have been established in order to meet the environment and climate challenges mentioned here.

1.1.3 HSE facts in the Norwegian petroleum industry

The Petroleum Industry in Norway aims at reducing risks to people, facilities and the environment. However, the HSE-work is still in need of improvement. During the past ten years six people have been killed in accidents in the petroleum industry (PSA included land-based plants in the statistics from 2004, because regulatory responsibility for these facilities was transferred to them).

The frequency of personal injuries went down from above 70 injured per 1000 years worked in 1978 to about 40 injured per 1000 years worked in 1994 at the fixed installations. Furthermore, reports from the petroleum industry show a decline in

reported personal injuries in the period 1998–2007 (Petroleum Safety Authorities, 2008) (Figure 3). There was a substantial reduction in the frequency of reportable personal injuries in the 2000–2004 period, which subsequently stabilised at this level. However, the reduction from 2000 to 2004 might be explained by a change at company level in the classification of injuries at the boundary between medical treatment and first aid. The latter was not included in the statistics after 2005 (Petroleum Safety Authorities, 2008). This fact, among other things, led to some concern within the industry. Although safety was considered an important issue, the number of accidents did not decrease. This has been a focus for discussions in recent years.

Injury frequency is lower for operator employees than for contractor personnel in the petroleum industry (Petroleum Safety Authorities, 2008) and this might tell us something about who carries out the most dangerous jobs. Drilling and well-operations are performed almost exclusively by contractors. Where job categories are more comparable, such as administration, catering and construction/maintenance, there is little difference between injury frequencies for operator and contractor employees.

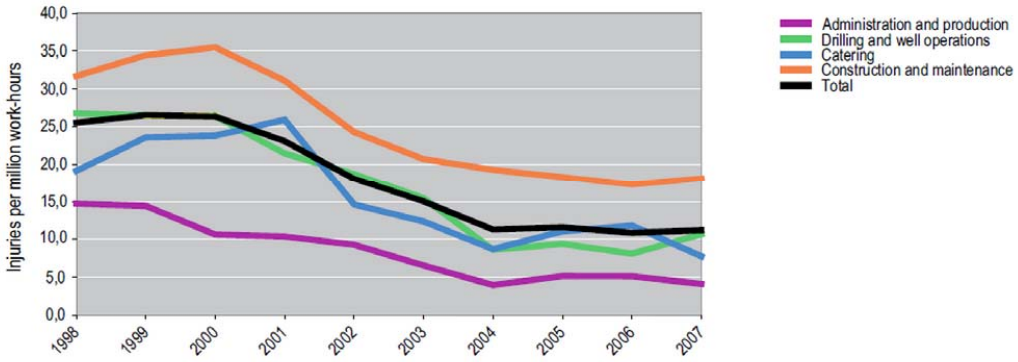

Figure 3 Personal injury frequencies by job category on permanent positioned installations in the petroleum industry (Petroleum Safety Authorities, 2008).

During 1992–2003 47% of the reported work-related illnesses at offshore installations were musculoskeletal disorders (Morken et. al., 2007). Heavy loads or lifting and

repetitive, monotonous work are the main reported reasons for these illnesses. In the 2005–2007 periods, we have seen an increased number of reports of work-related hearing loss due to noise (Figure 4) (Petroleum Safety Authorities, 2008). Many job categories are exposed to a higher level of noise than the limit stipulated in the HSE regulations, and personnel are dependent on hearing protection to prevent damage to hearing. However, we do not know if there is a genuine rise in the number of cases of hearing loss or if this is related to an increased focus on the problem. After musculoskeletal illness and hearing loss, skin problems constitute the largest group of diagnoses. A considerable number of cases involve eczema on the hands. This might be a consequence of contact with oil-based substances.

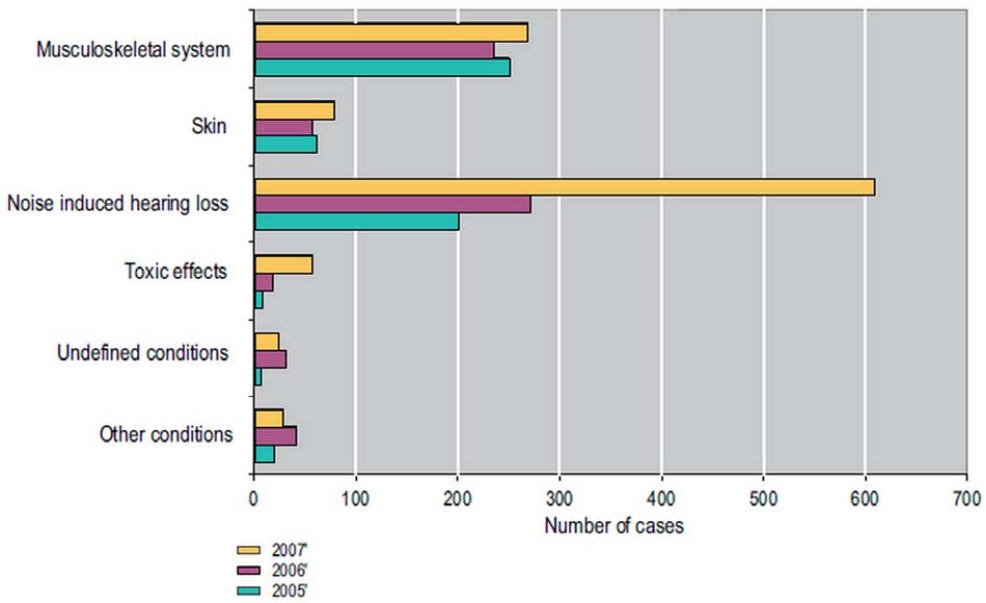

Figure 4 Work related diseases 2005-2007 in the petroleum industry (Petroleum Safety Authorities, 2008).

The Petroleum Safety Authority Norway (2008) concludes, in the report "Trends in Risk level 2007", that the indicators reflecting major accident risk show a statistically significant reduction over the course of the past three years, compared to the average for the period 2000–2006. This applies both to production and mobile facilities.

Since 2002 there has been a significant reduction in the number of hydrocarbon leaks with a leak rate of more than 0.1 kilo per second (Figure 5). The number of incidents related to drilling and wells connected to production and exploration drilling and ships on a collision course also shows an improvement the last years (Petroleum Safety Authorities, 2008).

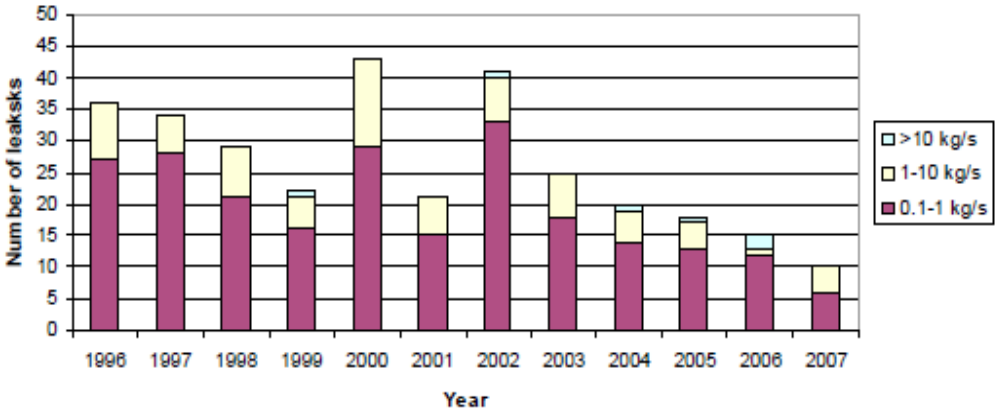

Figure 5 Number of hydrocarbon leaks exceeding 0.1 kg/s, 1996-2007 in the petroleum industry (Petroleum Safety Authorities, 2008).

The Norwegian Pollution Control Authority (SFT) is a directorate under the Ministry of the Environment. The Authority reports a reduction of emissions from hazardous chemicals from the oil and gas industry from 1998 to 2007 (Figure 6) and an increase in the emissions of green house gases (Figure 7) (Norwegian Pollution Control Authority, 2008).

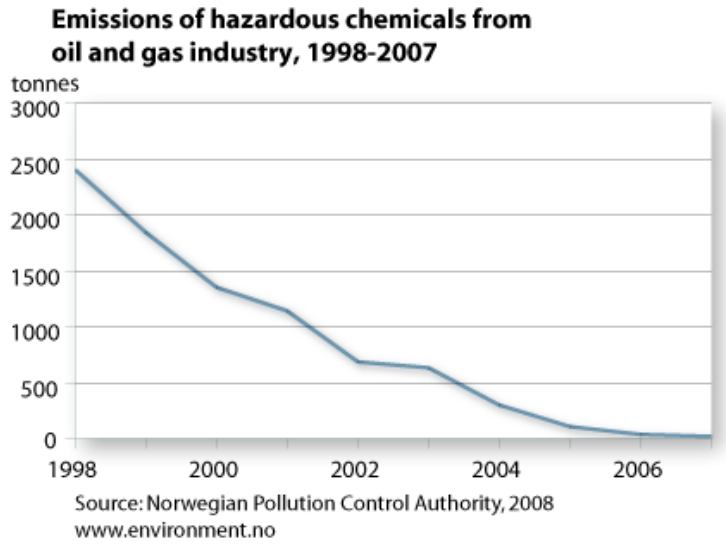

Figure 6 Emissions of hazardous chemicals from oil ad gas industry, 1998-2007 (Norwegian Pollution Control Authority, 2008).

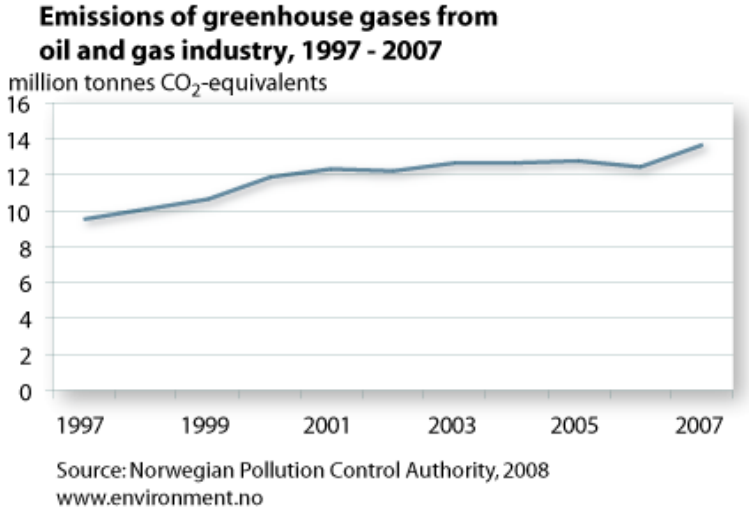

Figure 7 Emissions of greenhouse gases from oil ad gas industry, 1997-2007 (Norwegian Pollution Control Authority, 2008).

1.1.4 HSE culture in the petroleum regulation

In 2001 the Government of Norway presented a white Paper on HSE on the Continental Shelf (Stortingsmelding no 7, 2001/2002). This report stated that the authorities were concerned about the safety performance, as previously mentioned. The concept “HSE culture” was introduced in this report and identified as a priority area. The Petroleum Safety Authority Norway underlined this priority in its further regulatory work. The Norwegian petroleum industries framework regulation for HSE of 1 January 2002, chapter 3, section 11, specifies that enterprises must have a sound health, environment and safety culture, saying: “The party responsible shall encourage and promote a sound health, environment and safety culture comprising all activity areas and which contributes to achieving that everyone who takes part in petroleum activities takes on responsibility in relation to health, environment and safety, including also systematic development and improvement of health, environment and safety”.

The guideline to this section states: In order to make it clear that this section applies across the entire scope of application of the regulations, the concept “health, environment and safety culture” is used instead of the more established term “safety culture”. However, the authorities did not define “HSE culture”. To define the content of the concept of “HSE culture” became a challenge for the companies, and the companies in the petroleum industry in Norway had different approaches on how to work with this concept “HSE culture”. Some companies developed huge programs for employees and contractors to emphasise safe behaviour in workshops, where both management and personnel committed themselves to safe behaviour in their work. Other companies developed management and employee programs underlining the differences between culture and structure. Structure was understood as requirements and procedures and culture were understood as leadership, interaction, attitude and behaviour. Training programmes were developed based on the different culture dimension.

Discussions were raised among the three-party cooperation – employer, unions and the authorities – on whether the programmes were sufficient for strengthening the HSE culture. The employer focused primary on the individual level in the programmes, whereas the employee organisations wanted to focus on the frame conditions. In September 2004, PSA stated in a notification a concern about actors in the petroleum industry focusing too much on employee's attitude and behaviour. The Authorities underlined that HSE culture was about a continuous, critical and extensive work related to technical safety and management systems in addition to the organisational, psychosocial and behavioural approach.

PSA made a theme-pamphlet named "HSE and Culture" in 2004 (Petroleum Safety Authorities, 2004). The pamphlet provided perspectives on how to understand the concept and input on how the requirements for good HSE culture could be fulfilled. The authorities stated that the prerequisites for a good HSE culture were that health, safety and environmental work were not viewed separately and that there was a good balance between the individual's responsibility in the HSE work and the company's responsibility for facilitating good working conditions. The pamphlet was meant to be a tool for the industry in its work on improving the HSE culture, and emphasised a stronger focus on the "H" and "E" in addition to continued work to improve the HSE.

To secure good cooperation between the three-party cooperation in the Norwegian petroleum industry, the "Safety Forum" was established in 2001 to initiate, discuss and follow up relevant safety, emergency preparedness and working environment issues in the petroleum industry, both offshore and at onshore facilities, in a tripartite perspective. "The Safety Forum" is the central arena for cooperation among the parties in the industry and the authorities as regards health, safety and environment in the petroleum activities on the Norwegian continental shelf and onshore. Examples of key projects and processes followed up by this Forum are chemical health risk, groups at risk and the Risk Level Project.

The Risk Level Project was initiated in 1999/2000 to develop and utilise a measuring tool which illustrates the development of the risk level on the Norwegian shelf. The project is important to the industry by contributing to a universal understanding of risk level development among the parties. Both qualitative and quantitative methods are used. The project describes indicators, so-called defined hazard and accident situations (DFUs), which are critical to safety and the working environment. It also includes questionnaire surveys, interviews, field work and other studies to form the basis for social science analyses. The project focuses on major accidents, work accidents and selected working environment factors such as noise and chemical exposure.

1.2 Health, safety and environment culture –theoretical framework

The root of the word culture arises from the Latin world "colore", which means to cultivate. "Culture" is a commonly used word and can signify art, theatre, film, sport etc. We often use the word with a prefix such as "national culture", "sub-culture", "organisational culture" and now also "HSE culture". In 1952 Kluchhohns and Kroeber (Kluckhohns and Kroeber, 1952) tried to classify the culture concept. They discussed 162 different definitions of culture. The concept is still debated in the literature and there are different definitions, traditions and understandings; e.g. anthropologists have a different understanding of culture from that of many management and organization theorists (Haukelid, 2008). This has implications on the discussion of culture; if and how culture can be measured and if there might be a common culture within an organization.

Edgard Schein's definition (1985, page 12) of organisational culture is often used;
"A pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way you perceive, think, and feel in relation to those problems" .

In this definition culture is perceived as the shared understandings in a given organization, also called the integration perspective.

Alvesson (2002, page 3) define culture as:
"The shared rules governing cognitive and affective aspects of membership in an organisation and the means whereby they are shaped and expressed"

Alvesson's understanding of culture is that cultures do not necessarily establish clarity, shared orientations and consensus among broad groups of people, but still offer guidelines for coping with instances of ambiguity without too much anarchy or confusion (Alvesson, 2002).

The concept "safety culture" has been discussed in the international literature since 1986, e.g. in the report on the Chernobyl nuclear accident from the International Atomic Energy Agency (INSAG, 1988). Cox and Flin (1998) and Guldenmund (2000) reviewed the literature on safety culture and showed that "safety culture" developed as a concept because it was difficult to explain a linear connection between one causal factor and various big accidents in the industry in the early eighties (Cooper, 2000). Lack of a positive safety culture was used as a concept in explaining these accidents and catastrophes. It was proposed that the main reasons for the disasters and potential future accidents did not only include technical faults or individual human errors committed by the frontline workers. The management, organisation and attitudes of the personnel were also noted to influence safety. The theoretical framework on safety culture started to be developed in the nuclear industry (Lee and Harrison, 2000; Cooper, 2000) and later in other industries like aviation (McDonald et al., 2000), the transport sector, including railways (Clarke, 1999; Farrington-Darby et al., 2005), healthcare sector (Singer et al., 2003), chemical industry (Donald and Canter, 1994), manufacturing (Cheyne et al., 1998) and in the offshore industry (Mearns et al., 1998; 2001; 2003; Høivik et al., 2008). In the Norwegian petroleum industry "safety culture" was first used in the late 1980s in relation to drilling operations (Haukelid et al., 1991; Haukelid, 1998).

Even though "safety culture" has been a popular concept for explaining accidents, the theoretical fundament has been criticised as ill-defined. There has been no consensus on the content of a safety culture or the consequences, and there are no satisfactory models of safety culture (Guldenmund, 2000). A definition of "safety culture" is proposed by the advisory committee on the safety of nuclear installation (ACSNI, 1993, page 23): They define "safety culture" as

> *"the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of an organization's health and safety management".*

Richter and Koch's definition of safety culture (2004, page 705) underlines the connection between organisation, work and safety:

> *We define safety culture as the shared and learned meanings, experiences and interpretations of work and safety – expressed partially symbolically – which guide peoples' actions towards risks, accidents and prevention. Safety culture is shaped by people in the structures and social relations within and outside the organization.*

Within this tradition culture consists of shared elements, e.g. attitudes, values, assumptions and norms, held amongst the members of a group, and are transferred between groups of people. Glendon (2000) discuss three levels of culture used in the literature: the most accessible and visible, behaviour and artefacts; the intermediate level: values, norms and strategic beliefs; and the deepest level: underlying assumptions, invisible, preconscious and taken for granted.

The concept of "safety culture" and the concept of "HSE culture" seem to be related to the concept of "organisational culture", insofar as HSE are elements of an organisation's culture. Haukelid (2008) stresses that safety culture should not be something separate from – or in addition to – an organisational culture, but constitute an integrated part of this culture. Following Richter and Koch (2004), he views safety

culture as a focused aspect of the organisational culture and the organisation's culture cannot be considered to be a closed system. It is not only local conditions within the organisation that determine the culture of its members. The culture will be influenced partly by external (national, regional) conditions and the (educational, social-economic, religious) background of its workforce (Guldenmund, 2007).

1.2.1 Culture and climate

"Safety culture" and "safety climate" have often been used interchangeably, although "climate" has been described as reflecting attitudes, perceptions and beliefs, while "culture" is more complex, reflecting values and norms (Mearns and Flin, 1999). Safety climate may be seen as a "snapshot" of the safety culture, and reflects the perception of an organisation shared by those participating. It is also more superficial and transient than culture (Flin et al., 2000).

Neal et al. (2000) argued that employees' perceptions of the policies, procedures, and practices relating to safety comprise the safety climate; however, others have offered more wide-ranging definitions, in which safety climate is viewed as a current-state reflection of the underlying safety culture (e.g., Mearns et al., 2001; 2003), and so encompasses a broader range of elements, including attitudes toward safety.

1.2.2 Health and working environment and the HSE culture concept

The expansion of the "safety culture" concept to include health, working environment and environment introduced factors other than the major accidents and catastrophes that were originally the background for the safety culture concept. Occupational health and working environment are closely related to the workers' everyday work situation and include individual health, well-being and psychosocial working environment as well as ergonomics and human factors, chemical working environment, noise, and the physical work conditions. The part of HSE work related to environment concerns; preserving biological diversity and keeping emissions and discharges low, has until 2002 not been a part of the international "safety culture" concept. The word "culture" has not been commonly used in connection with occupational health and working

environment or environment in the literature. Only safety has been associated with culture, when discussing the underlying causes of major accidents. Norway was among the first to introduce the HSE culture concept in the regulations.

There seems to be a relationship between health and leadership in organisations. Organisational health research during the past decade has shown that organisation is a strong factor influencing the well-being of employees (Cotton and Hart, 2003). Mearns et al.(2003) found a relationship between good health and safety management and accident statistics. Mearns and Hope (2005) investigated this relationship further and found that the perception of an organisation's commitment to health was significantly related to safety outcomes. Occupational health issues have been important in workplaces in affluent countries for many years and have been seen as critical for improving the health and safety of employees. It is generally agreed that the working environment needs to be systematically improved in order to avoid accidents and work-related diseases (Frick et al., 2000). Occupational health practice services have traditionally been focused on prevention of occupational diseases and control of adverse effects on the health and safety of workers. The focus has been on avoiding sickness, accidents and illness. However, WHO (1995) stated that psychological and social well-being also ought to be an important area of focus for occupational health practices, and that new principles should go beyond the mere prevention and control of adverse effects to the positive promotion of health, the improvement of the work environment and the work organisation.

Preventing occupational diseases and controlling adverse effects on the health of workers are important aspects of HSE work in socially responsible companies. The incidence of work-related diseases and work-related sickness absence can be indicators of the quality of the working environment and be seen as a part of the company's HSE culture. Sickness absence is caused by a variety of factors, including factors related to the physical working environment (Allebeck and Mastekaasa, 2004) and to organisational factors such as management style, work pressure and work overload (Michie and Williams, 2003; Nielsen et al., 2006). Work-related diseases are

usually developed over a period of time and diagnosed outside the companies. Occupational accidents are acute and immediately visible at the work place and are accordingly perceived as more dramatic than occupational diseases. This difference between injuries and diseases could be one reason for the focus on safety culture and climate as precursors to prevent accidents and injuries.

1.2.3 Assessing HSE culture and climate

Culture is complex and has to be analysed in different ways to be fully understood, different methods must be used to get insight to the levels of culture.

The petroleum industry in Norway has many health and safety performance measures such as number of fatal accidents, lost-time injuries, serious incidents, undesired incidents, sickness absence, accidental oil spills, work related diseases, breach of security and hazardous waste recovery. These measures are all “lagging” indicators (performance measures that represent the consequences of actions previously taken) and may be correlated with HSE studies or be a part of a HSE culture analysis. “Leading indicators” (a measure to provide early feedback on performance) may be used to analyse the HSE culture in an organisation by analysing policies and strategies, goals and plans, health and safety competence, visibility of managers, reporting practice, experience transfer to learn from best practice or from accidents through the organisation, motivation, job satisfaction etc.

Safety culture researchers often focus on the values and assumptions of the organisational members with respect to safety, and emphasise the role of organisational norms and socialisation influences on safety behaviour and safety outcomes. They usually use many sources and qualitative methodologies such as field work, observations, written descriptions and interviews. Climate surveys might be one of the methods one might use in order to gain deeper knowledge about the culture.

Safety climate is usually explored through questionnaires, often composed of thematic questions relevant to safety. Many different scales have been developed (Flin et al.,

2000; Guldenmund, 2000; 2007) to show the employees' subjective opinions of an organisation's safety culture. However, Guldenmund (2007) argued that safety climate research has basically been attitude research.

Different approaches are probably needed in order to get insight to the HSE culture in an organisation just as for studies of safety culture. HSE climate surveys provide information about subjective opinions on HSE conditions and HSE management. However, a climate approach will not provide a sufficient picture of the culture related to HSE in the company. Observation of work practice, written documents, manager style and communication and interviews will give a deeper insight into the common culture that affects the practice in the company.

Reviews of safety climate literature (Guldenmund, 2000; Flin et al., 2000) have identified numbers of measures used in a safety climate surveys. Flin et al. (2000) identified themes important for safety climate in 19 studies in nuclear industry, oil and gas industry, chemical sites, factories, manufacturing plants, aircraft, transport and construction. These themes included management, safety system, risk, work pressure, competence and procedures/rules. The factor 'management' emerged in 72% of the studies as important (Flin et al., 2000).

Guldenmund (2007) divided the items within safety climate research into organisational level (the processes taking place at higher organisational levels, e.g. manager teams deciding policies, strategies, goals), group level (processes within groups or teams the respondent works in) and individual level (the particulate process that involve the respondent, or the attitude level). Although a large amount of research has focused on which safety measures should be included in the make-up of a questionnaire, there is still confusion over the number and type of safety climate measures that should be included. There are, however, a number of safety climate measures that are commonly used, for example management commitment, supervisor competence, priority of safety over production, and time pressure (Flin et al., 2000).

2 AIMS OF THE THESIS

The main objective of this study was to gain more knowledge about factors that affect the health, safety and environment in the Norwegian petroleum industry and to discuss how these factors might be part of the concept "HSE culture". It has been of special interest to gain more knowledge of organisational and working environment factors that effect health and safety in the petroleum industry.

More specific aims:

- To gain more knowledge of the various ways the health, safety and environment culture concept was understood and defined among employees with and without leadership responsibility (Paper I)
- To investigate the possible associations between working conditions and the registered health and safety results (Paper II)
- To compare working environment among onshore and offshore employees (Paper III)
- To analyse if company belonging or local working environment is the most important factor for safety climate in the offshore petroleum industry (Paper IV)

3 MATERIALS AND METHODS

Several approaches would have been possible for this study. A combination of qualitative and quantitative methods has been chosen. This increased the possibility of showing different aspects within the areas.

The data in this thesis are gathered from several sources, shown in Table 1. In Paper I we analysed interviews from 31 workers from different organisational levels in one petroleum company in Norway. The same company's annual surveys of self-reported working conditions were analysed in Paper II and III. Data from the Petroleum Safety Authorities project "Trends in Risk Levels" were analysed for the five largest companies on the Norwegian continental shelf in Paper IV.

Table 1 Data source and number of employees offshore and onshore in four studies of HSE and culture and HSE climate in the Norwegian Petroleum industry.

Paper	Data source	Year	Number of employees	Number of employees Offshore	Number of employees Onshore	Number of companies
Paper I	Interviews	2003	31	*	*	1
Paper II	Company survey	2003	3023	1933	1006	1
		2004	3094	2067	1123	
	Registered data	2000-2004				
Paper III	Company survey	2003	2907	2010	897	1
		2004	3212	2133	1079	
		2005	2960	2100	860	
Paper IV	Joint industry survey	2005	4479	4479		5

*Employees from onshore and offshore departments, some are working onshore and offshore

The study had a main focus on one petroleum company. The company studied in Paper I, Paper II and Paper III, had its headquarters in Norway and was the largest operator on the Norwegian continental shelf. It was an integrated technology-based, international energy company primarily focused on upstream oil and gas operations. The company employed approximately 32 000 employees in 40 countries. In 2008 the

company was an operator for 39 producing oil and gas fields and was the world's largest operator in waters more than 100 metres deep. The company's onshore facilities in Norway were active within gas treatment, crude oil reception, refinement and methanol production. The production averaged more than 1.7 million barrels of oil equivalent per day and it was one of the world's largest crude oil and gas suppliers.

Paper IV has data from five petroleum companies' operating at the NCS and the contractor employees working for them. 54% of the employees were employed in or worked for the largest company with 19 offshore installations. The second and third largest company employed 21% and 12% of the population, respectively, and had 10 and 7 offshore installations, respectively. The two smallest companies, with respectively two and three offshore installations, staffed 8% and 5% of the total workers. The number of operator and contractor employees per company varied between 244 and 2390 employees and the number of employees in the five operating companies varied between 111 and 1415.

In this thesis we have studied six factors (Table 2). Not all of the factors are studied in all the papers. Paper I includes all of them. The other studies are partly based upon the first study, looking at some of these factors in more detail or from another angle.

Table 2 Factors that affect workers subjective opinions of HSE culture and HSE climate, in four studies in the Norwegian Petroleum industry.

Study	Management	Behaviour	Competence	Proce-dures	Colla-boration	Physical conditions
Paper I	+	+	+	+	+	+
Paper II	Perception of nearest manager Confidence in management	HSE behaviour	+	+	+	-
Paper III	Perception of nearest manager Confidence in management	HSE behaviour	+	+	+	-
Paper IV	Safety management and involvement Safety versus production	Safety prioritisation Individual motivation	+	System compre-hension	-	-

3.1 Paper I

Design: In Paper I we used a qualitative research design. It was an interview study including 31 employees from different parts of onshore and offshore business units in one company, including both blue-collar and white-collar workers.

Measures: Individual semi-structured interviews were used including questions formed to explore work-related issues which could explain aspects of HSE culture. Few topics were included: HSE culture, health and working environment, safety and environment. 4 persons performed the interviews, two at the time.

Analysis: Giorgi's phenomenological analysis (1985) in four stages were used: a) reading the material to get a sense of the whole; b) reading the same descriptions more slowly to identify different meanings representing different aspects of HSE culture, and coding these; c) abstracting the meanings within each of the coded groups; d) summarising the contents of each code group to generalise descriptions reflecting the most important elements in the informants' opinion of HSE culture and HSE challenges. The four researchers did their own coding and then discussed the code categories and the meaning.

3.2 Paper II

Design: In Paper II we used a longitudinal design of both self-reported data and data from a company register.

Measures: The company in the study has performed annual surveys of self-reported working conditions since 1986 among both onshore and offshore workers. The company survey was not standardised; it was developed by the company and revised every year. This survey had items related to the factors that emerged as important to understand HSE culture in the interview study in Paper I. The statements in the company survey are closely aligned to organisational climate questionnaires (Schneider and Gunnarson, 1991). The items were phrased as "I have confidence in …" or "In my unit we have …" and were to be answered on a six-point scale ranging from one ("fully disagree") to six ("fully agree"), where six was the best score. In addition, "not relevant" was a response option. The self-reported surveys of working conditions were distributed in the electronic mail system to all employees once a year. A personal e-mail was sent to all employees, with a link to the electronic questionnaire and an assurance of anonymity. The questionnaire was sent only to the company's own employees, not to the contractor staff. Data from 2003 and 2004 were used in this study. The response rates for the surveys were 71% in 2003 and 76% in 2004. In this study we included items on working onshore or offshore, department, age, gender, perception of nearest manager, confidence in management, HSE behaviour, competence, collaboration and procedures. These factors were found by a factor analysis.

We also analysed health and safety performance measures from the same company's files: Sickness absence, recordable injuries, serious incidents and undesirable incidents. The petroleum company used the same reporting system for HSE data in all the departments in Norway. Data on recordable injuries were obtained for 2000-2004. The company has procedures for processing the reported data, from immediate notification of the incident or injury to investigation and follow-up of corrective and

prevention activities (Berentsen and Holmboe, 2004). Data on sickness absence were collected from the human resources registration tool in the company.

Statistics: The individual data in the self-reported survey were aggregated to department and business unit level. Descriptive statistics were used in the form of percentages. Explorative principal component analysis was used to assess factorial structures of the items from the survey. To test the internal consistency of the indexes in the study, Cronbach's alpha values were calculated. Two sample t-test was used to test differences between offshore and onshore workers. Pearson's correlation analysis was performed to calculate the correlation between the six factors emerging from the factor analysis and recordable injuries, serious incidents, undesirable incidents and sickness absence. Linear regression analyses were carried out for each factor separately to study the relation between factors in the self-reported working condition survey and injuries summarised for 2000–2003 and 2000–2004.

3.3 Paper III

Design: A longitudinal study design from 2003 to 2005 was performed. The employees came from offshore and onshore plants.

Measures: We analysed data from the same company survey as in Paper II. We used items from the annual surveys of self-reported working conditions on working onshore or offshore, age, gender, perception of nearest manager, confidence in management, HSE behaviour, competence, collaboration, and procedures. The response rates for the surveys were 70% in 2003, 76% in 2004 and 72% in 2005.

Statistics: The individual data in the self-reported survey were aggregated to department level. Descriptive statistics were used to describe the number of employees, departments, age groups and gender distribution. A general linear model univariate test was used to test differences between offshore and onshore departments. An independent-samples t-test was used to test differences among offshore and onshore departments. Adjusted means and confidence intervals were calculated.

3.4 Paper IV

Study design: This study was a cross-sectional study including 4479 employees in 2005.

Measures: We used questionnaire data from the project ”Trends in Risk Levels – Norwegian Continental Shelf”, called “The Norwegian offshore risk and safety climate inventory” (NORSCI). The items in this survey were developed by others, but the survey contained relevant items on the factors that emerged as important for HSE culture in the company studied in Paper I–III. The questionnaire was limited to factors of relevance to safety and working environment. Scoring on safety climate followed the Likert scale from 1 to 5 expressing agreement or disagreement. Questionnaires including items on type of employment, age, gender, company, installation they were working on, safety prioritisation, safety management and involvement, safety versus production, individual motivation, system comprehension and competence. These items were partly similar to the factors studied in paper I–III. The data also included five companies, not only one.

Statistics: Descriptive statistics on individual data were used to describe each company and the total sample concerning employment status, gender, age and number of installations. A factor analysis was performed for the 2005 items. Cronbach’s alpha was calculated to test the internal consistency of the dimensions. Pearson Chi-square test was applied to test the age differences between the operator and contractor employees. Mean scores were calculated for each item and each dimension. To test the differences in mean scores of the dimensions between the operator and contractor employees in the five companies and on the 41 installations, one-way analysis of variance (ANOVA) was used. Effect size was used to measure the effect of the relationship between the scores regardless of the sample size. ANOVA was also used to estimate adjusted explained variance (R^2) for each dimension for operator and contractor employees in the five operating companies and 41 installations separately. Mixed model statistics were performed to study the six health and safety climate dimensions and the different levels of management of the workers; company and installation, and in addition an analysis was made through including work in an

operator company or a contractor company as a random factor, with age and gender as covariates.

3.5 Ethical issues

The author of this thesis is the first author of all four papers and is employed by the company studied in Paper I–III. Also, one of the other authors in Paper II and III is employed by the same company. Thus, the author has conducted a special attention to do the research in accordance with recognised ethical standards. A researcher's background and position will affect what they choose to investigate, the angle of investigation, the methods judged most adequate for this purpose, the findings considered most appropriate, and the framing and communication of conclusions (Malterud, 2001). Planning, carrying out and reporting on research have been done with focus upon research ethics and in close cooperation with research institutions. It was important to cooperate with external researchers as a strategy for being able to question findings and perform interpretations.

The author was manager of the company's research program "Human factors and HSE culture" when the research was initiated. She became a research fellow at the University of Bergen in 2003 and has done the analysis in cooperation with researchers from different Universities in Norway and UK. In 2007 she became the vice president of health and working environment in the same company. This close relationship between the researcher and the company has of course importance, causing bonds of loyalty. This would have been a large problem in a study of evaluation of the working environment. However, the aim of the thesis was to gain more knowledge of organisational and working environment factors that affect health and safety in the petroleum industry not to evaluate these factors. Hence, to be employed in the company and the position of the author was of less importance. Permission was given from the company to publish the results of the HSE culture study in international journals.

In the qualitative study in Paper I, we selected information rich employees form different places in the company. They were selected based on their positions and different fields of operations, gender, age and experience. The researchers came both from within the company and from research institutions. The interview guide and the interviews, the analysis and the writing were developed within this group of researchers to maintain adequate distance from the study setting (Malterud, 2001). In Paper I we used citations that underlined expressions from more than one employee; informants should not be recognised. This was also emphasised to the participants before the study started when they gave their permission to take part in the study. All informants were given a report with the results of the interview study. We did not ask about health information or sensible individual data. The interviews were taped and transcribed and information was given to the informants that the data will be maculated when the study is finished.

In paper II and III we used data from a company-wide survey. We did not use individual data or health data and it was not possible to identify individuals. The authors used aggregated data to department and business unit levels. We did not have access to the individual data in these studies. In paper II we also used data on injuries, serious incidents and undesirable incident from the same company's HSE database. This is an open database and the number of injuries and incidents were analysed at the same aggregated organisational level as the company-wide survey. The data on sick leave came from the human resource registration tool in the company, this was also aggregated data, and no individual health information was available.

In Paper IV approval to analyse data from NORSCI were given to the researchers at the University of Bergen by The Petroleum Safety Authorities Norway. Approval was also obtained from each of the five operating companies that were studied. It was emphasized that the company identities should not be revealed. To assure the anonymity of the five operating companies, they are identified as A, B, C, D and E in Table 2 and as numbers 1 to 5 in Table 3 with no link between the letters and the

number assigned to the respective companies. We did not use individual data and no health data.

4 RESULTS

4.1 An explorative study of health, safety and environment culture in a Norwegian petroleum company (Paper I)

Research question: To gain more knowledge of the various ways the health, safety and environment culture concept was understood and defined among employees with and without leadership responsibility

The informants used the concept “HSE culture” in three ways. The most common way was descriptive, outlining specific characteristics of the organization as they regarded as relevant to HSE. The informants gave both positive and negative descriptions. Secondly a causal way of using the concept was used; the term was used more or less synonymously with concepts such as behaviour and attitudes. HSE culture was conceptualized as a factor with a causal effect on the HSE results of the organization. And a systemic way were applied for the concept were HSE culture is the holistic relationship between various phenomena influencing HSE in the organization. Safety was the topic mentioned most frequently, especially by employees at the operational units. However, occupational health and the working environment were also identified as important. Managers and employees differed little in the use of the concept of HSE culture and their opinions concerning the HSE challenges.

Management was described as important by all employees. Behaviour, competence, collaboration, procedures and the physical environment were also found to be important to a sound HSE culture. Putting these results together, they can be illustrated as an HSE culture umbrella (Figure 8). This figure illustrates the main results of the study; managers and employees are partners in a system of interrelationships, and they have different roles and actions in the HSE work. The umbrella also illustrates that several factors are important and necessary to express the HSE culture.

Figure 8 An umbrella as a framework for communication about health, safety and environment culture developed from a study of workers in a petroleum company in Norway

4.2 Associations between self-reported working conditions and registered health and safety results (Paper II)

Research question: To investigate the possible association between self-reported working conditions and registered health and safety results in a petroleum company in Norway.

Confidence in management, both in 2003 and in 2004, was significantly negatively associated with the mean of the sum of recordable injuries for 2000–2003 and 2000–2004 respectively, adjusted for gender, offshore and onshore work. Recordable injuries were negatively correlated with all the working condition factors. This means that the better results the business units had on the self-reported working environment and organisation survey, the fewer registered accidents had occurred.

Self-reported responses regarding the perception of the nearest manager and confidence in management were significantly negatively correlated with sickness absence when analysing all offshore and onshore departments. The higher the mean score was on the management items, the lower the sickness absence rates. However,

these results were not significant when dividing the material into offshore and onshore work. We found significant differences between onshore and offshore departments for sickness absence. The sickness absence for offshore departments was 6% and for onshore departments 3.9% in 2003. In 2004 the sickness absence was respectively 5.8% and 3.7%.

Offshore workers reported lower scores for all working condition factors, and there were significant differences between the two groups on perception of nearest manager, confidence in management and procedures in both 2003 and 2004. Significant differences between offshore and onshore departments were found for collaboration and competence in 2004 only.

4.3 Nearest management is important for health and safety (Paper III)

Research question: To compare working environment among onshore and offshore employees

Onshore workers were generally more satisfied with all organisational and working environment factors than offshore employees in a company survey on working conditions in 2003, 2004 and 2005. Perceptions of the nearest manager differed significantly between the offshore and onshore departments for all years and for all items, except for one question in 2003 and 2005. The item "Finding the information I require in the electronic information systems I use is easy" differed significantly between the groups for all three years.

Three of the four items about confidence in the management differed significantly between offshore and onshore responses in one or two of the years. The fourth item "To my friends I speak of the company as being a good company for which to work" differed significantly in all three years. Three of the four items concerning HSE behaviour differed significantly between onshore and offshore departments both in

2004 and in 2005. Five items about competence differed for one or two years. The item “I am satisfied with my career opportunities in the company” differed significantly between the offshore and onshore departments in all three years.

4.4 What is most important for safety climate; the company belonging or the local working environment? (Paper IV)

Research question: To analyse whether company belonging or local working environment is most important for safety climate in the offshore petroleum industry

For all six healths and safety climate dimensions analysed in this study the installation factor explained a greater percentage of the variance than did company belonging for both operator and contractor employees when these were analysed separately. Installation (local working environment) explained more than company also when age and genders were included in the model.

We found significant differences between the employees in the five operating companies and between the contractor employees working for these five operating companies within the safety climate dimensions ”Safety prioritisation”, ”Safety versus production”, “Individual motivation”, ”System comprehension” and ”Competence”.

Contractor employees answered more positively on the health and safety dimensions than operator employees, except for the dimensions ”Safety versus production” and ”System comprehension” in 3 and 2 operating companies respectively. The highest mean scores were found for the dimensions “Individual motivation” and “Competence”, and the lowest for “Safety versus production” and “System comprehension”, both for operator and for contractor employees.

The 41 installations differed significantly in mean scores on all the health and safety dimensions for operator and contractor employees. The mean scores on the dimensions “System comprehension” and “Safety versus production” displayed the greatest

variations for all employees on the 41 installations, and it displayed the smallest variations on the dimensions “HSE behaviour” and “Competence”.

5 DISCUSSION

5.1 Main findings

5.1.1 Interpretation of the HSE concept (Paper I)

HSE is a much broader concept than safety. This has implications for the HSE work in the companies. The Petroleum Safety Authorities Norway expects the industry to do HSE planning and performance to include all HSE risks to be controlled, measured and improved. In the interviews in Paper I, many informants, especially from the production units, only addressed safety and not occupational health, working environment and the environment when we asked for their opinions about HSE culture. This might reflect what was being highlighted and communicated by the company earlier on.

It has been a long tradition in the petroleum industry improving engineering solutions and the safety management system. Mearns and Reader (2008) write that for many years, improving safety performance has been focused exclusively on safety matters in the petroleum industry as has been the case in other high risk/high-reliability industries. This is also seen in the scientific literature, where studies of safety climate and safety culture studies dominate. The international safety researchers have not taken the integrated HSE concept into use. With a few exceptions using the HSE culture and HSE climate concept (Parker et al., 2006; Hudson, 2007) safety climate and safety culture studies have been published focusing on safety and accidents as outcome only. One explanation for this may be that the safety culture concept was introduced as a feature in explaining the major accidents. However, The International Association of Oil and Gas Producers (OGP) made a pamphlet in 2005 called “Human Factors, a means of improving HSE performance”. They introduced a five-step HSE culture ladder, a way to improve HSE. The factors culture/working environment, management system, people and facilities/equipment were underlined as important, but most of the examples in the pamphlet were associated with or connected to accidents and accident investigations.

This has also been observed by other authors. Mearns and Hope (2005) note that: “Interestingly, the rapidly growing literature on safety culture makes little, if any, reference to the concept of health or to the environment, although many organizations have HSE or HSEQ (health, safety, environment and quality) departments”.

Safety must be prioritised; however, a lot of employees in the petroleum industry suffer from hearing loss due to workplace noise (Morken et al., 2005), skin disorders connected to chemical substances and musculoskeletal disorders due to difficult working positions, heavy lifting or psychosocial factors (Morken et al., 2007). There has been a discussion in the industry and in the news lately if there might be a connection between possible chemical exposure in the petroleum industry and health effects. The occupational diseases, which usually occur over time, are not as visible as occupational accidents. This difference between injuries and diseases could be one reason for the focus on safety culture and climate as precursors that can be addressed to prevent major accidents and injuries, although the occupational health problems are the ones that affect most employees.

It may be of importance for the companies to know how HSE and HSE culture is used and understood by employees at different levels in the organisation in order to work systematically to improve HSE. The same approaches to HSE must permeate the organisation. One suggestion is that managers must go forward and lead the systematic HSE work in the company. Mearns and Reader (2008) discuss the problem of motivating safety in the UK offshore petroleum industry, as there is a lack of both positive and negative reinforcement regarding safety performance. They suggest more imaginative forms of interventions such as the supervisors being supportive towards the health and well-being of the workforce, based on their research results showing a connection between activities to improve health and safety performance.

5.1.2 HSE culture is a complex concept (Paper I)

Few informants used “HSE culture” in a holistic manner in the interviews. In a holistic, systemic model, attention is turned towards the interplay between the various aspects of a system. This means that the HSE culture approach in the company may be observed through the physical arrangements, the leadership of the company, the local managers commitment to HSE, the procedures (known and understandable), organisational system and through the workers competence and behaviour. The task is to understand how one phenomenon reflects other phenomena.

The interviews in Paper I show that the factors that was important for HSE culture seem to be factors also found in the safety climate literature (Guldenmund 2000; Flin et al., 2000). Management, behaviour, competence, procedures, collaboration and physical working environment seem to be important.

Although the interviewed persons in paper I used the concept “HSE culture” in several ways, managers and employees recognised for the most part the same themes as being the important ones for HSE, and they differed little in their uses of the concept of HSE culture and their opinions concerning the HSE challenges. This reflects the fact that there was a common opinion about HSE culture in the company. This might be in accordance with the integration perspective (Schein, 1985) where culture is perceived as the shared understandings in a given organisation.

However, since there are several ways of understanding the concept “HSE culture”, the differentiation perspective (Martin, 1992) fits with our findings in Paper II, Paper III and Paper IV. Here a significant difference was found between offshore and onshore workers regarding opinions about the self-reported working conditions. In Paper IV differences were found between the companies and the installations. The differentiation perspective emphasises the lack of consensus between interpretations and meanings in an organisation and the focus is usually on sub-cultures. There are at least some broadly shared rules, which are necessary if the concept of culture is going to have any meaning at all (Alvesson, 2002).

5.1.3 Management is important (Paper I, II, III, IV)

Management was frequently mentioned as important for an organisation's HSE culture in the interview study (Paper I). The employees wanted visible managers who understood and complied with HSE challenges and, through their decisions and actions, could function as role models. This is in line with Flin et al. (2000) who found the factor "management" to be the most important one in safety climate studies.

When we analysed subjective working environment and workplace incidents and sickness absence in Paper II, we found that the number of recordable injuries was significantly correlated with confidence in management. Sickness absence was also strongly related to management factors. This seemed to verify the study of Mearns et al. (2003) who found that management commitment to health and safety emerges as a key predictor of accident incidence. Proficient safety management practice was furthermore associated with fewer official accident reports.

In Paper IV we found that the factors "System comprehension" and "Safety versus production" displayed the greatest variations for all employees on the 41 installations operated by the five operator companies on the Norwegian Shelf. These dimensions contained items about management systems and management practice within maintenance, reporting and work processes. When analysing self-reported working environment offshore and onshore (Paper II and Paper III), it appeared that management factors like presence, visibility and involvement in the work were important for workers' job satisfaction. Reason (1997) asserts that the management's commitment to safety is a fundamental component of an organisation's safety culture.

Guldenmund (2007) argued that it is important to study HSE culture by assessing HSE climate on different management levels. In this thesis we used HSE culture interviews (Paper I) and HSE climate items (Paper II–IV) on organisational, group and individual levels. In Paper II we found upper management, the factor "confidence in management", to be significantly negatively associated with recordable injuries. We

did not find this for the factor “nearest management”. This might be in contrast to Paper IV where we found that for all the studied dimensions of the health and safety climate, the installation factor (local working environment, group level) explained a greater percentage of the variance than did company belonging (organisational level). The findings in this study may be explained by the fact that the management levels are difficult to separate in such surveys. People respond to the safety climate survey based on their own experience regarding health and safety, expressed through their own and their colleagues’ behaviour, local health and safety systems and prioritisation from the installation management. Company policy may be viewed as distant from the installation/workplace and hence not be especially influential on their attitudes. The relation between high scores on climate surveys and few numbers of injuries may not be present using all types of survey scales. On the other hand, supervisors explain, justify and apply higher management’s policies to the workforce and are thus responsible for the notions that are prevalent among the workers (Guldenmund, 2007). However, Zohar and Luria (2005) assumes that supervisory discretion within a company may stem from several sources such as interpretation of procedures, tasks not covered by the procedures and possible conflicts between performance quantity versus quality (e.g. production speed vs. safety precautions). Leader–member exchanges involve interpersonal dynamics that are only partially governed by formal procedures, and individual beliefs and attributions influence supervisory interpretation and the implementation of formal procedures.

5.1.4. Differences between offshore and onshore employees opinions of working conditions (Paper II and III)

We found differences between offshore and onshore employees regarding their perceptions of the working environment in a Norwegian oil and gas company. The offshore and onshore departments differed in particular on items related to perceptions of the nearest manager and on items about finding electronic information. Offshore workers were generally less satisfied with all organisational and working environment factors.

A study from UK shows that the offshore installation managers report difficulties in motivating and controlling crucial safety aspects of workforce behaviour even though they are aware of the importance of such leadership (O'Dea and Flin, 2001). This may reflect problems particular to offshore work, as indicated by the present study. It might be that offshore management is more demanding when it comes to the special shift patterns. Perceptions of the nearest manager differed significantly between the offshore and onshore employees in our sample from 2003, 2004 and 2005. This may be explained by the differences in shifts systems and having more than one manager to report to offshore.

At the offshore installations nearest manager and employees are living together 24 hours a day. This provides a greater opportunity for communication during meals and coffee breaks and should make communication and confidence building easier. However, our surveys did not have items concerning the work–family interface. The absence from family and friends for periods of two weeks at a time may be a source of stress and dissatisfaction (Parkes, 1998). Possible conflicts associated with partner absence or other psychosocial stressors regarding working on remote locations may be explanations for more dissatisfaction with work among offshore than among onshore employees. Also, such factors as 24 hours noise and living close to other people could be important for understanding the differences between the offshore and the onshore workers.

Sickness absence differed significantly between the onshore and offshore departments in 2003 and 2004, offshore workers having a higher percentage of sickness absence than onshore workers, as shown in Paper II. Offshore employees must pass a medical examination every second year to ensure that they are physically and mentally fit for the demands of the offshore environment. Offshore workers, based on the selection criteria, have better health than the general onshore population. However, it may be easier to go to work with sickness when the employees have the possibility to go home if the illness develop during the day (as for onshore workers), than when you need to travel by helicopter. The offshore employee must be healthy and feel well when

entering a new 14 days 12 hour shift period and this may cause a different pattern of sick leave.

5.1.5 HSE in petroleum companies

Although it was not an aim of the study to evaluate the focus on HSE in the petroleum industry, the findings of our study warrant some comments. However, we have not been able to compare these results with other industries, and the findings must be interpreted with caution.

We found a uniform and relatively high reporting on the ”Safety management and involvement” dimension by analysing the five companies discussed in Paper IV. This may also be seen as an expression of the high focus on HSE in the offshore Petroleum industry in Norway. The results of our study indicate that many of the employees are aware of the focus on the HSE-issues from the top management and the authorities, and have adopted it as a part of their own attitudes and behaviour. On the other hand, this finding must be interpreted with caution, due to a relative low response rate in this study.

However, the other papers in this thesis confirm that there is a major focus on HSE in the petroleum industry in Norway. In Paper III the item “In my entity, the zero mindset (zero accidents, injuries or losses) forms the basis for planning and implementing our work” did not differ between onshore and offshore employees in the company. The mean scores were high, reflecting the HSE focus in the company. The high values of mean satisfaction on organisational and working environment factors in all departments support these findings. A weakness of these findings might be that the surveys were performed by the company itself. Although anonymity was assured, this may have caused better results than the real ones. However, also the opposite could be the case, as anonymous complaints may be exaggerated.

According to Reason (1997), a reporting organisation is important for good health and safety performance. A reporting culture is based on trust, and the purpose is to learn

from experience in order to avoid unfortunate incidents. The existence of a reporting culture can be discerned from the high response rate on the studied company's survey about working conditions in Paper I-III.

The workers employed in the five operating companies in Paper IV differed in the safety climate dimensions "Safety prioritisation", "Safety vrs production", "Individual motivation" and "System comprehension" which may be explained by different safety cultures in the five companies. Reason (1997) emphasise the learning organisation as important for health and safety performance. The companies might learn from each other how to improve HSE performance and to build a strong and sound HSE culture.

Lack of competence on risks of diseases may be one explanation for why the attention to health and working environment culture at the workplaces is less in focus than safety culture and accidents. If managers believe that only health professionals like physicians, nurses, ergonomists and occupational hygienists should deal with health and working environment risks, the attention in the company will be low. Managers are responsible for a healthy working environment and the managers' competence within occupational health risks is a prerequisite for sufficient focus on prevention of diseases and sickness absence and promotion of workers' health. The sickness absence in the company in paper I-III is low compared to other industries in Norway. However, the high incident of reported work related diseases, especially for musculoskeletal diseases, hearing loss and skin disorders, is a clear signal to the management teams that more must be done to secure healthy workplaces.

5.1.6 The HSE culture concept

Although we have, through our research, indicated what seems to be important, we still think it is difficult to define the "HSE culture" concept. Based on the definitions of "safety culture" used in the nuclear industry (ACSNI, 1993) and Richter and Koch's (2004) definition, the following definition of "HSE culture" encompassing working environment, health and environment is suggested:

> *"HSE culture is the shared and learned meanings, experiences and interpretations of an organisation's working environment and how this influences people's decisions and actions against risks for diseases and accidents, and promote the health, environment and safety awareness".*

In this definition the working environment is in focus, understood as technical design and equipment, the organisational structure and systems (e.g. competence, regulations/procedures) and how these influence the individual's awareness, decisions and actions within these frameworks systems. The employer/manager is responsible for the planning, managing and control of the working environment (Ministry of labour and social inclusion, 1997).

The Petroleum Safety Authorities regulation concerning HSE culture from 2002 will be revised for activities offshore and for land facilities in 2009. In the regulations submitted for consultation the Authority underlines, in the guideline, that culture is not an individual characteristic but developed through interaction between people and framework conditions. Managers' responsibility and behaviour is described as important factors. This is in line with our findings. Managers on different levels are the front figures and responsible for the HSE work in the companies.

The interaction between the managers and the workers is the main part of the HSE culture umbrella, as the fabric. The factors behaviour, competence, collaboration, procedures and physical conditions are the spokes. We believe that a figure like the HSE culture umbrella is a good way to communicate important factors that can be used to improve HSE. As petroleum production is an internationally industry a globe has been put behind the HSE culture umbrella to signify the national and local culture which has an impact on the HSE culture at the workplaces (Figure 9).

Figure 9 Health, safety and environment culture umbrella with the globe as a framework for communication.

We think it is wise to use an illustration like the umbrella to communicate HSE culture work in the company. “HSE culture” is a complex concept and difficult to communicate.

5.2 Methodological considerations

5.2.1 The qualitative study (Paper I)

In order to get insight into the HSE culture in the organisation we needed to use different research approaches. Our first study was qualitative, to gain insight to the subjective experiences and understandings of HSE culture in the company and industry by not using a framework developed by researchers. Qualitative research explores the richness, depth, and complexity of phenomena. A further methodological triangulation, e.g. fieldwork and participant observation, could have mapped "tacit knowledge", basic assumptions and "webs of significance" and would probably have improved the study.

Four researchers collected and analysed the interviews. The different academic backgrounds made the analyses richer as the researchers brought different perspectives to the interpretation of the data. However, it might be that the information collection and analyses could have been better if one or two researchers had carried out the whole study. We should have obtained more information about the informants, especially on different management level, in order to perform more analyses of possible differences between employees and managers on different levels in the organisation. However, this might have made it more difficult to protect the individuals participating in the interviews. The way the study was performed the informants interviewed can not be recognised.

5.2.2 The quantitative studies (Paper II, III, IV)

Establishing causal links between safety culture or climate measures and safety performance in different industries is difficult. In Paper II we found a relationship between self-reported working environment concerning management functions and injuries. This relationship may be interpreted as causal, due to the longitudinal design. However, there might be confounding factors present that were not known to the researchers. There were few recordable injuries every year. We used the sum of recordable injuries from 2000 until 2004 and this might have influenced the results.

A longer observation period might have improved the study. On this basis, parts of the surveys of self-reported working environment and organisation surveys might probably be used as indicators of risk of injuries. However, more studies are needed to confirm this.

Paper IV had a cross-sectional design, making causality difficult to evaluate. A longitudinal design of a similar study would be of great interest.

We used self-reported working environment surveys to get insight into some elements of the organisations' HSE cultures. The questionnaires used in these studies had items that were found to be relevant for safety culture. These factors seem to be important factors in understanding HSE culture and to measuring HSE climate. Other methods could have been used as well, but we decided to concentrate the studies around the findings from the interview study.

The self-reported working environment questionnaire used in Paper II and III was not standardized and it was administered by the company itself. However, the questionnaire had been used and tested since 1986. One factor lending support to the reliability of the data was that the results were stable over three years. The instrument was a general instrument for measuring organisational climate and not constructed to be correlated with health and safety results as we did in Paper II. If more or other items had been included, such as more than one item concerning procedures and other items within HSE behaviour and collaboration, different results might have been obtained.

The instrument used in Paper IV was validated in a former study, and five of the six dimensions were stable through 2001, 2003 and 2005, whereas the sixth dimension, "Competence", was integrated in the 2005 solution and showed a good fit with the total model. In Paper IV the adjusted R^2 was low, indicating that there are other variables that explain the results as well, in addition to the company belonging or the installation. This might for instance be accident involvement, job experience and

individual factors. This study was important as it included data from the main part of the petroleum industry in Norway, five operating companies and a large number of contractor companies, and not only data from one company. Although the response rate in the study was relatively low, the responses for the different categories of personnel corresponded closely to the distribution found in the industry (Petroleum Safety Authority Norway, 2006). A weakness was that the company belonging and the installations were closely correlated and therefore difficult to separate. The results must be interpreted with some caution due to the close relation between these two factors.

The results in Paper II and Paper III would have been more precise if individual data instead of aggregated data had been used for all analyses. However, in these papers we used data from more than one year, which ensured that the results were not occasional.

The strength of the study in Paper II was done due to the fact that the datasets came from different data sources and were independent. Complete datasets of both the survey of self-reported working conditions and the company's file of safety and sickness absence data were used. Because data sources differed, we had to aggregate the data from the survey of self-reported working environment to correlate it with health and safety data. The analyses were performed at the lowest possible organisational level, using departments whenever possible. The data material was, however, extensive and the surveys had very high response rates.

5.2.3 Ethics and loyalty

Can a person employed in a company perform a study of the HSE culture in this company? Some persons might say it is not possible. However, maybe it is not possible to do such a study with only researchers from outside of a company either? This question has been given considerable thoughts during the study. To be employed in one of the companies studied has opened many doors which might have been closed for other researchers. To get access to the data bases in the company and

understand what possibilities they had, could not easily be done by an external researcher. To be allowed to interview persons in the company could have been difficult as well for an outsider.

On the other hand, as previously described, the studies have been planned with a clear knowledge about the possible interactions between data, loyalty, background and position (Malterud, 2001). Studies involving evaluation of the companies have been avoided, and the researchers have worked together in teams, to reduce the possibility of influence on the results. With researchers both from the company and outside, the results have probably become more balanced than with only one partner participating in the process. The candidate has at no point been allowed to publish any results without the research group's approval.

A weak part in the study was the interviews of persons. However, assuring their anonymity was important during this work, clearly underlining that the information would not be given to anyone outside the research group was probably very important. On the other hand, we can not know to what extent this made employees' answers out of pure loyalty to the company and not by their heart. Another weak part is the questionnaire results, as there always are persons who do not respond if they fear that their answers might be seen by authorities. The extent of this problem is not known. However, the anonymity, with no questionnaires with names or numbers on and given assurances of confidentiality, was a good method for this situation.

5.2.4 Generalization of the results

The factors, found by the interviews, seemed to reflect important factors to the HSE work and culture in the company. Our results in the Papers I, II and III were obtained from one company only, and generalisations of the results should be made with great caution. However, findings from paper IV included data from 5 companies. Hence, we think it might be possible to generalise from these studies to the Norwegian offshore industry as a whole, and also have an impact on other types of industry with multiple locations. The five companies are all international oil and gas companies, operating

both in Norway and internationally. This may support the possibility that the findings can be generalized to companies in other countries as well. Similar studies ought to be performed in other countries to see if the same findings can be obtained. The results may be influenced by other national cultures, other frameworks set by the authorities and different working environments and living conditions.

6 CONCLUSIONS

This thesis has shown that "HSE culture" is a concept with several meanings. Management, behaviour, competence, procedures, collaboration and physical conditions are factors of importance. The main focus in the company studied in papers I, II and III was safety, less on health, working environment and the environment.

This study has further shown that management is very important for the employees' understanding of HSE culture and also between self-reported working environment concerning management functions and injuries. Management style and trust in the manager are important factors when it comes to personal injuries. The company's working and organisational survey might be used as an indicator of risk of injuries.

Onshore workers were more satisfied with all organisational and working environment factors. Differences in management style and resources, type of shift work and living conditions might be important in explaining the differences and should be studied further.

Local HSE work on the installations and the HSE work by the company are important to the HSE culture among the workers. Although a good policy for HSE must be set up by the top managers to initiate the good HSE work, this is not enough to produce good health and safety results on the local workplaces; it must be followed up locally. This is of major importance to the workers, the companies themselves, as well as for petroleum authorities.

6.1 Suggestions for further research

The interpretation of the concept "HSE culture" is important, insofar as it affects how the workers, both with and without leadership responsibility, deal with occupational health, safety and work environment issues. Different aspects of the HSE culture should be investigated in more detail. Further studies on different levels of

management and health and injuries should be performed. Understanding the interplay between occupational health, safety and environmental issues and how they are prioritised in relation to each other and in relation to other organisational goals, e.g. productivity and finance, could be part of an important development of our understanding of how socially-responsible organisations define and articulate their values and conduct their business.

There might be important factors not included in this study, which for instance may explain the difference between installations and companies in Paper IV. We suggest further research on factors such as health promotion activities, accident involvement and job experience.

Surveys of self-reported working environment and organisation can probably be used as indicators of risk of injuries. Further studies are needed to clarify whether these relationships are valid in other settings.

The differences in perceived working environment and the differences in health and safety results onshore and offshore must be further studied to enable us to understand and initiate the right actions needed to increase the offshore workers' satisfaction with the working environment.

A follow-up study with interviews in the petroleum company may be important in order to find out if the HSE culture has developed the past years. More longitudinal studies as in Paper II would give the industry more knowledge about organizational, individual and technical factors that effect HSE in this industry.

REFERENCES

Allebeck, P., Mastekaasa, A., 2004. Swedish Council on Technology Assessment in Health Care (SBU). Chapter 5. Risk factors for sick leave – general studies. Scand J Public Health Suppl. 63:49–108.

Alvesson, M. *Understanding Organizational Culture.* Sage, London; 2002.

ACSNI. Human Factors Study group. *Organising For Safety.* HSE Books, Norwich; 1993.

Banks, M.H., Clegg, C.W., Jackson, P.R., Kemp, N.J., Stanford, E.M., Wall, T.D., 1980. The use of general health questionnaire as an indicator of mental health in occupational studies. J Occup Psychol. 53:187–194.

Berentsen, R., Holmboe, R.H., 2004. Incidents/accidents classification and reporting in Statoil. J Hazard Mater. 111:155–159.

Chen, W.Q., Yu, I.T.,Wong, T.W., 2005. Impact of occupational stress and other psychosocial factors on musculoskeletal pain among Chinese offshore oil installation workers. J of Occ and Env Med 62: 251–256.

Cheyne, A., Cox, S., Oliver, A., Tomas, J.M., 1998. Modelling safety climate in the prediction of levels of safety activity. Work and Stress 12(3):255-271.

Clarke, S., 1999. Perceptions of organizational safety: implications for the development of safety culture. Journal of Organizational Behavior 20(2):185-198.

Cooper, M.D., 2000. Towards a model of safety culture. Safety Science 36: 111–136.

Cotton, P., Hart, P.M., 2003. Occupational wellbeing and performance: A review of organisational health research. Australian Psychologist 38(2):118-127.

Cox, S., Flin, R., 1998. Safety culture: philosopher's stone or man of straw? Work and Stress 12(3): 189–201.

Donald, I., Canter, D., 1994. Employee Attitudes and Safety in the Chemical-Industry. Journal of Loss Prevention in the Process Industries 7(3):203-208.

Eide, I., 1990. A Review of exposure conditions and possible health-effects associated with aerosol and vapor from low-aromatic oil-based drilling-fluids. Ann Occup Hyg. 34:149–157.

Eide, I., Brandsdal, E., Malvik B., 1992 a. Subjective and objective evaluation of an office environment. Environ Int. 18**:**63–72.

Eide, I., Brandsdal, E., Bjorseth, O., 1992 b. Subjective and objective evaluation of the indoor environment in an enclosed 24-hour society on an offshore installation. Environ Int. 18:371–379.

Farrington-Darby, T., Pickup, L., Wilson, J.R., 2005. Safety culture in railway maintenance. Safety Science 43(1):39-60.

Flin, R., Mearns, K., O'Connor, P., Bryden R., 2000. Measuring safety climate: identifying the common features. Safety Science 34:177–192.

Frick, K., Langaa, Jensen, P., Quinland, M., Wilthagen, T. *Systematic occupational health and safety management. Perspectives on an international development*. Elsevier Science Ltd., Amsterdam; 2000.

Gardner, R., 2003. Overview and characteristics of some occupational exposures and health risks on offshore oil and gas installations. Ann Occup Hyg. 47:201–210.

Giorgi, A. Sketch of a psychological phenomenological method. In: Phenomenology and psychological research. Edited by Giorgi, A. University Press, Pittsburgh;1985.

Glendon, A.I., Stanton, N.A., 2000. Perspectives on safety culture. Safety Science 34(1-3):193-214.

Guldenmund, F.W., 2000. The nature of safety culture: a review of theory and research. Safety Science 34*:*215–257.

Guldenmund, F.W., 2007. The use of questionnaires in safety culture research – an evaluation. Safety Science 45:723–743.

Haukelid, K., Engh, K., Mellem, J.T. *Retningslinjer for sikkerhetsmotiverende tiltak*. In Norwegian [Guidlines for Safety Measures]. Rogaland Reasearch, Stavanger; 1991.

Haukelid, K. *En Historie om Risiko. Antropologiske Betraktninger om Sikkerhet, Bedriftskultur og Ledelse i Norsk Oljevirksomhet.* In Norwegian. [A history of risk. Anthropological reflections on safety, corporate culture and management in the petroleum industry in Norway]. Centre for Technology and Human Values, University of Oslo, Oslo; 1998.

Haukelid, K., 2008. Theories of (safety) culture revisited - An anthropological approach. Safety Science 26: 413-426.

Hellesøy, O.H. *Work Environment Statfjord Field.* Universitetsforlaget, Bergen; 1985.

Hovden, J., Lie, T., Karlsen, J.E., Alteren, B., 2008. The safety representative under pressure. A study of occupational health and safety management in the Norwegian oil and gas industry. Safety Science 46:493-509.

Hudson, P., 2007. Implementing a safety culture in a major multi-national. Safety Science 45(6):697-722.

Høivik, D., Brandsdal, E., Moen, B.E., 2007. Associations between self-reported working conditions and registered health and safety results. J of Occ and Env Med 49(2):139-147.

Høivik, D., Brandsdal, E., Moen, B.E., 2008. Nearest management is important for health and safety. A longitudinal study of perceived working conditions in offshore and onshore petroleum industry. Maritime Medicine Journal 8(1):38-55.

Høivik, D., Moen, B.E., Mearns, K., Haukelid, K. An explorative study of health, safety and environment culture in a Norwegian petroleum company. Accepted for publication in Safety Science, online 30th December 2008.

INSAG: *Basic Safety Principles for Nuclear Plants.* International Nuclear Safety Advisory Group, International Atomic Energy Agency, Safety Series No 75 INSAG-3, Vienna; 1988.

International Association of Oil and Gas Producers (OGP): *Human Factors, a means of improving HSE performance.* 2005. Available from: http://www.ogp.org.uk/ (accessed 2008-17-12).

Karlsen, J.E., Lindoe, P.H., 2006. The Nordic OSH model at a turning point? Policy and Practice in Health and Safety 4:17–30(1).

Kluckhohns, C.K.M., Kroeber, A.: *Culture: a Critical Review of Concepts and Definitions.* Peabody Museum Papers, Cambridge; 1952.

Lauridsen, O., Tonnesen, T., 1990. Injuries Related to the Aspects of Shift Working – A Comparison of Different Offshore Shift Arrangements. Journal of Occupational Accidents 12:67–176.

Lee, T., Harrison, K., 2000. Assessing safety culture in nuclear power stations. Safety Science 34(1-3):61-97.

Martin, J. *Culture in Organisations: Three Perspectives.* Oxford University Press, New York; 1992.

Malterud, K., 2001. Qualitative research: standards, challenges and guidelines. Lancet 358(9280): 483–488.

McDonald, N., Corrigan, S., Daly, C., Cromie, S., 2000. Safety management systems and safety culture in aircraft maintenance organisations. Safety Science 34(1-3):151-176.

Mearns, K.J., Flin, R., Gordon, R., Fleming, M., 1998. Measuring safety climate on offshore installations. Work and Stress 12:238–254.

Mearns, K.J., Flin, R., 1999. Assessing the State of Organizational Safety-Culture or Climate? Current Psychology 18:5–17.

Mearns, K.J., Flin, R., Gordon, R., Fleming, M., 2001. Human and organizational factors in offshore safety. Work and Stress 15:144–160.

Mearns, K.J., Whitaker, S.M., Flin, R., 2003. Safety climate, safety management practice and safety performance in offshore environments. Safety Science 41:641–680.

Mearns, K., Rundmo, T., Gordon, R.F.R., Fleming, M., 2004. Evaluation of psychosocial and organizational factors in offshore safety: a comparative study. Journal of Risk Research 7:545–561.

Mearns, K., Hope, L. *Health and well-being in the offshore environment: The management of personal health.* Research report 305. Health and Safety Executive, UK; 2005. Available from: http://www.hse.gov.uk/research/rrpdf/rr305.pdf. (accessed 2008-15-11).

Mearns, K.J., Reader, T., 2008. Organizational support and safety outcomes: An un-investigated relationship? Safety Science 46:388–397.

Michie, S., Williams, S., 2003. Reducing work related psychological ill health and sickness absence: a systematic literature review. J of Occ and Env Med 60:3–9.

Ministry of labour and social inclusion. *Systematisk helse-, miljø- og sikkerhetsarbeid i virksomheter (internkontrollforskriften).* [Systematic Health, Environmental and Safety Activities in Enterprises. The internal Control regulation]. Oslo; 1997.

Ministry of Petroleum and Energy. *Facts 2008 - The Norwegian petroleum sector.* Ministry of Petroleum and Energy, Oslo; 2008. Available from URL: http://www.npd.no/English/Produkter+og+tjenester/Publikasjoner/Faktaheftet/Faktaheftet+2008/fakta2008.htm (accesssed 2008-15-11).

Morken, T., Bratveit, M., Moen, B.E., 2005. Rapportering av hørselskader i norsk offshoreindustri 1992-2003. In Norwegian. [Reporting of occupational hearing loss in the Norwegian offshore industry 1992– 2003]. Tidsskr. Nor Laegeforen, 125: 3272–3274.

Morken, T., Mehlum, I.S., Moen, B.E., 2007. Work-related musculoskeletal disorders in Norway's offshore petroleum industry. Occup Med. 57:112–117.

Neal, A., Griffin, M.A., Hart, P.M., 2000. The impact of organizational climate on safety climate and individual behavior . Safety Science 34(1-3): 99-109.

Nielsen, M.L., Rugulies, R., Christensen, K.B., Smith-Hansen, L., Kristensen, T.S., 2006. Psychosocial work environment predictors of short and long spells of registered sickness absence during a 2-years follow up. J of Occ and Env Med 48:591–598.

Norwegian Pollution Control Authority. State of environment, Norway, 2008. Available from: URL: http://www.environment.no/Tema/Vannforurensning/Olje-og-gass/ (accessed 2008-05-12).

O'Dea, A., Flin, R., 2001. Site managers and safety leadership in the offshore oil and gas industry. Safety Science 37(1):39-57.

Parker, D., Lawrie, M., Hudson, P., 2006. A framework for understanding the development of organisational safety culture. Safety Science 44(6):551-562.

Parkes, K.R., 1998. Psychosocial aspects of stress, health and safety on North Sea installations. Review, Scand J Work Environ Health 24:321–33 (5).

Parkes, K.R., 1999. Shiftwork, job type, and the work environment as joint predictors of health-related outcomes. J Occup Health Psychol. 4:256–268.

Parkes, K.R., 2002. Age, smoking, and negative affectivity as predictors of sleep patterns among shiftworkers in two environments. J Occup Health Psychol. 7:156–173.

Parkes, K.R., 2003. Shiftwork and environment as interactive predictors of work perceptions. J Occup Health Psychol. 8:266–281.

Petroleum Safety Authority Norway, 2004. HSE and culture. Available from: URL: http://www.ptil.no/news/launching-theme-pamphlet-on-hse-culture-article1184-79.html (accesssed 2008-15-11).

Petroleum Safety Authority Norway, 2006. Trends in Risk Levels 2005. Available from: URL: http://www.ptil.no/English/Helse+miljo+og+sikkerhet/Risikonivaa+paa+sokkelen/RNNS+Fase+6+%282005%29+Sammendragsrapport/coverpage.htm (accessed 2008-15-11).

Petroleum Safety Authorities. *Annual report 2007 Facts.* Stavanger, Norway; 2008. Available from: URL: http://www.ptil.no/news/the-petroleum-safety-authority-norway-s-annual-report-2007-facts-section-article4463-79.html (accessed 2008-15-11).

Reason, J. *Managing the Risk of Organizational Accidents.* Ashgate Publishing, Hants, Aldershot; 1997.

Richter, A., Koch, C., 2004. Integration, differentiation and ambiguity in safety cultures. Safety Science 42:703-722.

Rundmo, T., 1992. Risk Perception and Safety on Offshore Petroleum Platforms. Perceived Risk, Job Stress and Accidents. Safety Science 15(1):53-68.

Rundmo, T., 1995. Perceived risk, safety status, and job stress among injured and noninjured employees on offshore petroleum installations. J Safety Res. 26:87–97.

Rundmo, T., Hestad, H., Ulleberg, P., 1998. Organisational factors, safety attitudes and workload among offshore oil personnel. Safety Science 29(2):75-87.

Ryggvik, H., Smith-Solbakken, M. *Norsk Oljehistorie - Blod, svette og olje*. In Norwegian. [Norways oil history - Blood, sweat and oil]. Norsk petroleumsforening (3). Ad Notam Gyldendal ISBN 82—417-0856-4; 1997.

Schein, E. *Organizational Culture and Leadership*. Jossey-Bass, San Francisco; 1985.

Schneider, B., Gunnarson, S. *Organizational climate and culture: the psychology of the workplace.* In Jones, J.W., Steffy, B.D., Bray, D.W., eds. Applying Psychology in Business. Lexington Books, New York; 1991:542–551.

Singer, S.J., Gaba, D.M., Geppert, J.J., Sinaiko, A.D., Howard, S.K., Park, K.C., 2003. The culture of safety: results of an organization-wide survey in 15 California hospitals. Quality & Safety in Health Care 12(2):112-118.

Statistic Norway, 2007. Available from: URL: http://www.ssb.no/english/subjects/06/02/sykefratot_en/arkiv/ (accessed 2008-15-11).

Steinsvåg, K., Bråtveit, M., Moen, B.E., 2006. Exposure to oil mist and oil vapour during offshore drilling in Norway, 1979–2004. Ann Occup Hyg. 50:109–122.

Steinsvåg, K., Bråtveit, M., Moen, B.E., 2007. Exposure to carcinogens for defined job categories in Norway's offshore petroleum industry, 1970 to 2005. J of Occ and Env Med 64: 250–258.

Stortingsmelding no.7 (2001-2002). Om Helse, Miljø og Sikkerhet i Petroleumsvirksomheten. In Norwegian. [White Paper no.7, 2002; On health, environment and safety in petroleum operations], Ministry of Labour and Government Administration, Oslo.

Ulleberg, P., Rundmo, T., 1997. Job stress, social support, job satisfaction and absenteeism among offshore oil personnel. Work and Stress 11:215–228.

Zohar, D., Luria, G., 2005. A multilevel model of safety climate: Cross-level relationships between organization and group-level climates. J of Appl Psychol 90:616–628.

WHO. Global Strategy On Occupational Health for All. The Way to Health At Work: Recommendation of the Second Meeting of the WHO Collaboration Centres in Occupational Health, 11-14 October 1994 Geneva, World Health Organization, Beijing, China; 1995.

Errata

Errata

Page 47 Last sentence. *"…. and it displayed the smallest variations on the dimensions "HSE behaviour" and "Competence"* should be *"…. and it displayed the smallest variations on the dimensions "Individual motivation" and "Competence"*

Paper 1 Page 8, last section. "*Data in this study is from 2002"*, should be "*Data in this study is from 2003"*.

Paper 2 Reference 21. "*Høivik D, Opheim M, Bovim R, Bye R. HMS-kultur i Statoil. Hva vi i Statoil vil legge i HMS-kultur begrepet. In Norwegian. [HSE culture in Statoil. What we understand about the concept of HSE culture in Statoil]. Trondheim: NTNU; 2003"* should be: "*Høivik D, Bye R. Health Safety and Environment Culture in International Exploration and Production (INT), Statoil. NTNU; 2004."*

Paper 2 Table 2. Response rate (%) should in 2003 be Offshore 71%, Onshore 74%. In 2004 Offshore 76% and Onshore 81%.

TABLE 2
Number of Employees Responding to a Survey on Working Conditions and Number of Departments and Business Units in 2003 and 2004, in a Petroleum Company

	Number of Employees		Response Rate (%)		Number of Departments/ Business Units	
	2003	2004	2003	2004	2003	2004
Departments						
Offshore	1933	2067	71	76	60	63
Onshore	1006	1123	74	81	30	29
Total	3023	3094			90	92
Business units	5433	5475			14	14