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Abstract

According to the Petroleum Safety Authority Norway (PSA, 2017), the safety trend within the oil and gas industry is moving in the wrong direction with regard to high-potential incidents. In order to achieve a positive development again, there is a need for further improvement in terms of identifying and implementing effective preventive measures and learning from incidents. Due to this, it is of high importance to gather more knowledge about which types of measures are effective, and which are not. In 2011, the PSA conducted a study on causal factors and conditions linked to gas release incidents (PSA, 2011). The study revealed that the majority of the direct causes were linked to technical and human factors, while the underlying causes primarily were linked to organizational factors. The PSA (2013) concludes that to reduce the number of gas leak incidents, a higher focus on organizational measures and learning is needed.

The objective of this study is therefore to generate knowledge on effective organizational measures and learning processes of practical importance. In order to achieve this objective, the thesis is based on two intertwined research questions: 1) "What are the characteristics of effective organizational measures and learning from incident processes?" and 2) "What can the oil and gas industry and the concrete company studied in this thesis acquire from these characteristics in their work with prevention of high-potential incidents?".

In order to answer the research questions, a literature review, semi-structured interviews and document analysis are performed. The purpose of the literature study is to identify the state of the art within the research area of effective organizational measures and learning from incident processes. The empirical basis of the document analysis is investigation reports and reports on proposed and implemented measures. The purpose of this empirical part of the thesis is twofold. First, to gather information about effective measures and learning from incident processes from front line personnel. Second, to gather information about the potential for improvement within the industry and within the studied company.

One of the key findings of the study was effective organizational measures are formulated as SMARTER actions with clear closing criteria, where the formulation is balanced properly between goal-oriented and prescriptive, and which ensures sustainability provided by a traceability in governing documents or other systems. Furthermore, it was found that the learning from incident process is only effective if all the phases of the process is properly executed. However, involvement of frontline personnel, safety delegates and others was identified as a significant contributor to achieving a successful learning from incident process. Moreover, it was recognized that the studied company (and the industry) needs to do some changes in their practices in the three last phases of the learning from incident process (planning intervention, intervening and the evaluating phase).

The implications of the study were identified as of importance not only for the studied company, but also for the industry in order to prevent high-potential incidents, such as gas leaks. The most significant practical implications were recognized as the importance of right involvement of personnel, proper formulation of measures and evaluation of measures and the learning from incident process. In addition, theoretical implications were identified as a need for more research on involving safety delegates in the learning from incident processes, how to avoid negative effects by using KPI systems, and lastly, how to ensure effective learning in shift-organizations.

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Contents

Abbreviations

BBN: Bayesian Belief Network
EI: Energy Institute
ERP: Enterprise Resource Planning
HAZOP: Hazard and Operability study
HC: Hydrocarbon
HSE: Health Safety and Environment
GPS: General People Survey
IAEA: International Atomic Energy Agency
KPI: Key Performance Index
LEAN: Principle of production philosophy
MTO: Man Technology Organization
NCS: Norwegian Continental Shelf
OMT: Risk modelling – integration of organizational, human and technical factors
PSA: Petroleum Safety Authority Norway
RIF: Risk Influencing Factor
SAP: Enterprise resource planning system software
SINTEF: Scandinavian research organization
SMART: Smart, Measurable, Attainable, Relevant, Date for commence
SMARTER: Specific, Measurable, Achievable/Accountable, Realistic/Reasonable, Timely/Time-bound, Effective, Reviewed

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1. Introduction

1.1 Background

According to the Petroleum Safety Authority Norway (PSA 2017), the safety trend within the oil and gas industry is moving in the wrong direction with regard to high-potential incidents. High-potential incidents are considered in this context as incidents which puts a whole organization into danger. A significant example of this is hydrocarbon (HC) leaks. During the last 15 years, the Norwegian oil and gas industry has achieved a significant reduction in the number of HC-leaks. However, most of this reduction was achieved during the first ten years of the period. During the last five years, the reduction rate has stagnated (PSA, 2016). According to the latest RNNP (Risikonivå i Norsk Petroleumsvirksomhet), risk level of Norway's petroleum activity report, the number of HC leaks actually increased from 2015 to 2016 (PSA, 2017), with reference to the below figure 1.1. In addition, it is observed that the number of 1-10 kg/s leaks have increased significantly the last five years.
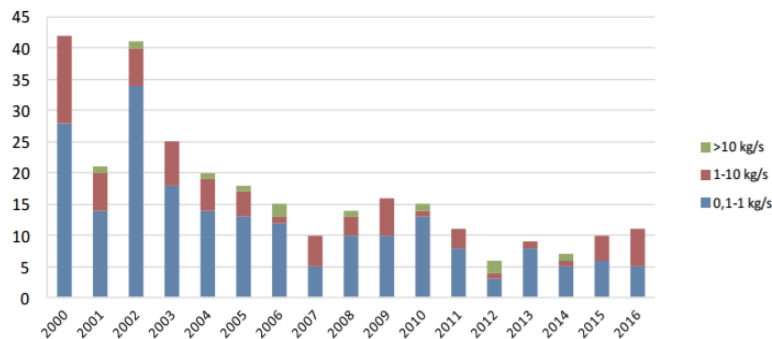
FIGURE 1.1 NUMBER OF LEAKS PER YEAR, ALL INSTALLATIONS ON THE NCS (PSA, 2017)

In order to achieve a positive development again, there is a need for further improvement in terms of identifying and implementing effective preventive measures and learning from incidents. Due to this, it is of high importance to gather more knowledge on which types of measures are effective, and which are not. An obvious challenge related to this is that the effect of each measure is unclear, which hampers the prioritization process when choosing measures. In addition, due to the present downturn in the industry, allocating the resources efficiently is even more critical.

Safety measures can be divided in three groups, namely immediate, corrective and preventive measures. These again, can be differentiated into technical, human and organizational measures. In 2011, the PSA conducted a study on causal factors and conditions linked to gas release incidents (PSA, 2011). The study revealed that the majority of the direct causes were linked to technical and human factors, while the underlying causes primarily were linked to organizational factors. The PSA (2013) concludes that to reduce the number of gas leak incidents, a higher focus on organizational measures and learning is needed. According to the study, the main contributing factors were poor planning and risk evaluation, lack of communication, lacking procedures and documentation, faulty work practices, and inadequate competence and training. Furthermore, the

RNNP 2011 report presents the typical measures which were recommended in the investigation reports. These were linked to competence/training, technical design and condition, procedures/documentation and check-out/control/verification.

The stagnation of the positive development in the number of HC-leaks indicate that there is a need to gather more knowledge on effective preventive measures. This is also the aim of the present study, which is based on an empirical investigation of a large oil and gas company operating on the Norwegian Continental Shelf (and on other shelfs world wide). In these insecure times of low oil prices, the company (and even the industry) is at pressure to perform more efficiently, while still maintaining a high level of safety. Meanwhile, the RNNP 2015 report indicates that many companies on the NCS struggle with reducing their number of HC-leak incidents, due to this matter.

1.2   Objective and Research Question

Based on the above mentioned arguments, the objective of this study is to generate knowledge on effective organizational measures and learning processes of practical importance. This means that the study aims to identify preventive measures and learning processes that are of practical value for the oil and gas industry in general and for the company studied in this thesis in particular. In order to achieve this objective, the thesis is based on two intertwined research questions:

1. ***What are the characteristics of effective organizational measures and learning from incident processes?***
2. ***What can the oil and gas industry and the concrete company studied in this thesis acquire from these characteristics in their work with prevention of high-potential incidents?***

In order to answer the research questions, a literature review, semi-structured interviews and document analysis are performed. The purpose of the literature study is to identify the state of the art within the research area of effective organizational measures and learning from incident processes. The state of the art is considered as the highest level of development achieved at the present time of this study. Hence, the literature study will shed light on research question 1. The interviews are done with informants within the case-company (hereafter referred to as The Company) with in-depth knowledge of action processes performed in the aftermath of serious HC-leak incidents. The empirical basis of the document analysis is (a) investigation reports and (b) reports on proposed and implemented measures. The purpose of this empirical part of the thesis is twofold. First, to gather information about effective measures and learning from incident processes from front line personnel. Second, to gather information about the potential for improvement within the industry and within The Company. Hence, the interviews and the document analysis will shed light on both research question 1 and research question 2.

1.3 Limitations

The scope of this thesis is to identify the state of the art of effective organizational safety measures and learning from incident processes and compare it to the reality presented by a major oil and gas operator on the Norwegian Continental Shelf (NCS) who faces major risk. This implies that technical safety measures are not taken into consideration in this thesis. Moreover, information gathered from the major oil and gas operator is considered solely a case. Hence, literature and comparisons from other sectors such as health and nuclear industry will be also be included. In this way, the conclusion of the thesis will apply to areas beyond the oil and gas industry.

Although the given company has been involved in several severe gas leak events during the last ten years, only a few of them will be analyzed qualitatively and quantitatively in this thesis. As severe gas leak events are quite rare and non-frequent, the effect of organizational measures is not easily measured in these cases. Semi-structured interviews and document analyses are therefore chosen for the empirical study of the gas leak events.

1.4 Approach

In order to reach the objectives, the process of the thesis will be divided into four primary phases. An outline of the research approach is illustrated in figure 1.2. The first phase will be based on a literature study, presenting the state of the art. Due to lack of literature on this subject in the oil and gas industry, gathering knowledge on experiences and recommendations from other sectors, is necessary.

FIGURE 1.2: RESEARCH APPROACH

The second phase is the empirical phase. In addition to the state of the art, it is also a need for looking into how these issues are faced in real life. Based on information from the major oil and gas operator, the reality of these issues can be empirically presented based on investigation reports and on reports presenting proposed and completed measures. In the investigation reports, measures are recommended given each event, while in the other reports, the measures chosen to be implemented are listed. The data presented in these documents is quantitatively and qualitatively analyzed. Furthermore, specific gas leak incidents is qualitatively analyzed with interviews of several employees with different roles who were involved in the selected accidents. Hence, semi-structured interviews was conducted. The third phase of the thesis is the analytical phase where the difference between the state of the art (from literature) and the reality (the company) is analyzed. The fourth phase is the presentation of the results. In this phase, deviations and concurrence in the analysis will be presented. In addition, new success criteria for effective organizational measures

will be presented. Furthermore, the study will result in recommendations of areas in which the company needs to look deeper into in order to meet the "ideal description" given as the state of the art.

1.5 Structure of the Report

The rest of the thesis is as follows:

- *Chapter 2* introduces relevant and existing theoretical background literature. The state of the art of effective organizational measures and learning from incident processes is presented.
- *Chapter 3* presents the methods used in the empirical phase of the thesis, namely interviews and document analysis.
- *Chapter 4* presents the findings of the interviews and document analysis
- *Chapter 5* presents the discussion and implications of the findings. Limitations and recommendations for further studies are also presented in this chapter.
- *Chapter 6* presents the conclusion for the thesis, and suggestions for the analyzed company.

2. Theoretical Background

This chapter presents relevant literature on the topics of safety measures, organizational measures in particular, learning from incidents processes, including investigation, planning, intervening and evaluating phases. The theoretical background represents the state of the art.

2.1. Organizational Accidents

According to Reason (1997) organizational accidents are often catastrophic events that occur within complex modern technologies such as nuclear power plants, commercial aviation, the petrochemical industry, chemical process plants, marine and rail transport. Organizational accidents have multiple root-causes involving many people operating at different levels of their respective companies. On the contrary, Reason argues, individual accidents are accidents where both the agent and the victim of the accident, both caused and affected the specific persons or groups. Individual accidents however, usually have organizational origins. For example, an offshore fatality is typically the result of a chain of several distinct failures. All technological organizations produce something as manufactured goods, transportation of people, financial or other services, extraction of raw materials and so on. However, to the extent that productive operations expose people and assets to danger, Reason claims that all organizations require various forms of protection to intervene between the local hazards and their possible victims and lost assets.

2.1.1 Active Failures and Latent Conditions

As humans design, manufacture, operate, maintain and manage technological systems, it is clear that human decisions and actions implicate in all organizational accidents (Reason, 1997). If accidents were always individual accidents, the discovery of unsafe acts immediately prior to the bad outcome would probably be the end of the story. However, it is difficult to establish the causal links between top-level decisions and specific events.

Obviously, no defensive layer is ever entirely intact, and no system is a 100% reliable. As Reason claim, each barrier has gaps and holes created by combinations of active failures (errors and violations committed by front-line personnel) and latent conditions (the consequences of top-level decisions having a delayed-action effect upon the integrity of various defensive layers). Sharp-end human failures are nowadays considered as consequences rather than as principal causes. It is acknowledged that people working in complex systems make errors or violate procedures for reasons that generally go beyond the scope of individual psychology. These reasons are latent conditions (Reason, 1997).

2.1.2 Organizational Culture

Culture is defined as the knowledge, values, norms, ideas and attitudes that characterizes a group of people. The HSE (Health Safety and Environment) culture is observable through the difference

between the statements and actions of the people. According to Reason (1997), a proper safety culture is characterized by being well-informed. A well-informed organization has good reporting systems, promotes justice, is flexible and adaptable, and it learns from its experiences (PSA, 2004). It is important for the reporting culture that critical incidents and nearly events are outlined. However, some might experience that reporting equals extra work, and the benefit diminishes. Trust is needed in order to promote reporting and promote workers to admit their mistakes. The motivation behind the reporting should be to learn from the experience and prevent similar incidents from occurring. Humans make errors often, and to avoid damages, accidents or losses, it is required that safety measures are implemented.

A righteous culture implies that the people are encouraged and rewarded for gathering important safety relevant information, but there is still a defined line between acceptable and unacceptable behavior. A flexible culture adapts effectively to changes and new situations. It handles both normal and high workload, without affecting safety and robustness. A learning culture relates to how knowledge and experiences are systemized and how this is dealt with on a daily basis. Learning and sharing knowledge across is important for a HSE-culture. A transfer of information and experiences between workers from different companies, disciplines, installations must be provided. According to PSA (2004), a good flow of information is a criteria for success.

2.2 Organizational Measures

Safety measures are actions taken to reduce risk and improve safety. These are often called corrective, preventive or remedial actions. Preventive measures are typically implemented to avoid a hazard from occurring, while corrective measures are implemented after a hazardous event has occurred. Safety measures are in many ways linked to barriers and barrier management, as different safety measures are implemented to strengthen or rebuild technical, organizational or operational barriers.

In the aftermath of an unwanted incident, there is an increasing focus on organizational measures, and less on technical (PSA, 2011). The reason for this is due to a rise of awareness on that most errors and failures can be traced back to system errors (meaning organizational errors). Hence, organizational measures are implemented. These measures are typically linked to competence, experience and knowledge, procedures and governing documents, safety and risk assessment (understanding and compliance), communication, conflict of objectives, maintenance, responsibility and roles, management and design.

2.3 Organizational Learning

A learning organization is an organization that is capable of developing and acquire knowledge, in order to modify its behavior to new knowledge and insight (Rosness, Nesheim & Tinmannsvik, 2013).Organizational learning includes integrating the learning from incidents into the organization itself, and not only into the individuals in which the organization consist of. This implies that the

learning would result in changes for the plant, equipment, policies, procedures, training, competence assurance, supervision, resourcing priorities, and other management systems. Hence, learning becomes permanently integrated in the organization and is preserved even though the people involved in the incident are gone. Furthermore, sustainable learning and effective sharing of information will reduce the number of employees who have substantial "blind spots", which are defined as information that the organization knows, but not the individuals. In addition, organizational learning theories stresses the importance of potential differences between what is said or written versus what is actually done (Drupsteen & Hasle, 2014).

2.4 Learning from Incident Processes

The prevention of accidents is closely related to learning from incidents. According to Le Coze (2008) and Lindeberg (2010), effective learning from incidents calls for follow-up steps and measures that lead to effective interventions. Depending on the particular author, the learning from incident process consist of several stages or steps. Two models will be presented in this subsection.

The Energy Institute

The Energy Institute (2016) presents Learning From Incidents (LFI). This model, presented in figure 2.1 below, includes reporting, investigation, recommendations and actions, broader learning, change and evaluation. According to the Energy Institute (EI), LFI processes should involve giving people the time and resources to reflect on and make sense of the information communicated, enabling them to make the changes necessary to reduce risk. In addition, it includes the organization embedding and monitoring changes in order to ensure that even if people leave the organization, measures to prevent incident reoccurrence are preserved. In order to provide learning, the organization should implement sustainable actions, ensure a good organizational culture, perform a sufficiently deep investigation, understand which stakeholders that can influence and shape the learning process, guard that messages are properly transmitted and received and ensure openness, transparency and sharing of information (EI, 2016).
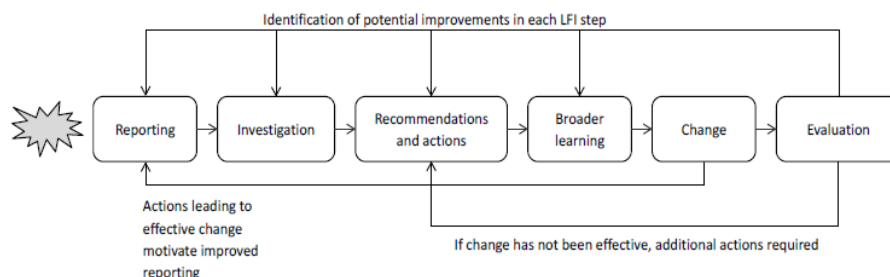
FIGURE 2.1 LEARNING FROM INCIDENT (EI, 2016)

Critical Steps in the Learning from Incidents Process

Drupsteen et al. (2013: 65), presents the model in figure 2.2 below. The model is developed based on large systems used by petrochemical and petroleum companies, expert opinions and a literature review. The quality of each step depends on the drivers, methods, resources and outputs (Baguley, 1994). The success of the total learning process is relying on each of the stages, as they will be the input for the next stage. As the learning from incident process is sort of a chain of steps, it follows the "garbage in, garbage out" principle. This implies for instance that the recommendations the management presents will not be effective if the investigation was inadequate or lacking. In addition, according to Drupsteen et al. (2013), communication through the whole process is essential in order to achieve a successful outcome.
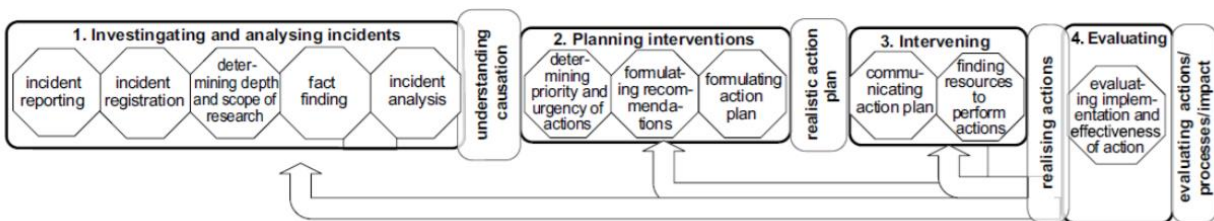
FIGURE 2.2 MODEL OF THE LEARNING FROM INCIDENT PROCESS (DRUPSTEEN ET AL., 2013: 65)

In addition to the models presented by Drupsteen et al. (2013) and EI (2016) there are also other models. However, in the literature study, solely these models will be considered. The following subchapter tittles are structured according to the Drupsteen et al. (2013) model, where the focus is on the three last stages of the model.

2.4.1 Investigating and Analyzing Incidents

Investigations are important for uncovering errors, omissions and improvement potentials in order to prevent similar incidents in the future. According to Drupsteen et al. (2013), the investigation and analyzing incident stage consists of incident reporting, incident registration, determining the depth and scope of the research, fact finding and incident analysis. See figure 2.2 above. Presenting in-depth investigation theory and analyses is out of the scope of this thesis, yet it is still an important stage in the learning from incident process.

The learning from incident process requires knowledge and understanding of root causes, active failures, latent conditions, and alternatives to prevent future reoccurrence. These are crucial outputs of all incident investigations. However, these outputs can be influenced if the company has an unfortunate organizational culture, such as a "blaming-culture". On the contrary, a "no-blame culture" enables transparent and honest reporting which is necessary for the analysis of the incident reporting.

According to EI (2016) blockers in the investigation and analyzing incident stage are many. Some of them are insufficient management commitment, lack of trained/competent investigators,

reluctance of providing full story (worry of being blamed or incriminating others), lack of comprehensive identification or underlying causes, difficulty of establishing human errors and lack of early learning.

2.4.2 Planning Interventions

In the planning intervention stage, a realistic action plan is formulated. The quality of these recommendations are based on the output of the incident investigation. The main steps in this stage is to determine priority and urgency of actions, formulating recommendations and formulating an action plan. See figure 2.2 above.

Determining Priority and Urgency of Actions

An important part of the first step in this stage is to prioritize and select the options that are expected to provide the highest effect. Prioritizing recommendations can prevent an organization from becoming over loaded with actions (especially when actions are also being generated through reviews, audits, safety tours, etc.) (EI, 2016). The International Atomic Energy Agency, IAEA (2005) emphasizes the preference of selecting measures that strengthen already existing programs and defense in-depth barriers, rather than developing new. In other words, when existing barriers remain weak it is ineffective to develop new barriers. Meanwhile, in health care, the criteria for priority is based on: 1) the *severity* of the condition/incident, 2) the *benefit* of the measure and 3) *cost effectiveness* (NOU 2014:12, 2014). In health care, the overall objective is to provide the highest possible number of healthy life years (NOU 2014:12, 2014), while in this context, the overall objective is to reduce the risk and increase the overall safety level of the organization. It is therefore essential that the prioritization process follows this objective, and ensures that the chosen measures provide the highest overall safety level for the organization. By overall safety level, it implies that the measures must not crowd each other out, nor provide an overall negative effect due to overloading or increasing the complexity of the organization. As the resources are scarce, it is important that the right and effective measures are selected based on proper prioritization criteria.

Formulating Recommendations

Recommendations are typically (but not exclusively) developed by an investigation team as a basis for developing concrete measures. EI (2016) highlights that the recommendations should address both direct and underlying causes, and it should be clear who is responsible and which part of the organization it applies to. The EI (2016) highlights that the wording should be free of emotive or judgmental language, it should not be vague or open to interpretation nor sound authoritarian or overly prescriptive. Also, the recommendations should be worded as single stand-alone items that includes an explanation of why it is made. How to achieve the desired outcome should be specified by the organization. The intent of the recommendation should be clear and broader learning points for the organizations/industry should be emphasized. The EI guideline (2016) emphasizes the importance of including line managers in the process, in particular at the stage where

recommendations are formulated. The reason for this is that the line managers usually have the best expertise and ultimately are the ones who will implement the actions. Hence, recommendations written solely by an investigation team is not a recommended process. In addition, the EI emphasize the importance of involving personnel with frontline experience when developing recommendations, since they usually have a deeper understanding of the issue at hand. This is also emphasized by e.g. Drupsteen and Hasle (2014) and Størseth and Tinmannsvik (2012).

Formulating Action Plan

According to Drupsteen et al. (2013) and the Energy Institute (EI, 2016) the measures given in the action plan should be based on the recommendations from the planning process and constitute the following characteristics: specific, measurable, attainable, relevant and time-bound. Hence, the measures are referred to "SMART actions". Similar to this definition, the IAEA (2005), referrers to the wider acronym SMARTER which includes the words specific, measurable, achievable, realistic, timely, effective and reviewed. According to EI (2016), the recommendations should be translated into SMARTER actions in order to make them easier to address and close-out.

Furthermore, the Energy Institute recommend that derived measures should not duplicate measures that already are in the system, as this can lead to an overload of measures. According to IRIS and Austnes-Underhaug et al. (2011), the timeframe of the investigations are often limited which causes the investigated companies to have more focus on closing the actions, then rather focusing on learning. This overproduction of measures lead to a "measures fatigue" (Austnes-Underhaug et al., 2011). This implies an improper prioritization process. According to the authors, stress, time restrictions and nervousness for new incidents and investigations, lead to too many, too quick and too less thought-through measures. In addition, the follow-up of measures is in many occasions lacking. As revealed in the study, it is hard for the workers to deal with a great number of measures, as it affects the total overview of the risk level.

The failure to address recommendations from earlier investigations has been seen as a precursor to many major accidents (EI, 2016). Hence, the measures must be traceable. Meaning, it should be clear when a measure is completed and closed. Specific criteria should be set and information should be provided in order to demonstrate that the criteria is withheld (EI, 2016). The statement of closing criteria facilitates the evaluation process of the effect of implemented measures. It is crucial that responsibility and ownership of the measures is established early, so that the owners are continuously held responsible for following up and closing the measures. According to EI (2016), measures tend to be easily closed-out, resulting in a less of effect than what was expected. The Energy Institute suggest that verifications, periodic reviews, interviews or performance indicators could help ensure and control that implemented measures are effective. This will also ensure that the actions are closed out in a timely and robust manner (EI, 2016).

2.4.3 Intervening

The third phase in the action process presented by Drupsteen et al. is the intervening phase. This phase regards the realization of the action plan, by communicating action plan and finding resources to perform actions. To ensure that the responsible leaders and workers establish ownerships to the remedial actions is the main requirement in this phase. Time limitations, no sense of ownership and fear of additional tasks were identified as apparent bottlenecks in the intervening phase.

Communicating Action Plan

Communication can be conducted in several ways, in both oral and written form. The authors of Drupsteen et al. (2013) stresses the importance of communicating the action plan and its objectives throughout the organization. This is essential in order to wake initiative and incentive to share the lessons learned. The involvement of personnel at all levels is necessary and important in both the planning and intervening phase. If excluding relevant personnel, this party may not understand the context and "buy in" to the change (EI, 2016). These incidents can help make use of knowledge that has led to sustained changes in companies. As claimed by the authors, there are many techniques for communicating incident lessons within organizations. For instance, the use of older incidents can encourage a discussion. Another suggestion is to develop a forum for sharing lessons learned and communicating with other operating units (EI, 2016).

Finding Resources to Perform Actions

Sufficiently amount of resources, such as time, money, manning and technology, must be available. The senior managers must ensure that sufficient amount of resources are available in order to handle the risks. They must have an oversight of all measures implemented. Senior managers should provide an overview of action implementation to ensure that appropriate resources are made available to match the risks involved. According to (Austnes-Underhaug et al., 2011), it is important that when decisions are made on a high level, extra resources are given to the ones who implements the measures on lower levels.

2.4.4 Evaluating

The authors of Drupsteen et al. (2013) emphasize the need for evaluating whether a measure was fully realized and fully effective. See figure 2.2 above.

Evaluating Implementation and Effectiveness of Action

This phase involves evaluating whether the actions are performed or not (first-order learning) as well as whether the actions were effective or not (second-order learning) (Drupsteen et al. ,2013). Moreover, it is essential to identify reasons why a given measure did not provide the intended effect. This is needed in order for the organization to improve their learning capability. Hence, the organization must to learn how to learn in order to continuously improve. The output of this stage in the learning from incident processes is an evaluation of action and processes, and the impact on the organization, and its safety performance (Drupsteen et al., 2013).

Hence, it is expected to learn something from the incident and the process. This learning should result in measureable changes to equipment, behaviors, processes and management systems, which will prevent, repeat, similar or event different incidents (EI, 2016).

2.5 Previous Studies on Effective Organizational Measures for HC Leak Incidents

In a study by Gran et al. (2012) the effect of proposed risk reducing measures was assessed by expert judgements. The applied inputs were firstly which risk influencing factors (RIFs) the measures would have an impact on. Secondly, the importance of the effect (low/medium/high), and thirdly, additional structural changes to the model. By applying Bayesian Belief Networks (BBN), the overall effects, given as percentage in risk reduction, can be calculated. The calculated values are presented in table 2.2 below. Observing the results, it is obvious that the measures with the highest expected effects are related to increasing the focus on the psychosocial work environment through greater degree of involvement across levels and disciplines. Yet, the effect of each measure varied in relation to different scenarios. These are however not shown in the table. For instance, the OMT model (integration of organizational, human and technical) predicted an overall effect of 15% of measure number 6, when it actually varied from 8% for scenarios caused by error in isolation/blinding/planning, to a 91% risk reduction for scenarios caused by incorrect isolation/blinding. It should be noted that the measures presented by Gran et al. (2012) do not represent a complete list of measures, and the results are therefore limited to the actual evaluated measures.

TABLE 2.1: RISK-REDUCING MEASURES FROM RISK OMT PROJECT (GRAN ET AL. 2012)

No.	Measure	Risk reduction (BBN)
1a	Work processes training work on normally pressurized equipment	7,0%
1b	Change the procedure for safe job analysis and pre-work dialogue with a greater emphasis on hydrocarbon leaks (major accidents)	1,5%
2	Increase emphasis on leaks (major accident potential) in the training of managers and executives	6,4%
3	Compliance program: conduct training in action compliance	14,2%
4a	Increase focus on the psychosocial work environment through greater degree of involvement across levels and disciplines	25,9%
4b	A subset of 4a is to improve involvement of contractors	5,4%
5	Improve availability and faster updating of technical documentation	5,1%
6	Improve labelling of process equipment i.e. more uniform labelling in accordance with technical documentation, in combination with improvements of established practice for radio communication	15,0%
7	Improve management of change, especially routines for quality control and the handover from modification projects to operation	15,0%
8	Formalize requirements to the work process "Work on normally pressurized equipment" in form of new procedures	13,7%
9	Develop procedures for the preparation and use of specific checklists from drainage/sampling	10,1%

Furthermore, a study by Adejugba (2013), concluded that the mechanisms contributing to the reduction of hydro carbon leaks are multidimensional. Adejugba (2013) recommends encouraging to report, provide a central industry information access point, ensuring continuous safety awareness among the workforce, efficient management of equipment contracting processes and ensuring that

the industry continues to exploit all mechanisms that have contributed to the present reduction of incidents.

In addition, SINTEF conducted a study engaged by the PSA in 2010-2011, where they identified concrete measures in order to reduce the risk of HC releases. In the study (PSA, 2011), four operating companies stated that company management/technical support, operator/technician employees, technical design and condition of the installation were the most critical measures in relation to risk reduction of HC leaks in the period 2002-2010.

Furthermore, SINTEF conducted a study by Mostue et al. (2014), where the authors compared causes of HC leaks from the PSA study with other typical events in the oil and gas industry. The study presented identified risk reducing measures and areas of improvement for the different types of events. The recommendations were to have more focus on complex operations that can deviate from normal daily work, ensure learning and experience transfer of information from incidents and to perform improvements in terms of defining precise and concrete measures.

A downside with the above-mentioned studies of proposed measures is that they are only derived from the causes and they have not been subject to empirical testing. Nevertheless, quantitative evidence-based evaluations of measures against events with low frequency is challenging as the output measure rarely occurs. Lofquist (2010) referrers to this problem as "the art of measuring nothing", which implies the challenge of measuring safety as an outcome variable in ultra-safe industries.

2.6 Summary of the Theoretical Background

The literature presents several aspects that are interesting for this study. Due to the scope of the present study, not all of them will be considered in further detail. Figure 2.3 below presents the main characteristics of success criteria identified in the literature. The presented bullet points are the focus areas for the further research of this thesis.

1. Investigating and analyzing	2. Planning Interventions	3. Intervening	4. Evaluating
⇒ *Sufficiently deep* **investigation** ⇒ *Clear* **causal relationship** ⇒ **Involvement** *of the right people*	⇒ *Recommendations address both* **direct and underlying causes** ⇒ *Concise and not open for interpretation nor overly prescriptive* **wording** ⇒ **Prioritization** *according to highest overall increase in safety level* ⇒ **SMARTER** *actions* ⇒ **Involvement** *of line managers and personnel with frontline experience* ⇒ *Avoid* **overproduction** *of measures (measures fatigue)* ⇒ *Clear* **closing criteria**	⇒ **Communication** *(use of older incidents, forum of sharing lessons learned, etc.)* ⇒ *Enough* **resources** *(manning, time, money, etc.)* ⇒ **Involvement** *of workers at all levels* ⇒ *Establish* **ownership** *of measures*	⇒ *Evaluation of* **effect** *(verifications, periodic reviews, interviews or performance indicators)* ⇒ *Evaluation of* **implementation** *of measures (whether measures were fully realized)* ⇒ *Evaluation of* **learning** *(improvements of the stages in the learning from incident process)*

FIGURE 2.3 SUMMARY OF SUCCESS CRITERIA FROM LITERATURE

3. Methodology

This chapter presents the methodological aspects of the thesis. The methods are procedures or techniques used in order to gather and analyze information. These are often distinguished between *quantitative* and *qualitative* methods. Qualitative methods focuses on gathering opinions and experiences that cannot be expressed by numbers or measurements. Meanwhile, quantitative methods focuses on transforming information into measurable units, such as percentages, averages or standard deviations. Other differences between these methods are related to the gathering of information. These differences are demonstrated in table 3.1 below. By using these methods, an improved understanding of the society, MTO and the interaction between these is achieved.

Table 3.1: Characteristics of quantitative and qualitative methods (Dalland, 2000):

Quantitatively oriented	Qualitatively oriented:
Precision - display the most accurate reflection of the quantitative variation	Sensitivity - display the best possible reproduction of the qualitative variation
Width - little information about many investigation units	Depth - much information of few investigation units
The average - display the common ground, the representative	The distinctive - display the specifically, the deviating
Systematics - questionnaires with predefined answer options - systematic and structured observations	Flexibility - interview characterized by flexibility, without answer options - unstructured observations
Remoteness from the field - the information is gathered without direct contact with the field	Proximity of the field: - the information is gathered with direct contact with the field
By parts - the information gathered is related to separate phenomena	By whole - the information gathered aims to display cohesion and unity
Explanation - aims to convey explanations	Understanding - aims to convey understanding
Observer - the researcher sees phenomenon from the outside - the researcher endeavors neutrality and distance	Participant - the researcher sees phenomenon from the inside - the researcher recognizes impact and participation
I-It-Relation - Between researcher and examination person it is a I-It-relation	I-You-Relation - Between researcher and examination person it is a I-It-relation

3.1   Research Strategy

There are several approaches to reach the answers throughout a research process. The research strategy guides the research from questions to answers. Blaikie (2010) presents four research strategies, namely: *inductive, deductive, retrospective and abductive*.

Inductive research strategy considers earlier observations in order to say something about the future. Hence, one wishes to develop a theory, a rule or a principle on a phenomenon based on empirical observations. A classical example is: "Based on the observations of several black ravens, it is concluded that all ravens are black".

Deductive research strategy may be used to test the developed theory, rule or principle from inductive research. By performing a deductive research, the theory is hypothetically tested. Following the strategy leads to clarity and a reduction of the uncertainty factors. However, a

problem with this "testing" strategy, is that they do not confirm that something is true, only that the theory is false or not true.

Retrospective research strategy considers an investigation of a phenomenon or issue that has occurred in the past. These studies commonly consider secondary data collection, based upon data available from previous studies or databases.

Abductive research strategy is similar to deductive and inductive approaches in a way that it is applied to make logical inferences and construct theories. The researcher seeks to develop the 'best' explanation among many alternatives in order to explain 'surprising facts' or 'puzzles' identified in the initiation of the research process (Bryman & Bell, 2015). When explaining the "surprising facts" or "puzzles", the researcher can combine both, numerical and cognitive reasoning.

This thesis follows the inductive, deductive and abductive research strategies. The theory behind effective organizational measures and process is tested (deductive research strategy), while new theory on the subject is presented based on observations (inductive).

3.2 Information Gathering

The strategy of gathering information for this study was to first find relevant theoretical background information, and then gather data. In this way, a few expectations on how the reality looks was established, and thereby, gather empirical data to examine whether the expectations match the reality. The expectations are therefore based on earlier empirical findings and theories. Unfortunately, this may lead to a limited spread of information, as the researcher will only look for information that is relevant, and the findings tend to be biased in relation to the initial expectations. The access of information is then limited and the researcher risks that crucial information is overlooked (Jacobsen, 2005). Ideally, the researcher should start the research process with an open mind before the information is gathered and systemized.

In research, the use of empirical data is a subject to specific rules. For instance, the data must be used precisely and should be systematically chosen. This is essential in order to not defile the results, and it prevents the researcher from using the information in which pleases the expectations. The researcher often caters to groups or individuals which are expected or thought to have contributions to the research. This is a strategic choice of informants, which enables the systematic selection.

When gathering information, it is essential to establish what the information shall be used for and the value it has for the study. Its relevance for the main objective, its reliability and validity are three important factors that needs to be considered when evaluating the information. For instance, when humans are the source of the information, it needs to be evaluated who is thought to provide the most exhaustive answers. It is therefore important that the chosen informants are selected carefully in order to display the relevant information linked to the issue at hand.

The gathering of information in this thesis was conducted by applying semi-structured interviews and document analysis of investigation reports and reports on proposed and completed measures. Ellefsen (1998) stresses that by using several methods and approaches in a study, the validity and the insight of the phenomenon is improved. However, the thesis focuses mainly on the qualitative semi-structured interviews.

3.3 Document Analysis

Document analysis applies historical, written sources as the basis for the research (Dalland, 2000). It refers to the various procedures involved in analyzing and interpreting data generated from the examination of documents and records relevant to a particular study. A range of different types of documents can be useful as empirical material. The term document has a wide range of meanings. Documents can be used in a combination of other information gathered, or alone. However, it is essential that there is a close relation between the documents and the objective of the research. The documents have to provide answers to the questions asked. In addition, documents can both be analyzed quantitatively and qualitatively. Quantitative analysis of documents involve a counting of a property or characteristic with the documents, such as number of measures or recommendations. Qualitative analysis of documents imply that the researcher interprets the meaning of what is written.

3.3.1 Document Format

3.3.1.1 Investigation Reports

Investigation reports follow a specific format. The level of the investigation, often local, external or by corporate, depends on the severity of the incident. The investigation team often consist of investigators with different background, which is beneficial in order provide a best possible picture of the incident. Furthermore, investigation reports include background information, a description of the incident, actual and potential consequences, root-causes (including barrier failures and deviations), warning and preparedness, other conditions, and recommended actions. The listed recommended actions are established with the intention of preventing similar incidents from occuring, and to generally improve the overall HSE-level on the installation. Each listed action is reasoned for, by a given description and/or explanation.

3.3.1.2 Reports on Proposed and Implemented Measures

The reports on proposed and implemented measures also follow a specific format. After an incident and investigation, a report on proposed and implemented measures is written. These reports include an extended explanation of the measures where type, deadline, status, responsible unit and person, description of the measure and evaluation confirmation etc., is listed. Most of the measures are derived from the recommendations in the investigation reports.

3.3.2 Conducting Document Analysis in This Study

The selected incidents for this study, were investigated by both the PSA and the company. The company provided the necessary documents. Information linked to the incidents were gathered from the investigation reports and reports on proposed and implemented measures. 32 investigation reports and reports on proposed and implemented measures were provided and 15 of these incidents where selected based on the oil and gas leak degree of severity. Only incidents of a 1 or 2 degree were analyzed. Degree 2 is defined as 1-10 kg/s or short-term >10 kg/s, while degree 1 is defined as >1-10 kg/s or short-term >100 kg/s. Hence, the incidents reviewed were quite severe. The relevant information from the two different type of reports were plotted into Excel sheets. The documents were both quantitatively and qualitatively analyzed. As this thesis focuses mainly on measures and not root-causes and consequences, most time and focus were given to the reports on proposed and implemented measures.

3.3.2.1   Investigation Reports

From analyzing the investigation reports, it was expected to find answers related to the following success criteria presented in figure 3.1:

1. *Investigating and analyzing*	2. *Planning Interventions*	3. *Intervening*	4. *Evaluating*

⇒ *Sufficiently deep* ***investigation***
⇒ *Clear **causal relationship***
⇒ ***Involvement** of the right people*

⇒ *Recommendations address both **direct and underlying causes***
⇒ *Concise and not open for interpretation nor overly prescriptive **wording***
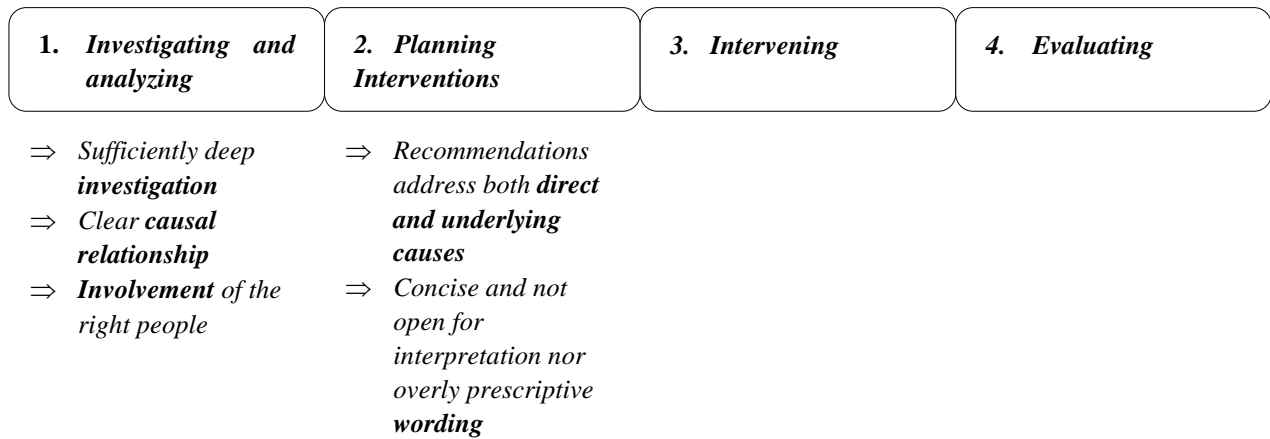
FIGURE 3.1 DOCUMENT ANALYSIS OF INVESTIGATION REPORTS

Thus, with regard to investigation reports, it is analyzed whether the investigations are sufficiently deep, the causal relationship is clear, the investigation team consist of the right people (right competence and background) and the recommendations addresses both direct and underlying causes. In addition, it is analyzed whether the recommendations are concisely formulated, not open for interpretation nor overly prescriptive.

3.3.2.2   Reports on Proposed and Implemented Measures

From analyzing the reports on proposed and implemented measures, it was expected to find answers related to the following success criteria presented in figure 3.2:

1. *Investigating and analyzing*	2. *Planning Interventions*	3. *Intervening*	4. *Evaluating*
	⇒ **SMARTER** *actions* ⇒ *Avoid* **overproduction** *of measures (measures fatigue)* ⇒ *Clear* **closing criteria**		⇒ *Evaluation of* **effect** *(verifications, periodic reviews, interviews or performance indicators)* ⇒ *Evaluation of* **implementation** *of measures (whether measures were fully realized)*
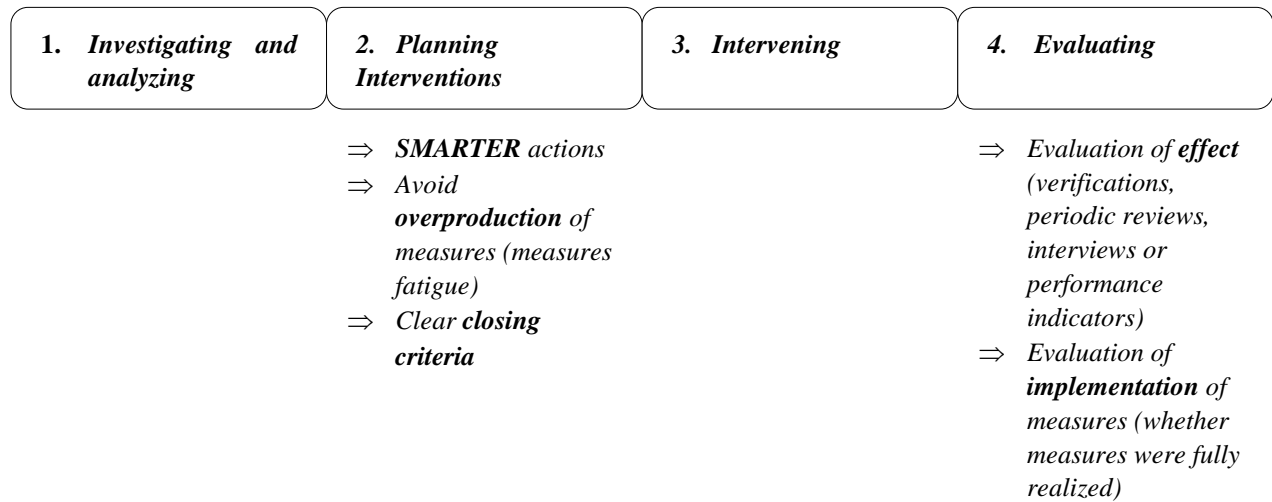
FIGURE 3.2 DOCUMENT ANALYSIS OF REPORTS ON PROPOSED AND IMPLEMENTED MEASURES

Hence, in the reports on proposed and implemented measures it is analyzed whether the measures are formulated as SMARTER actions, whether they are sustainable and have clear closing criteria. In addition, the average number of measures per incident and the average closing time of measures, is presented. This will give an indication of an overproduction of measures (measures fatigue) which can overload the organization. Moreover, the reports are reviewed in terms of evaluation points. Moreover, it is analyzed whether the effect of the measure is evaluated or whether the implementation of the measure was fully realized.

3.3.3 Strengths and Weaknesses of Document Analyses

Strengths

It is an advantage that all of the analyzed documents are in the same format, as they are in this study. Hence, it is easy to compare the documents to each other. In addition, only specified personnel are allowed to compile the reports. These are typically investigators or leaders. This implies that the documents are credible and valid.

Weaknesses

Although the documents have the same structure, the content may not always have the same quality. Numerous of people, with different background and competence, write the documents, thus, the quality therefore varies. Some write very technical, while others write the reports in order to make them understandable for everyone. It is also a weakness in these content analyses that they are very dependent on the researcher's background and perspective. Furthermore, it might be difficult to

spot the relevant information in the documents. Sometimes, one needs to see beyond the words to spot relevant information, as information is not given, it is found. In addition, it might be unclear how many documents that are enough for the analysis (quantitatively, but also qualitatively). In this thesis, it is assumed that 15 samples (reports) are adequate.

3.4   Interview

The method of interviewing can be applied when the researcher wishes to gather information by communicating with people. The interviewer is the instrument used to gather and interpret the answers provided by the respondents. The qualitative interview method aims to understand the phenomenon based on interviewee's point of view, and have an open mind for new and unexpected phenomena.

3.4.1 Conducting Interviews in this Study

In total, eight number of interviews were conducted, with twelve number of informants. All informants were kept anonymous in the thesis. The interviews were conducted through a video conversation, where both parts could see and hear each other. All informants agreed upon the use of a tape recorder, given that the recording was deleted after use. In this way, it was easier to focus on what was said and what follow-up questions to ask next. The duration of each interview lasted approximately for two hours. According to Jacobsen (2005), this amount of time should be adequate in order to reveal all relevant information. In the beginning of each interview, the informants were given an introduction to the background and the relevant research questions.

3.4.2 Interview Format

In this thesis, semi-structured interviews were conducted. Semi-structured interviews are partly structured, as the researcher has predefined the objective of the study/interview. This implies that the interview focuses on certain areas of interest, and the interviews have developed an understanding of this subject. Even though, an interview guide is made in advance, the interviewer is not restricted to solely ask these questions during the interview. The researcher is able to outline and ask follow-up questions that is not preplanned (Kvale & Brinkmann, 2009).

3.4.3 Informants

The selection of informants were based on employees who plan, implement and follow-up on measures, hence a selection of purposive sampling (Patton, 2001). Purposive sampling implies that the respondents were selected according to some predefined criteria that fitted with the objective of the study, and not randomly. The predefined criteria for the informants were that their professional background varied and that they were familiar with processes of implementing safety measures. In addition, it was of importance for the research that the studied industry was a high-risk industry. The two installations, Installation A and Installation B, are both operated by The

Company. These installations were chosen as they both experienced a serious gas leak incident in recent time.

All interviewees were employed in The Company. The interview requests were sent out early, and all informants participated voluntarily. The interviews were conducted both individually and in groups of two. Individual interviews have the benefit of providing significant amount of information from an individual person's perspective, however it is more time demanding. Group interviews have the benefit of leading to an interesting discussion between the respondents, providing good input that could be neglected during individual interviews.

The different roles of the informants were platform manager, safety delegate, technical manager, construction engineer, process leader, production manager, operations and maintenance manager , task manager for design and integrity and manager of safety and sustainability. Due to the agreements of anonymity and confidentiality, each informant is given a number (from 1-12) such that it is not possible to identify the role (and possibly the name) of the informant. However, it can be revealed that five of the informants came from Installation A, and the seven other came from Installation B.

3.4.3.1   Question Format

Interview questions should be formulated such that the informant is led into answering something other than "yes" or "no". There are closed-format and open-ended-format questions. Closed-format questions are often used in quantitative research and questionnaires. The answer options are limited and the approach is best suited to collect specific information given by answering to given alternatives that are most suited. Open-ended questions however, these are more common in qualitative research as the informant is free to answer with his or her own words. In this study, the questions are mostly formatted as open-ended, yet a few closed-ended questions are also asked.

3.4.3.2   Interview Guide

In the planning phase of the interview, an interview guide should be sent to the informants. The guide presents appropriate open-ended questions that allow the researcher to gain insight into the research question. In addition to the questions, the guide should also include metadata on the researcher and the respondent(s) as well as a brief introduction to the research question. The interview guide for this thesis was developed in collaboration with SINTEF employees in order to cover to most essential subjects of their total research delivery to The Company. Therefore, as this thesis is only a small part of the delivery, a few of the questions in the interview guide are not quite relevant for this thesis. The irrelevant questions are included in the interview guide, however the answers to these are not discussed nor considered further in this thesis.

From interviewing the selected informants and asking the questions provided in the interview guide (Appendix A), it is expected to find answers related to the following success criteria presented in figure 3.3:

2. Investigating and analyzing	2. Planning Interventions	3. Intervening	4. Evaluating
⇒ Sufficiently deep **investigation** ⇒ Clear **causal relationship** ⇒ **Involvement** of the right people	⇒ Recommendations address both **direct and underlying causes** ⇒ Concise and not open for interpretation nor overly prescriptive **wording** ⇒ **Prioritization** according to highest overall increase in safety level ⇒ **SMARTER** actions ⇒ **Involvement** of line managers and personnel with frontline experience ⇒ Avoid **overproduction** of measures (measures fatigue) ⇒ Clear **closing criteria**	⇒ **Communication** (use of older incidents, forum of sharing lessons learned, etc.) ⇒ Enough **resources** (manning, time, money, etc.) ⇒ **Involvement** of workers at all levels ⇒ Establish **ownership** of measures	⇒ Evaluation of **effect** (verifications, periodic reviews, interviews or performance indicators) ⇒ Evaluation of **implementation** of measures (whether measures were fully realized) ⇒ Evaluation of **learning** (improvements of the stages in the learning from incident process)

FIGURE 3.3 SEMI-STRUCTURED INTERVIEWS

In addition, it is expected that the informants will present new aspects of success criteria that is not currently revealed in the literature. As the company is considered very professional in terms of safety and risk management, it is considered likely that the industry can learn from the company. Hence, the inductive approach of the research.

3.4.4 Strengths and Weaknesses of Semi-Structured Interviews

Strengths

If the researcher comes from the outside (external researcher), he or she is more likely to approach the problem with open eyes and objectivity. Even though, distance does not guarantee objectivity (Patton, 1980), it was certainly beneficial that the interviewer was not employed in The Company. A face-to-face interview is advantageous as it allows the interview to be more flexible and loose, and opens for rephrasing and follow-up questions. In addition, facial expressions, body language and the interviewee's mood can be observed. By conducting the interview by video, all of the benefits of a face-to-face interview as achieved. In addition, all interviews were audio recorded in order to make the most use of the answers. It allowed the researcher to pay full attention to the participants, which made it easier to keep a good pace, ask follow-up questions and avoid important information to be lost.

Moreover, it was favoring that the interviews were conducted in Norwegian, which was the native language of the interviewer and all informants. This reduced the risk of misunderstanding and misinterpreting the questions or answers. Furthermore, having formulated an interview guide with open-ended questions allowed for honest and detailed answers. This is not always achieved when using other methods. Additionally, the interviewees were assured to be anonymous in order to protect the informants and provide honest answers. When conducting interviews, it is a risk for the respondent to be affected by what he or she thinks the researcher wants to hear, and by the fact that they are under examination. However, it did not seem as though this was an issue for this study. The informants themselves spoke openly and honest of their opinions, impressions and experiences. The format of the interview was constructed in a way that the findings were based on what the interviewees chose to share.

Weaknesses

It is a risk, when performing interviews, that the interviewer is biased and formulates the questions in a way that the answers are put into the mouths of the informants. As the interviewers always have to familiarize themselves with the background material, it is difficult to stay objective through the whole process. Furthermore, it is challenging to time the interviews in order to make sure that all questions are asked and fully answered. As touched upon earlier, the ideal time of an interview is between 30 minutes to two hours. In some cases, two hours is not enough, and other times it is too much. In this study, two hours seemed a bit too short, as there were follow-up questions that should have been asked, but were not due to the time schedule. In addition, it is difficult to select the most qualified and honest informants. It is not always obvious in advance, who will provide the most useful information. By conducting quantitative questionnaires, this does not matter, however qualitative semi-structured interviews are time-demanding are requires a prioritization and careful selection of the informants. Semi-structured interviews are highly dependent on the informants. If the informants are not talkative or willing to open up, it is difficult for the interviewer to gather information from the interview. Fortunately, with only a tiny exception, this was not an issue during the interviews for this study.

3.5 Validity and Reliability

According to Dalland (2012), the intention of all research is to achieve credible knowledge. In order to accomplish this, the requirements of validity and reliability must be fulfilled.

3.5.1 Validity

According to Lincoln and Guba (1994), the validity includes two key criteria: internal validity, whether the findings are believable (credible) and external validity, whether the findings and conclusions apply to other contexts (transferability). The descriptive foundation is used to understand or explain the research problem. The validity therefore refers to the quality of the interviews, the transferability of relevant theoretical assumptions and observation of the phenomenon and variables, and the clear and convincing discussion and conclusion for the real situation.

The information or data material must be valid, which implies that it must be relevant for the research question. The validity is low if the material irrelevant, improper or inapplicable for the research objective. By applying several methods, the validity of the research is increased. In this thesis, qualitative semi-structured interviews and document analyses are applied. The work has been quality-checked by the supervisors at University of Stavanger and SINTEF, in order to ensure that the methods and findings matches with the research question.

The interview guide is attached in the appendix (Appendix A), which enables repetition of the interviews. However, it is not guaranteed that the same answers will be given, as the method is very subjective. The follow-up questions varied slightly, which also may affect a possible reproduction of the interview. Yet, it is considered likely that the informants would have provided similar answers, if the interview guide was used on a later occasion. The resulting information is therefore relatively controllable.

The selection of the respondents were limited to people who had been involved in the two incidents. Selecting respondents based on other criteria could have provided different aspects. Furthermore, the study reveals that several aspects reoccur, but it is hard to conclude upon whether this is valid for the whole company or even the whole industry. As mentioned, the informants were promised anonymity, hence their answers are therefore believed to be honest and impartial.

The findings were also validated with the supervisor at University of Stavanger and the co-supervisor at SINTEF. The external validation, may reveal whether the findings are relevant for others than solely the particular installation or company. This might be hard to evaluate.

Internal validity was achieved as the proper questions were raised, opinions and views of the research topic were considered, data was close to the reality, and the transcripts of the interview facilitated the interpretation linked to the research questions. External validity was also achieved as the findings and conclusion had the potential to be transferred to other companies in Norway.

The transferability potential is due to the fact that the company comply with similar requirements of the Norwegian Law and regulations and the same guidelines regarding major accidents.

3.5.2 Reliability

Lincoln and Guba (1994) use "dependability" or "consistency" which closely correspond to the notion of reliability. The findings are considered reliable if other researchers accomplish the same results based on the same methods and information. The reliability increases when the findings of this thesis, correspond with findings from other studies or the overall delivery of SINTEF to The Company. In this context, the reliability depends on how the informants are affected by the researchers. Interpretations, and especially misinterpretations, are challenging for the reliability in every qualitatively analysis. It is hard not to be biased.

The reliability also depends a lot on the interviewers effort and his or hers way to influence the informants. This might have been challenging in the beginning as most of the informants were busy working or had free-periods at the time. However, through continuous and motivating approaches to the installations, the informants got involved in the research and expressed their willingness to share information. By having an open mind, the biases are weakened, and the validity and reliability are strengthened. The interviews were conducted as open conversations, where the questions followed a guide. In this way, the respondent was free to talk unconditionally. As the interviewer had a proper background knowledge on the subject, this improved the dialog. With respect to the "consistency" of the research, most of the interviews were conducted with persons who were found to have the most significant information and could contribute the most.

4. Findings

As mentioned, the main source of information for this thesis is the semi-structured interviews. The focus is therefore aimed on these interviews, and less attention is provided for the investigation reports and reports on proposed and implemented measures.

4.1. Introduction to The Company

The Company is an international oil and gas operator, who is operating several installations on the Norwegian Continental Shelf. Two of these installations are Installation A and Installation B. Installation A is located onshore and the organization had a severe gas leak incident in 2009, while Installation B is located offshore and suffered a severe incident in 2015.

Once a severe gas leak event occurs in The Company, immediate reporting to the land organization is done, and shortly after, immediate actions are taken. Both internal and external (PSA) investigators investigate the incident and publish an investigation report afterwards. Once the report is published, The Company establishes committees for the measures. These committees typically include the leaders on the investigated installation (organization). In the aftermath of the *measure meetings*, the committee reformulates the recommendations from the investigation report, into measures in the reports on proposed and implemented measures. Responsible people or groups for each measure is established. A description of the measure, comments, a deadline, the responsible unit and other aspects are listed. Once a measure is implemented, the measure is closed in the report. Once all measures are closed, the report is completed. The owners of the measures are reviewed upon key performance indexes (KPI) on whether they manage to close the measures within the deadline. However, they have the option to postpone the deadline, if agreed upon between the leaders.

4.2 Findings from Document Analysis of Investigation Reports

4.2.1 Investigating and Analyzing

As the actual investigation is not in the focus area of this thesis, solely the recommended actions are prioritized in the analysis of the investigation reports. However, a few observations of the company's practices are presented regarding the other criteria.

Sufficiently Deep Investigation

After an incident occurs, the company start the investigation within a couple of weeks or months if it is delayed. The analyzed reports implied that most investigation reports contain information on both triggering and underlying causes. Some investigation reports, often the newer investigation

reports, also include causes related to the organization and leadership. It is clear that the company has a high focus on determining how the barriers functioned in relation to the MTO perspective.

Clear Causal Relationship

Whether the causal relationship is clear, is difficult to comment on, as it cannot be directly observed in the investigation reports. It is observed that The Company present both direct and underlying causes, however causes related to leadership and the organization are not always presented. Beyond this, the analysis of the investigation reports could not provide further findings on whether the causal relationship was clear, or if there were other unidentified causes.

Involvement of the Right People

The 15 investigation reports demonstrated that The Company has focus on involving the right people during the investigation. The investigation teams included professional investigators, experts and specialists. In addition, a representative of the safety service or a safety delegate was included in the investigation team. Moreover, personnel who had directly or indirectly been involved in the incident were interviewed. This included both offshore and onshore personnel. 10-40 interviews were held during the investigations.

4.2.2 Planning Interventions

Recommendations Address both Direct and Underlying Causes

By first glance, it is obvious that The Company has done a few changes in relation to how they structure the recommendations in the investigation reports. As the oldest analyzed incident is from 2007 and the newest is from 2015, it goes without saying, that a lot has been done during the eight years. It is observed that the recommendations in the reports from 2007 until 2012 followed a different structure. Meanwhile, in recent years a new structure is followed. The new structure emphasizes "recommendations of learning" instead of solely recommended actions. By focusing on the learning aspect, the company ensures that they address underlying causes in addition to direct causes. In the newest investigation reports, it is therefore easier to spot the learning and improvement points in which the investigation team recommends. In addition, it forces the investigation team to address both direct and underlying causes. In the oldest investigation reports, there were solely long lists of actions, where the actions were categorized as "long-term" or "short-term" and so on. In these reports it is not clear for the reader to whom it concerned, what they should learn nor what the expected result was. Hence, not all recommendations in the investigation reports address both direct and underlying causes, however this concerned particularly the oldest reports, which lacked proper structure and systematics.

Concise and not Open for Interpretation nor Overly Prescriptive Wording

In addition to the structure of the reports, the formulation of the recommendations in the investigation reports has changed as well. The immediate and corrective actions are

observed as more concise and prescriptive than the preventive measures. In the latest reports (2012-2015) it is observed that the use of "must" and "shall" has become more common than the earlier terms "should" and "evaluate whether". In addition, the new structure in the latest reports contain a column that specifies which group, role or department (audience) in which the recommendation is meant for. This ensures that the formulation of the recommendation is understandable for who it might concern. Hence, the formulation of the recommendations in the investigation reports nowadays are more concise and less open for interpretation than before.

4.3 Findings from Document Analysis of Reports on Proposed and Implemented Measures

4.3.1 Planning Interventions

<u>SMARTER Actions</u>

It is clear that the formulation of each measure varies. However, there were no indications on that The Company have had focus on formulating SMARTER actions. Even though some measures were formulated quite specific, many of them were still formulated vaguely, by using "evaluate" and "the organization should".

"Evaluate the need for condition surveillance of regulation valves from initiation of production"

The organizational measures are rarely formulated to be measureable or accountable. Despite the fact that deadlines are sat for all measures, not all measures should be time-bound/timely. Meaning that not all measures should be or even can be closed under the given circumstances. Several examples of this was observed in the reports: "Continuously observe…" and "improve cooperation…". However, if a measure is formulated as "to change the governing documents or work practices", then the measure would be time-bound. Only then would it have a long-lasting effect. Additionally, it is obvious that the organizational measures are rarely reviewed. Technical measures on the other hand is apparently often tested before they are closed, however, this is not done for the organizational measures.

<u>Avoid Overproduction of Measures (Measures Fatigue)</u>

Given the 15 reports, the average number of measures per incident is 28,1, whereas approximately 60,1% of these are preventive measures, 28,3% are corrective measures and 11,9% are immediate measures. Some of the measures also contained "sub measures", which implies that the numbers might be higher. Yet, 28 measures seem a lot to handle after an incident.

The average closing time of each measure is 141,5 days, however as all actions are not initiated at the same time, the average closing time of a whole incident report is 1027,9 days or approximately 2,8 years. In addition, some of the reports were not closed yet, which implies that the average number is even higher. Hence, this indicates that the investigated organization is out of step and struggles with a high work load for nearly three years after an incident.

Clear Closing Criteria

The average closing time of each measure is estimated to 141,2 days. It is observed that the preventive actions require the most time to close. Immediate and corrective measures are usually closed within a few days, as these are "physical" and technical measures, which need to be executed in order to secure the installation and start producing again. The closing criteria for these measures are therefore quite implicit. On the contrary, the closing criteria for the preventive measures are observed as very vague and unclear. Many preventive measures in the reports indicate that they have been closed too early. An example of this is a measure where lack of personnel was the issue. The last comment on the measure was: "working on acquiring qualified consultants", when it in fact should have been closed after qualified consultants were acquired. Measures being closed too early, also imply that they are not verified, evaluated or tested before they are closed. Another example of this was a measure related to a leadership training program. The measure was closed when all leaders had performed the program, and not after testing the leaders on their new acquired competence.

Even though most reports on proposed and implemented measures lack clear closing criteria, there are exceptions. After an incident in 2009, the following was written in the report:

"Closing criteria: Reference to guidelines must be provided. The guidelines must describe how incidents of this character shall be communicated when there are uncertainties related to the issue".

However, this is the only report, of the 15 reports, where closing criteria were defined.

4.3.2 Evaluating

Evaluation of Effect (verifications, periodic reviews, interviews or performance indicators)

Of the 15 analyzed reports, no reports showed indications of that the company evaluated the effect of organizational measures before they were closed. This seems to be done solely for the technical measures. The effect of measures related to training and change in procedures for example, should be easy to evaluate, however this is rarely done. In the reports, there were no indications of that the effect of the training or change in procedures had been evaluated. This is unfortunate because it does not really show whether the personnel have learned something or if they know what to do the next time when similar incidents occur.

Evaluation of Implementation of Measures (whether measures are fully realized)

As mentioned, evaluating technical measures after they have been implemented is often done. For example by pressure testing. However, the organizational measures does not seem to be evaluated whether they were fully realized or not. Procedures are implemented and training is executed, but the organization has never gotten confirmed that the personnel are aware or follows the new procedures, or if the training strengthened the emergency preparedness of the personnel.

An example of this, was observed after an incident in 2009. In this case, the measure was to learn and go through the incident. This measure was simply closed, with no reference to how this had been realized, and if the personnel actually had learned anything.

4.4 Findings from Interviews

The findings are presented according to the stages illustrated in figure 2.2 by Drupsteen et al.(2013).

4.4.1 Investigation and Analyzing Incidents

Sufficiently Deep Investigation

The Company follows a systematic way of proceeding through this process. As confirmed by Informant 5, the investigators uses a lot of tools and systematics in order to find the root causes, the sequences of events, the consequences etc. Furthermore, similar incidents in the company and the industry were also considered. In addition, historical data documented in SAP was used to track the first time similar errors had occurred on the specific equipment. Both old and new technical demands were considered in order to decide what should be done regarding the design basis. The informants claimed that it is also beneficial to look outside the organization, to other companies.

The investigation team usually covers root-causes, active failures and latent conditions linked to an incident. However, as mentioned, the informants stated that The Company should ensure that all investigators are unbiased. According to Informant 5 and Informant 4, the investigators should be open-minded when they start the investigation, and not biased.

"Members of the investigation group claimed on the first day of the investigation that this was a red (very severe) incident, before we had even started investigating. I considered resigning from the investigation, because there were members of the investigation team that had already made up their mind on the conclusion." – Informant 5

"Occasionally, one can get the feeling that they are being biased. That they have made up their mind, before they have even started investigating. The investigation report will therefore be affected by this. One does not always agree with everything in the investigation report, and there

are probably a few reports where it is clear that the underlying causes are not correctly identified."
–Informant 4

Furthermore, the informants claimed that an appropriate mandate for the investigations, which specifies clear expectations for the outcome, is very important in order to sufficiently investigate the incident.

Clear Causal Relationship

According to the informants, the causal relationship incident is improved if the investigation is slightly delayed and an internal investigation is started in advance. When asked why some reports did not find the proper causal relationship, Informant 4 answered that this was linked to whether the investigators were biased or not. In addition, it is essential for the investigation in the learning from incident process that the investigators have the right competence and attitude, and that the composition of the team is satisfactorily. If these requirements are not fulfilled, the investigators might not hit the correct root cause of the incident.

Informant 6 explained that it is easier to find the immediate causes than the underlying causes. Once an investigator digs into the underlying causes, it is revealed that there is rarely only one causing factor. In order to avert more severe incidents, Informant 6 therefore recommends that The Company should dig deeper into underlying causes when handling less severe incidents. Instead of doing this, the organization is left with measures such as "observe continuously" or "adjust up or down", rather than digging down to the true underlying causes of the incident and actually learn and prevent similar incidents from happening.

Involvement of the Right People

Involving the right people in the investigation stage was claimed by the informants to be beneficial for establishing proper recommendations. Hence, ensuring high quality of the recommendations indirectly led to more effective organizational measures.

Furthermore, involving the right people has proven to lead to an effective learning process as well. When asked whether involvement of the right people is a success criterion for an effective learning from incidents process Informant 5 answered:

"Most definite it is" – Informant 5

A proper involvement facilitates the transfer of further work to the local workers. This is emphasized with the following statements:

"One sees that facility relevant knowledge is always beneficial. Not just to find the best measures, but also to have a good takeover for the further work. Once the investigation team has finished

their work, one might have a lot of questions if the involvement is poor throughout the investigation process." – Informant 2

"You need a good dialog with the workers. I believe this is very important, so that you do not sit on your own, with your own thoughts afterwards." – Informant 7

Informant 5 adds that since the first-line personnel know the facility better than anyone else, even better than the investigators, it is important that they are involved. According to Informant 4, involving the first-line personnel is something they still need to work on. He continues by explaining:

"First-line leaders of the shift are always included and the ones that were involved in the incident are often interviewed, and have an opportunity to speak their mind. However, further down the line, we probably have more to work on." – Informant 4

In addition, Informant 4 stressed that it was beneficial to involve the safety delegates at some point in the investigation. When asked what he recommended to do in order to improve the involvement of the first-line personnel, Informant 5 answered:

"Personally I am a fan of using the bottom-up principle instead of top-down. To start at the bottom instead of the top, because then you really involve the personnel." – Informant 5

Furthermore, the informants at The Company claim that a success criterion for a good investigation report and effective measures is that the local workers have time to reflect, learn and take action on their own before the investigation team appear on site. If the investigation is slightly delayed, there is a better chance that the local workers have time to take ownership and commitment to the incident investigation. In addition, the informants told that they preferred when local leaders and the investigation team adjusted and formulated recommendations together.

Hence, according to the informants, involvement of first line and sharp-end personnel is a clear benchmark for success. The question is how this should be done in practice. The Company does not currently have any guidelines to describe this, except what is stated in The Working Environment Act. The leaders on the facility normally interview the relevant personnel shortly after an incident. However, people working at different levels may have different views on things. Therefore, a common problem is that the statements given at the lowest level do not always correspond to what is communicated on the highest level in the organization. Informant 7 adds that people based onshore tend to sit more with their own thoughts, while personnel working offshore tend to be a lot more hands-on

4.4.2 Planning Interventions

Recommendations Address both Direct and Underlying Causes

When the causes are clear it is easier for the local workers to formulate and prepare measures based on the recommendations written in the investigation reports. If the recommendations are poorly formulated then this will be reflected in the measures:

"If I puncture my car, it is obvious that I need to fix it. However, that is not the cause of the punctuation. Occasionally I find that the measures are too easy, and one does not address the underlying cause of the incident" –Informant 6

Hence, recommendations that address both direct and underlying causes are required in order to achieve effective organizational measures and learning processes. Informant 6 explains that they have a lot to work on with this matter. The relation between recommended measures and root causes varies as the composition and competence of the investigation team also vary.

"It is always easy when you are in an investigation team to shoot arrows into a great area, because you always hit something" – Informant 5

The informants stated that The Company could improve their practices on ensuring that they address both underlying and direct causes in the recommendations they formulate.

Concise and not Open for Interpretation nor Overly Prescriptive Wording

The findings from the interviews indicate that concise, not open for interpretation nor overly prescriptive wording of the recommendations are indirectly providing effective organizational measures. Informant 5 emphasized that a regular operator, automatician or mechanic might not be able to understand the whole perspective of the incident, and it is therefore crucial that the investigators formulate their recommendations to be understandable for everyone. In addition, he claimed that it is also crucial for an effective learning process.

When the investigation team formulates recommendations, these are often very rounded, and it is up to the local workers to sharp them and find the shape providing the highest increase of safety. It is very varied how "packed" the recommendations in the investigation reports are.

"We had an incident this fall which was very demanding. The investigation report was on the other end of the scale (the bad end). They had packed a lot into each recommendation, making it very unclear what had to be done. We have measures meetings after an investigation, but if we cannot figure out the recommendations, we will be left with a lot of questions afterwards." –Informant 4

In addition, Informant 4 explained that if many measures are "baked" into one recommendation, then the outcome can deviate from the expectations and motivation behind the recommendation. When asked whether, the formulations could be a little vague, Informant 6 answered yes, and it

would have been an advantage if the safety service or safety delegate were more involved in this process.

Informant 7 claimed that the recommendations are rounded by intention. He stated that the investigators formulate the recommendations openly, because it should be up to the local leaders to sharp them, and formulate the measures in a way that works best for themselves.

"I believe that the investigators intentionally avoided formulating the measures too concise and sharp, and rather transferred the responsibility of this to the people in charge." – Informant 7

Informant 7 got the impression that the investigators were solely interested in sketching causes and errors, and then develop recommendations for further actions.

Prioritization According to Highest Overall Increase in Safety Level

According to the informants the guidelines of The Company on this is clear: the most important factor for prioritizing actions is personal safety. When asked what is the most important criterion for selecting measures, Informant 5 answered:

"Without discussion, personal safety." – Informant 5

Furthermore, prioritizing according to feasibility is seen as an important criteria for being able to follow-up the measures. Even though The Company ideally should focus on prioritizing according to overall increase in safety this is not always straight forward due to a tough and tight market. Costs are therefore still a significant factor.

"Obviously, risk and safety are the leading factors, however, we often have to fight for the same resources, and thus it becomes a prioritization issue." –Informant 3

"It can be challenging to plan and implement measures based on costs. In today's situation, especially in the oil and gas industry, we do not swim in money any longer." – Informant 5

Some informants claimed that costs are not an issue, while others strongly disagree. However, Informant 2 claimed that costs are to be ignored if there are technical elements that deviate from the requirements given at the design phase of the machine. Informant 4 explained that as the resources are limited, it is important that they choose the correct measures.

"After an incident and investigation, it is a risk of focusing too much on it, and let go the focus on other things. Unfortunately, some things are prioritized in order to simply satisfy a certain system, and the consequence is then that you lack resources for something that would have provided a much better overall safety level." – Informant 4

"You simply have to prioritize the measures according to everything else that requires money"- Informant 4

By saying this, she is indirectly implying that costs cannot be ignored when prioritizing measures, and that sometimes, they decide to not implement measures based on expected cost.

SMARTER Actions

The several informants imply that the process of developing the recommended actions into safety measures is perceived as overall good. Most of the measures are quite concrete with reference to requirements.

"The formulation of the measures are very rounded. A part of our job is to sharpen them in order to find the shape that provides us with an increase in safety" – Informant 2

Currently, The Company does not consider the SMARTER concept as a checklist when deriving measures. Furthermore, a part of the job of deriving measures is to make them more specific in terms of describing the job, closing criteria and deadline. Hence, a few of the components of the SMARTER concepts is considered, while others are not.

"I believe that most measures can be checked out with that description, but I do not look at the specific criteria when I formulate a measure." – Informant 2

However, it is clear that when measures are being derived, they must provide an expected effect. This implies that there is an expected benefit in terms of safety, reliability, money etc. In addition to this, the informants at Installation A, explained that to them, it was very important that the measures are formulated in a way which makes them sustainable. Sustainable measures are meant to have a long-lasting learning effect due to the fact that the measures are traceable or rooted in governing documents. The workers at Installation B also focused on the learning effect of each measure.

"One of the measures was "Go out and see visually". I am not very fond of this because it then relies on single individuals. If the handover is lacking and the problem at hand is not well understood, the measure becomes very weak. It is depending on a single person and not a system or an organization." – Informant 6

In addition, Informant 6 explains that The Company could improve how they formulate the measures in terms of being more specific and ensuring learning from the incident.

"As I said, notifications on repairing something does not provide a learning effect to me." – Informant 6

Furthermore, Informant 11 and Informant 12 explained that the recommendations in the investigation reports are almost only "copied and pasted" as proposed measures. A consequence of this is that the measures are very rounded and goal-based.

"We have several measures that are very roundly formulated. The sharper the better, however a room for maneuver is also beneficial. It is therefore difficult to state the best practice" – Informant 11

"It is a bit like we "cut and paste" and write the solution directly from the investigation reports." – Informant 12

The informants explained that recommendations formulated as goal-oriented was beneficial, while organizational measures should be formulated more prescriptive. When asked whether it was usually clear what the aim of the organizational measure was, Informant 11 answered yes, however the formulation of the measure on this should be worked on.

"I think we need to be more specific on how we are going to reach the goals of these measures" – Informant 11

Involvement of Line Managers and Personnel with Frontline Experience

Even though, mainly leaders participate in the measures meeting, the first-line personnel are often consulted on the measures.

"This is always consulted with the ones who have participated in interviews, surveys and provided facts along the process. It is also common practice to involve the safety delegate." – Informant 1

In addition, the facility workers attempt to have an ongoing communication with the investigation team. Informant 5 stated the following:

"The facility workers attempt to continuously communicate with the investigators during the investigation, and inform them on what they have found and what they have implemented as immediate measures, or long-term measures for that matter." – Informant 5

Informant 9 and Informant 6 claimed that the safety delegate are the most important to involve in this phase. Informant 6 claimed that they have the ability to see things from a different angle than the leaders and the front-line personnel.

"Because safety delegates are not supposed to think of time, money and those things. They shall think of what benefits us and protects us best in our situation, based on a HSE perspective." – Informant 6

Avoid Overproduction of Measures (measures fatigue)

In relation to *overproduction* of measures and *measures fatigue*, the informants agreed upon that this is also a problem in their organization.

"Most definitely. I can identify with your statements. If one has not sharpened the measures enough and the motivation behind it is unclear, measures can be produced just to satisfy the system. It is then probably a chance of overproducing at this point." – Informant 4

"All verifications generate their own measures. Often there are many measures, and it becomes a case of prioritizing them based on what needs to done first. Yet, it might be easy to fall into the regime of documentation, which has characterized The Company for a while." – Informant 3

"It is almost as though if they only come up with a few measures, it will seem as though they have not done their job properly." – Informant 5

"In the end, when you have a lot of measures, you get a very relaxed attitude towards it. Then it becomes a bit like "the boy who cried wolf"." – Informant 6

The last comment by Informant 6 indicates that too many measures lead to a measures fatigue, which is described in the literature. If the recommended measures are not sharp or specific enough then they have to be "broken up" into several more sharp and concrete measures. According to informant 1, this is apparently the main reason why there are so many measures in the reports on implemented measures.

"Often, when measures are not sharpened enough and the benefit of them is not clear, more measures are added just to be sure that the system is satisfied. Then there is a chance of overproducing measures." - Informant 4

Another problem, according to Informant 3, is that it has become a habit to add several layers of barriers, just to ensure that a similar incident will never occur again. While the intention of the extra barrier is good, it pushes the organization into an unfortunate condition.

"Maybe we add the extra barrier just to be really sure. Maybe add the one percentage extra of increase in safety, while in meantime they also increase the complexity and load on the organization" –Informant 3

"The consequence is that it can overload the organization, by delaying all the daily tasks in order to work on the measures." –Informant 5

Several measures take months or even years to implement, and it is clear that the more measures produced, the longer the organization will be overloaded.

"In 2009 we had a severe leak incident. The last measure related to this was closed in 2015 or 2016" – Informant 1

According to the informants, this is very unfortunate, because overloading the organization may actually increase the likelihood of new incidents occurring. In order to avoid an overproduction of measures, Informant 4 suggested the following:

"Hopefully in the future we manage to find measures which really provide an effect, and rather tone done on measures which provides maybe an effect of 1% on the overall safety level. Because we face a risk of not using our energy in the right places, where it is most needed." – Informant 4

"I strongly believe that in order to be good at something we must prioritize a few things to focus on." – Informant 4

"Personally I believe in quality over quantity. With that being said, we see that many measures are often baked into the recommendations from the investigation report. This is why we can see in the reports on proposed and implemented measures that "one feather has become five hens"." – Informant 5

Yet, on the contrary, Informant 9 provided another perspective to it.

"34 might sound a lot, even insanely much and maybe too much too handle. Yet, they (the measures) are pretty spread throughout the organization." – Informant 9

This implies that it might be hard to prove that there is an overproduction of measures based on the number of measures.

Clear Closing Criteria

As stated by the informants, in order to evaluate implementation and effectiveness of actions, the *closing criteria* should be clearer. The closing criteria can be very open. It is acknowledged that the closing criteria formulated for organizational measures are a bit more vague than for technical measures.

"For technical parts, if they are implemented in the field, this is enough to close the measure" – Informant 2

As for today, most organizational measures are closed after they are implemented and not after they have been evaluated. This statement is verified by Informant 4:

"On most occasions, the measures are closed after being implemented, and rarely after an effect is observed." – Informant 4

According to the informants, this is due to their KPI system, which pushes them in the direction of closing the measures as soon as possible, in order to reach their monthly performance goals. Hence, they use KPI systems to measure effectivity, absence, overtime, etc. This often lead to people being eager on closing the measures.

"We get a bit eager on closing things, such as measures that are still on the list at the end of the year. Obviously, this is very unfortunate for the HSE." – Informant 6

A consequence of this is that many measures are closed too early. Informant 6 provided a concrete example of this:

"Just before Christmas I got a question on closing a measure on "strengthening the collaboration with the safety service". They wanted to close this one. I, on the other hand, argued that this is not something that should be closed as it should be a continuously process of collaboration. Hence, I disagreed about closing the measure, because this is something we still have to work on. The measures are formulated poorly. It is not "closable" because it is not an action that is measurable or time-bound." – Informant 6

Informant 3 suggested that in order to prevent this, a new code in the reports on proposed and implemented measures could be added. Instead of completing the measure from "implemented" to "closed", there could be a step between called "up for evaluation". However, he could also see the challenge with this and commented:

"Ideally we should see an effect before you close them, but you cannot always observe or measure the effect of an organizational measure" – Informant 3.

In addition, it is suggested that an assigned person or group follows up the measures until closure, who can see the whole picture. When asked how measures are formulated in terms of closing, Informant 5 answered that essentially measures are closed after being implemented, tested and verified, however, this is not always done.

"You shall not checkout something before you are a hundred percent sure that it works. However, there are always people trying to hide their errors. Still, I do agree upon that the measures could be more concisely formulated as "shall not be closed before implementation and verification is completed." – Informant 5

Informant 5 explained that there are many things that require the experience of the user before the effect of the measure can be verified. According to Informant 8 and Informant 9, it is very beneficial to have a closing committee. This ensures that one person alone cannot close the measure without

discussing it with someone else. Such that, no one can close the measure without bringing it up in the closing meetings. However, the practice of establishing a closing committee after an incident is only observed on Installation B. This practice is therefore unknown for others, outside their organization.

As the workers on Installation B follow a six-week cycle, it is clear that the changes are later adapted there, than for those who go to work every week from Monday to Friday. The informants at Installation B stressed that it is extra challenging to ensure that all personnel have learned from the incident when they are working in shifts. A typical measure is to transfer information to all shifts.

"It is often written: "Inform all shifts". Hence, after six weeks, this measure is closed. This is typical." – Informant 6

A problem with these type of measures and formulations is that they do not describe what the expectations are in terms of learning, and how the learning should be verified.

4.4.3 Intervening

Communication (use of older incidents, forum of sharing lessons learned etc.)

Several informants concluded that good communication is essential for achieving an effective learning from incident process. Informant 4 claimed that learning packages are spread down the lines, but the communication on this is weak. Informant 3 stated that it might be difficult to really understand and learn from the learning packages.

"We ourselves had to read the investigation report, interpret what this meant for us, and what we could learn from it. And these arrive quite often, so it is very demanding for us to work in detail with these things." – Informant 3

This statement indicated that lack communication or poor communication, unable a good implementation of measures and learning from incident processes. Informant 4 provided a concrete example of how they successfully managed to learn from a similar incident, and take actions based on what they learned:

"Our installation was in many ways similar to the installation of where another incident occurred. What we decided to do was to simply reach out to my colleague down there and ask what really happened. We talked about the culture and environment at the installation and tried to grasp what we felt was essential for us. There have surely been other gas leak incidents where we should have done the same" – Informant 4

Furthermore, according to Informant 6, personnel working in shifts have greater challenges in terms of communication and learning, as they are off work for several weeks a time. As the workers log off for four weeks, and are not in "work mode", it is difficult to come back and "log on" again for two weeks.

"Obviously, we lose a lot of information." – Informant 6

Thus, Informant 6 claied that it is important with a proper handover between the shifts. On the other hand, how engaged and interested a worker is to learn, is very person-dependent according to Informant 7.

"I therefore prefer to have meetings for the newly arrived personnel and for those who have been at work for one week. This sharpens the workers who have been there for a week, as they know that they have to convey what they were told last week and have experienced during the past week. In addition, the personnel who have just arrived know that they have to convey the information they get to the next shift arriving. Everyone is sharpened, everyone is given the same information and everyone has the same baseline." – Informant 7

Another communication problem introduced by Informant 7 is that the responsibility of something is linked to a specific position or role offshore, while onshore the responsibility follows a specific person. This can be challenging if the person is away or headhunted to another place, and the process is delayed or put on hold due to this.

"To transfer information continuously in an "on-and-off" organization is very demanding."- Informant 9

A shift organization is more complex, and it requires more time to spread information, than in a regular organization where all workers are in the office at the same time every week. For instance, if a shift leader is handling an issue in his shift, it is possible that the measure is not sustainable and nor shared with other shifts. In addition, Informant 2 explained that it is very important, according to the LEAN principle, to create engagement and motivation.

According to Informant 5, hands-on and pre-job conversations could be used proactively in order to prevent accidents from occurring. By doing this, recent incidents may come in handy. Learnings from previous incidents, near-misses and experiences of others are built into these conversations.

"When the investigation is over, there will be questions and doubts, it is therefore important that the local personnel can ask questions during the investigation process." – Informant 5

Many organizational measures are difficult to ensure that have been implemented properly and communicating these is therefore necessary. According to Informant 4, the close collaboration

between the disciplines at the facility is crucial for maintaining a good communication through action processes.

"I believe that it is one of the strengths of our organization that the operations, maintenance and technical (disciplines) cooperate and work closely every day. I think it is the key to succeed in a work context." – Informant 4

Another problem related to communication is the physical gap between the leaders who sits in an office and the operative personnel in the process facility. According to Informant 5, a lot of the information can be misinterpreted when it passes through several levels.

"If you start at the lowest level in the organization and tell something, and it passes through several management levels, then often what is told at the lowest level does not correspond to what is told at the highest. It is depending on the communication part. In these cases the leaders must put on a suit, go out and actually speak face-to-face with the workers." – Informant 5

Enough Resources (manning, time, money etc.)

According to the informants, resources in terms of money is at times an issue, but most often, measures are implemented regardless of costs when a major incident has occurred. It is however clear, that times have changed in recent years, and costs are ought to be reduced.

Time on the other hand, is often considered a limiting resource as stated by the informants. According to several informants, after an incident, there is a tight schedule and a lot of work pile up. Due to a downturn in the industry, the manning is reduced and at the same time the remaining personnel are told to work more efficiently.

Each project deal with their own maintenance intervals based on risk and lifetime, thus the time perspective and extent of the measure should be considered accordingly. As stated by Informant 6, even though measures are formulated properly, if they lack time or personnel to perform the job, then the measure will not be satisfactorily implemented. She explained that involving the personnel in the process is important, but they must also have time to do the job.

"The main issue is to have the time to do everything that we are supposed to. When all preparedness tasks, training and meetings are pushed into the work hours, the organization is at pressure" – Informant 6

"We can formulate effective measures, but we also need time to execute them." –Informant 6

"You cannot drive five cars to Voss if you only have two drivers" – Informant 5

Informant 6 elaborated that time, manning and money are critical resources in these times of low oil prices. When the gas leak at installation B occurred, both Informant 7 and the investigators confirmed that it was crucial that they were two operators in the control room at the time. This facilitated the emergency preparedness and implementation of the immediate actions. During the time of the incident, it was very fortunate that they were two, because they were actually meant to be only one. Due to this matter, the management changed the practices and saw the need for having two operators in the control room. This indicated the importance of having adequate manning (resources), when an incident occurs. The increase of manning in the control room has now been implemented as a measure all over the Norwegian continental shelf, by requirements from the PSA.

Involvement of Workers at All Levels

According to Informant 6, it is common that workers who have not been involved earlier in the process, tend to forget what has been done with the measures, because not everything is executed immediately. On Installation A, they have had good experiences with doing so-called "reality checks" in the facility areas on a daily basis. In addition, the informants at Installation A identified a close collaboration between the technical and maintenance disciplines as beneficial. The leaders discuss with the facility workers what needs to be done related risky operations. In this way, the leaders are ensured that all personnel understands their tasks.

"When we do this, we have discovered that it has a "raising effect", as we ask questions, initiate reflection and check up on them later. I believe that this is one of the most powerful tools we have been using on our team in recent time" – Informant 1

Informant 2 agreed with Informant 1, and added that it is important that when involving workers, these are given concrete expectations in terms of deliverance and that the leaders have to be present and ask for that delivery by showing engagement and interest.

"We are ten people, plus the executive manager. On average we spend 1,5 hours a day out in the facility, and with two facilities this is approximately 15-20 hours a week. According to the feedbacks, this is something that the workers appreciate." – Informant 1

According to informant 1 and 2, the presence of leaders out in the field is a success criterion for ensuring compliance. Furthermore, when asked what is needed for an effective implementation of measures, Informant 7 answered:

"Involvement. Especially with the safety service/safety delegates. I find this very important. "- Informant 7

Informant 8 and Informant 9 agrees with the above statement as well, as the safety delegates have the ability of looking at the issues with the eyes of their colleagues.

Establish Ownership of Measures

As stated by Informant 4, in order to establish ownership it is important that the person understands the measures. This is depending on enough time to do so. According to Informant 6, it is very person-dependent as some consider the process facility as their "baby", while other consider it strictly as a job. As reported by the informants the establishment of ownership should preferably be done in the planning phase of the measures.

"What we hope to see in the end is more a top-down approach. That the operator takes an ownership to why the incident occurred and what they need to do in order to prevent it from happening again. That the line leaders do the same. Currently it is like one just sits there, gets the reports and "now we are going to do this and that", instead of actually taking ownership to it down the lines." – Informant 4

As stated by Informant 6, the personnel should establish an ownership of the measures once they arrive onboard. They arrange so-called "New-onboard meetings", where everything that has happened is discussed.

"Based on this, you are supposed to establish an ownership to what you potentially have to check out or pay attention to." – Informant 6

In theory, this is a good practice, however when working in shifts, it is more challenging. Informant 6 explains that it is much easier for personnel working every day and are close to everything on a daily basis.

"You often have to rely on others when you are away. You trust the people around you to have control over things." –Informant 6

Another problem, introduced by Informant 6, is the frequent replacement of leaders in The Company. According to the guidelines in The Company, every leader should ideally be replaced within four years.

"Obviously, these leaders do not have the same knowledge or ownership to the measures and incidents which occurred before their time." – Informant 6

According to Informant 9, it is important that the leaders are engaged and have expectations on how to live up to the standards and how to withhold the attention to it.

4.4.4 Evaluating

Evaluation of Effect (verifications, periodic reviews, interviews or performance indicators)

Despite the fact that the informants claimed that they prioritize measures based on expected effect, they admit that they rarely actually evaluate the effect afterwards.

"To measure the effect of what we do over time, to see whether we have accomplished what we wanted, I am not sure that we actually do this." – Informant 1

Several informants concur with Informant 1's statement. It can therefore be assumed that the effect of each measure is not evaluated in the aftermath. However, they agreed that this should be done.

"I think it should be a topic. I think it is a good approach and a good tip to pass forward." – Informant 1

"They (the measures) should at least be evaluated if there has been an investigation." –Informant 6

When asked whether there is a system for evaluating the changes on the shifts, Informant 6 answered:

"If there is an action on something that has to be implemented on all shifts, there should be an additional measure for checking up on it within a year, whether it actually has been executed. However, this is never done because this would lead to an extra point on the list, which is not welcomed." – Informant 6

The informants explain that technical measures are easy to evaluate because they are concrete and sustainable by nature. However, organizational measures are more complex, as the effect of these cannot always be measured or observed. Informant 1 provided a good example of an issue in relation to this matter:

"For example, how do you measure compliance? Because this is related to cultural and human factors."- Informant 1.

He stated that once you have something related to human and organizational factors, repetition and precision is required. According to Informant 1, they have experienced good effects with measures related to competence and compliance.

"You see that what keeps reoccurring is competence and compliance issues. If we had followed the routines and processes, a lot had gone well." – Informant 1

On Installation A, they have observed a good effect of a measure related to "competence checkout". Implementing this measure ensured the right competence of all operators working on the facility, at all time.

Furthermore, according to Informant 5, a way to evaluate the effect of a measure is to review the improvement proposals of the given process or procedures, provided by the workers. Apparently, everyone are able to enter proposals into the governing documents and write exactly what they want. These proposals or suggestions can also be gathered by a face-to-face conversation with the users.

In order to review the effect of many measures, typically organizational measures, The Company performs a survey every year, called the General People Survey (GPS). The results of the survey provide indications of the state of the organizational culture, the trust in the leadership, whether the workers feel safe at work and other factors. The GPS may also indicate whether actions should be taken, as for instance a change of leaders or leadership.

According to Informant 4, it is rather easy to close approximately 80% of the measures after an incident, yet the remaining 20% may require more time. He explained that if the description of the measure was clearer and sharper, it would be easier to observe or measure an effect. I.e.: "measure shall not be closed before implementation and verification is completed". Technical measures are obviously easier to check whether are working or not.

In the *closing meeting* the measures are evaluated whether they have become part of a routine. When it comes to changes or improvement in skills, these changes are not always checked. When the measures are closed, no one goes back and evaluate whether they have had an effect or not. Informant 5 claimed that a suggestion for evaluating the effect of a measure could be to just talk and listen to the workers.

"Sometimes a face-to-face conversation is better than 2-3 A4 sheets of documentation." - Informant 5.

Moreover, when it comes to closing measures and process safety, not everyone agrees on what is sufficient design. This is not clear in The Company, nor in the industry. The measures are closed when they are as expected to be, and this can take years.

"For instance, in 2009 we had a major leak, and the last measure developed after this incident was closed in 2015 or 2016" – Informant 1

It was observed as important to take advantage of the competence and experience of the investigation team as they work on several investigations and have a lot to contribute with. The investigation team is composed of people from different departments and disciplines. The downside of this is that it can be demanding to reach the investigators later on. The investigation team does not really have any supervisory responsibility. Monitoring and follow-up is totally absent from their part. According to Informant 3 and Informant 4, the investigation team should be more available after the implementation of measures has started.

none_Evaluation of Implementation of Measures (whether measures were fully realized)_

As stated by several informants, the evaluation of whether the measures were fully realized should be consulted with a third party, or the investigation group. Nowadays, the investigation team proceed to other investigations once the report is published. Informant 3 admits that this is a problem:

"Maybe it should be systemized in a way that made them come back and evaluated us after a given period of time. Now it is a bit like "here are the measures, you can decide whether you want to implement them or not", then the team dissolves and proceed to another investigation or other tasks they have" – Informant 3

Informant 4 adds that the investigation team is often very competent and has a lot to contribute with, and therefore should be consulted in terms of evaluating the measures, and ask "have you achieved what we wanted?". This never happens, according to Informant 4. It is considered as advantage if the investigators could revisit the installation and review what they have done since the incident. Informant 5 stated the following:

"The investigators are usually composed of people from different parts of the company. Trying to reach them after the investigation is finished, might therefor be difficult. I believe that it is a great weakness of the system that the investigation team solely writes a report, recommends measures and then disappears. Then, it is up to the local leaders to decide how they should solve the problem, with what tools and processes and what documentation to use in order to close the measures. The questions is then whether the measures are closed sufficiently or not? Moreover, sufficiently for whom? The local facility? The investigators? It is a big hole actually." – Informant 5

Informant 5 provided a simple example of this problem:

"You can compare it to a simple everyday-issue. You are going to take your car to a periodic vehicle inspection and you get a few remarks on something you need to fix. Are you then allowed to drive? No, you must fix the car and get someone to verify that you have actually fixed it." – Informant 5

In addition, Informant 3 suggested that the local workers could be better at this themselves as well. He commented the following:

"We need to start with ourselves. Because it is not like after one or two years we go back and see whether the measures worked the way they should have. When they are closed, they are closed. We do not have an evaluation session afterwards." – Informant 3

Informant 5 provided an example of a measure which was implemented, but not fully reviewed.

"Unfortunately we had an incident at another installation, where the root cause was linked to knowledge of a work practice. This existed and was in the systems, however it was in a place where it was unnatural for the users to look for it." – Informant 5

When asked whether she felt a need for a third party to evaluate their performance on the measures Informant 6 answered: "Yes". She stressed that in their 12 hour workday, a lot is already pushed in, and little time is left over for other things.

"We must then decide whether we shall sit down for two hours and evaluate how effective the completed measures from 2015 have been, or if we should repair the engine so that we can restart the water production? It is kind of like this." – Informant 6

It was revealed that after the incident on Installation B in 2015, the establishment of a closing committee ensured that measures where not closed by single individuals, but a group of people. According to Informant 11, this was beneficial.

"It was very beneficial to have more people on evaluating whether the measure was fully realized" – Informant 11

"The more severe (incident), the more necessary it is" – Informant 12

Evaluation of Learning (improvements of the stages in the learning from incident process)

According to the informants, it is essential when evaluating the learning from an incident that it can be traced back to somewhere, and that it is not just a "memorizing activity". Informant 1 explained this with the following statement:

"What I think is important with learning, which we not have managed yet, is sustainable measures. Meaning that it is not up to the individual "to remember", but it rather ends up as a change in the technical systems or demands. It can then be found in our governing documents or as a new routine in our work processes." –Informant 2

As mentioned, transferring information to all shifts is a common measure to implement. Informant 6 expressed her concern on whether the learning is sustainable.

"If you had asked someone to "retell what was told", which is really what we are talking about here, or "what did we learn from this?", "what did we get?", "what shall we do with the information we are given?", then answers would be very unambiguously." - Informant 6

It is clear that The Company has a great focus on learning from incidents, and that this is essential for preventing future similar events. Informant 1 justified this by saying:

"The purpose here is learning. For example, in one to two years ahead, "where did the measures from the incident in 2015 end up?" Because as we have the experience, there is a learning aspect to it, right?" – Informant 1

Once The Company has acknowledged the learning aspects of an incident, they create learning packages in which they spread throughout The Company and sometimes also throughout the industry. Informant 2 stressed the importance of spreading the learning by saying:

"It is important that it is spread in all directions, where it is needed. Internally, it is shared through our networks, professional networks. In addition, the experiences are shared across companies, and vice versa." – Informant 2

However, due to complexities of each incident, it is up to each installation to consider whether the learning aspects are relevant for them or not. The learning is often only shared through a page of specific information on the root causes, recommended learning points etc., with reference to the investigation report and the report on proposed and implemented measures. The perception of these learning packages are that they are not able to really communicate the important learning aspects the best possible way. Informant 1 explained why there is a problem with these single slides of information:

"When severe incidents occur in The Company, by reading these pages we learn something, but do be really understand it? Then a week passes, and we slowly start to forget it. An experience of something must lead to a change somewhere. For example in the governing documents, in the factory or other. Then you actually manage to implement something which removes the root causes of the incident." – Informant 1

"Do you learn by reading, or by actually implementing it into the systems?" – Informant 1

According to Informant 4 and Informant 5, it is common practice that the slides are read and later forgotten, without really grasping the true essence of what happened.

"It is solely information you get before you jump into your daily tasks again" – Informant 4

"My impression is that we get it and then forget it. It goes straight out again." – Informant 5

As it occurs several incidents on a yearly basis in The Company, it is not easy for each installation to pick up on all the learning aspects that they should have.

"There is information available in a database where anyone can search for incidents, but to be honest, who has time to do this when there are several other tasks that are just as important?" – Informant 6

To this problem, Informant 4 suggested the following:

"What we see as a good solution to this, is that a superior group in The Company could look at all severe incidents, make the learning packages, send them to the facility owner, who then decides whether there is something they need to take further to their installation, or not." – Informant 4

It is observed that proper systematics for learning from incidents in The Company has been lacking, and lack of systematics is perceived as an inhibitor for learning.

Something interesting discovered by interviewing personnel on Installation A, was that they are developing a new module which will ensure sustainable learning. This module emphasizes the importance of sharing experiences.

"The experiences we have gained through an incident and investigation are important that we share. This is also something that PSA has criticized us for. We are not good enough on learning from other incidents." – Informant 4

Specific learning points are added into the module with reference to the incident. In this way, it is established a traceability and measures related to learning which take advantage of the reports on proposed and implemented measures. Currently, it is a pilot project on Installation A, but they have already observed positive signs of it working.

"I see that local measures are sent to me on this, because the system makes an automatic evaluation on "Who can learn from this?". There is a group that works with the selection of who it might be relevant for." – Informant 1

"You subscribe to certain HSE incidents"- Informant 1

"With the new systematics it will be made a "HSE experience" report in the reports on proposed and implemented measures. Here we can search on what we learned from other recent incidents and what measures we implemented. It is going to be great to have everything in one place" – Informant 3

Without being involved in the "sustainable learning" project, Informant 6 asked specifically for the possibility of making searches in the reports on proposed and implemented measures. She suggested that since you are logged on as a personal user of the system, it should automatically reveal incidents or information relevant for your specific discipline. As stated by the informants at Installation A, a system like this is needed in order to really learn from an incident, especially in larger companies such as The Company. Informant 1 provided an example, which proved when the learning is not sustainable:

"When you have an organizational barrier, to make it sustainable it must be rooted somewhere, so that it cannot suddenly disappear when leaders or personnel change. Because suddenly then, you do not have that practice any longer." – Informant 3

"We want to avoid short-termed individual learning"- Informant 3

Another aspect revealed, was the importance of also learning from less severe incidents and "weak signals".

"Then the great question arises: does it have to be a yellow or red incident before we start learning?" – Informant 1

"I believe that there is too little focus on the incidents that have a lower degree of severity. These should get a bit more "color" in the classification system, or focus in the reports on proposed and implemented measures." –Informant 4

In addition, Informant 6 elaborated that weak signals also can be spotted in the annual GPS's. For instance if workers have reported their concern on something, and feel as though they are not being heard, or taken seriously. Informant 5 suggest that the learning from incidents should be implemented in the daily pre-job and hands-on conversations. He stressed that there is too little focus on the "green" events, and this is unfortunate as many green events one day might become a "red". When asked to provide his most important improvement proposals for reducing the probability of future HC leaks, Informant 5 answered:

"Transfer of experiences, loyalty, learning across and to take the time to do it right the first time" –Informant 5

Furthermore, on Installation A they have made a slightly correction to the closing meetings. They now call it "closing meeting, sustainable learning". This is to avoid that things are put between two stools and to provide a better leadership-focus to the measures, and ensure that they are being followed up. Informant 1, talked highly of this meeting, and said:

"Now we actually manage to close them (the measures). And ensure that they do not pass without having quality and precision." – Informant 1

Informant 7 stressed the need for a proper handover in order to learn:

"It was a similar incident on January 27th. Us, who were working when this regulation valve blew, did not get any information on this while we were off work." – Informant 7

Informant 8 explained that leaders have most of the responsibility on promoting learning.

"The fact that leaders are engaged. To promote the strategic learning someone has to request results, follow-up and engage." – Informant 8

When asked whether the learning across was sufficient, Informant 9 answered:

"Yes in this case, it was extremely good. It was repeated probably over a hundred times. It was shared with other companies. However, I still would say that it is often not done sufficiently. I might be too sharp on this, but we do it too rarely" – Informant 9

Furthermore, Informant 9 explained that on a higher level, they have HSE meetings where more severe incidents are shared, and the most important learning points are caught. The severe incidents are often properly shared, however, according to Informant 9 they could improve on a daily basis. In addition, Informant 8 explained that they also try to focus on learning from successful operations.

"The focus have been on the ones who were successful and performed well. "What did they do to avoid HC leaks?". – Informant 8

5 Discussion and Implications

The objective of this study is to generate knowledge on effective organizational measures and learning processes of practical importance. This means that the study aims to identify preventive measures and learning processes that are of practical value for the oil and gas industry in general and for the company studied in this thesis in particular. In order to achieve this objective, the thesis is based on two intertwined research questions:

1. ***What are the characteristics of effective organizational measures and learning from incident processes*?**
2. ***What can the oil and gas industry and the concrete company studied in this thesis acquire from these characteristics in their work with prevention of high-potential incidents?***

5.1   What are the Characteristics of Effective Organizational Measures and Learning from Incident Processes?

The literature study gave clear answers to what characteristics were of importance in the investigating and analyzing phase. These were mainly sufficiently deep investigation, clear causal relationship and involvement of the right people. The findings in the empirical analysis supported the characteristics identified in the literature. In addition, the informants shed light on a couple of other significant aspects. Firstly, an appropriate mandate for the investigation which specifies clear expectations for the outcome. Secondly, that the investigation team is "up-to-date" on methodology and systematics for use in the investigation Third, in addition to involving operational personnel with knowledge on relevant processes systems in the investigation (causes and measures), the informants also expressed the importance of involving safety delegates in this phase. Figure 5.1 below, illustrates the key findings in this phase.
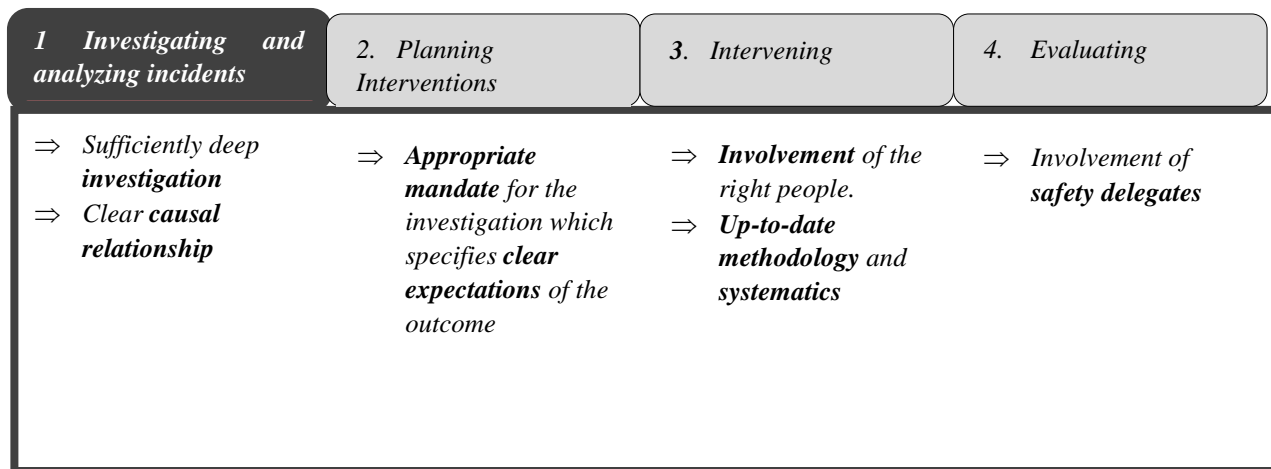
1 *Investigating and analyzing incidents*	2. *Planning Interventions*	3. *Intervening*	4. *Evaluating*
⇒ *Sufficiently deep* **investigation** ⇒ *Clear* **causal relationship**	⇒ ***Appropriate mandate*** *for the investigation which specifies* **clear expectations** *of the outcome*	⇒ ***Involvement*** *of the right people.* ⇒ ***Up-to-date methodology*** *and* ***systematics***	⇒ *Involvement of* **safety delegates**

FIGURE 5.1 KEY FINDINGS IN THE INVESTIGATING AND ANALYZING PHASE

Several significant characteristics were identified in the planning interventions phase. These were related to recommendations addressing both direct and underlying causes, concise and not open for interpretation nor overly prescriptive wording, prioritization according to highest overall increase in safety level, SMARTER actions, involvement of line managers and personnel with frontline experience, avoiding overproduction of measures (measures fatigue) and clear closing criteria. The empirical analysis confirmed the importance of several of the characteristics identified as the state of the art. In addition, it was revealed by the informants that there are also other aspects that affect the learning from incident process and the effectiveness of the measures. Firstly, a measures meeting where the investigation team and the local leaders together adjust and formulate the recommendations. Secondly, a formalization of the treatment (spread and sharing) of the learning packages was observed as beneficial. Thirdly, according to the informants at Installation A, formalizing measures in order to achieve sustainability, requires a change or traceability rooted in the governing documents in order to achieve a long lasting effect. Fourth, the informants stressed that the key is to select only a few areas to focus on and try to reach the few stated goals. Lastly, the informants expressed the need for finding a balance between formulating goal-oriented measures versus strictly prescriptive measures. Figure 5.2 below, illustrates the key findings in this phase.

1 Investigating and analyzing	2. Planning Interventions	3. Intervening	4. Evaluating
⇒ Recommendations address both **direct and underlying causes** ⇒ **Sustainable** and **traceable** *(long lasting) measures and learning*	⇒ Recommendations are **concise** and **not open for interpretation nor overly prescriptive** ⇒ **Few focus areas** *to concentrate on* ⇒ **Balance** *between goal-oriented and prescriptive*	⇒ **Involvement** *of line managers and personnel with frontline experience* ⇒ **Avoiding overproduction** *of measures (measures fatigue)*	⇒ Involvement of **safety delegates** ⇒ **Clear closing criteria** ⇒ **Formalization** *of treatment of measures*

FIGURE 5.2 KEY FINDINGS IN THE PLANNING INTERVENTION PHASE

The literature addressed several characteristics of importance in the intervening phase. These were mainly communication (use of older incidents, forum of sharing lessons learned etc.), enough resources (manning, time, money, etc.), involvement of workers at all levels and establish ownership of measures. In addition to this last point, the informants added that it was important to include the safety delegates at this stage. Furthermore, it was identified in the interviews that it was important to have a close collaboration between the technical and maintenance disciplines and to have a proper understanding of the risks involved in the implementation and closing stages. In relation to communication, it was stressed that the handovers must be satisfactorily written. The informants claimed this as crucial in shift-organizations. Figure 5.3 below, illustrates the main findings in this phase.

2 Investigating and analyzing	2. Planning Interventions	3. Intervening	4. Evaluating
⇒ **Communication** *(use of older incidents, forum of sharing lessons learned etc.)*	⇒ **Involvement** *of workers at all levels* ⇒ **Close collaboration** *between disciplines*	⇒ Involvement of **Safety delegates** ⇒ **Understand the risk picture** *of implementing and closing measures*	⇒ **Establish ownership** *of measures* ⇒ **High quality** *on* **handovers** *(particularly important in shift organizations)*

FIGURE 5.3 KEY FINDINGS IN THE INTERVENING PHASE

Furthermore, the literature study also gave clear answers to what characteristics were of importance in the evaluating phase. These were mainly evaluation of effect (verifications, periodic reviews,

interviews or performance indicators), evaluation of implementation of measures (whether measures were fully realized) and evaluation of learning (improvements of the stages in the learning from incidents process). In addition, it was identified in the interviews that the involvement of safety delegates and leaders was crucial at this point. Lastly, the informants on Installation B addressed the advantage of having a closing committee at this stage, in order to ensure that measures are not solely closed by one person, but by a group of people who together agrees upon that the measure can be closed. Figure 5.4 below, illustrates the main findings in this phase.
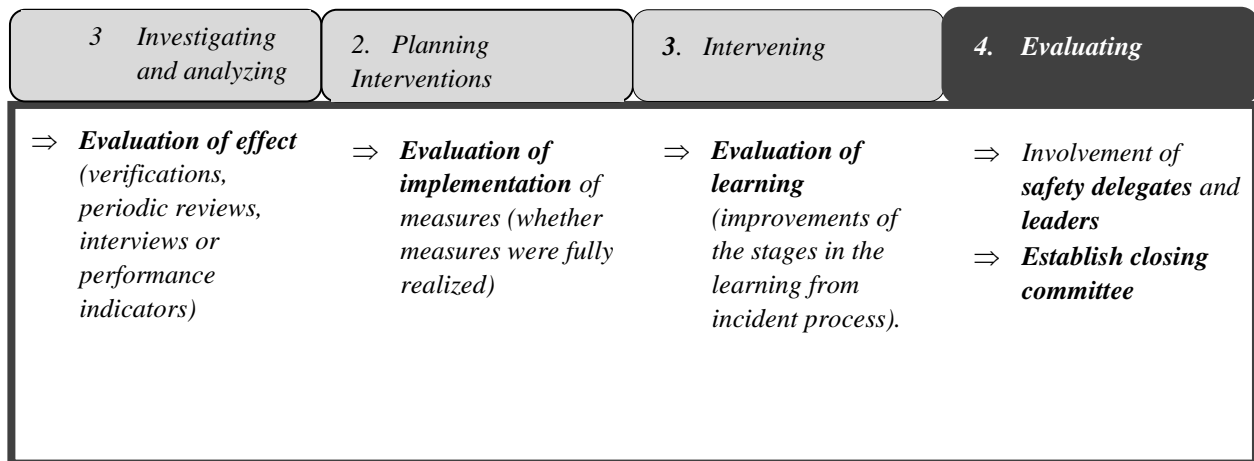
3 *Investigating and analyzing*	2. *Planning Interventions*	3. *Intervening*	4. **Evaluating**
⇒ **Evaluation of effect** *(verifications, periodic reviews, interviews or performance indicators)*	⇒ **Evaluation of implementation** *of measures (whether measures were fully realized)*	⇒ **Evaluation of learning** *(improvements of the stages in the learning from incident process).*	⇒ *Involvement of* **safety delegates** *and* **leaders** ⇒ **Establish closing committee**

FIGURE 5.4 KEY FINDINGS IN THE EVALUATING PHASE

5.2 What Can the Oil and Gas Industry and the Studied Company in this Thesis Acquire from these Characteristics in their Work with Prevention of High-Potential Incidents?

The empirical analysis provided several practical and theoretical implications. The practical implications in this sense are considered what The Company and the oil and gas industry should focus on in order to prevent high-potential incidents. The theoretical implications are recognized as aspects in the empirical analysis in which the literature have not managed to shed enough light on, however was reported by the informants as important for achieving effective organizational measures and effective learning from incidents.

5.2.1 Practical Implications

The most significant practical implications identified in the investigating and analyzing phase was that The Company and possibly the industry should work on involving first-line personnel and safety delegates. The involvement of safety delegates was addressed by several informants as very important. Based on what was observed in the investigation reports and expressed by the informants, The Company matches the state of the art on most parts of the investigation phase. The

Company digs deep into the direct and underlying causes and makes a great effort on determining causes related to the incident. However, according to the informants the quality of the investigation report still deviates due to personal differences of the investigators. The informants expressed their concern on whether the investigators managed to stay unbiased through the investigation. The informants addressed biased investigators as an inhibitor of a successful investigation. Furthermore, it was observed that The Company mostly fit the "ideal description" in terms of involving the right personnel in the investigation. First line personnel are interviewed, experts are consulted and the safety delegates are included in the investigation team. In addition, according to the informants, the causal relationship incident is improved if the investigation is slightly delayed and an internal investigation is initiated in advance

Furthermore, several aspects were identified to have practical implications in the planning phase. First, to become better on prioritizing and avoiding overproduction of measures. Second, a need for identifying where it is beneficial to lift the development of measures to higher management levels. Third, the organization should acquire more time to discuss and understand the measures in the measures meetings and apply a more "top-down" approach to the development of measures and acquire more ownership to the measures in the sharp end. Forth, to establish clear closing criteria and specify what needs to be done in order to close the measure. Fifth, involving operative personnel and safety delegates in the planning process. In addition to this, it was identified by the informants a need for the investigation team to be available for clarifications *after* the investigation and measures meetings. This practice was not common at the present time of this study. Another interesting factor, in which the industry should learn from The Company, is that they have started directing the focus on to learning, which is identified in the literature as important. Furthermore, even though a few informants were familiar with the SMARTER principle, they admitted to not directly apply it. However, The Company seem to have focus on formulating measures that are sustainable and provide a learning effect, which is closely related to the SMARTER principle. In addition, the informants admitted that The Company did not always formulate the measures as prescriptive, but rather goal-oriented. The reason for this was claimed to be caused by people copying and pasting the recommendations directly from the investigation reports, in to the reports on proposed and implemented measures. Moreover, the informants expressed divided opinions on whether the right personnel was involved in the formulation of the measures. Some informants claimed that front-line personnel was involved to the extent where it is beneficial, while others disagreed and stated that the operative personnel should be more involved in order to determine whether a measure was feasible in real life. In addition, the safety delegates elaborated on the importance of involving them in this process as well, which is not always done. In addition, as reported by the informants, it seemed as though The Company prefers implementing many easy solutions rather than going for more expensive measures that really provide an effect. However, it is difficult for any observant to conclude on whether they are doing it wrong or right, because each incident and case is exclusive and unique. Moreover, as the informants stated, the measures must be prioritized according to everything else that needs to be done. With that being said, the informants claimed that The Company tend to overproduce measures. This was implied in the document analysis as well, but could not be confirmed by only analyzing the number of measures,

closing time etc. Furthermore, it was obvious that The Company does not match the state of the art on establishing clear closing criteria of measures. The Company has no particular routines for addressing clear closing criteria when formulating measures. This was confirmed in the document analysis and the interviews. This is unfortunate as the literature expressed the need for clear closing criteria for achieving an effective implementation of measures.

An important practical implication identified in the intervening phase was that The Company's procedure for changing the implementations status and closing measures is insufficient. Nowadays, the measures are closed after implementation and not after evaluation or review. This is a weakness in the learning process, and it is clear that it enables the measures from being SMARTER actions. A suggestion made by the informants were to introduce new status codes into their system. The new codes could be for instance "in process", "up for evaluation", "executed" and "closed". Thus, the measures should not be closed before they are evaluated in terms of implementation, learning and effect. In the intervention phase of the learning from incident process, The Company both match and deviate from the state of the art. The Company try to communicate and spread the learning packages from incidents, however they are not always successful. The sharing of single pages of information is expressed by the informants as not an effective approach to communicate learning. In addition, it is clear that The Company faces extra challenges as many of their employees work in shifts. They are therefore depending on a high quality of the handover in order to achieve a successful implementation of measures. The informants confirmed that the handover is not always satisfactorily written. If the personnel had more time on their hands, the quality of the hand-over might improve. The informants claimed that they always had a lot to do after an incident, and at times both time and manning could be a limited resource. Hence, The Company's practices deviate from the state of the art as the leaders does not seem to acquire enough resources in the intervention phase. Moreover, as touched upon earlier, the ownership of the measures (and the responsibility) is perceived as very person-dependent, and this should be worked on.

The practical implications identified in the evaluation phase were numerous. Firstly, to become better on evaluating measures related to compliance. Secondly, to evaluate effect of measures and not only the realization of the measures. This implies that today The Company only reviews whether the measure is executed, and whether the new measure has been established as a new routine in their work practices and governing documents. However, it is not reviewed whether a) the practice is changed, or b) if necessary competence to follow the new practice is present. Thirdly, it is important to develop an open culture where questions and recommendations regarding the governing documents are welcomed, at the same time, as one is compliant to these. Forth, it was identified a need for evaluating the effect and learning of implementing a measure after a given period of time. It was suggested by the informants that a third party or the investigators could revisit the investigated installation, and review the status and effect of the measures. Moreover, as the closing criteria for each measure is non-existent, it is not clear how each measure and the learning from the incident should be evaluated before the measure is closed. Aside from the single report (of the 15 reports) where clear closing criteria very given, The Company has not managed to state any demands on how an organizational measure should be effect evaluated or verified before it is

closed. Hence, The Company's practices clearly deviates from the state of the art at this point. After implementing a measure, the company did not confirm whether a measure was effective or if the learning from the incident was sustainable. The same problem was identified in Drupsteen et al.'s (2013) survey where it was indicated that if an evaluation was done, it aimed solely at determining whether the measure was performed or not, and not on preventing reoccurrence or evaluating the quality of the remedy.

5.2.2 Theoretical Implications

A significant theoretical contribution of the study was the importance of involving the safety service or safety delegates in order to achieve a successful implementation of measures and learning from incidents. Neither the model presented by Drupsteen et al.(2013) or the Energy Institute considers this aspect. They only focus on involvement of operative/frontline personnel and local leaders. This might be due to the high status and power of the safety delegates in Norway have compared to in other countries, where the Drupsteen et. al (2013) and EI studies were conducted. However, the informants stressed the need for involving the safety delegates in all phases of the learning from incident process. Especially when planning measures (action plan), as they have the ability of seeing things from another perspective.

Another significant theoretical contribution identified in the interviews on Installation B, was how extra challenging the learning from incident processes is for personnel working in shift-organizations. Ensuring that the learning effect of an incident is sustainable is difficult in these organizations, as it requires additional repetition of information and handovers of high quality. The reviewed literature does not seem to consider this aspect, which is unfortunate as most personnel on offshore installations work in shifts. Informant 7, addressed that repetition and choosing a few areas to focus on for several months, was the key to ensure that all shift-workers actually learned from the incident. Beside from incidents occurring at their own installation, is also important that the learning across other organizations and industries is sustainable. The informants identified these as important criteria for success, however more research is required in order to confirm this.

In addition, the study also recognized that occasionally, the use of KPI systems may provide a negative effect, which is not properly addressed in the literature. It was identified by several informants that measures are closed too early due to The Company's KPI system. The informants claimed that the action owners closed the measures too early in order to improve their KPI values. Having a KPI system may be beneficial in many ways, however in terms of ensuring a proper implementation on measure, the KPI system provides a negative effect on the organization. The informants stressed this as a major issue, and had no suggestions on how to deal with it. The literature introduces that KPIs could be used to measure the effectiveness of a measure, however it does not present how to balance the positive and negative effects of having such a system. Identifying the best practice for this matter is out of the scope of this thesis, however it is stressed that more research and literature is needed on this subject.

5.3 Limitations and Recommendations for Further Research

The findings and the implications of this study should be interpreted with some methodological limitations in mind. Firstly, due to the nature of semi-structured interviews, ensuring unbiased responses is challenging. Confirming or rejecting the occurrence of biased responses due to social desirability is impossible in this context. Thus, a recommendation for further studies would be to replicate the study and strengthen the findings by underpinning the interviews with real life observations of the investigators, leaders and personnel. Secondly, the topics addressed in the study are generic and not necessarily restricted exclusively to the oil and gas industry. Hence, it would be interesting if future research examined success criteria for effective organizational measures and learning from incident processes in other industries or sectors. Lastly, as a result of the design of the study and sample size (number of reports and informants) the findings are not generalizable in the traditional statistical sense. Regardless of this matter, the particular empirical setting is still considered to highlight relevant empirical information on an under-investigated area, believed to be transferable to other industries as well. However, it could still be interesting for further research to examine the findings with a more quantitative research design. Despite these limitations, the findings and the implications that we have drawn from them should be relevant and important for preventing high-potential incidents.

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6 Conclusion

In this thesis, two research questions were raised and addressed on identifying effective organizational measures and effective learning from incident processes, and identifying what the studied company and the oil and gas industry can acquire from the knowledge on this topic.

The literature review and the empirical study identified several characteristics of effective organizational measures. The most evident characteristics were measures formulated as rather prescriptive then goal-oriented, SMARTER actions with clear closing criteria and measures providing a sustainable (traceable and long lasting) effect. In addition, it was found that involving the right people (especially operative personnel and safety delegates) in the work of formulating measures, is particularly beneficial for the outcome.

The characteristics of effective learning from incident process were identified as many. The following were found as the most significant contributors to an effective learning from incidents process:

➢ Involvement of the right personnel through the whole process
➢ Sufficiently deep investigation, clear causal relationships,
➢ Recommendations which address both direct and underlying causes and learning aspects,
➢ Proper formulation and prioritization of measures (avoiding overproduction) with clear closing criteria,
➢ Implementing measures by satisfactorily communication (particularly regarding handovers) and enough resources
➢ Evaluating the effect, the learning and the realization of the measures afterwards,

With this being said, it goes without saying that in order to achieve a fully effective learning from incident process, all phases must be effective and fully realized. Nevertheless, the study concludes with Drupsteen et al. (2013, p.75):

«However, an approach to improve the learning from incidents process should consider the process as a whole and not only separate steps or stages. Organizations often focus mainly on improving one or two steps, such as investigating and analyzing incidents. This can only marginally increase learning potential for the overall learning process, as the learning potential curve illustrates.»

Furthermore, it was recognized that The Company and the industry need to work further on learning from incidents and formulating effective measures. The Company's practices does not fully match what was stated as the state of the art. It was observed that The Company does not formulate measures as SMARTER actions, establish clear closing criteria nor evaluate measures based on effect, learning and implementation. In addition, the empirical study revealed that The Company should revise their practices for involving the right personnel in all phases, communicating (particularly handover) and sharing lessons learned, prioritizing measures and avoiding

overproduction of measures. Moreover, according to the literature, the leaders in The Company should revise how they establish ownership and ensuring enough resources for the measures.

The empirical study revealed several aspects in which the literature has not covered sufficiently. The involvement of the safety service and safety delegates was pinpointed by the informants as very important. Safety delegates work in the operative end and have the ability of seeing things from a different perspective. According to the informants interviewed, the safety delegates should be involved during the whole learning from incident process. In addition, how to effectively learn, when working in shifts was identified as a major issue. Unfortunately Drupsteen et al. (2013) or EI (2016) did not address the best practice for ensuring learning in these type of organizations. In addition, it was revealed that The Company's use of KPI's had a negative effect on the eagerness to close measures too early. Further studies is required on how to benefit from using KPIs without experiencing a conflict of interest in terms of closing measures too early.

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8   Appendices

Appendix A- Interview guide

Introduction:

- Can you tell us a bit about your background/experiences and role in The Company?
    - What was your role during the investigation of the incident?
    - What was your role during the follow-up process?

Learning from Incidents:

- What are the essential inhibitors/obstacles of effective follow-up and learning from incidents?
    - Can you elaborate with common examples?
- What are the most important promoters of learning from incidents?
    - Can you provide common examples?

Investigation:

- What do you think of the recommended measures in the investigation reports? Do they represent a good baseline for the further follow-up?
- Do you perceive that the investigation report provide a wide analysis of the causes and measures (MTO)?
    - How do they address direct and underlying causes?
- Have the investigators gone far enough into the chain of causes?
- How is the involvement of front-line personnel in the investigation?
- Who is included in the investigation team?

Recommended actions:

- Did the local leaders come up with new measures, meaning measures that were not recommended in the investigation report?
    - If so, which?
- Did the local leaders decide to not follow up on any actions recommended in the investigation report?
    - If so, why not?
- The formulation of the recommended measures are often rounded. Why is this?
    - Is this positive or negative for the organization?
- After the incident, there were x number of recommended actions in the investigation report, which later has become y number of measures in the report on proposed and implemented measures. Why is the difference so significant?
    - What do you think of the number of measures listed?
    - Do you perceive that there is an overproduction of measures?
    - If yes, what consequences can this lead to?
- How was the findings from the investigation from PSA followed up?
    - Did the findings correspond to what The Company had found in their investigation?

Decision process of measures:

- How is the transition between recommended actions in the investigation report, to the concretization of measures to follow up locally?
    - What is your experience with the measures meeting?
- Do you use any sort of systematics/guideline when you formulate and choose measures?
    - If not, did you miss it?
    - Are you familiar with the SMARTER term?
    - If not, explain what characteristics a measures should have?

- What evaluations do you perform in order to ensure a long lasting effect of a measure?
- What type of measures are often chosen?
    - o What type of measures are rarely chosen?
- How concisely are the measures formulated? (Goal oriented versus prescriptive).
- What measures do you have positive experiences with? That are perceived as beneficial?
- To what extent do you perceive that an effective measure is shared between installations, shared across to other companies?
    - o Do you have a system/routines for doing this?
- Is the balance between long-term preventive measures and short-term corrective measures satisfactorily?

Implementation of measures:

- How do you ensure a proper implementation of measures?
    - o Information, involvement, capacity/resources, roles and responsibilities, deadlines)
    - o Is there used any form of systematics or guidelines?
    - o If not, did you miss it?
- How is learning from incidents communicated when implementing measures?
    - o How are learning packages communicated?
    - o What challenges do you identify at this part?
    - o To what level is the learning lifted?
- If any, what are the limiting resources when performing measures (money, manning, time, etc.)?
    - o What is the consequence of having limited resources when implementing measures?
- How are the frontline workers is involved in the implementation of measures?
- Are the leaders able to establish ownership, motivation and engagement?

Follow up and closing of measures:

- On what terms are measures closed? After decision of closing, after implementation or after evaluation of effect?
    - o Are the closing criteria for each measure clear? Could it be unclear what is needed in order to close?
    - o Do you find a need for clearer closing criteria?
    - o Are measures closed too easy/early?
- Can you elaborate on the function of the closing committee?
    - o What are the advantages of having such a committee?
- Are the measures followed up after closure? I.e. evaluated?
    - o Is the effectiveness of the measure evaluated?
    - o Is the learning effect evaluated?
    - o Is evaluated whether the implementation of the measure fully realized?

Specific measures:

- How do you ensure that this specific measure is long-lasting (sustainable)?
- On what terms do you close this type of measure, which is naturally a continuous process?
- Is the organization good enough on lifting measures and learning up to other parts of the company or the industry?
- Is this specific measure formulated clear enough?
    - o Do you actually know what to evaluate?
- There are many measures formulated by "evaluate" or "assess". Are these measures binding enough?
    - o Should one try to stay away from these type of measures and replace them with specific descriptions of measures? Or does it work nicely?
    - o Should the evaluation take part before writing the measure in the report?

In conclusion:

- What are the three most important measures for avoiding HC-leaks in the future?

- How can the process in relation to decisions and implementation of measures, in the aftermath of an HC leak, become better than today?