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**An Evaluation of the Framework for Risk-Based Audits in
the Offshore Industry**

How are audits implemented internally and externally with regards to safety valves on offshore installations, and is this in line with academic risk theory?

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Abstract

The offshore industry has been, and still is, one of the most important industries for economic and industrial development in Norway. Considering the important role this industry plays, combined with the potential hazardous consequences of faulty equipment or human error on offshore operations, the development of well-functioning risk management regimes is integral. One such risk management regime is the act of performing audits. To prevent any undesirable consequences, audits are conducted regularly, both on an internal-, external-, and authority level. While there are many risks related to offshore activities, risks related to PSVs are of particular importance as these represent the last safety barrier on offshore platforms. This dissertation attempts to evaluate whether audits conducted on PSVs in the offshore industry on the Norwegian continental shelf are in line with academic risk theory.

This research project is based on evidence provided by actors working on or within the limits of NCS on an authority-, operator-, and supplier level. The aim of the dissertation is to explore the conceptual understandings found within the offshore industry, as well as to evaluate the current industry framework for audits in the offshore industry to determine whether the framework can be considered risk-based from an academic risk theory perspective. While the project does not aim to create a new framework, it does attempt to provide guidelines for further development.

The main findings of this dissertation indicate that while the governing standards and related documents on their own cannot be considered risk-based, audits of PSVs on the NCS can be considered risk-based and in line with academic risk theory as a holistic process across all levels. However, the current regime is vulnerable and can quickly deteriorate. Another challenge identified is the difference in understanding of the risk concept, which indicated a sectorial problem related to the successful implementation of a consensus within the industry.

This dissertation found that further research on this topic is needed and identified three important topics which could require further attention. These topics relate to the ambiguity of conceptual understanding within the industry, experience-based learning which may lead to the dilution of knowledge over time, and the need further development of standards.

Keywords: Risk, audits, PSV, offshore, regulations, PSA, risk tolerability

Abstrakt

Olje- og gassindustrien har vært, og er fortsatt, en av de viktigste næringene for økonomisk og industriell utvikling i Norge. Grunnet den viktige rollen denne industrien spiller i kombinasjon med de potensielle ødeleggende konsekvensene av defekt utstyr eller menneskelig feil på offshore operasjoner, er utviklingen av velfungerende risikostyringsregimer særst viktig. Et slikt risikostyringsregime kan være å gjennomføre tilsyn. Slike tilsyn gjennomføres regelmessig både på et internt-, eksternt- og myndighetsnivå for å forhindre uønskede konsekvenser. Det er mange risikoer relatert til offshore aktivitet, men risikoer relatert til PSVer er spesielt viktige da disse representerer den siste sikkerhetsbarrieren på offshore plattformer. Med dette i grunn forsøker denne oppgaven å evaluere hvorvidt tilsyn gjort på PSVer på offshore plattformer på norsk sokkel er i tråd med akademisk risiko teori.

Dette forskningsprosjektet er basert på aktører som jobber innenfor rammeverket av norsk sokkel på et myndighets-, operatør- og leverandørnivå. Målet for denne oppgaven er å undersøke den konseptuelle forståelsen innenfor bransjen, og å evaluere det nåværende rammeverket for tilsyn i olje- og gassindustrien for å stadfeste hvorvidt tilsynene kan konkluderes å være risikobaserte fra et akademisk risikoteoretisk perspektiv. Målet for dette prosjektet er ikke å utvikle et nytt rammeverk, men heller å forsøke å fremlegge retningslinjer for utviklingen av et nytt rammeverk.

Funnene i denne oppgaven indikerer at på tross av at dokumentene på egenhånd ikke kan konkluderes å være risikobaserte, kan man argumentere for at tilsyn på PSVer på norsk sokkel er risikobaserte og er gjennomført i tråd med akademisk risikoteori på et helhetlig nivå mellom alle nivåene. Dette er derimot en sårbar prosess som kan forvitres over tid. En annen utfordring identifisert er forskjellene i forståelsen av risikokonseptet som peker på et sektorielt problem relatert til en vellykket implementering av en konseptuell konsens innenfor bransjen.

Denne oppgaven konkluderer at videre forskning på dette temaet er nødvendig og har identifisert tre viktige temaer som kan trenge videre oppfølging. Disse temaene relaterer til tvetydighet i den konseptuelle forståelsen innenfor bransjen, erfaringsbasert læring som kan føre til utvanning av kunnskap over tid og videre utvikling av standarder.

Foreword

First and foremost, we would like to thank our supervisor, Frederic Emmanuel Boudier for your valuable inputs and your continuous support. Furthermore, we would like to extend a warm thank to our informants for your invaluable insights and your gracious help. Without you, this dissertation would not be possible. We would also like to thank our fellow students for all the collegial and friendly conversations we have had together. You have motivated and helped us throughout this experience, and we can only hope we have done the same for you. Lastly, we would like to extend a heartfelt thank you to our parents for your continued love and support throughout the entirety of our studies. Not once did your doubt, and encouraging words were never more than a phone call away.

Jørgen & Linn,

2022

List of abbreviations

| | |
|-------|-------------------------------------|
| ALARP | As Low As Reasonably Practicable |
| CA | Continuous Auditing |
| CBA | Cost-Benefit Analysis |
| CEA | Cost-Effectiveness Analysis |
| FAT | Factory Acceptance Testing |
| HSE | Health, Safety, and Environment |
| IAF | Internal Audit Function |
| ISO | International Standard Organization |
| NCS | Norwegian Continental Shelf |
| PM | Preventative Maintenance |
| PM | Preventative Measure |
| PSA | Petroleum Safety Authority |
| PSV | Pressure Safety Valve |
| RAC | Risk Acceptance Criteria |
| RBAA | Risk-Based Audit Approach |
| RBAP | Risk-Based Audit Planning |
| SRA | Society for Risk Analysis |

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1 Introduction

The art of risk anticipation has become increasingly prevalent in the 21st century. Private and public sectors alike are allocating increasingly large portions of their resources to risk prevention and risk-related contingencies (Hutter, 2011). Considering this, the concept of risk-based approaches is becoming increasingly integrated into disciplines across industries in relation to risk management and audits. While risk-based thinking has been a well-integrated practice in industries such as the health industry for many years, this practice was only formally introduced to the energy sector in 2018 through the ISO 19011 standard. Considering the importance of risk management within this sector, the shift towards a risk-based approach is one of notice.

One issue concerning this shift is the ambiguity surrounding the concept of a risk-based approach. While ISO 19011 defines this concept as «*an audit approach that considers risks and opportunities*» (ISO, 2018, p. 6), this definition raises certain questions related to which risk concept this interpretation is referring to, as well as how this should be interpreted by the different levels of the offshore industry. Considering the prevalent role the concept of a risk-based approach has been given, it is important for the successful implementation of such approaches in the industry and the continuous safety on NCS that there is a consensus related to the interpretation of this concept. If the interpretation of the concept differs, this may cause friction between the different levels when risk-based audits are performed. Considering this, it is integral to clarify what a risk-based approach is, as well as to evaluate the framework used for risk-based audits in the offshore industry.

1.1 Topic question

The starting point for this dissertation was an informal conversation with individuals working in the Norwegian offshore industry. Throughout this conversation, it was uncovered that there exists uncertainty related to concept of a risk-based approach. Such an approach has been strongly encouraged by legislators within the sector in relation to offshore activity. This

uncertainty mainly related to what a risk-based approach is, what it ensues in relation to risk-based audits, and what is considered best practice for this. Considering this, it seems that there is a lack of research related to this particular practice within this sector. While many resources have been allocated to develop the HSE division within the industry, the topic of a risk-based approach has not gained enough focus. Considering that risk-based approaches and risk-based thinking is becoming an increasingly important part in HSE, it is important that the different levels of the industry arrive at a consensus related to what this approach ensues for the different parties to ensure the successful implementation of a new approach. This dissertation aims to take a closer look at risk-based approaches within this sector by evaluating whether the concept is adequately defined, and the approach that the industry is currently applying can be considered risk-based according to academic risk theory.

The main purpose of this project is to evaluate the practices on the different levels of the offshore industry and develop some criteria for a risk-based approach to audits. To do this, it is important to develop a commonly accepted understanding of what a risk-based approach is and clarify what this ensues for operators and legislators alike. This project's purpose will be a twofold attempt: first, it will attempt to clarify what a risk-based approach ensues. Second, it will use this foundation to evaluate the framework for risk-based audits in the Norwegian energy sector both for internal audits and external audits. This dissertation takes a closer look at risk-based audits on PSVs on offshore platforms to emphasise the importance of successful implementation.

With this foundation in mind, the topic question of this dissertation is:

How are audits implemented internally and externally with regards to safety valves on offshore installations, and is this in line with academic risk theory?

To answer this topic question, this dissertation has developed two research questions:

1. How are audits conducted on offshore safety valves (PSVs), on an authority, operator, and supplier level?
2. Can these audits be considered risk-based when compared to the criteria for a risk-based approach as presented in chapter 2.3?

1.2 Limitations

While many industries have a well-integrated risk-based approach, the focus of this dissertation is how a risk-based approach is implemented in the Norwegian offshore industry. While it would be prudent to design a functional and universal framework for such an implementation, this is outside the scope of this dissertation. Rather, the aim of this dissertation is not to change the pre-existing framework within the sector, but it will attempt to evaluate it and provide further recommendations for future improvements. Moreover, this dissertation will emphasise offshore activities rather than onshore ones, as the consequences of offshore-related activities have the potential to be severe, not only to the companies and states that are involved, but also for international waters, the environment, and human lives.

While this research project includes several references to highly technical challenges, it is important to note that this project will not provide a deep dive into any technical concepts, such as the technical function of PSVs or mechanical functions of an offshore installation. Considering the purpose of this dissertation, it was deemed prudent to use technical examples, but the main purpose is to provide an understanding of how the processes related to risk-based audits and approaches are implemented and provide an evaluation of this.

1.3 Structure

This project is structured as follows; Chapter 2 will present the theoretical foundation of this dissertation. As there are many definitions of concepts related to risk, chapter 2 will present definitions of key concepts, as well as relevant theories related to risk. Considering the plethora of definitions related to the risk concept, this dissertation has chosen to divide these definitions into two categories: theoretical definitions and practical definitions. Furthermore, this chapter will discuss different aspects related to the tolerability of risk. All this considered, seven criteria of what warrants a risk-based approach will be presented. Chapter 3 will present the methodology that has been used to gather and analyse data. It will provide a justification of approach, how the data has been gathered, which ethical concerns have been considered, and how these challenges will be presented in the data analysis. Chapter 4 will present the results obtained through the content analysis and the interviews. These results will then be applied for further discussion and analysis in light of the theoretical foundation in chapter 5. Lastly, chapter 5 will provide a data analysis of this project's findings, and some recommendations for further development and research will be provided.

2 Theoretical foundation

To adequately evaluate the framework for internal and external risk-based audits on safety valves in the offshore industry and compare the framework to academic risk theories, it is appropriate to present a theoretical foundation for further analysis. This theoretical foundation will attempt to close the gap in knowledge related to risk-based approaches in the offshore industry. Considering this, the following chapter will explore relevant literature which in its entirety will form a theoretical framework to be applied in chapter 5.

One central aspect of this dissertation is the concept of a risk-based approach, which is a concept often applied by operators and legislators within the offshore industry alike. However, there has been done little research on the definition of this concept. While some of the commonly applied frameworks have presented some definitions, these are often ambiguous in nature. Considering the relations between the concept of a risk-based approach, and the concepts of risk and risk tolerability, it is integral for the understanding of what a risk-based approach is to properly define such concepts. For the purpose of this dissertation, this chapter aims to provide clarity to these concepts. This chapter will first attempt to develop a functional definition to the concept of risk. Second, it will provide an introduction to the tolerability of risk, which will provide clarity of what dictates a tolerable risk, and how this should be analysed. Third, it will present seven criteria for what constitutes a risk-based approach. While the research material on this topic is somewhat lacking, the criteria presented are a composition of theories related to the risk concept and risk tolerability.

2.1 The ambiguity of risk

For the purpose of developing a working understanding of the concept of a risk-based approach, it is integral to explore the ambiguity of the risk concept. To adequately explore the nature of a risk-based approach, one must first understand and define what risk is and how it can be applied. This chapter will provide a presentation of various risk concepts which are derived from numerous scholars. To gain an adequate understanding of the topic question one

must create a functional understanding of the concept itself. For the purpose of this dissertation, it is deemed important to explore both the theoretical and practical application of the concept, and to explore the ambiguity related to the risk concept. While the concept of risk has several definitions, the common trait is that certain actions can change the outcome of an event. The concept may refer to both intended and unintended actions, and the outcome of these. For the purpose of this project, the interpretation of risk is defined as a hybrid between social constructivism and realism, which will later be referred to as constructive realism.

2.1.1 Theoretical definitions

In the theoretical realm there are generally two competing perspectives: realism and social constructivism. The realism perspective argues that risk should be defined through mathematical equations and a narrow definition of what undesirable effects entail. Furthermore, the notion of probabilities is based on simplifications of the world (Renn, 2008). This perspective illustrates a classic understanding of risk, and is often applied in economic analyses, such as CBAs and CEAs, and in the field of engineering. The normative assertion of the risk concept relates to the attempt of calculating the foreseeability of potential harm. According to Rigakos and Law (2009), harm is an event to be avoided or controlled. Considering this, it is important to understand the potential occurrences of negative consequences to be able to control or avoid risk. From a realist perspective, this understanding is best expressed through mathematical probabilities and estimates, thus, the understanding of risk is closely related to technical knowledge. In other words, from a realist perspective, risk is viewed as a statistical deviation from the expected outcome (Rigakos & Law, 2009). The benefit of such an approach is that it offers a simplified understanding of the world through its narrow definition. Moreover, such a perspective enables one to more easily be able to evaluate, compare, and communicate risk in a simplistic manner. However, the disadvantage of this approach is also related to its narrow definition. Adopting such a perspective on risk may lead to a plethora of challenges related to developing adequate models. These challenges include developing models that adequately account for the probability and consequence aspect, as well as yielding sufficient information about risk. In addition, when dealing with uncertainties relating to risk, discerning estimates exclude the

uncertainty aspect of risk. Considering that such definitions do not address neither cultural context, risk source, nor uncertainty, this provides a narrow understanding of risk, which may lead to less beneficial risk management (Renn, 2008).

While the realism perspective is still prevalent in risk theory, most contemporary scholars have made a shift towards a more holistic understanding of risk, which goes beyond the economics and mathematical equations. This paradigm shift is vital to the development of a functional risk-based approach related to offshore activity, as this is a complex area with numerous different concerns. An opposing perspective is presented through the social constructivism perspective. This perspective focuses on how people, both as individuals and in groups, understand and interpret the future. Understanding risk as social constructivism means understanding how risk is constructed by individuals, groups, organizations, and institutions. Social constructivism views risk as a concept to be used for social sciences and philosophy (Renn, 2008).

The social constructivist perspective offers many interpretations to the risk concept. One way of interpreting the social constructivist perspective is presented by Engen et al. (2016). They view risk as an event that occurs, whether that be as a result of natural causes such as earthquakes or landslides, as a result of premeditated actions, or as an accidental outcome caused by human error. As a result, the potential outcomes of such events are near indefinite (Engen et al., 2016). According to Engen et al. (2016), risk can be described as the possibility of an undesirable event caused by natural events or human activities. Thus, according to the social constructivist perspective, risk is defined as any situation where something of human value has been put at stake and the outcome of these events is characterised by uncertainty (Engen et al., 2016). Such broad definitions allow the risk concept to be applied to a wide variety of disciplines but may lead to a less precise approach to risk management. Moreover, such a definition can be helpful to encompass the complexity related to the offshore industry.

Another way of interpreting the social constructivist perspective is presented by Lupton (2013). She claims that broad definitions of risk may allow for a wider understanding of the concept outside of risk expert groups. She also explains that different groups, such as

laypeople, media, politicians, and risk experts, experience and interpret risks differently. The explanation for these differences is explained through negative perception theory. From a sociocultural perspective risk is interpreted as a phenomenon that is increasingly pervasive in society, it is interpreted as subjective, and manageable. Furthermore, risk can be attributed to choices, responsibility, and blame (Lupton, 2013). This perspective, while not directly connected to the concept of a risk-based approach, is important to consider given that risk perception is a pertinent part of adequate risk management.

Aven and Thekdi (2021) note that risk often is associated with negative consequences. As such, they define risk as including both the desirable and undesirable consequences of an activity, and the adhering uncertainties related to the probability of such consequences (Aven & Thekdi, 2021). Although other scholars often address the issue of uncertainty, Aven and Renn (2010) emphasises that the degree of uncertainty and severity of events is an important aspect to be considered (Aven & Renn, 2010).

These definitions offer a plethora of interpretations of the risk concept. While some focus on equations and statistical probabilities, others emphasise human perception and societal values. This makes the risk concept difficult to comprise, thus making the concept of a risk-based approach all the more ambiguous. As there is a certain lack of consensus related to this concept, it is integral for the understanding of a risk-based approach to adequately define the risk concept in a manageable and practicable manner.

2.1.2 Practical application

Thus far, this dissertation has presented several theoretical perspectives on the risk concept. While these concepts are not necessarily mutually exclusive or exclusively opposing, they do raise a question of how this ambiguity may affect the practical application of the concept. To adequately define this concept in relation to the offshore industry it is pertinent to explore some of the practical definitions of the concept. There are several organisations that have adopted practical definitions of the risk concept. For the purpose of this dissertation,

definitions set by the SRA and ISO have been selected because these organisations have been deemed the most relevant to the topic question as both of these organisations are comprised by risk experts.

The SRA defines risk as relating to the consequences of an activity which impact something humans value. The activity itself may be interpreted in a wide sense, in which one may include natural phenomena as well as human actions, and they mainly focus on the negative or undesirable consequences (SRA, 2018). Considering this, the SRA views risk as something that must be seen in relation to the consequences on human values of a given activity. This is a broad definition which is designed to ensure that the understanding of conceptual risk-related topics may be simplified and applicable to a widespread variety of fields.

ISO, on the other hand, defines risk as the effect of uncertainty on objectives. While the definition itself is very broad, it is accompanied by three notes to provide context and practical application. First, effect is defined as a deviation from the expected outcome. Contrary to the SRA definition, this effect may be positive, negative, or both, and address both opportunities and threats. Second, the objectives addressed can vary in aspects and categories and can be applied on different levels. Third, risks are usually expressed in terms of potentialities, consequences, likelihood, and sources (ISO, 2018). As the ISO definition is incorporated with professional risk experts' concepts of risk, understanding the notes to the entry is important. ISO's definition is aimed at specific risk management, as it is a holistic guideline on how to manage risk and tackle risk-related issues. Contrary to the SRA definition the ISO one is made with the goal of being a guideline, and to supplement other frameworks also made by ISO, where the definitions can be used interchangeably.

One reason for why the definitions of these organisations differ may be that their aim differs. While both the SRA and ISO focus on risk assessment, perception and communication, risk management and governance, and they both are comprised by experts, they aim at different audiences. The SRA consists of risk experts with a widespread academic background and their main goal is to create a standardised definition of risk (SRA, 2018). ISO, on the other hand, is an organisation comprised by risk experts from a variety of national standards

organisations who aim to provide technical, commercial, and industrial standards for risk practitioners. Considering this, ISO's definition of risk is aimed at risk practitioners rather than a broader audience (ISO, 2018).

2.1.3 Interpreting the risk concept

Considering the ambiguity related to the risk concept, and the many definitions identified, it is important to acknowledge that it is integral for the understanding of a risk-based approach to decide on a concise definition of the concept. For the purpose of this dissertation, it is necessary to adopt a nuanced definition which accepts the premises set by the realism perspective, as well as including social sciences as such sciences account for the human aspects of risk. These aspects include the human acceptance level of risk, their justification of risk, and avoidance of risk. This was deemed prudent at the concept of a risk-based approach is ambiguous itself, and that offshore activity is complex by nature.

Furthermore, it is deemed important to include social sciences in the risk concept as it can enrich and inform risk managers regarding public concerns. While mathematical definitions are important for setting upper risk limits and for measuring effect, it lacks perspective on other important concerns. By including social sciences to the concept of risk it can assist risk managers in both identifying and explaining concerns from the public and explain the context of risk-taking to the public. Furthermore, it can assist in revealing cultural meanings and associations in cases where risk management is in conflict with such values. Social sciences can also assist in articulating objectives of risk policies, establish fair procedures and institutional trust, and reduce inequities. Lastly, it can be helpful in implementing an evaluation design programme. While social sciences reconcile the social aspect of risk-taking it still faces drawbacks. One such disadvantage is that all the attributes are manmade. This means that individuals or groups will make judgements based on certain worldviews, which will vary depending on who they are. Secondly, there is no common denominator as there is no way to measure cultural or social acceptability (Renn, 2008).

While the realism and the social constructivism perspective differ in definitions, several attempts on reconciling these concepts have been made. One such attempt has been made by Aven (2012), who has based his definition on two premises: The first premise relates to the distinction between the concept of risk and risk management. According to Aven (2012), the main goal of such a definition is to distinguish between the concept of risk and risk management as a process. He defines risk management as being the adequate measures which are taken to protect humans, the environment, and other assets from undesirable consequences of activities, while at the same time balance different concerns, such as HSE (Aven & Vinnem, 2007). One apparent difference between these two concepts is that while risk management is closely related to the concept of risk, the concept of risk is not necessarily meant to be interpreted as risk management.

The second premise is to distinguish between the concept of risk and risk perception (Aven, 2012). Slovic (1987) defines risk perception as the level of which people experience risk and evaluate and characterise potentially hazardous activities. The field of risk perception research encompasses how individuals or groups judge risk, perceive, and understand risk communication, and how these attributes affect the level of trust in regulators, policies, and risk experts (Slovic, 1987). Risk perception is dominated by various unknown factors which impact what types of risks are deemed to be acceptable, and which are viewed as unacceptable. While it can be swayed by evidence, this is not necessarily the case: More often than not, risk perception is affected by individual and group experiences, exposure, media coverage, and a long list of other factors (Duffey & Saull, 2008). One danger of emphasising risk perception too much in the concept of risk is that the definition itself becomes biased. While all definitions are biased to a certain degree, the degree to which subjectivity is deemed important when considering the risk concept. Aven (2009) argues that subjectivity, or perception, should not play a central part in the concept of risk because perception cannot be generalised for widespread use. He illustrates this notion by expressing that the difference between the concept of risk and risk perception is that the risk exists but is yet to be perceived (Aven & Renn, 2009). In other words, a risk may exist without risk perception relating to the given risk having occurred.

Thus far, this dissertation has explored a variety of interpretation of the concept of risk. As there are different perspectives and understanding on the concept of risk, the general definitions of risk will vary between scholars. On one hand, the SRA's risk-analysis-related glossaries incorporate different perspectives, which causes a systematic difference in overall qualitative concepts and their measurements (SRA, 2018). ISO on the other hand is specified to help risk managers in a practical way, with clear guidelines. It may be prudent to criticise ISO's definition due to its rigidity considering the use of having risk tied to an "objective" (Aven, 2020). Considering the scope of this dissertation, it has been deemed most prudent to apply the definition of ISO in combination with a social constructivist perspective for further analysis, as these combined were deemed the most encompassing definition identified.

When managing safety and the connected risk, there is a hierarchy of goals that can be used, including criteria and requirements, such as: the Vision Zero idea by some energy companies where they aim to have no accidents. Or RAC where an upper limit of risk is calculated and set. Should the upper limit be exceeded then risk-reducing measures need to be implemented. (Aven, 2015). Other requirements can be related to the performance of safety systems and barriers or related to specific design and function of components in a system. An example of such a barrier is audits.

Considering these aspects, this dissertation found that the most functional definition of risk is one which adopts ISO's definition, as this definition encompasses the mathematical and statistical concerns, in addition to social constructivist concerns to fully grasp the complexity of risk management. Furthermore, RACs should be established before attempting to implement measures, as RACs can say something about what should be achieved before implementation. The Norwegian petroleum regulations require that RACs are established before the risk assessments are done. This is a way to explore all options before settling on a decision (Aven, 2015). These criteria need to be reflective of the safety objectives and characteristics of the activity. They also need to be time limited and defined based on the activity (Bai & Jin, 2016).

2.2 Risk tolerability

A concept closely related to the risk concept is the concept of risk tolerability. Risk regulation is a field that is constantly challenged by new risks and the subsequent quest to find better methods of organising, anticipating, and controlling these risks. As sciences and technology develop in new directions, the correlation between local and distant infrastructures and communication channels is increasing. It is important to note that the level of which one can anticipate risk is limited, and seemingly unrealistic expectations of control may emerge. However, anticipation is a central component to the modern concept of risk. The ability to anticipate risks is crucial to prevent, regulate, and manage them over time. It is, however, worth noting that there is a difference between risks and actual events. Beck (2009) makes a distinction between risk as an anticipated event, and catastrophe as an actual event. In other words, risks must always be seen as events that are threatening (Hutter, 2010). Considering this, risk can be viewed as events anticipated to occur, and because of this it is important to make a clarification of what dictates the tolerability of risk, what a risk-based approach is, and what is not (Hutter, 2010).

While there exist a plethora of models for measuring risk tolerability, this dissertation identified two models which are particularly relevant to both the concept of a risk-based approach and to the complexity related to offshore activity. One way of measuring the tolerability of risk is to approach it as an ALARP process. In short, the ALARP principle is a principle which dictates that an operator must demonstrate that a given risk is reduced to be as low as reasonably practicable. This means that an operator has a duty to prepare proportional safety cases and adhering safety measures in which the operator identifies safety critical elements, ensures that these adhere to set performance standards, and is able to demonstrate that these measures and standards comply with an ALARP principle (Coeckelbergh, 2006). Furthermore, the ALARP principle dictates that a risk reduction measure should always be implemented as long as it cannot be demonstrated that the cost is grossly disproportionate to the obtained benefit (Abrahamsen & Abrahamsen, 2015). According to Abrahamsen & Abrahamsen (2015), the ALARP principle can only be considered appropriate if the grossly disproportionate criterion is interpreted differently for different contexts. Considering this, the

ALARP principle must range from one extreme, in which decisions are made with reference to a set expected value, to another extreme, where the cautionary principle is adopted without reference to CBAs or CEAs (Abrahamsen & Abrahamsen, 2015).

While the ALARP principle may be implemented through different strategies, one way to implement the ALARP principle is by implementing a CBA or CEA. In such a process the grossly disproportionate criterion is set as follows; the cost is considered to be grossly disproportionate to the obtained benefit if the expected cost is x times higher than the expected benefit. The variable x is set by the operators, which ensures that the value of x can vary based on the context in which it is applied. However, it has been emphasised that CBAs and CEAs do not appropriately addresses uncertainties due to their foundation on expected values. Considering this, it is suggested to apply a layered approach to better address uncertainties. As suggested by Aven (2011), a layered approach addresses uncertainties to a larger extent and is therefore a more appropriate approach to the ALARP principle (Abrahamsen & Abrahamsen, 2015). As illustrated by figure 1 a layered ALARP approach may look like this.

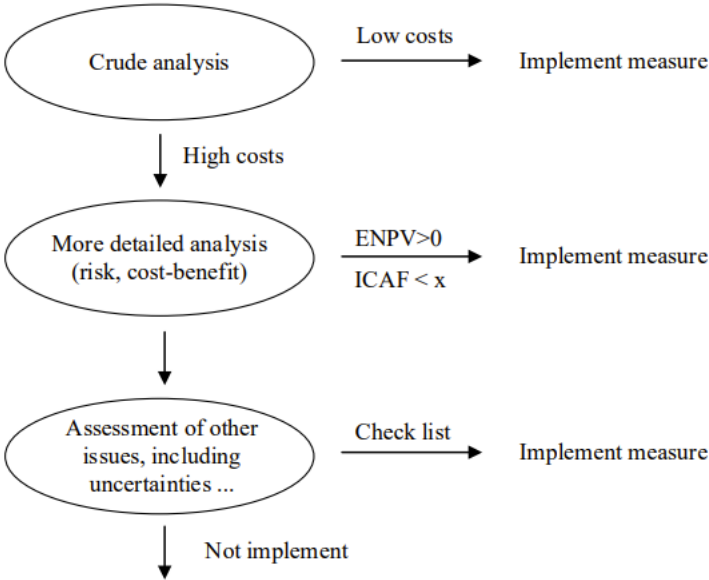


Figure 1. A layered approach to ALARP (Aven, 2011).

A layered approach consists of three steps; In the first step one must conduct a crude or simple analysis. If the cost of a safety measure is low, it is apparent that it should be implemented without further analysis. In cases where the cost cannot be considered as low, a more detailed analysis needs to be conducted. For the second step of this approach, one conducts a CBA or CEA. In cases where the costs can be said to be grossly disproportionate to the benefits obtained, it may still be appropriate to implement a safety measure. In such cases it may be prudent to assess other issues, such as uncertainties and other attributes (Aven & Vinnem, 2010). It is important to note that costs and benefits are not necessarily interpreted as monetary values, and that conducting step two, CBA or CEA, without acknowledging the limitations of using the same unit of measurement, may lead to less than prudent analyses. While it is impossible to conduct transparent and consistent decision-making processes without using the same unit of measurement, it should be noted that additionally evaluating other attributes may be prudent to provide a clear image of the decision-making process at the same time as one appropriately addresses uncertainties (Abrahamsen et al, 2011).

This process is often applied in the Norwegian petroleum industry, as required by PSA regulations relating to risk management in the petroleum activities since January 1st, 2002. These regulations dictated that the operator is responsible for formulating acceptance criteria relating major accidents and to environmental impact (Aven & Vinnem, 2010).

There is an argument to be made that risk audits can be viewed as different steps of a layered approach to the ALARP process. As for the crude analysis step, this can be viewed as a simple internal audit, where it is blatantly clear that the set acceptance criteria will be met and that all regulations are adhered to. Concerning the more detailed analysis step, it can be argued that this is either the internal audits or the external audits. Such audits may provide a more detailed understanding of the risks involved, and the expected advantages or disadvantages of different strategies. If either of these are not adequate to make a conclusion, the third step of the layered approach may be conducted by comparing the internal and external audits to provide a multi-attribute understanding of the risk, as well as the related advantages and disadvantages.

Another way to model risk is through adaptation and mitigation of a risk. One example of this is presented by Leinchenko and Yohe (2010). They claim that one must model risks related to climate change by including both adaptation and mitigation in the process. Furthermore, this process must be functional within a framework which consider both long-term goals and short-term objectives (Leinchenko & Yohe, 2010). While this model is mainly focused on climate change, it can also be applied to other areas, such as risks related to offshore activities, as will be explained later in this chapter.

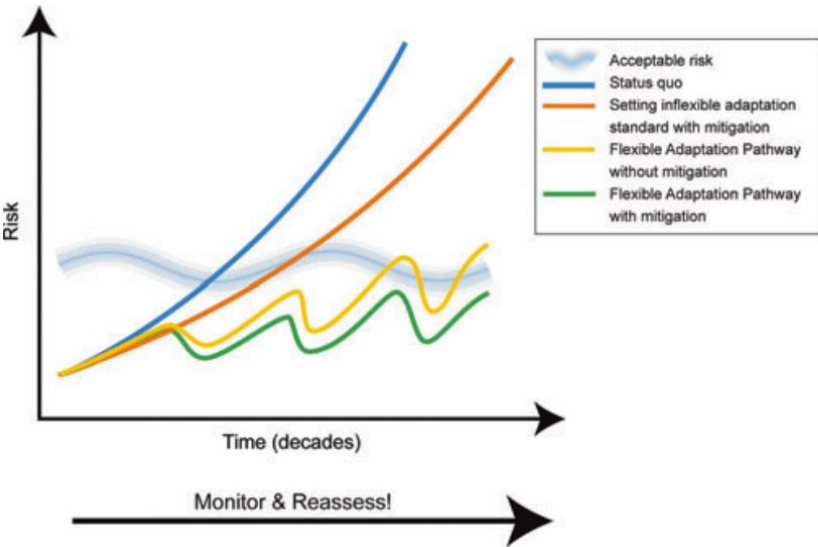


Figure 2. Flexible adaptation and mitigation pathways (Leinchenko & Yohe, 2010).

Figure 2 presents a schematic illustration of multiple possible futures for climate change adaptation and mitigation. As the “acceptable level of risk” is illustrated as a wavy horizontal line, this marks the fluctuating relations to this concept. Considering this figure, it becomes clear that if one were to remain on the current trajectory, illustrated by the blue line, the acceptable level of risk would be crossed in a relatively short time span. The orange line illustrates the development if one were to set inflexible standards done in conjunction with mitigation actions. While this may be viewed as a better solution than maintaining the status quo, it will still cross into a state of unacceptable level of risk at some point. The yellow line creates a pathway that Leinchenko and Yohe (2010) refer to as a “flexible adaptation

pathway”, which can be described as an arrangement of adaptation strategies that are meant to be developed and implemented by experts as the knowledge of the field evolve. The main challenge related to this pathway is that adaptation alone, neglecting to implement mitigation actions, will not be enough to keep the issue within an acceptable level of risk. Considering this, the green line is a pathway that combines mitigation actions with the flexible adaption pathway as a strategy to stay within the acceptable risk level indefinitely (Leinchencko & Yohe, 2010).

Considering the model of flexible adaptation, this may also be suitable for modelling offshore related risks, as the horizontal risk is illustrated by a constant. The acceptable level of risk is in most cases not a fluctuating variable, thus making this representation acceptable.

Furthermore, as it is often the case that risks increase over time if no action is taken, the “status quo” representation may be accurate. As the orange line illustrates, inflexibility within an organisation may often lead to increased risks over time, this can also be said for other risks than climate change. In the same way flexible adaptations can be viewed as a better solution than that of the inflexibility pathway, it is still not adequate to address risks in the offshore industry. As seen in the case of climate change, this dissertation proposes that the mitigation and flexible adaptation pathway is the most sustainable strategy to maintain an acceptable risk level over time within the offshore industry.

While there are many other manners of measuring the tolerability of risk, this dissertation will mainly focus on an ALARP process and the flexible adaptation and mitigation pathways process to model risk as these provide a relatively broad spectre to measure the tolerability of risk.

2.3 Criteria

The previous paragraphs of this dissertation have presented different risk concepts and strategies for measuring the tolerability of risk. While the theories related to the risk concept and risk tolerability provide important input for conceptualising the concept of risk-based

approaches in the petroleum industry, these theories need to be viewed holistically to create a functional understanding of risk-based approaches. This chapter will explore seven identified criteria of risk-based approaches in light of risk-related theories presented above.

As a precursor to presenting the criteria themselves, this dissertation found it important to present the process which led to the identification of the criteria. The starting point was the development of a working risk concept. As previously stated, it is important to gain a functional understanding of risk to develop a functional definition of the risk concept. If the risk definition itself is riddled with ambiguity and unclarity, this will negatively affect the effectiveness of the approach itself. Considering this, it is seen as vital to adopt an adequate definition of the risk concept which encompasses both statistical outcomes and social concerns. Furthermore, it is deemed necessary that the risk-based approach should be based on clear goal settings to avoid any confusion related to scope. These goals should be flexible in nature to ensure that if new evidence contradicts or renders the previous re-existing goals void, new goals are set. The dissertation also found that to ensure that the risk-based approach is functional, it is integral that it is successfully implemented throughout the entire organisation. To obtain this, a risk-based approach must be viewed as a dynamic process which is continuously implemented across disciplines.

To adequately implement a risk-based approach, this dissertation also found that it is important to apply proportional measures. This is both helpful to obtain cost-effectiveness within the organisation and can also help the organisation to prioritize their focus areas. Moreover, it has been deemed integral to incorporate flexible adaptation to the approach to ensure that the strategies reflect the risks at hand, and that mitigation is included to the approach to ensure that risks are handled adequately.

As Aven (2018) stated, it is important to consider and exploit any positive consequences that may arise throughout risk-reduction processes (Aven, 2018). This was also identified to be important to ensure a functional risk-based approach. If the positive consequences are not considered, the organisations may miss opportunities for development and knowledge acquisition. Lastly, this dissertation deemed it important to implement risk-modelling to the

risk-based approach. This is important to gain a holistic understanding of the risk management process, both through risk reduction, through evaluation of the strategies implemented, and to the approach as a whole.

Considering this, this dissertation has discerned seven criteria that must be fulfilled for an approach to be considered risk based. The approach must:

1. Present an adequate definition of what risk is. This means that the definition of risk must be practicable (or functional). While it does not need to be a universal definition, it must be functional within the framework of which it is applied (Aven, 2012). Furthermore, it must address both uncertainties and consequences (Aven & Thekdi, 2021; SRA, 2018), and lastly, it must consider *both* statistical outcomes, the scope of undesirable effects, and the anticipation of risk (Rigakos & Law, 2009; Renn, 2008; Hutter, 2010).
2. Be based on identifiable and obtainable goals. These goals should be defined by experts and must be adjusted as new evidence is uncovered (ISO, 2018).
3. Be a dynamic process which is integrated within the entire organisation. To manage risk, it is important to create a functional risk culture throughout the organisation (Abrahamsen et al, 2011).
4. Be based on proportional measures. The risk-reducing measures put in place must be proportional to the risk at hand. This may mean to apply the ALARP principle to the approach (Aven & Vinnem, 2010).
5. Consider flexible adaptation to the approach. Such strategies should be developed and implemented by experts and must also encompass mitigation actions for it to be functional (Leinchencko & Yohe, 2010).
6. Consider potential positive opportunities. While risk is often associated with negative consequences, it is important for a risk-based approach to also consider the potential positive consequences of their strategies, and be able to exploit these (SRA, 2018; ISO, 2018; Aven, 2018).
7. Include risk modelling. This step is important to obtain a flexible, functional, and dynamic understanding of the risk management process (Hutter, 2010; Leinchencko &

Yohe, 2010; Abrahamsen et al, 2011). Such modelling may include ALARP, flexible adaptation pathways, and CBAs.

It is important to note that it is not enough for an organisation to fulfil only one or some of these criteria to be considered risk based. The respective organisations need to fulfil all of them. For example, it is not adequate to develop a functional definition of the risk concept if it does not address uncertainties and consequences. Furthermore, if the goals set by the organisation are vague, this can have a negative effect on the approach, and will therefore not be considered risk based. The dynamic process step of the risk-based approach is important to provide a holistic implementation of the risk management process. If the organisation lacks a functional risk culture, this may negatively affect the safety culture within the organisation. Moreover, it is important that the measures put in place are proportional to the risks they are meant to mediate. An inflexible strategy where the measures are disproportionate to the related risks would contradict the flexible pathway described in step 5. It is also important for the growth and functionality of the organisation to consider and act upon the positive opportunities that may come as a result of their risk reduction strategies. Lastly, it is vital to apply risk modelling to the organisation for it to be considered a risk-based approach. This is due to the importance of understanding the intricate aspects of risk management and the risks itself. Considering this, if an organisation does not comply with the criteria described above, it cannot be said to have integrated a risk-based approach.

2.4 Summary

The theoretical framework presented above forms the foundation for this dissertation, and this foundation will be applied to analyse the topic question in the analysis portion. The theories presented in this chapter have been based on the works from a broad range of risk experts and scholars. First, this chapter has presented relevant views on the risk concept and theoretical perspectives on risk governance. Such clarifications are important to adequately understand how these concepts are applied throughout this dissertation. Second, this chapter emphasised a constructivist realism perspective, as such a perspective can account for both statistical

outcomes as well as social sciences. As such, a constructivist realism perspective can better explain and manage the nuances related to the risk concept, and the adhering uncertainties.

Third, this chapter presented theories related to risk tolerability. Understanding risk tolerability is prudent to provide a framework for evaluating the level of adequacy of risk actions that are implemented. Furthermore, this chapter has explored different strategies for managing risk. Such strategies include RAC which assists operators and legislators to decide an upper limit of risk levels within an operation, and the ALARP principle, CEA, and CBA. Moreover, this chapter has explored different strategies of modelling risk with the example of flexible adaptations and mitigation pathways. This model illustrates that risk measures cannot be static defences against risk events as risk evolves and fluctuates.

With this theoretical foundation, this dissertation presents an understanding of how to measure whether an approach is risk-based or not. All this considered, this dissertation has developed seven criteria which need to be fulfilled for an operation to be considered to adhere to a risk-based approach.

With a base in this theory, this dissertation seeks to answer the following research questions:

1. How are audits conducted on offshore safety valves (PSVs), on an authority, operator, and supplier level?
2. Can these audits be considered risk-based when compared to the criteria for a risk-based approach as presented in chapter 2.3?

3 Methodology

According to ISO (2018), the results from audits can provide input to the analysis aspects of business planning and can contribute to the identification of improvement needs and activities. When conducting an audit, it is prudent to have a range of criteria, these can be one by one or in combination such as requirements in system standards, policies and requirements specified by relevant interested parties, statutory and regulatory requirements, a system process, or management system plans relating to a specific output (ISO, 2018).

When managing complex safety systems and organisational accidents most organisations favour a form of process controls for managing human behaviour. However, for the purpose of managing system safety involving hazardous operations, most organisations are reliant on negative outcome measures that both record and manage adverse events such as production loss and fatalities. The issue with reliance on negative outcome measures is that it provides unreliable data on the intrinsic safety of a system. The data collected is often too sparse and lacking detail, this making it a less effective system than what is considered adequate when managing potentially hazardous risks (Reason, 2016).

An audit is a process to obtain evidence and evaluate it against certain criteria. This process is systematic, independent, and documented to provide the most objective evidence possible, and then evaluating it objectively to determine whether the audit criteria are met. Audits are separated into three groups which are 1st party, 2nd party, and 3rd party audits (ISO, 2018). 1st party audits are carried out by or on behalf of the company itself, and while one requirement of an audit is for it to be independent, this does not make the 1st party audits void as there are criteria to prevent bias in the audit process. 2nd party audits are external parties, whether a business partnership with their own auditor(s) or an independent company performing the audit. 3rd party audits differ from 2nd party audits as they are aimed towards certification or accreditation. Or they may be aimed towards the statutory or regulatory requirements to check whether a business is conformed to its applicable laws and regulations. As such they are either done by regulatory agencies or appropriate auditing organisations (ISO, 2018).

The purpose of the criteria outlined in chapter 2.3 is to evaluate whether these audits can be considered risk-based according to the academic risk theory. These criteria relate to the holistic understanding and implementation of the risk concept, risk reduction strategies, and risk culture.

This chapter will present this project's methodology and the evaluations this methodology is based on. The main purpose of methodology is to explore how empirical research has been performed in order to test and generate knowledge (Johannesen et al, 2010). This chapter will present the strengths and weaknesses of this project, as well as provide the reader with an understanding of how the research is performed.

3.1 Justification for approach

This dissertation aims to explore the extent of which an audit performed on offshore activities on the Norwegian Continental Shelf can be considered risk-based and evaluate the status quo for such risk-based audits. The theoretical framework presented in chapter 2 established a set of criteria for such an evaluation, and such evaluations may be vital for the understanding of risk and safety on offshore activities. Considering this, this dissertation's topic is relevant for safety authorities and operators alike.

The literature review uncovered that there are a plethora of definitions and meanings related to the risk concept. Furthermore, it revealed that it was difficult to establish a pre-existing framework for what constitutes a risk-based approach. In other words, the concept of a risk-based approach is veiled with ambiguity. Considering this, it was deemed vital for this project to approach experts within the safety authorities, operators on the NCS, and suppliers, as well as perform a content analysis to adequately uncover the meanings behind these concepts. In order to do this, a qualitative approach was considered the best method for gaining a working understanding on this project, as this was deemed the most prudent and effective method of acquiring the most valid and reliable data. To obtain any meaningful results from such an endeavour it was integral for the reliability of this study to apply an open and flexible

approach, as such a method makes it easier to obtain a deeper understanding of the research topic (Jacobsen, 2015).

The prerequisite for qualitative studies is an inductive approach to the relation of conducting science and achieving a theory: the theory comes from science and its empirical data (Jacobsen, 2015). Qualitative studies aim to understand a phenomenon or the social world through an analysis of information gathered from an interviewed person's opinion of the phenomenon or a participant of the social world, this is called an epistemological standpoint (Jacobsen, 2015). Considering this, the topic question of this dissertation is as follow:

“How are audits implemented internally and externally with regards to safety valves on offshore installations, and is this in line with academic risk theory?”

3.2 Data collection and analysis

This project applied interviews and content analysis of public documents as its main method for data collection. This is a methodology often referred to as triangulation. Triangulation is a process where one gathers empirical data from different sources with the purpose of complimenting each other. By combining multiple practices for data collection one can add depth and complexity to the inquiries made (Fusch et al., 2018). Føllestad (2012) claims that triangulation ensures a more holistic perspective on the data gathered than what a content analysis or interviews could provide by themselves (Føllestad, 2012). Triangulation was used in this project to gain a further understanding of the information and data collected from the interviews. Considering that the research question in large relates to routines and procedures, it was deemed appropriate to compliment and evaluate the data collected from the interviews with the standards set by the respective organisations as a means of validating the findings, among these are the NORSOK standard Z-008 and the ISO 19011. Below is a list of documents applied in this dissertation.

| Title of document | Author(s) | Year of publication | Type of document and area of usage |
|--|---------------------|----------------------------|---|
| ISO 190011:2018 | ISO | 2018 | Standard for risk audits. Universal |
| Gransking av hendelser | PSA | 2022 | Procedure. Internal |
| Veiledning til prosedyre for revisjoner i PTIL | PSA | 2021 | Guidance document. Internal |
| Revisjon – Prosedyre | PSA | 2021 | Procedure. Internal |
| NORSOK Z-008 | Standards Norway | 2017 | Standard for NCS. National |

Figure 3. Documents for content analysis.

These documents were used both as complimentary data and as single-standing sources for data collection and analysis. Some of these documents were obtained through the informants, as these describe internal procedures, while others were selected for their universal usage on audits and were found through document searches. The data collected from both the interviews and the content analysis were critically analysed for the purpose of gaining a more in-depth understanding of the topic at hand. It was important for the robustness and validity of this research project to see the documents in light of the interviews, especially considering that the informants were selected on the basis of their specific skill set. This selection process is further elaborated later in this chapter. While the PSA informants referenced NORSOK S-001, DNV STF 101, and NORSOK Z-015 these documents are highly technical and therefore outside the scope of this dissertation.

The main advantage of using triangulation is, as mentioned, to obtain valid results. For example, while the documents obtained through PSA, as well as the NORSOK and ISO standards may provide guidelines for how processes should be implemented, these documents lack nuances which can more easily be understood through interviews. Moreover, the interviews may uncover deficiencies in the practical application of the steering documents. Considering this, triangulation is a method applied to strengthen the validity of the results.

For the purpose of this project, it was also deemed necessary to categorise the thematic sections of this project. This was done to ensure that the data applied in this project, both related to the interviews and the content analysis, kept within the scope of the research project. These categories followed the same recipe for both the interviews and the documents, and included data related to the risk concept, data related to the interpretation and implementation of a risk-based approach to audits, data related to the implementation of audits on a general basis, and data related to the implementation of audits on safety valves. This is a form of data reduction and exclusion (Johannessen et al, 2010). As it is not appropriate to include all the data from the documents and the interviews, a selection of relevant information was made. While this can be done through automatic programmes, this project chose to do this manually to ensure that the meaning of the statements from the interviews were preserved. Furthermore, it was deemed integral to do this manually to adequately condense the content from the documents.

Lastly, it is important to mention that the steering documents analysed for this research project has been integral for the understanding of the topic question. While the data gathered from the interviews provided meaningful insight in how the practical application of audits are preformed, it was vital for the integrity of the project to analyse the documents these practices are based on.

3.3 Interviews

Considering the topic question and scope of this dissertation, it was deemed to be most prudent to apply semi-structured open interviews for data collection. This approach was chosen to appropriately uncover the interpretations and meanings found in professional operators and legislators in the field. When attempting to uncover such interpretations and meanings, it seemed most appropriate to apply an approach where the subjects have an opportunity to answer in an open and flexible manner. This structure allows the creation of confidentiality and trust between the interviewer and interviewee as the interviewee can be met at their own terms and in comfortable surroundings (Jacobsen, 2015).

Furthermore, semi-structured interviews allow for both flexibility and planning where the interviewers can understand a phenomenon from the informant's point of view (Kvale et al., 2015). Lastly, such an interview structure allows for innovation if the informants should bring forth new subjects which were not previously identified and that need follow-up questions. The goal is that the information gathered is both reliable and valid. This will be true if the information is relevant, trustworthy, and authentic. This will ensure correct conclusions are used in the discussion part (Jacobsen, 2015).

Lastly, Andersen (2006) highlights the importance of correct documentation to keep trustworthiness and authenticity in the information (Andersen, 2006). The interviews were conducted by asking as open questions as possible. This was done to prevent any ambiguity as a result of leading the question. Moreover, considering that semi-structured interviews performed with open questions allows the interviewers to provide follow-up questions, this method was deemed the most prudent for this project, as different expertise may need different follow-up questions to gain the same level of meaningful knowledge.

The theoretical foundation of which this dissertation was based upon covered the risk concept, risk tolerability, and risk-reduction strategies. For the purpose of this dissertation, these theoretical concepts were applied to design seven criteria for what constitutes a risk-based approach. These criteria were then operationalised and applied to create an interview guide divided into four categories for the purpose of answering the topic question previously presented. The categories applied were designed to provide a general flow and structure throughout the interviews. Applying the seven criteria as a starting point for the analysis, the interviews attempted to provide insight in the interviewee's general understanding of the risk concept, as well as the concept of risk-based approach. Furthermore, the interview guide was designed to uncover what meaning a risk-based approach holds in different organisations, how risk-based audits are performed, and to which extent this is affected by their understanding of the definitional frameworks. While the interview guide formed a starting point for the interviews themselves, it was not applied subservient. It was important for the validity of this project that the questions asked were applied as guidelines rather than a strong-hold for the interview objects. As the interview objects have various backgrounds,

flexibility was important to uncover meaningful information. Lastly, it is important to note that this project used audio recordings and transcribing methods to ensure correct paraphrasing and quotations from the interviews.

3.3.1 Selection

It was deemed most functional to attempt to gain a greater understanding of the knowledge gathered through a variety of informants to adequately answer the topic question of this research project. The starting point of this dissertation was to decide on which levels the informants should be picked from, whether that be on an authority-, operator-, or supplier-level. This dissertation found that it was most prudent to choose informants from all the levels to gain the most nuanced and holistic understanding of how a risk-based approach is implemented in the energy sector. Following this, it was attempted to establish contact with several individuals from PSA, operators on NCS, and suppliers. Many of these were based in Stavanger, which seemed particularly appropriate regarding resources and time restraints, but considering the scope of this dissertation, certain individuals based in both other Norwegian cities and other countries were invited due to their expertise to gain the most nuanced understanding of both operations, practices, and concepts possible. The final selection consisted of two representatives from PSA, one representative from the operational side, and two representatives from the supplier side.

3.3.2 Selection of informants

While there is no standard for how to choose informants in a qualitative study, it is important to choose informants that provide meaningful knowledge. This means that the data collected from the informants must be considered verifiable and valid (Kvale & Brinkmann, 2009). Considering this, the selection of informants was based on the expertise within their respective fields, and their understanding of the topic question.

Most of the requests were made through informal conversations facilitated through different platforms. Throughout the process it was a continuous evaluation of whether the informational foundation was good enough, or whether more informants were required to gain a meaningful understanding of the topic. In total five interviews were conducted, and it was concluded that the gathered data was adequate to meaningfully answer the topic question when adding a content analysis of relevant documents to the research design. This research project concluded that the quality of the data gathered was adequate to properly answer the topic question, and that the backgrounds and knowledge of the informants were specific and informative enough.

The informants consisted of experts with a wide variety of competence, among others valve specialist, risk management, engineering, and offshore technology. Such variety may provide a more nuanced understanding of how risk-based audits are implemented and performed on the different levels. Throughout the dissertation the informants have been named according to their affiliation. Informant A1 and A2 mark the representatives from the authorities, informant O is the representative from the operational level, and informant S1 and S2 represent the supplier level. Below is an overview of the informants.

| Informant | Level | Duration of interview | Date of interview |
|------------------|--------------|------------------------------|--------------------------|
| A1 | Authority | 32 min | 05.04.22 |
| A2 | Authority | 22 min | 05.04.22 |
| O | Operator | 42 min | 06.04.22 |
| S1 | Supplier | 34 min | 11.04.22 |
| S2 | Supplier | 30 min | 11.04.22 |

Figure 4. Overview of informants.

3.3.3 Conducting the interviews

For the purpose of this dissertation, the interview guide applied was categorised in four parts: The first category related to the informants' backgrounds, as this provided clarity to their relevance to the research project. This section also covered their respective roles within their organisations, also to highlight their relevance. The second category related to the risk concept and the uncertainty concept. This section provided important insight into how the informants understand the risk concept. Furthermore, this insight might provide important information of how different organisations conduct risk-based audits. The third category related to risk-based approaches. The questions adhering to this section was crudely based on the criteria established in chapter 2. This was done to provide a baseline for further analysis in light of the theoretical foundation. The last category, related to how one performs an audit and how, and if, risk perception relates to audits. The informants were also asked to provide an example of how they would perform an audit in practice. Similar to the third category, these questions were founded in the criteria established in chapter 2. All of the questions asked are considered relevant to the topic question of this dissertation and provide input and discussion material to be used for further analysis.

To ensure valid data from the informants, it was important to ensure that the informants understood the questions asked. In order to ensure this, the informants were given a short introduction of the themes and aims of the dissertation in the form of an interview guide. This was presented on the day of the interview. While the themes and aims were introduced to the informants in the information letter, it seemed prudent to provide a short reminder shortly before the interviews commenced. Furthermore, several follow-up questions were prepared to help the informant to elaborate on their answers or to help clarify a question. The informants were also reminded on the day of the interviews that the interviews were to be recorded, and they were asked for their consent. Recordings were deemed suitable as it is an easy method of preserving the data, and it also allows for a better focus during the interview (Jacobsen, 2015). Moreover, recordings allow for better citation and information iteration, and therefore reduce the chances of misinterpreting data. As certain interviews were conducted in Norwegian, these were transcribed in Norwegian, and then translated to English. Lastly, all subjects were

asked if they could be contacted at a later point should clarifications, elaborations be necessary, or uncertainties.

3.4 Ethical concerns

It was important for the integrity of this research project to ensure that all research ethics were followed. As such, in accordance with the wishes of the informants participating in this research project, all personal information beyond their organisational sector and function has been anonymised. Written consent from the informants was used to ensure that the data gathered through interviews could be used as long as the informants were not identifiable. This choice was made to ensure that the data used would not in any way, shape, or form harm the informants' roles or their organisations. This letter also provided the informants information about the project, its purpose, and how the data would be used and managed. Furthermore, all informants were informed that they could withdraw their contribution at any time, and that any subsequent direct quotes would be sent to the informants for approval. There are both advantages and disadvantages of providing such information letters. The advantages are that the informants have the opportunity to prepare themselves for the questions, and this in turn may result in more reflected and thought-through answers. On the other hand, the informants may become more passive and rigid in their answers due to constraints from their organisations.

Anonymity has been further protected by not naming the informants in the dissertation, but they have been assigned terms such as technical expert, authority auditor, and company auditor for the purpose of data analysis. Audio recordings will be deleted after use. Throughout the process of completing this dissertation, the importance of adhering to ethical guidelines and laws has been a focal point. Kvale and Birkman (2015) explain three main points to accomplish an adequately ethical dissertation: Informed consent, confidentiality, and consequences (Kvale & Birkmann, 2015). These points are considered when conducting and using information from the interviews.

3.5 Strengths and weaknesses of the research design

When conducting qualitative interviews, it is critical to assess the quality of the data gathered by discussing validity and reliability (Jacobsen, 2015). This dissertation has from the start been conscious and systematic to attain reliable and valid data. In the following chapter, these strengths and weaknesses will be discussed.

Validity in this context relates to whether the data collected is contributing to answering the topic question or not. To secure that the data is valid, the participants are experts in their respective fields with relevant knowledge of technical expertise, risk, and audits. While some informants have the focus area of technical expertise, others have the necessary expertise within the field of risk-related and equipment-based audits. Including these two aspects should be a strength as it diversifies the risk perspectives of both the audit and the object of the audit. To further secure validity the interview guide was made with the purpose of covering the subject this dissertation covers. This guide was used through all the interviews to ensure all the participants answered the same questions and to be consistent. While the semi-structured nature of the guide makes it somewhat inconsistent as it can evolve in different ways throughout the interview, one such an example was that an informant never mentioned risk modelling even when given ample opportunity to do so. Nonetheless, by continuously assessing whether the questions in the guide were being answered, all the topics were covered. Both during and after the interviews there the informants' understanding of the information given was addressed, as according to Jacobsen (2015) the informants' understanding of how the interviewers conclude on their information is important (Jacobsen, 2015). Therefore, along with follow-up questions during the interview, there was a summary to ensure all the topics were covered and any misunderstandings could be addressed.

It is important to note that the answers obtained by means of interviews may be affected by biases both from the informants and the interviewers. Pre-existing assumptions and knowledge may affect the data, and thus have impacted the results of this research project. To counter such biases, it has been important for the validity of this research project to apply

content analysis. Such documents may provide more reliable and neutral aspects of the different concepts this dissertation evaluates, thus may provide a more nuanced perspective.

On a final note, it is worth reiterating that the aim of this dissertation is not to change the existing framework, rather to provide an evaluation and further recommendations for authorities, operators, and suppliers. Moreover, qualitative studies are affected by the research objects and their perceptions. Such studies are also affected by the literature and theories applied, and as such, the evaluation and recommendations may be affected by these factors, thus, potential biases may exist.

4 Results

This chapter will present the results retrieved from the content analyses, as well as the results from the interviews conducted. As previously mentioned, these data have been processed and is not an encompassing review of the documents or the interviews, but rather a presentation of the relevant material from these. First, this chapter will present the results of the ISO 19011. Second, it will provide a presentation of the NORSOK Z-008. Third, it will present the results of the internal PSA documents, and last, it will present the results comprised from the interviews. These results will later be applied for a condensed data analysis to measure to which degree the Norwegian offshore industry can be considered risk-based in their approach to audits.

4.1.1 ISO 19011: Management systems auditing

ISO 19011 is the governing standard used in auditing enterprises. The main focus of this standard is the successful implementation of risk-based audits to enterprises across disciplines. This chapter will present how the ISO standard recommends that audits are conducted. It will also provide some criteria of what warrants a risk-based approach in an audit context according to this document. The introduction of the ISO standard provides a presentation of the usage area for the standard and guidelines on which types of organisations the framework is meant for. Through the introduction, it is clear that this standard aims to provide guidance to organisations of all sizes and types, as well as any scope of the audit. It specifies that both individuals and larger groups can use the standard and that it should be used as a baseline with appropriate adaptation to the specific audit in question. Furthermore, the document states to be available to a broad range of potential users, as stated both to auditors and organisations that need management system audits for contractual or regulatory requirements. Furthermore, it says that users can apply this as a guidance document for developing their audit-related requirements. Lastly, the document states to be flexible regarding the maturity and size of a company's management systems (ISO, 2018).

The document states that an audit is a systematic, independent, and documented process for obtaining evidence and evaluating the evidence to determine whether it matches a set of criteria and principles. These principles are made to aid both the execution of the audit and by providing the correct information for the audit subject to act on and improve its performance (ISO, 2018). If adhered to, these principles should also hold a significant role in the reliability of the audit or audit programme and the replicability of the audit to verify its results. The document then presents these seven principles:

The first principle relates to integrity. Integrity in this setting means for the auditor to perform their activities ethically, honestly, and responsibly, hence only conducting activities they are competent and capable of achieving. Auditors should be fair and unbiased in all their work and impartial, and should they have an exposed position, they need to be sensitive to any influence exerted on them while conducting the audit (ISO, 2018).

The second principle relates to the fair presentation and the responsibility to be truthful and accurate. Findings, conclusions, and reports should all reflect these values. Unresolved differences in opinion between the audit team and the auditee should be reported as communication between auditor and auditee. This also needs to be truthful and accurate and as timely and complete as possible (ISO, 2018).

The third principle addresses due diligence and professional care. The tasks assigned to an auditor are often important to both safety and security. The confidence placed in the auditors by their clients and stakeholders should be exercised with due care, and the auditor should make reasoned judgments (ISO, 2018).

The fourth principle addresses confidentiality. Information security is of paramount importance. The auditor may come across confidential information, which could be detrimental to the audited organisation. As such proper handling of data and reporting is essential (ISO, 2018).

The fifth principle relates to independence, as this is the very basis for remaining unbiased. The auditor should remain free of responsibilities that could result in a conflict of interest. For 1st party audits, the auditor should be independent of the audited activity. In smaller organisations where this is difficult, every effort to remove bias and encourage objectivity should be made and documented. Findings and conclusions should only be based on the evidence gathered during the audit (ISO, 2018).

The sixth principle addresses an evidence-based approach. This principle introduces why the audit process needs to be based on evidence. The audit needs to be rational and reproducible to achieve reliable results and conclusions through a systematic process. The results need to be based on verifiable evidence. Samples are used due to time constraints which are subject to change over time, and therefore the correct samples are required to have enough confidence in the evidence gathered (ISO, 2018).

The seventh principle relates to a risk-based approach. ISO states that a risk-based approach is one where both risk and opportunities are considered. Such a danger-benefit model should influence the audit's planning, execution, and reporting. This way will ensure that the audit relies on information that is significant for the client and that the objectives of the audit are reached (ISO, 2018).

According to the ISO standard, context is vital to provide enough meaning and clarity to the intended message. During an audit, process context is key to understanding the auditee. Therefore, the auditors should consider organisational objectives, relevant external and internal issues, needs and expectations of relevant interested parties, and information security and confidentiality requirements (ISO, 2018).

The information should include objectives for the audit programme, the risks and opportunities associated with the programme including the actions to address them. The scope of the audit needs to be communicated, and if there is an audit programme, the individual audit following this programme should be specified along with the schedule for and type of

audit. Lastly, criteria selection, who should conduct the audit, and other relevant documented information should be communicated (ISO, 2018).

The ISO standard states that the objectives of an audit programme are, in general, more specific than the principles and communication guidelines listed above. The goals with the objectives are also, in large, the same as communicating properly, guiding the audits to yield the most prudent information, and performing the audit(s) as efficiently as possible. While setting objectives, this should be done consistent with supporting the auditee's management system and policy (ISO, 2018). Of note are the aspects of risk, where the superior goal is to identify "... *risks and opportunities to the auditee*" (ISO, 2018, p. 9).

Moreover, ISO emphasises that there are risks both with the process itself and the function being audited during the auditing process. The process is prone to bias, but also physical errors and unforeseen events. Parts of the audit which are the most exposed to these faults are the planning process, the allocation of resources, selection of the audit team, implementation of the audits, monitoring of the audits, and control of documented information. The risks associated with these tasks range from setting wrong objectives that miss the audit's goals, to having insufficient time and wrong competence. According to ISO, another risk is related to how documents are controlled, such as confidentiality leaks or misplacing of documents (ISO, 2018). While looking at the risks of auditing, there are opportunities to be discovered. When selecting auditing team members matching the competence needed to the competence of the team members can yield benefits beyond the goals of the audit. When planning an audit programme, one can look at the possibility of having audit teams conduct their audits at the same time to save on travel and downtime of the function(s) being audited (ISO, 2018).

While the actual establishment and implementation of an audit programme are mentioned in detail further in the ISO 19011 document, more information about it is not necessary for the context of this thesis. These functions of an audit programme include assigning necessary competence of individuals, establishing the extent of the audit programme, and determining resources in the establishment phase. Other functions include defining objectives, scope, and

criteria, selecting audit method and team members, assigning responsibility, and managing results and records in the implementation phase (ISO, 2018).

As previously mentioned, the ISO 19011 standard includes risk-based thinking in its audit process. During the planning phase, the auditor shall consider the risk imposed by the audit process and inform and explain these risks to the client, the auditee, and the audit team. The detail of these risks shall also be in relation to the complexity and the scope of the audit. Should the audit team not have enough competence or be composed wrong, they could miss important information needed for an accurate audit. If the team uses the wrong sampling technique, the results will be skewed and not represent the population it should. The team should also look for opportunities to improve efficiency and effectiveness (ISO, 2018).

The results of the ISO standard shows that while the ISO standard contains considerable more information on practical details of an audit, for instance, audit planning details, assigning of work, and preparation of documents to be used in an audit, these aspects of the audit are outside the scope of this dissertation. One aspect worth mentioning is that later the ISO standard introduces some generic knowledge and skills of management system auditors where the standards states that “*an auditor should be able to understand the types of risk and opportunities associated with auditing and the principles of the **risk-based approach** to auditing ...*” (ISO, 2018). Although, this is all the information given on what previous risk-related knowledge is needed to conduct an audit.

4.1.2 NORSOK Z-008: Risk-based maintenance and consequence classification

The NORSOK standard aims to reduce operating costs and project execution times for petroleum installations on the NCS. The intention was for the industry to develop better, more cost-effective standards on the NCS to make the NCS an attractive investment and activity spot internationally. This chapter will focus mainly on the methodology for risk-based maintenance management. Audits on PSVs are performed as part of a maintenance procedure and is covered by the standard. The NORSOK standard is considered one of the governing

standards on NCS and it mentions both the importance of maintenance and audits: “*A key to good maintenance is a well-organised management team taking responsibilities in implementing the principles herein and verifying the results*” followed by “*this will typically involve the following: ... the leaders should plan and institute audits of the organisation, supplier and contractors*” (NORSOK, 2017, p. 19). Maintenance in this document is defined as a “*combination of all technical and management actions intended to retain an item in or restore it to a state in which it can perform as required*” (NORSOK, 2017, p. 19).

The NORSOK Z-008 standard mainly focuses on risk-based management. While this includes more than just audits, it is still relevant as audits are part of maintenance. The scope of the NORSOK standard is to cover a broad range of maintenance and consequences; in particular, of interest for this dissertation are the parts “*definition of risk model and failure consequence classes*” and “*description of how to establish an initial management programme, and how to update an existing programme*” (NORSOK, 2017, p. 1).

The introduction of the NORSOK standard provides several items of interest for this dissertation. As stated above, areas that encompass risk-related items are of particular interest. The first is “*how to use risk and reliability analysis to establish and update PM programmes*”, and the second is: “*how to aid decisions related to maintenance using the underlying risk analysis*” (NORSOK, 2017, p. vi). The NORSOK document presents a list of purposes. Following this, an explanation of how the standard can be applied in a design phase is introduced. A design phase is when the responsible organisation establishes an initial maintenance programme such as manning requirements, spare part selection, or system configurations. Secondly, an area of use is the preparation for the operation phase, where one develops the management programme into the maintenance management systems, along with a further selection of spare parts (NORSOK, 2017).

The NORSOK standard introduces a list of definitions related to maintenance. It also contains risk and risk-based maintenance definitions. Risk is defined as “*a combination of the probability of an event and the consequence of the event*” (NORSOK, 2017, p. 10). The NORSOK standard also mentions in a note that it references ISO 20815:2008 for further

important information regarding the definition of risk. However, the ISO 20815:2008 standard does not present further clarifications on what is meant by risk as a definition. Furthermore, a risk-based inspection is: *“a decision-making technique for inspection planning based on risk, compromising the probability of failure and the consequence of failure”* (NORSOK, 2017, p. 10).

On the methodology for risk-based maintenance management, the NORSOK document highlights the importance that all maintenance decisions be based on a risk assessment. The key element of such an assessment is a risk-based maintenance task selection process. Furthermore, the document states that as crucial as this risk assessment is, of equal importance are well-defined work processes and management commitment to the task (NORSOK, 2017).

The NORSOK standard elaborate on risk management through the decision criteria presented. These risk decision criteria are supposed to be executed according to and evaluate against defined criteria. According to the document, these criteria are supposed to be set according to overall company goals for HSE and production and cost. The criteria must also be adequately communicated to all personnel involved in risk decisions and operational personnel. This is to be done by risk matrixes, typically a 3x3 matrix up to a 5x10 matrix, where a set of three principles is to be followed. Firstly, the matrixes used for maintenance should align with the overall company risk but be customised for maintenance to aid planning and prioritisation. The matrixes should have common terminology for communication risk. Secondly, the same criteria should be used for all equipment, also equipment covered by other standards such as load-bearing structures and drilling equipment. Lastly, consequences from functionality losses shall consider standby redundancy and reduce impact consequently (NORSOK, 2017).

NORSOK Z-008 presents a chapter on managing a maintenance programme. While not a comprehensive description in the broader sense, it still presents an adequate description for this dissertation (NORSOK, 2017).

Results show that maintenance can be illustrated as a work process where products are produced with low HSE risks and high performance. Overall, there are resources, management of maintenance, and results; while the elements in each of these can be further detailed, a summary is presented below to provide an adequate understanding for such a programme.

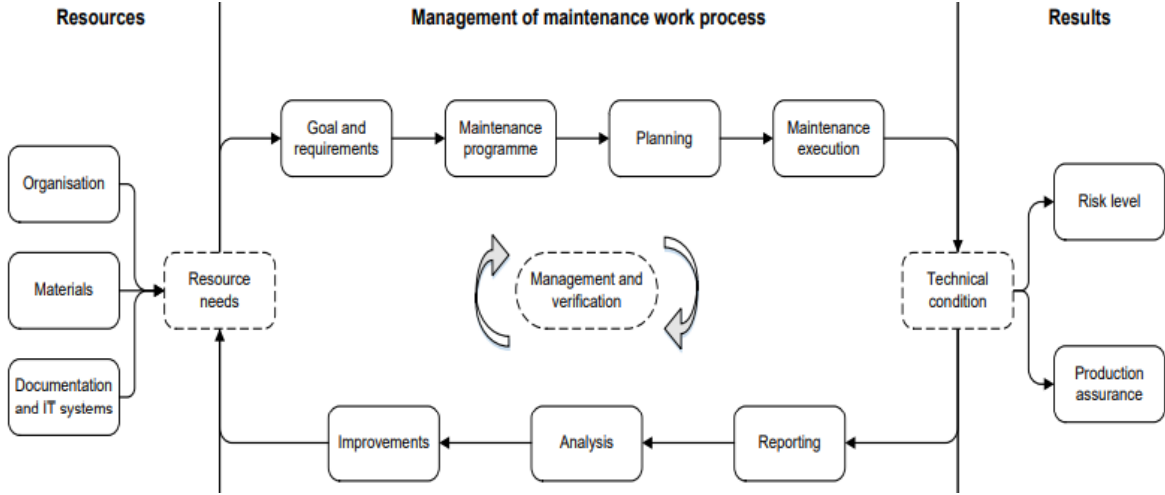


Figure 5: Maintenance management process (NORSOK, 2017).

The first of these elements are the resources which consist of everything the organisation already has access to, such as people and their competence, consumable materials, and data/documentation on previous maintenance or equivalent. These provide the resources needed to perform maintenance (NORSOK, 2017).

The second step is the management of maintenance work process. First, this addresses goals and requirements. This step is not absolute but rather a guideline where it focuses on ambition levels. These are risk, production, and cost, followed by regulatory requirements, and other relevant issues. Second, a maintenance programme should be based on failure(s) that can influence safety and production and the associated risk. This part should include the indirect handling of maintenance, such as written procedures and testing, as well as a minimum personnel qualification. Third, there is a planning aspect to consider. This should be a

structured set of tasks which accounts for activities, frequencies, procedures, resources, and time required concerning maintenance. This planning should consider prioritising corrective and preventative work based on the impact expected on HSE and cost and production. Last, the direct handling of the maintenance is called maintenance execution. This phase is both preparation such as work permits and carrying out the information. Both maintenance and inspection work are to be conducted safely and cost-effectively. On a final note, operational priorities shall be based on risk assessments (NORSOK, 2017).

The management of maintenance work process described above leads to a technical condition divided into three categories: risk level, production assurance and cost. The risk level is measured by HSE performance, barrier element reliability status, or related indicators. Production assurance means that the asset is performing at its optimal in terms of the economy while at the same time following its framework, rules, and applicable regulations. Cost is related to preventative and corrective work, and other relevant aspects (NORSOK, 2017).

Reporting is the collecting and quality assurance of data and presenting this to maintenance relevant parties with defined indicators. This data and following analysis can range from root cause analysis to fail tree analysis, while the improvement aspect deal with implementing and monitoring the improvements (NORSOK, 2017).

Lastly, the results found that a risk-based maintenance programme is established through a consequence classification system, specifically through a task selection process. As seen in figure 6, this task selection process can be viewed as a layered approach explained in 2.2 but lacks some of its attributes. This approach is divided into three layers describing the consequences as high, medium/low or containment. Containment is here in a separate group as it requires a different approach. The top line in the figure explains the process where classified consequences are high. This leads through a Failure mode and criticality analysis into a risk analysis. This risk analysis leads to either a Task selection or a CBA. These again lead to a decision of either preventative maintenance or planned corrective maintenance

(NORSOK, 2017). The bottom line in this figure is outside the scope of this dissertation and, therefore, will not need further clarification.

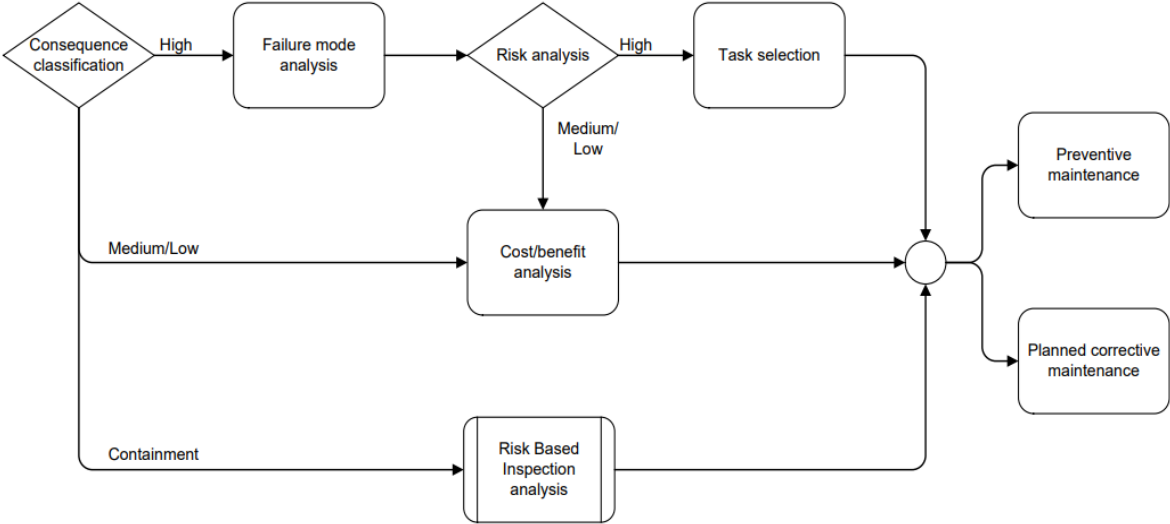


Figure 6: Layered approach (NORSOK, 2017).

4.2 Internal PSA documents

For the purpose of dissertation, it is prudent to review the guidance documents made by the PSA as a single item for evaluation. An important aspect of this document is that it, in large, is based on the ISO 19011 document, but as emphasised in the introduction, it is more specific for the PSA to use in accordance with rules and regulations both in Norway and on the NCS.

Two of the documents relate to revisions/audits, where the procedural document on audits is the main body, and the guidance for the procedure on audits is the supplement. The guidance document elaborates on certain aspects. These documents will be referred to as the same unit: “Procedure for audits”.

As discussed earlier in this dissertation, there are differences between revisions and audits. While these documents are mainly concerning revisions, through their introduction, the PSA defines audits as a “*systematic, independent and documented process of obtaining audit-proof objectively and deciding whether certain audit criteria are accomplished*” (PSA, 2021, p. 2). This definition is close to a word for word same as the how the description of what an audit is earlier: “*An audit is a process to obtain evidence and evaluate it against certain criteria. This process is systematic, independent, and documented to provide the most objective evidence possible*”. (ISO, 2018, p. 1). Considering this, the Norwegian word “revisjon” will be translated to audits in English.

Results show that performing audits is a step-by-step process, often considered a year in advance. First off are the laws and regulations to be considered. Then the planning phase starts. Firstly, in the planning phase, it is to choose a method for conducting the audit. Then a foundation or a reason for the audit is required. Furthermore, one needs to verify whether a previous audit resulted in directives. Lastly, the planning phase is to complete the working documents for the audit (PSA, 2021). In the conduction phase, the first step is to send a warning of an audit. An observation role is advised to be prepared from the company being audited. Then an opening meeting is held, followed by a meeting with relevant union and safety representatives. Safety representatives then accompany the auditor through an inspection of relevant areas. Afterwards, a summary meeting is held (PSA, 2021). Lastly, observations and an audit report are made in the conduction phase. The last part of an audit is the closing letter. Some of these aspects will not be presented as a whole in the following chapters, but those relevant to the dissertation will be (PSA, 2021). The presented parts will be analysed in the next chapter.

The first point the PSA document (2021) emphasises is the availability to access ships, installations, and buildings and access to the necessary documentation to perform an adequate audit. This is accomplished through Norwegian law, giving authorities access to do this (PSA, 2021).

When performing audits, the documents dictate that one needs the right reason to conduct one. This happens a year in advance, during the planning phase for the coming year. But while the objects for audits are planned a year before, they are prone to change as, throughout a year, other information can be presented, such as events, applications to delay, consent applications, other audit activities, or new yet to be conducted activities. When the actual planning begins, these items need to be accounted for. This foundation is based on whether the PSA has done similar audits/audits on others, general information they found on others, how they followed up such findings, and what experience they found others used concerning the results (PSA, 2021).

When planning the audits, according to the PSA documents, one of the items that need planning is the method used during the audit. These methods can range from presentations, interviews, observation of activities or meetings, verifications of systems, or inspections. Choosing one of these depends on the object being audited and how one can arrange the gathering of information. Furthermore, an audit can verify previous directives made by the PSA. These directives must be accounted for, and relevant practice should be conducted by both authorities and the one being audited. When performing audits where previous directives are decided, the audits performed are not “new” but rather a confirmation (PSA, 2021).

The documents state that when conducting the audit process, there are 11 steps to be followed. Some of these are not relevant for this dissertation and as such, will be mentioned briefly, while others are more relevant and, therefore will have more detail. The first step is to warn the business that it will be audited. This letter will include, among other items, clearly defined goals, reference to legal basis, timing, and plan. These are the most notable. Furthermore, it mentions additional relevant information for the business to either produce for the auditor or be aware of before or during the audit (PSA, 2021). The second step is an opening meeting. During this meeting, one continues in line with what was said in the information letter, along with supplemental and more precise information. Furthermore, a safety representative is invited to a meeting and the inspection (PSA, 2021).

Steps three and four both relate to the actual inspection. Neither step is predefined, and both are situation dependent (PSA, 2021).

Step five addresses the need for a summary meeting. This is where the auditor presents their findings, which are factually corrected by the audited should there be a need. This can include misunderstandings or general misconceptions identified (PSA, 2021). Step six is writing the audit report. This is supposed to be a neutral product which includes deviations or improvement findings. It may also include a section of “other comments” with other relevant information (PSA, 2021). Step seven refers to the quality management of the entire process. This step includes the audit leader verifying that everyone relevant is included in the process. Subject leaders verify the actual subjects. And lastly, should the rapport be of severe economic consequences or bring media attention, a media person and a legal representative have the chance to be involved (PSA, 2021). Step eight is to send an audit letter. Along with the information in the actual letter, there is information if the audited should inform other involved parties. Should there be a need for traceability of why certain orders are imposed on the audited, this should also be presented (PSA, 2021). Step nine and ten is information on the imposed corrective actions. Step eleven is verifying that the audit is archived correctly (PSA, 2021).

Concluding audits is, according to the PSA documents a three-step process; the first step is to review the response from the audited. This step includes verifying that orders are followed up and dealt with by the audited. The second step is to update the information attained in the answer to internal documents. Step three is to send a letter to the audit subject to inform them that the audit is completed (PSA, 2021).

The document highlights the importance of trust and respect across the sector. All contact with operators, suppliers and others is built upon mutual respect and trust. From the authorities' side, this is done by following the rules and regulations applicable at the time and place of the audit. Furthermore, all audits shall be summarised to assess whether learning and improving the audit is needed (PSA, 2021).

4.3 Safety Valves (PSV valves)

While there are many valves on an offshore installation, PSVs, more commonly referred to as safety valves, are of particular importance. Such valves are considered to be the final safety barrier when all other barriers fail, and the main purpose of a PSV is to prevent the accumulation of pressure, and protect lives and equipment against overpressure (Hellemans, 2010; Matthews, 2010). PSVs are designed to open and relieve excess pressure when needed, and then reclose and prevent any further flow of fluids when normal conditions have been restored at an installation. Such valves are spring loaded and are actuated by a static pressure upstream to the valve (API, 2000). For the purpose of testing, this responsibility of PSVs lies on the operator. According to PSA, they have certain audit intervals, depending on type of both valves and installations, and should be tested by applying valve pressure and evaluating the function of the PSV. This valve pressure should be x % over the installed value, and a fault is detected if the PSV does not open with 120% of the set points, or over 50 bars, whichever is lowest of the two. This indicator should be registered per PSV. Below is a figure which illustrates the system limits for safety valves (PSA, 2018). PSVs are considered highly critical to safe operations, as faulty PSVs may have serious consequences both to human lives, equipment, and production loss (Hellemans, 2010). Considering the importance of these valves, it is of particular interest to review how these are audited, and whether this audit process can be considered risk-based.

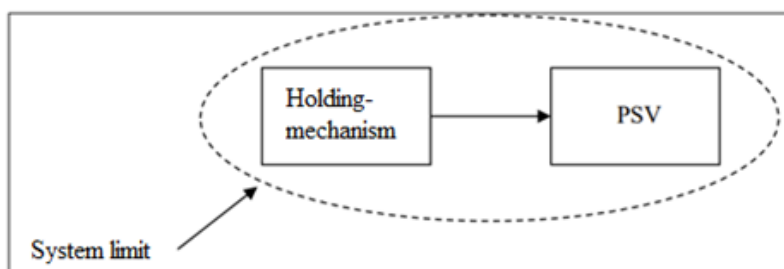


Figure 7. System limits for safety valves (PSA, 2018).

4.4 Understanding risk-based approaches in the energy sector

Throughout the interviews this dissertation identified six main topics related to the literature. This section will present these; first, it will present how the risk concept is interpreted and applied on different levels of the energy sector. Furthermore, it will present what a risk-based approach means to these levels, what the goals of the respective organisations are, and how they perform an audit. This sub-chapter is structured to reflect the adhering topic question and interview guide. Lastly, it was considered most prudent to conceptualise the information gathered based on the informants' adhering level.

As a starting point it is important to understand how the responsibility concerning audits is divided between the levels in the energy sector. Through the interview with informant A1, also briefly mentioned by informant O and S1, there is a difference in the level of responsibility the different organisations hold. As illustrated by figure 8, the authorities are responsible for checking that laws and regulations are being followed. This responsibility is shared with operators who perform external audits. While the authorities are responsible for general system audits and for overseeing that any issues that are in breach with regulations are fixed, the operator is responsible for more in-depth audits on equipment and systems. These audits are more frequent than those of the authorities. The operators conduct external audits on behalf of the owners and partners and are responsible for ensuring that the operations are in compliance with both internal standards as well as laws and regulations. In this manner, the operators are responsible for a larger portion of the operation than the authorities are. The on-site crew on the rigs, as well as the suppliers are responsible for performing internal audits. Such audits are regularly performed on platform equipment and steering systems, and the on-site crew is responsible for supervising all equipment and ensuring safe operation. The suppliers, on their end, are responsible for auditing equipment before it is installed on the platform.

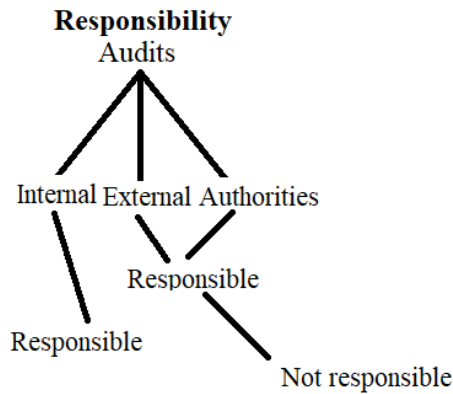


Figure 8. Illustration of responsibility.

4.4.1 Interpreting the risk concept

For the purpose of understanding what a risk-based approach means to the sector, as well as how it is implemented, it was deemed an important starting point to gain an understanding of how the informants interpret the risk concept.

When questioned about how the informants choose to describe risk, all of the informants provided a working definition of the risk concept. However, the result from this inquiry showed that while all the informants have some interpretation of the risk concept, not all appeared to link this concept to the uncertainty concept. Most of the informants associated the risk concept to consequences, or rather the measures used to *avoid* negative consequences. Three of the informants also strongly related the risk concept to HSE management and the possibility of financial loss. Most of the informants emphasised the reliance on different standards, both internal standards and procedures, and on international standards, such as ISO documents.

All the informants were able to provide a working definition of the risk concept, and all the informants emphasised that they actively apply the risk concept in their position. On the use

of the concept, it seemed that while all of the informants' positions are strongly connected to the concept, some apply this concept more explicitly in their work, in the form of presentations and audits, than others who may use it more in direct relation to their HSE programmes. Informant A1 noted that they interpreted that the calculations and algorithms gain more traction today than what the robustness in safety design does. Moreover, it was noted by the informant that they experienced that the industry was somewhat confused by the difference of ALARP and CBAs, which they presented as an issue.

On the note of the HSE programmes, informant O associated the term risk with “... *something that can induce an HSE incident. (...) When someone says risk to me, I think: make sure no one gets hurt.*” This points to a focus on procedures and inherent values within the organisation. Overall, it appeared that all the informants emphasised a holistic risk picture; that it was integral for understanding the risk concept to see and evaluate all known factors. As informant S2 said “... *risk is the total evaluation of an incident occurring. You are analysing all the factors that are available that could influence the operation that you are addressing.*”

Concerning the uncertainty concept, the informants showed varying degrees of connections made between the risk concept and the uncertainty concept. Informant A1 defines risk as “... *the consequences with the uncertainties (...) We have quite good control over the consequences, (...) but we have an issue regarding the uncertainty.*” However, it is worth noting that this might be due to an assumption from the informants that the uncertainty concept is an inherent part of the risk concept.

4.4.2 The concept of a risk-based approach

When asked about a risk-based approach, all informants claimed to have an integrated risk-based approach in their organisation, but it is seemingly a difficult concept to interpret. The concept itself seemed to cause some confusion with the informants. The descriptions of what a risk-based approach varied a lot between the informants. Some could not provide a working

description of what a risk-based approach means, while others provided different interpretations.

Informant A1 described a risk-based approach as “... *a method for validation that is taking uncertainty into consideration (...) the method should take best practice into consideration (...) to get a risk-based approach it is important to know what your goal is.*” While informant A2 emphasised that a risk-based approach should have a strong focus on choosing a focus area and prioritising certain problem areas, as “... *you can't be everywhere all the time.*” Informant O emphasised that it is important to use risk as a starting point. This informant states that “... *the starting point would be the risks, or risky activities, and then you set up audits to further control the risks.*” While informant S1 emphasised a HSE perspective, and that risk-based approaches are related to avoiding the possibility of arising HSE issues.

On the follow up question related to how the organisations implement such an approach, the answers from the informants were also varied. For informant A1 and A2, it was important to note that they are not responsible for implementation outside their jurisdiction. Informant A1 emphasised that the risk analysis is the responsibility of the respective operator, and that authorities would not be able to holistically audit an entire facility. However, the informant stated that they perform spot checks based on knowledge gathered from internal and external audits, and that they follow up known or assumed issues. Informant A2's answer concurred in large with this statement but furthered on that note by explaining that their organisation has certain parameters which help them divide the resources and pinpoint focus areas.

Informant O related the implementation of a risk-based approach to an implemented risk culture within the organisation. This informant also elaborated on how they implement a risk-based approach within the organisation by stating: “*There are two things with risk-based approaches. The first would be to identify the audits that matter in order to set up audit programmes. In this context, I am quite confident about our risk-based approaches, which is a combination of formal and informal assessment. Second, when you come to the execution of single audits, we have no such a clear risk-based approach. In this context, we largely rely on the experience of the team members and their ability to address risky matters along with the*

audit. Thus, our focus is to engage highly experienced team members. However, the risky matters will be reflected in the checklist but without being addressed explicitly. Finally, we are always reviewing the risk registers of the auditee and include a deep-dive of this in the audits.” This answer is largely a technical one, which is in contrast to informant S1, who related the concept of risk-based approaches to internal HSE processes. Informant S1 related the implementation of a risk-based approach to “... *internal questionnaires with people (...) related to the HSE statistics (...) you check the HSE statistics to the number of incidents.*”

As an additional follow-up question, the informants were asked how they were prepared to utilise any positive opportunities that might arise from the implementation of a risk-based approach. Informant A1 related this to map and utilise the competence of the team, and other relevant parties in the best capacity possible. Furthermore, informant A1 spoke of encouraging the operators to share their knowledge between the operations. Both informant O and S1 related this as providing employees the opportunity to suggest any improvements they could find and implement the suggestions that are feasible.

4.4.3 Organisational goals

On the question related to the goal of their organisation, the informants provided answers that largely related to risk reduction and risk aversion. Informant A1 stated that their organisations’ main goal is to ensure that the NCS is the the safest shelf in the world in relation to offshore activity. As an extension of this, informant A2 elaborated that their position was mainly to contribute to safe work environments, as well as reducing the emission of hydrocarbons, and work towards reducing the probability of major accident hazards. Informant O related the organisational goal to responsibility to the owners of the organisation. They stated that it was important for the organisation to deliver value safety and security to the owners. Informant S1 claimed that their overall goal was to have zero risk in their operation and execution of projects. They emphasised the focus on HSE in their operations.

4.4.4 Performing an audit

When asked about how their organisation performs an audit, informant A1 explained that they start planning the audits for the coming year in November. Informant A2 supplemented this statement by explaining that different scopes of an audit require different methods of performing it. The scope of time an audit takes depends on the focus area. The more people involved, the wider is the scope for the audit. It was made clear that an audit may be done in one day, or it might take a full week, all depending on what sort of focus area the respective audit has. For the purpose of the audit, informant A1 stated that *“About four to eight weeks before the audit we send a notification letter to the operator. Before that we usually call just to make sure that they have space for us, and during that call we also inform of topic and scope of the audit.”*

Informant A1 stated that the audits often start with the operator presenting a status report onshore. Then the auditors implement interviews with questions related to regulations and internal steering documents. Following this, informant A1 explained that the auditor then does a deep dive into the steering systems to check system statuses and how the equipment is classified in the operator’s systems. When needed the auditor also goes offshore to do physical inspections on the platform, and to conduct interviews with the crew. All this accumulates into a report. Informant A1 also emphasised that while the operator is under no obligation to apply standards to their internal steering documents, the regulations dictate that if the operator does not apply standards, they are obligated to document that their safety level is as good as, or better than the standards.

On the operator side, audits are conducted in a similar manner according to informant O. Informant O stated that they begin their audit by putting together a team consisting of a variety of competent individuals. This group is then trained to consider and focus on the goal and process of the audit rather than focusing on a nice-to-know list. It is important for the audit to have a concise scope of the audit and stay within the parameters of this. According to informant O, the audit process starts with a kick-off meeting related to the structure of the report, scope of the audit, audit checklist, and audit notice. Informant O stated that *“I very*

rarely start with a predefined checklist, even though we do some similar audits. I prefer to re-make the checklists as a way of starting the process. This is also useful to get the audit teams onboard, for the teams' alignment and understanding of the task in hand." After this, informant O explained that the audits consist of early meetings with the one who is getting audited to clarify expectations and to provide the audit subject with the chance to show themselves from the best side. As informant O emphasised, impressions matter.

"If we get a good impression of them in these pre-meetings, we believe that they know what they're doing. There have been pre-meetings where the auditees have been very well prepared, and thus also convincing with regard to what they are doing. In such cases, I usually foresee that the audit will go smooth and my expectations to any major findings are low. This is also usually the case. But I have experienced pre-meetings where the auditees are surprised about our expectations to the pre-meeting and totally unprepared. In such cases, I see a red flag and ask myself if they are focused enough."

Informant O

Following the early meetings, informant O explained that there is a gap of approximately two weeks before the audit is being implemented. The audit itself consists of a mixture of interviews, physical demonstrations, and physical inspection on the platform and steering systems. These aspects combined result in focus areas and the adhering report. Informant O also emphasised that it is important that the audit manager does not suggest too many improvement suggestions to the operator. This is because it may lead to too much noise in the project. The informant also makes a distinction between audits – tilsyn and audits – revisjoner by stating that while these concepts are used as one and the same in English, in Norwegian this distinction divides the manner of which authorities perform audits - tilsyn and how internal and external audits - revisjoner are performed by operators and partners. These types of audits are often more detail oriented and covers a broader area of application than what audits - tilsyn does.

Informant S1 also stated that the audits are mainly consistent on questionnaires and interviews with the employees. To ensure that the employees partake in these activities, informant S1 explained that there are internal incentives for participation, and according to the informant these incentives ensure a high rate of participation. The results from this in combination with the HSE statistics provides the organisation with focus areas for further improvement. The informant emphasised that *“if you check the HSE statistics, the number of incidents is extremely low, and this is the proof that the system works well.”* Informant S1 furthered on this notion by explaining that the HSE manager runs audits in accordance with internal guidelines and general standards. Informant S2 complimented this statement by emphasising that the organisation is certified by third parties, thus making the implemented audits quite comprehensive.

4.4.5 Goals of an audit

One of the questions asked related to the goals of an audit. For this question all of the answers received related to different perspectives of safety concerns. Informant A1 related the goal of an audit to effect. The informant claimed that the focus, or goal, of an audit should be on what effect the audit have on the overall safety of an operation, and the effective use of resources. It was stated that since the organisation has limited resources it is important to effectively use resources on issues that the operators might not be aware of. Informant A1 stated *“... often we have to do the same kind of audits many times at different locations to make sure they understand that this is something we really want them to do something about.”* Furthermore, the informant stated that in addition to make audits on operations, they also implement other types of aids, such as inhouse presentations from operators. This aid is also used as a follow-up between audits to ensure that the operator has the tools to manage identified issues.

Informant| A2 emphasised that the main goal of an audit is to deliver on what they are supposed to. The informant furthered on this notion by stating that a clearly defined goal and a checklist for what to audit is placed in the notification letter.

“A good audit is to actually deliver on your predefined goals which are stated in the audit notification.”

Informant A2

On the question of goals related to the risk-based audits informant O stated that the main goal of an audit for their organisation is to ensure that they are compliant with all laws and regulations. However, the informant emphasised that audits are in large related to ensure that an activity is safe. The informant views audits as a barrier for events, and thus emphasised that it is important to communicate anything that might be unsafe or unsecure across all relevant departments.

Informant S1 defined the goals of an audit by stating *“... more than 80% of the targets must be reached (...) otherwise it means that the system is not operating properly, and action must be taken.”*

4.4.6 Auditing PSVs

For the purpose of gaining a more in-depth understanding of how PSVs are being audited by the different levels of the energy sector, the informants were asked to provide an example of how this practice is done. Informant A1 stated that to detect a faulty PSV one must either do a deep dive on a detail level or check the system for any system alerts. If a faulty, or leaky, PSV is detected informant A1's organisation checks how the operator is managing this type of risk, what type of compensating measures are implemented, and then they follow up until the issue is redeemed. For informant A1's organisation the most important role is to check how equipment is tagged and classified to ensure that the maintenance systems work as they should. The informant furthered by explaining that by ensuring that the maintenance systems are working properly, any PSV failure should be detected before an incident occurs.

Informant A2 provided some further elaboration by explaining that their organisation does not preform PSV testing, as they are not inspectors, but rather have a role as auditors. In a case where the system alerts the auditors of a faulty PSV it is the operator's responsibility to amend the issue, but the auditor will ask the operator for a correction plan and error report. According to informant A2 the operator is also asked to provide an account or plan for how to avoid similar issues in the future, and how this will affect the design of their steering systems.

As for the case of external audits performed by partners, informant O explained that they have many barriers to detect such issues. However, the task of maintenance work is the responsibility of workers on the platforms. Informant O stated that the role of an auditor is to effectively communicate the issue across department and to ensure the error is corrected.

Informants S1 and S2 provided an in-depth explanation for how such an audit is performed before the PSV is shipped out. As informant S1 explained, a FAT is conducted before the valve is sent out. This test involves several tests. First, each valve gets tested with either pressure or nitrogen, depending on the requirements decided by regulations and standards for that specific valve. Then, they check that the valve opens at the requested set pressure and that it does not leak more than the allowed amount set by API standards. The last test involves back pressure tests which ensures that there is no external leakage to ensure the safety of the valves. Informant S1 emphasised that this is a process all PSVs go through before the PSV is sent out from production. As an addition to this, informant S2 explained that the PSVs are tested at 1,5 times the design pressure to ensure that safety concerns are accounted for. The informant also emphasised that these tests are both conducted before the client arrives, and then again with the client present. Before a PSV is certified, the client must sign that the tests have been conducted, and that this has been observed by the client representative.

4.5 Summary of the results

This chapter has provided a sectioned presentation of the relevant results for this research project. It has divided the different documents and interviews for the sake of tidiness, but for

the purpose of a more structured approach to the results it is prudent to condense and synthesise these. The table below presents how the results from both the content analyses and the interview analysis perform in accordance with the criteria presented in 2.3. The Cs marked on the Y-axis represent the criteria, while the documents applied and evaluated, and the informants are named accordingly on the X-axis. The columns provide answers to whether the different documents and informants have fulfilled the criteria or not. Inconclusive results are marked “IC”, and partially fulfilled criteria are marked “partially”.

| | C-1 | C-2 | C-3 | C-4 | C-5 | C-6 | C-7 |
|--------|-----|-----|-----|-----------|-----------|-----------|-----|
| ISO | Yes | Yes | IC | IC | Partially | Yes | No |
| NOROSK | No | Yes | Yes | Partially | Yes | IC | Yes |
| PSA-D | IC | Yes | Yes | Yes | Yes | No | No |
| A | Yes | Yes | Yes | Yes | Yes | Yes | IC |
| O | Yes | Yes | Yes | Yes | Yes | Partially | IC |
| S | Yes | IC | Yes | Yes | Yes | Partially | Yes |

Figure 9. Data results.

This summary provides a crude analysis of the results found. The purpose of this initial analysis is to provide a condensed introduction to the analysis, and this table will be further elaborated in the following chapter.

5 Analysis

Thus far, this dissertation has presented a variety of theories related to risk management, developed criteria for a risk-based approach to audits, and examined how the different levels perform their audits. This chapter will provide an analysis to help determine whether the different levels in the offshore industry and the documents they have based their practices on, can be considered risk-based. The chapter will be structured as follows: firstly, it will look at the written documents and evaluate these against the seven criteria set in 2.3. This includes the ISO standard, the NORSOK standard and the internal PSA documents. Secondly, it will evaluate the data gathered from the informants against the seven criteria. Lastly, for the purpose of a more extensive understanding, it will provide a cross-evaluation of the industry holistically.

5.1 An evaluation of documents

While there are many different strategies and standards which relates to performing risk-based audits, the ISO 19011 standard seems to be the governing standard applied in auditing enterprises, across disciplines. Whereas the standard claims to be risk-based, it neither provides a clear definition of what a risk-based approach is, nor does it provide a framework for evaluating whether an approach can be considered risk-based or not. Considering the theoretical foundation presented in chapter two, as well as the presentation of the ISO 19011, it is integral for this research project to affirm whether this standard can be considered to be risk-based according to the criteria presented in chapter 2.3. As the ISO standard is used as a starting point by the industry to design safety management regimes, the degree to which this standard can be recognised as risk-based may provide an indication of whether the industry practices can be considered risk-based. Furthermore, as this standard is widely applied within the Norwegian offshore industry, it is consequential for the resilience of the safety regime implemented on offshore activity that this standard is evaluated.

While the ISO standard seemingly is the governing standard for international enterprise auditing, the PSA applies the NORSOK standard when performing audits related to the

offshore industry. The presentation of the NORSOK Z-008 standard emphasised it as a leading guidance document on maintenance for the NCS. As with the ISO standard above, it is integral to affirm whether this standard can be considered risk-based according to the criteria presented in chapter 2.3. Evaluating this standard in light of the seven criteria presented in 2.3 may provide a more nuanced understanding of whether the industry practices can be considered risk-based or not. While it is integral to examine the governing standards applied in the offshore industry, it is equally important to evaluate some of the internal steering documents that present practical procedures relating to audits. As a governmental oversight agency, the importance of the PSA is of particular interest. Therefore, in addition to interviews with the PSA, the analysis of their internal documents is necessary to generalise or emphasise whether audits on the NCS can be considered risk-based. Considering this, all documents will be evaluated in light of the seven criteria presented in chapter 2.3.

5.1.1 Meeting criterion one

The first criterion relates to presenting an adequate definition of risk. This definition must be functional within its own framework and address uncertainties and consequences (Aven & Thekdi, 2021; SRA, 2018). Furthermore, it must consider statistical outcomes, the scope of undesirable effects, and the anticipation of risk (Rigakos & Law, 2009; Renn, 2008; Hutter, 2010). Based on this criterion, ISO is considered to present an adequate definition of the risk concept as it is practicable and adequately addresses the characteristics described in the criterion. While this may not be clear just from reading the definition itself, these characteristics are emphasised in the accompanying footnotes following the definition. Note one addresses the scope of effect, note two emphasises uncertainty and consequences, note three addresses risk anticipation, and note four addresses statistical outcomes (ISO, 2018). Based on this, the ISO standard adheres to the first criterion for risk-based approaches.

The very definition of risk that the NORSOK standard uses is “a combination of the probability of an event and the consequence of the event” (NORSOK, p. 10, 2017). This is not an adequate definition of risk. Aven (2012) argues that a probability-based definition cannot serve as a conceptual framework for defining and understanding risk as the chance of

risk is rarely defined, and probability, therefore, is void (Aven, 2012). However, this definition is always presented with additional information throughout the document, which renders this definition applicable in defined situations. Nevertheless, there is no mention of uncertainty in the document itself. Considering this, criterion one cannot be considered adequately fulfilled.

While the PSA documents contain no definition of risk at all, both through referenced documents and those supplying the documents, the PSA has a definition of risk. But as there is no mention of it in the document, this criterion will be revisited later in the evaluation of the interview with the PSA. While this might be an expression of these documents being an addition to other standards, this might create some ambiguity for the auditors who apply these documents for reference. It is ambitious to assume that all auditors adequately encompass all adhering documents when they have internal steering documents available. It might be more functional for these documents to also include a functional definition of risk to avoid misunderstandings. Considering this, for the purpose of the current evaluation, whether or not the first criterion has been fulfilled is considered inconclusive.

5.1.2 Meeting criterion two

The second criterion addresses goal-settings within the organisation. It states that the approach chosen must be based on identifiable and obtainable goals which are defined by experts and dictated by evidence (ISO, 2018). The ISO standard adheres to this criterion, as it states that any risk management process must have both identifiable and obtainable goals. Furthermore, the ISO standard dictates that such goals must be defined by experts within the respective field and that these goals must be adjusted as new evidence is uncovered (ISO, 2018). These values are addressed in the second principle of the ISO standard which emphasises the need for fair representation of data and the responsibility to be truthful and accurate in all reporting, findings, and conclusions related to the risk management process. Moreover, these values are further emphasised in the sixth principle of the ISO standard where it is stated that the results found from such processes must be based on verifiable

evidence. Considering this, the ISO standard can be concluded as fulfilling the second criterion.

The NORSOK document, on the other hand, focuses on ambition levels and realisable goals. While it does not precisely explain that these goals should be set by experts, the standard itself is to be used by experts and by extension, the goals would have a certain influence from said experts. Furthermore, the goals in the document are guidelines and, as such, will be flexible and prone to changes should new evidence be uncovered. While this is not as extensive as the ISO standard, the NORSOK standard does meet the general requirements in criterion two. Moreover, one could argue that the NORSOK standard should be viewed as an extension of, or an addition to the ISO standard. Therefore, criterion two can be concluded to be fulfilled by the NORSOK document.

When looking at the PSA documents, the goals set by the PSA regarding audits encompasses both predictable results and fair treatment of all operators and suppliers on the NCS. Furthermore, the goals set in each specific audit are done shortly before the audit is conducted (PSA, 2021). While the predictability and fairness of goals may contradict the need for adjustability, these are overall goals. Therefore, setting goals shortly before the audit allows for adjustability. Furthermore, the competence requirement that audit leaders have completed an internal learning programme or have formal education from a university means that the expert criterion is achieved. As such, the second criterion is considered fulfilled by the PSA documents.

5.1.3 Meeting criterion three

Criterion number three emphasises the need for a solid risk culture which ensures that risk management is a well-integrated dynamic process within the organisation (Abrahamsen et al, 2011). Based on the principles applied by the ISO standard, this criterion cannot be considered to be adequately fulfilled. While the sixth principle, which addresses the need for verifiable evidence, may lead to a well-integrated approach overall, this cannot be said to be conclusively proven as this principle also states that time constraints may lead to shifts in

focus over time (ISO, 2018). On a further note, this criterion cannot necessarily be dictated by the ISO standard at all, as it is up to the operators and legislators to have a well-integrated risk culture within their respective organisations. However, the need for a well-integrated risk-culture is integral for the successful implementation of a risk-based approach. Considering that one of the governing standards do not address this concept might be detrimental for the safe operation of offshore activities. While an argument could be made that it is sufficient for the organisations themselves to include this in their internal steering documents, this dissertation found that this cannot be considered adequate. As such, ISO does not adequately fulfil criterion number three.

For the NORSOK standard, this criterion is achieved through the very nature of the document. As this document is made to be used for all steps in the process it describes, its aim is to influence its users to implement risk-based thinking within their organisation. However, similar to the ISO 19011 analysis, this criterion cannot necessarily be dictated by the NORSOK standard at all, as it is up to the operators and legislators to have a well-integrated risk culture within their respective organisations. While the same argument could be made for the NORSOK standard as for the ISO standard, the NORSOK standard presents as more nuanced in relation to implementing a risk culture within an organisation. Considering the scope and aim of the document, the NORSOK standard is considered to sufficiently fulfil criterion three.

The PSA documents, on the other hand, state that the foundation that any audit shall be based upon is risk-based. This would, in turn, require the pre-existence of a risk-based strategy. While the document cannot prove whether there exists a functional risk culture within the organisation or not, the basis for it through governing documents exists. If the condition for this document being functional is that there exists a risk-based strategy within the organisation, it is reasonable to assume that the document adequately addresses the need for a well-integrated risk culture. Based on this PSA document, the third criterion is considered to be fulfilled.

5.1.4 Meeting criterion four

The fourth criterion stresses the need for proportional measures in relation to the perceived risk (Aven & Vinnem, 2010). The ISO standard addresses what they refer to as appropriate measures to a certain degree but fails to adequately provide any framework for such evaluations in their standard (ISO, 2018). While the ISO standard emphasises the need for flexibility for different organisations of various scales and goal settings, and this can partly be considered as one principle for proportional measures, this cannot be considered adequate for fulfilling the criterion at hand. One explanation as to why the ISO standard does not adequately fulfil this criterion may be that the ISO standard is a universal framework which does not cover such details. There is unfortunately some ambiguity related to what proportional measures are, as this will often vary between organisations. As such, this analysis found that it is inconclusive whether the ISO standard adheres to this criterion or not, as there is some ambiguity relating to certain aspects of it.

The NORSOK document, on the other hand, implies that the proportional measure is done through an RBI. RBIs are done to find faults and find the most cost-efficient way to fix them. However, CBAs are not enough to choose not to implement measures as stated in chapter 2.2 as it does not emphasise uncertainties. Even though there is a layered approach shown in figure 7 that is akin to the ALARP principle, it is insufficient to warrant a risk-based title alone. As previously stated, it is integral for any organisation to implement varied and nuanced strategies to managing risks. Seeing how the NORSOK standard does not adequately address proportional measures, criterion four is considered inconclusively fulfilled by the NORSOK document.

According to the PSA documents, it is important to address proportionality when conducting an audit. Throughout the last steps in conducting the audits and throughout the closing of the audits, there is a possibility to adjust imposed corrective actions if there are any. These are mainly conducted by the authorities, but the audit subject has the opportunity to add their own comments. This process ensures that all nuances of an audit related to which measures should be implemented have the opportunity to be addressed. As such, the proposed disciplinary

action can be modified to be proportional to the perceived risk by the PSA, thus making the fourth criterion adequately fulfilled.

5.1.5 Meeting criterion five

Criterion number five states that any risk-based approach must consider flexible adaption, and that such strategies must be developed and implemented by experts. Furthermore, these strategies must include mitigation actions in order to be functional (Leinchencko & Yohe, 2010). This criterion is partly addressed in chapter 7.2.2, letter f in the ISO standard. This letter states that the personal behaviour of the auditor must be versatile and adaptable in different situations (ISO, 2018). However, the standard does not address mitigation actions in their framework. There might be different explanations for these missing mitigation actions but considering the importance of implementing mitigation actions to a risk-based approach, the ISO standard only partly adheres to the fifth criterion for risk-based approaches.

Contrary to the ISO standard, the NORSOK standard addresses this through the adaptation of maintenance work processes as it is a feedback loop which allows for adaptation and new evidence to start a new process. Furthermore, the task selection process allows all uncovered evidence to be handled appropriately. Considering this, an argument can be made that this is an expression of flexible adaptation with mitigation actions included. Implementing measures through feedback loops offers several advantages related to both adaptation and mitigation, which also relates to effective learning and may contribute to a more effective implementation of a risk-based approach. As such, the fifth criterion is adequately fulfilled.

Flexible adaptation and mitigation are also addressed throughout the entirety of the PSA documents. As the audit team must have specific qualifications and experience doing audits and be chosen from their respective fields of expertise, they can also be said to be experts. The document itself seldom mentions a way to do specifics but rather the aim for each step. This offers the auditor some autonomy to adapt as the audit process moves forward. Furthermore, it ensures that mitigation actions can be implemented while at the same time

ensuring that the approach itself is flexible. Therefore, the PSA document is considered both flexible and adaptable for the experts to work with, thus making the fifth criterion is fulfilled.

5.1.6 Meeting criterion six

The focus of the sixth criterion is on the potential positive opportunities that may arise from risk-reducing measures, and an organisation's ability to exploit these (SRA, 2018; ISO, 2018; Aven, 2018). The ISO standard states that it is integral for organisations to consider opportunities that may improve the effectiveness of the audit activities. Ensuring that the organisation consider any positive opportunities can ensure an overall better risk management process within and across organisations. While the effectiveness of these processes cannot necessarily be measured by monetary values, it can also show effect through lower impact on environment, on HSE processes, and production value. As the ISO standard has a strong focus on such positive opportunities, it has the opportunity to provide a helpful focus to obtain a well-functioning risk-based approach to audits. Considering this, the ISO standard does adhere to this criterion.

While the NORSOK document clarifies that a consequence can range from positive to negative, it does maintain that an HSE consequence is always negative. Such a clarification allows for the management of maintenance process and the task selection process to identify and use the positive opportunity. While the focus is mainly on the negative aspects of HSE consequences, this standard does address the possibility for positive outcomes. It could be considered negative for this standard to have such a strong focus on negative outcomes, but contrary to other documents it does mention the exploitation of potential positive outcomes as well. Considering this, criterion six is viewed as being adequately fulfilled.

Contrary to the other standards, the PSA internal documents have no mention of positive opportunities. However, through the documents' flexible approach, such opportunities may be utilised despite the lacking mention of it. While these documents do not necessarily dismiss the utility of positive opportunities, they do not emphasise them either. This may have negative consequences for the auditor as they might not be fully aware of the implications

positive outcomes may have. In light of this, while the criterion may be achieved, it is not mentioned and, therefore, inadequate.

5.1.7 Meeting criterion seven

The seventh and last criterion addresses the need for risk modelling in an organisations' risk-based approach. This criterion is important for the overall risk management process and ties flexibility, functionality and dynamic integration to the approach itself (Hutter, 2010; Leinchencko & Yohe, 2010; Abrahamsen et al, 2011). As risk modelling and tolerability is not addressed in the ISO standard, it is conclusive that the standard does not adhere to this criterion. Considering that the ISO standard is a universally applied standard, it could have a plethora of negative consequences for the risk management process to negate the mention of the need for risk modelling. While such frameworks do not necessarily need to mention specific strategies, it is reasonable to desire that such strategies should be mentioned.

Contrary to the ISO standard, the NOROSK standard addresses both layered approaches and CBAs; as such, this standard is flexible, functional, and has a dynamic understanding of the risk management process. Considering this, criterion seven can be conclusively said to be fulfilled.

There are no mentions of risk modelling within the PSA documents. However, as this is a very specific document and not regarding a management process, the document itself can be a part of such a process. As such, one cannot conclude that this would not be risk-based. Lastly, an ALARP process could be recommended by the PSA as a way for an operator to handle risk. Considering this, criterion seven cannot convincingly be concluded to be fulfilled.

5.1.8 Summary

Considering the findings of this initial document analysis, the ISO standard can only be considered partly risk-based according to the risk-based approach criteria presented in 2.3.

However, it is important to note that the ISO standard is a universal framework which has been created with the objective of having a wide variety of usage areas in different types of enterprises. Because of this, it cannot be convincingly concluded whether the organisations that use the ISO standard can be considered risk-based or not from this analysis alone. While this evaluation may provide certain assumptions for further analysis, it does not provide firm enough grounds for any conclusive thoughts.

Considering these criteria, the NORSOK Z-008 standard has some severe deficiencies as it never mentions uncertainties. Additionally, this introduces a layered approach which is insufficient, according to Aven and Vinnem (2010), as one should never base the ALARP principle on a CBA without exploring relevant uncertainties. However, should an organisation be aware of these deficiencies and have well-implemented processes to deal with these, the rest of the criteria can be considered to be all fulfilled and, therefore, can be considered risk-based. Of note is the reliability on an ISO standard describing risk; during the research, it appeared that this was an outdated definition of risk.

This initial analysis has uncovered that the PSA documents on audits are partly risk-based. Furthermore, this document is based on the ISO standard 19011, analysed earlier. This standard does not adequately address the ISO standard's deficiencies adequately enough to warrant a different conclusion than what was reached regarding the ISO standard.

Furthermore, this document is not a universal framework and is mainly used by the PSA, making it more suited to conclude whether the PSA is doing risk-based audits. However, when discussing the seventh criterion, this document may be part of a more extensive process discussed in the next chapter. While this evaluation may provide certain assumptions for further analysis, it does not give firm enough grounds for any conclusive thoughts on its own.

5.2 Interview analysis

Thus far this analysis has evaluated some of the key written practices related to the implementation of risk-based approaches in the offshore industry and the PSA. To properly

evaluate whether these practices can be considered risk-based or not it is integral to analyse how the practitioners perform their duties in practice. This subchapter will present an analysis of the data collected through the interviews and evaluate them to the criteria founded in chapter 2.3.

5.2.1 Interpreting the concept of a risk-based approach

The first aspect of this analysis relates to the concept of a risk-based approach. Considering the topic and scope of this dissertation it was deemed necessary to examine how the different levels of the offshore industry interpret the concept of a risk-based approach. As made apparent by the content analyses, this concept is an ambiguous one with a clear lack of proper definition in the governing documents. While all the informants claimed to have a well-integrated risk-based approach in their organisation, the definition of such an approach was seemingly unclear when the informants were asked to provide a definition of what a risk-based approach entails. The answers provided by the informants indicated that the interpretation of the concept of a risk-based approach varies both between the different levels, and within the respective organisations. On an authority level there was some disagreement as to whether the focus should be on the goal and method, or whether it should be on having a clear focus area. The operator level emphasised risk mitigation and barrier control, while the supplier level interpreted the concept as being related to the successful implementation of HSE processes. Considering this dissonance in interpretation, there is a strong indication that the concept of a risk-based approach in audits is a somewhat confusing one. While all the informants do relate the concept of a risk-based approach to safety, it is unclear to which extent the informants experience clarity surrounding this concept. Moreover, it seems that the area of responsibility of each informant impact how they interpret the concept.

It was made clear through the interviews that the authority level of the industry is organisation is not responsible for implementation of a risk-based approach outside their own organisation or any adhering risk analysis that the risk-based approach should be based on in external capacity. The authority level is solely responsible for performing spot-checks, follow up on regulation breaches, and identifying problem areas based on organisational parameters on

external operations. Considering the role of the PSA, their approach to risk-based audits is seemingly impacted by their role as an overseer. Contrary to operator and supplier levels, the PSA's role is to ensure safe operations on the entirety of NCS, and as emphasised by one of the informants the organisation has limited resources which needs to be used effectively. As a result, the authority level's main responsibility is related to checking system errors rather than performing deep-dives on specific equipment. While this system is based on some degree of trust between the auditors and the operators, it is also stressed that trust between these levels is built over time, thus ensuring that new operations are more scrutinised than established ones. In a way, this trust building can be seen as an expression of a risk-based evaluation. Furthermore, such a form of responsibility level might impact how the authority level interpret the risk-based approach concept, as the level is reliant on big-picture thinking, and thus making their interpretation of the concept an administrative one. For the operator level, the area of responsibility is a quite extensive one. First, they, along with the authority level, are responsible for overseeing that all rules and regulations are being followed on their operations. Additionally, they are responsible for in-depth equipment and system checks. Such audits are continuous and have a generally wider scope than that of the authority level audits. Considering the wider scope of the area of responsibility for the operator level, this may affect their definition of the risk-based approach concept. The same can be said for the supplier level as their main area of responsibility relates to internal audits on equipment and production safety levels on factories. These aspects make it reasonable for this level to associate the concept of a risk-based approach to HSE processes.

The operator level focuses on the need to implement a risk-based approach through methods that suits the scope of the task in question and emphasised the use of checklists to implement and perform adequately. This may indicate that the operator level, in contrast to the authority level, is more involved in the risk analysis on the operation. It is reasonable to assume that the operator level's involvement in the risk analysis as well as the implementation of a risk-based approach impact them and makes them interpret the concept differently from the authority level. Furthermore, the operator level implements their risk-based approach is through a combination of informal and formal assessments. This provides the organisation with a wide arrange of opportunities for developing a robust risk-based approach. However, as emphasised earlier, it may become difficult to implement a risk-based with the inherent

confusion related to the definition of such an approach. Considering this, it was difficult to assess whether the process described by the informant can be defined as risk-based. Contrary to the authority level, it is seemingly more complicated to assess the operator's ability to implement a risk-based approach as they are more involved in the holistic process, from implementing a risk analysis to a risk-based approach to audit because of this confusion.

While the authority level and the operator level both relates the risk-based approach to audits to technical operations, the supplier level relates the concept to a more HSE oriented perspective. This may be an expression of the supplier level's focus on safety on factory related risks. Considering that the suppliers mainly work on the production of equipment, it is reasonable for the supplier to have a strong focus on factory safety. However, this focus may make the implementation of a holistic risk-based approach to audits difficult. While the supplier level stresses the focus on equipment and maintenance safety in addition to the focus on procedures and training, it seems, based on the responses during the interview, that the main focus is on HSE.

Considering these aspects, it seems that the way the different levels interpret the concept is heavily reliant on their position, their interests, organisational goals, and responsibility level. While most of the informants include many of the same aspects related to the concept, their interpreted goal and approach Moreover, the data gathered indicates that there is no consensus of what the concept entails, which may be problematic considering the emphasised implementation of such approaches by legislators.

5.2.2 Meeting criterion one

As presented in chapter 2.3, criterion one states that the organisation must present an adequate definition of the risk concept, which addresses uncertainties and consequences, statistical outcomes, undesirable effects, and the anticipation of risk (Aven, 2012; Aven & Thekdi, 2021; SRA, 2018; Rigakos & Law, 2009; Renn, 2008; Hutter, 2010). Considering the information gathered through the interviews it is clear that the manner of which the informants interpret the risk concept varies. While this at first glance might seem to constitute

a breach of criterion one, it is important to note that the informants presented definitions which mostly contained the same aspects if not the exact same definitions. All of the informants were able to provide a working definition of the risk concept, and most of them included uncertainty in one way or another in their definition. It is also worth noting that the different backgrounds of the informants may impact how they interpret different concepts. However, as previously stated, there is much ambiguity related to the risk concept. While the informants all provided adequate definitions of risk, the content of the concept differed between the informants. This ambiguity might create difficulties within and across organisations, and between the auditors and the audit subjects. If the fundamental understanding of the concept differs, this may affect the overall quality of the audit process as the starting point for what is prioritised and how the audits should be performed as these practices are affected by the concept itself. Furthermore, such ambiguity of a fundamental concept may affect the successful implementation of a risk-based approach, a functional risk culture, and the setting of RACs. It might be difficult for an organisation with widely varying interpretations of the risk concept to reach consensus of what proportional measures are, and how these should be implemented. While this dissertation found that the first criterion is met, it is not necessarily sufficient.

Despite there only being one informant who concisely implement the uncertainty concept to the risk concept, it is a reasonable claim that requirement is met. However, as this analysis shows, the inconsistency in how this concept is interpreted may result in future confusion and subsequent decrease in overall safety in the industry.

5.2.3 Meeting criterion two

The evaluation of criterion two, which states that the goals applied should be based on identifiable, obtainable, and flexible goals defined by experts (ISO 2018), will be conducted in two-fold: first it will evaluate the criterion against organisational goals, then the goal setting for audits. On the note of organisational goals, the authority level relates the goal of their organisation to the safety on NCS and upholding a safe work environment on operations. This goal is set by experts and can be considered identifiable and obtainable. It can also be

considered adjustable as the means of obtaining the goal will be adjusted according to new evidence uncovered. The operator level relates the overall goal to the responsibility to provide value safety and security the owners and partners of the organisation. This is both identifiable and obtainable, and it can be considered to be defined by experts as value safety is a measurable unit which must be adequately defined. Moreover, as in the case of the authority level, the means of the measures applied to obtain this goal will adjust as new evidence is uncovered. The same can be said for the answers provided by the supplier level, as the overall goal is to avoid risk in their operations. However, while the goal is identifiable and defined by HSE experts, it is not obtainable. Overall, the requirement can be said to be holistically fulfilled.

On the notion of audit goals, one informant stated that their organisation's goal of an audit related to obtaining the most effect on safety related manners and effective use of resources. This goal is both clearly defined and obtainable, as effectively use of resources and identifying potential risks in an operation is possible. Furthermore, what constitutes risk and effective use of resources is defined by experts, and will vary based on the evidence uncovered, it is reasonable to conclude that this requirement is met. Another informant stressed the need for a clearly defined goal in their answer, which further underlines that this requirement is met on the authority level. On the operator level it was explained that the main goal for an audit is to ensure that operations are in compliance with laws and regulations. This is also considered to be in line with the second requirement. The supplier level provided a statistical number to which the goal is measured. This is also a concise, identifiable, and obtainable goal. Furthermore, the supplier level indicated that if the set RAC is not met, action must be taken, which means that that this level also meets the requirement.

5.2.4 Meeting criterion three

The third criterion relates to create a dynamic and functional risk culture throughout the organisation (Abrahamsen et al, 2011). Considering the answers gathered on risk culture all the informants claimed to have a well-integrated risk culture in their organisation. However, this criterion can be difficult to measure as this largely relates to how well-functioning the

informants feel that their own risk culture is. While this criterion is a subjective one, this dissertation found that it could be adequately measured through the informants' explanations related to how they process HSE data. Most of the informants presented well-integrated practices for measuring safety within their own operations. Moreover, it seems clear by their answers related to audit performances, regulations, HSE management, and steering documents that this requirement is fulfilled by all levels of the sector.

5.2.5 Meeting criterion four

Criterion four states that the approach must be based on proportional measures. This means that the risk-reducing measures put in place must be proportional to the risk at hand (Aven & Vinnem, 2010). To gain a meaningful answer to this and to avoid leading questions the informants were asked to exemplify how they perform a risk-based audit on a faulty PSV. On an authority level this largely related to check that all equipment was classified and tagged correctly. Furthermore, they explained that if a faulty PSV is detected they focus on reporting, follow-up audits, management of internal routines, and plans for future avoidance. The operator level focuses on the need to communicate effectively to and with relevant parties, reporting, and adequate functionality of equipment. This accounts for proportional measures. On the supplier level explained that the risk audit contains multiple tests, also referred to as FATs, before the equipment is released from factory. This means testing functionality and resilience and ensuring safe operation. If any errors are detected, these are redeemed before factory release. Considering this, the requirement is fulfilled.

5.2.6 Meeting criterion five

Similar to criterion four, the question related to criterion five was asked in an open manner to avoid any leading answers. The informants were asked how they generally perform an audit to gain a meaningful understanding of which they consider flexible adaptation to their approach. Criterion five states that the organisation should consider flexible adaptation to the approach, and that the strategies applied should be developed and implemented by experts and encompass mitigation actions for it to be functional (Leinchencko & Yohe, 2010). The

authority level stressed that different scopes of an audit require different methods of performing it. Both the scope and content of the audit require the development of various methods for mitigation. The operator level focused on need to develop new checklists for each audit to ensure a holistic approach to the audit. For all intents and purposes, this indicates that there is flexible adaptation involved in the audit process. Based on the answers provided through the interviews, it seems that the supplier level has a strong focus on employee involvement in addition to HSE statistics ensures that the means and measures applied in the organisation is flexible and encompass mitigating actions. Considering this, the requirement is fulfilled on all levels.

5.2.7 Meeting criterion six

Criterion six relates to utilising positive opportunities (SRA, 2018; ISO, 2018; Aven, 2018). The authority level related the utilisation of positive opportunities to be able to utilise the expertise of the auditor team and the maintenance team in an efficient manner. It was also noted that in cases where new knowledge was generated during an audit it was deemed important to encourage sharing this knowledge with other operators to increase the overall safety level on NCS. Considering the scope of criterion six, this is considered fulfilled by the authority level. However, both the operator and the supplier level related this utilisation to providing the opportunity to suggest improvement that might be implemented. While it is reasonable to assume that they have some sort of system for this, this was not made clear during the interviews. On these levels it is concluded that criterion six is only partially fulfilled as while they do have a desire to utilise positive opportunities, they seemingly lack a functional system to map these.

5.2.8 Meeting criterion seven

The last criterion dictates that the organisations need to include risk modelling to their approach in order to be considered risk-based (Hutter, 2010; Leinchenko & Yohe, 2010; Abrahamsen et al, 2011). One informant emphasised that there exists some level of confusion related to the difference between the types of risk models, such as ALARP and CBAs. This

may indicate that this informant's organisation does not utilise risk modelling to an adequate extent when implementing an audit. Moreover, it was inconclusive from the answers gained whether the operator level utilise risk modelling in their audits. On the other hand, it was interpreted that the supplier level applied the use of FAT as a manner of risk modelling. By this, it is interpreted that the FAT provides some specifications for what is accepted in regard to error rates, leakage, and functionality. For the purpose of criterion seven, it seems that the only level to fulfil this requirement is the supplier level. Overall, this requirement is partially, if at all, fulfilled.

5.2.9 A cross-criteria analysis

Before providing a holistic evaluation of other pertinent findings, it is prudent to provide an overview of the analysis thus far. Below is a table overview of the findings obtained from the evaluations. The Cs marked on the X-axis represent the criteria, while the documents applied and evaluated, and the informants are named accordingly on the Y-axis. The columns provide answers to whether the different documents and informants have fulfilled the criteria or not. Inconclusive results are marked "IC", and partially fulfilled criteria are marked "partially". There have also been added some complimentary comments in the footnotes.

| | C-1 | C-2 | C-3 | C-4 | C-5 | C-6 | C-7 |
|--------|-----------------|------------------|-----------------|------------------------|------------------------|-------------------------|------------------|
| ISO | Yes | Yes | IC ¹ | IC ² | Partially ³ | Yes | No |
| NOROSK | No | Yes | Yes | Partially ⁴ | Yes | IC ⁵ | Yes |
| PSA-D | IC ⁶ | Yes | Yes | Yes | Yes | No ⁷ | No ⁸ |
| A | Yes | Yes | Yes | Yes | Yes | Yes | IC ⁹ |
| O | Yes | Yes | Yes | Yes | Yes | Partially ¹⁰ | IC ¹¹ |
| S | Yes | IC ¹² | Yes | Yes | Yes | Partially ¹³ | Yes |

Figure 10. Data results extended.

Considering the table presented above, the PSA internal documents is the only content in this analysis that does not include a functional definition of risk. However, it is important to note that the internal documents in question actively refers to the ISO standard which does include an in-depth definition of the risk concept. Because of this, it is considered irrelevant for the

¹ On a furthering note, this criterion cannot necessarily be dictated by the ISO standard at all, as it is up to the operators and legislators to have a well-integrated risk culture within their respective organisation.

² The ISO standard does address what they refer to as appropriate measures to a certain degree but fails to adequately provide any framework for such evaluations in their standard. While the ISO standard stresses the need for flexibility for different organisations of various scales and goal-settings, and this partly can be considered as one principle for proportional measures, this cannot be considered adequate for the criterion at hand. This may be caused by the universal usage of this standard.

³ This criterion is partly addressed in chapter 7.2.2, letter f in the ISO standard. This letter states that the personal behaviour of the auditor must be versatile and adaptable in different situations (ISO, 2018). However, the standard does not address mitigation actions in their framework

⁴ RBIs are done to both find faults but also to find the most cost-efficient way to fix them. But CBAs are not enough to choose to not implement measures as stated in chapter 2.2 as it does not emphasise uncertainties. As such, even though there is a layered approach shown in figure 7 that is akin to the ALARP principle it is insufficient to alone warrant a risk-based title.

⁵ The document clarifies that a consequence can range from positive to negative but that an HSE consequence is always a negative one. Such a clarification allows for the management of maintenance process and the task selection process to identify and use the positive opportunity. Whether HSE opportunities shall be included in this is debatable. Criterion six is therefore adequate when not considering whether HSE consequences can be positive.

⁶ While the documents contain no definition of risk at all, both through referenced documents and those supplying the documents, the PSA has a definition of risk. But as there is no mention of it in the document, this step will be ignored for the time being and visited later in the evaluation of the interview with the PSA.

⁷ The PSA internal documents have no mention of positive opportunities. However, through the documents' flexible approach, such opportunities may be utilized anyway. In light of this, while the criterion may be achieved, it is not mentioned and, therefore, inadequate.

⁸ There is again no such mention within the document. However, as this is a very specific document and not regarding a management process, the document itself can be a part of such a process. As such, one cannot conclude that this would not be risk-based. Lastly, an ALARP process could be recommended by the PSA as a way for an operator to handle risk

⁹ According to informant A1, there exists some confusion of the difference between the types of risk models, such as ALARP and CBAs. This may indicate that A1's organisation does not utilise risk modelling to an adequate extent when conducting audits.

¹⁰ Informant O related this utilisation to providing the opportunity to suggest improvement that might be implemented. While it is reasonable to assume that they have some sort of system for this, this was not made clear during the interview.

¹¹ It was inconclusive from the answers gained whether informant O's organisation utilise risk modelling in their audits.

¹² While the organisational goal is identifiable and defined by HSE experts, it is not obtainable. However, the organisation fulfils the requirement on the note of audit goals.

¹³ Informant S1 related this utilisation to providing the opportunity to suggest improvement that might be implemented. While it is reasonable to assume that they have some sort of system for this, this was not made clear during the interview.

overall evaluation that the internal PSA documents lack such a definition. Concerning criterion two, the supplier level was the only level to only partially fulfil this criterion. This criterion emphasises that the goals must be both *identifiable* and *obtainable*. It is difficult to argue that an emphasis on zero risk in operation is obtainable, as there will always be some level of risk related to operation. However, because the goal in question was considered to be functional, it was deemed irrelevant for the holistic evaluation to weight this in a negative manner, as the goal is not in conflict with safety in general.

The content analysis revealed that the ISO standard did not fulfil criterion 3. However, this is necessarily not relevant with regards to the type of document this is. As the phenomenon of risk culture is reliant on the respective organisation's own implementation, it is deemed somewhat unreasonable to expect that it should be included in the standard. However, it is important to note that it is reasonable to expect the respective organisation to have this criterion embodied in their internal steering documents. Concerning criterion four, the ISO standard is marked as inconclusive, while the NORSOK standard is marked as only partially fulfilling the criterion. While the ISO standard refer to the concept of appropriate, or proportional, measures, it fails to provide any further elaboration for what this means, thus potentially leading to confusion at what a proportional measure might entail for the auditor. The NORSOK standard mentions CBA and the ALARP principle as a manner of proportional measure, but the emphasis is on cost-effective measures rather than that of proportional measures. Moreover, it does not account for uncertainty in their analyses, thus only partially fulfilling the criterion.

Criterion five calls for flexible adaptation which encompasses mitigation actions (Leinchencko & Yohe, 2010). While the ISO standard does include flexibility in their guidelines, it fails to consider mitigating actions. However, it is important to note that the collected data does indicate that the other steering documents, as well as the auditors, have both flexibility and mitigation integrated in their procedures. Because of this, it is deemed as the industry holistically meets this criterion.

In contrast to this, little of the data collected adhere to criterion six. This criterion relates to the organisations' ability to utilise positive opportunities that might arise from risk-aversion or mitigation efforts (SRA, 2018; ISO, 2018; Aven, 2018). While ISO has utilisation of positive opportunities integrated in their guidelines, neither the NORSOK standard, nor the PSA internal documents acknowledge this. Furthermore, this criterion was only partially fulfilled by most of the informants. While all the informants claimed to do this, only one could provide an account for how to do this practically. Informants O and S1 did mention that they were open for suggestions and implementations, but neither were clear on whether or not they had a system in place for this, or how any positive opportunities were utilised. Considering this, the criterion is only considered to be partially fulfilled.

Criterion seven, which relates to including risk modelling to the risk-based approach was almost universally neglected. Neither the ISO standard nor the PSA documents mention it at all. For the informants it was deemed inconclusive as while provided the opportunity to include risk modelling during the interviews, neither the informants on the authority level nor the informant on the operator level mentioned it as a part of their audits. It was mentioned by informant A1 that they experienced some confusion within the organisation of what the difference between different risk models ensues. This was interpreted to be an indication that risk modelling is not commonly applied in the organisation. However, risk modelling is mentioned in the NORSOK standards, which should be applied by all operators and others related to NCS related operations. Considering this, it was mostly deemed inconclusive whether this is applied in the industry. Moreover, the informants on the supplier side provided a comprehensive explanation of how they apply risk modelling in their operation. In light of this, it is concluded that the industry does not fulfil criterion six to an adequate level.

As emphasised through this analysis, no single level of the industry can be considered to be fully risk-based. It is important to note that the different levels operate on different stages of the operation. An argument can be made that the different levels operate as barriers for the industry. However, while the industry holistically present better results than that of the single organisations alone, it can only be concluded, based on the findings thus far, that the industry as a whole is only partially risk-based.

5.3 A holistic evaluation

While this dissertation has largely focused on detail-oriented and fractioned evaluations, it was deemed prudent to provide a more holistic evaluation of the sector itself. Though it is important to understand how the levels and documents function on their own, it is equally vital for the understanding of the sector to view these in regard to each other. While the criteria detailed in this dissertation thus far indicate that the energy sector can only partially be considered to have implemented a functional risk-based approach, there are other considerations that must be accounted for. As previously mentioned, safety valves are considered the final safety barrier against overpressure on on- and offshore facilities. In other words, these valves are safety critical in operations and the consequences of a faulty valve may be severe. Considering this, it is important for the continued safety of NCS operations to gain a holistic evaluation of their audits.

For the purpose of a more comprehensive analysis, it also seemed prudent to evaluate some other topics related to the level of which the industry can be considered risk-based. The first topic identified relates to the concept of risk itself. As emphasised by the analyses performed in relation to criterion one, there is no clear consensus as to how to define this concept. The findings of this dissertation indicate that this dissonance in definitions within the industry might affect the implementation of a risk-based approach, as how the risk concept is defined seems to have an impact as to how a risk-based approach is viewed by the informants. However, it is important to note that this dissertation cannot convincingly conclude how large of an impact this definitional issue has on the industry. Nevertheless, it might be prudent for the industry to provide a clarification as to which definition is preferred. Obtaining a consensus of this fundamental concept might have a positive effect on the successful implementation of a risk-based approach.

The second topic identified relates to the concept of a risk-based approach. Akin to the dissonance related to the risk concept, it was uncovered that there was no consensus between the documents or informants as to what a risk-based approach entails. While the standards applied in the evaluation of a risk-based approach in the offshore industry emphasise the use of a risk-based approach, none of these standards provide an explanation for what such an

approach entails. As the results of the analysis of the interviews show, all of the informants claim to have a well-integrated risk-based approach, but their definition of such an approach differs in scope and depth. One clear advantage of lacking any comprehensive explanation for what this approach entails is that the auditor gains more autonomy on how to interpret it. This may lead to different implementations across various auditor levels and different organisations. Differences in implementations have the possibility to ensure a more goal-oriented approach for the organisations in question, which might lead to an increased safety level within the organisation. However, more autonomy on the auditors' part may lead to confusion when audits performed on different levels end up with different results. Concerns related to this may include an question of jurisdiction, best practice, and maintenance, and these may over time evolve into an issue related to safety on NCS operations. Considering this it may be prudent to add an explanation for what a risk-based approach entails for the different levels of the sector. While this list does not need to be extensive, some minimum requirements could provide some universal guidelines for the industry to increase the general understanding of what a risk-based approach is.

Moreover, such guidelines would partially resolve another topic which was uncovered in the analysis. This issue is related to the extent of which the knowledge within the organisation is based on experience-based learning. While this topic is not expressively covered by the criteria presented in chapter 2.3, it is arguably an extension of criterion number three, which emphasises that the risk-based approach must be a dynamic and integrated process within the organisation to ensure a functional risk culture (Abrahamsen et al, 2011). It is important for the longevity of safety on operations to ensure a functional and resilient risk culture within any organisation. This means that the risk-based approach must be seen as a dynamic process which is evaluated frequently. To ensure such a process it is vital that the learning is based on established routines and procedures. While there is no doubt that experience-based learning is integral for any organisation, at the same time it increases the risk of knowledge dilution over time. Informant O stated that experience-based learning was important for the implementation of a risk-based approach within their organisation. While this may provide new auditors great learning experiences, it is deemed important for the resilience of any organisation to ensure that there are procedures in place to avoid that important knowledge is not lost as experienced auditors leave the industry. Considering this, it is deemed integral that steering documents

should include procedures and learning documents, as well as an explanation of what a risk-based audit entail. In relation to PSVs such organisational flaws may lead to major accidents, as PSVs are safety critical. If a valve were to fail, the consequences of this could be extensive for both equipment, production, and human lives.

Another potential concern that was uncovered relates to the division of responsibility between the different levels. While this topic was not obvious at first, it became apparent when the informants were asked about the practical implementation of safety audits on PSVs. The supplier level, on their end, seemingly has implemented elaborate processes for auditing the PSVs before they are shipped offshore, and the supplier level responsibility ends after the PSVs are certified and shipped offshore for installation. Considering this, it is reasonable to assume that the PSVs are fully functional and safe when they arrive on the platform. However, it was deemed a bit unclear as to how the responsibility is divided between the different levels after installation. The authority level emphasised that to detect a faulty PSV one need to perform a system deep-dive, and considering the role of the PSA, this is outside the scope of their jurisdiction. However, if a faulty PSV is detected during a maintenance system check, the authority level will follow up on the case. One concern related to such cases is that undetected system flaws are not necessarily uncovered during these audits and have the potential to lead to large systemic errors, which in turn may cause damage to equipment, production, and human lives. Furthermore, it seems that the operator level, while responsible for performing audits, is not responsible for ensuring the functionality of PSVs. According to one of the informants, it is the responsibility of the offshore crew to maintain these valves. Considering this, while the big picture may be more complex than what the data from this research project has managed to uncover, it seems that there is not a clear enough responsibility division between the authority and the operator level. While it is important to maintain trust between the maintenance crew and the auditors, it is also important to ensure the safety of operations, especially relating to the functionality of PSVs. Considering the safety critical position PSVs hold on offshore operations, it may be appropriate to implement more focus on risk-based audits specifically on these valves.

On a final note, it is important to emphasise that the practices evaluated during this analysis are based on different national and international standards which are presented and analysed on their own. Considering that the analysis of these documents, of which all of the practices are based on, found that these standards cannot be considered fully risk-based, it is a question of foundation. Because the standards in themselves provide inadequate frameworks for obtaining a successful implementation of a risk-based approach, it is not unreasonable to claim that such limitations on the frameworks negatively affect the implementation of such approaches.

Based on the data gathered through the interviews there are seemingly few incidents related to PSVs in the industry today. While this may indicate that there is robustness in the system, it is imperative for the resilience of the safety on NCS based operations that these systems are continuously evaluated and improved. This is also emphasised through the results of the content analysis that has been performed in this dissertation.

6 Conclusion

The purpose of this research project has been a two-fold attempt; first, it set out to examine how a risk-based approach is implemented in the different levels of the offshore industry in regard to audits. Second, it attempted to evaluate whether this can be considered to be risk-based according to risk management theory.

This dissertation identified seven criteria that were deemed necessary for the successful implementation of a risk-based approach in any offshore related organisation. As a starting point it was integral to set a functional definition of the risk concept. For the purpose of this dissertation, it was seen as vital for the holistic understanding of the topic to adopt a concept which incorporated both a realism perspective and a social constructivist perspective. The definition this dissertation chose to implement was a combination of the ISO definition and the social constructivist perspective, as these combined was considered the most encompassing definition. In addition to relating the criteria to this definition, the criteria identified were based partially on the findings in the literature review, and partially on the ISO standard. It was deemed necessary to include certain aspects of the ISO standard as this is currently the governing framework for risk-based approaches.

Moreover, it was considered necessary to implement a combination of content analysis and qualitative research to gain a more impactful impression of the actual practices in the industry. The document analysis contained both the NORSOK standard and the ISO standard, as well as a selection of internal documents provided by the PSA. It was deemed prudent to include all these to obtain an extensive understanding of how audits are performed by the different levels, and what these practices are based on. Furthermore, the interviews gained an extensive understanding of how the different levels interpret concepts and how this affects the audits performed on NCS.

This dissertation found that while the documents the organisations apply as guidelines for their audits stress the need for a risk-based approach, the concept itself is vague. This may

result in confusion and an increased risk of an unintended incident on operation. Moreover, the confusion related to the concept may lead to misunderstandings in the implementation of audits between the different levels. Furthermore, it was uncovered that the learning within the different organisations is reliant on experience-based transfer between the auditors. This may result in the dilution of important risk knowledge over time, which may increase the risks on operations on NCS. Considering this, it is recommended to include a definition of the concept of risk-based approaches in the steering documents.

Furthermore, the evaluations performed in this dissertation found that neither the documents, nor the organisations adequately met the criteria set. For example, the ISO standard fails to conclusively address both criteria three and four, and it only partially addresses criterion five as it fails to address mitigation efforts. Moreover, it completely fails to address criterion seven, as it mentions no form of risk modelling. The NORSOK standard contains an outdated definition of risk which contains no mention of uncertainty; while it references an ISO document, this ISO document is also outdated. Considering the partial achieved criterion four, it ties back to the lack of dealing with the uncertainty aspect. While it mentions positive opportunities, it excludes positive HSE opportunities and therefore becomes inconclusive considering criterion six. The PSA document has no mention of risk but references other documents with adequate definitions, making the criterion inconclusive. The PSA document also becomes inconclusive as it never mentions how to incorporate positive opportunities. This concludes that all documents fail in some way to be risk-based.

A presentation on how the different organisations interpreted the concept of risk and risk-based approaches showed that there are substantial differences between the different levels. The interpretations ranged from the realist view of probability vs consequence to the constructive realist and uncertainty vs consequence to mitigation and barrier control and lastly, referring to it as HSE as a whole. This confirms the statement from chapter 2.1.4 that no single agreed-upon definition of risk exists. While the two first include a variety of simplifications, such as models, experiments, and expert judgements (Renn, 2008) in their understanding, only the second implements an aspect of social science. The third and fourth definitions can include both, but they may also not include it at all due to their broad nature.

This dissertation settled on a constructivist realist interpretation of risk to be the most fruitful in risk-based audits. This is accomplished in large only by one of the informants by definitions alone. However, evaluating the informants holistically, they all accomplish social science aspects. These aspects include the human acceptance level of risk, their justification of risk, and avoidance of risk, which makes governing risk more nuanced when one accepts the premises set by including social sciences as such sciences account for the human aspects of risk.

This leads to criteria one; all the informants were able to provide a working definition of the risk concept. All of them included an aspect of uncertainty in some way, all included consequences, and all included the social science aspect. Criteria one is met, but it is highly prudent of the sector to have one agreed-upon definition. While all the organisations had different goals of audits, this was explained to be due to the different stages of responsibility, and all were adequate in their own regards. Criterion two was achieved. All the organisations have a resilient risk culture integrated into their respective organisations; criterion three is achieved. Criterion four had differences due to the different responsibilities of the organisations interviewed. Still, they all adequately explained their processes to align with the requirements for an adequate fulfilment of criterion four. Criterion five requires a flexible adaptation to be in place. Both the PSA and the operator does this exceptionally well, as they individually adapt the audit to fit the goals set for that audit. The supplier also succeeds in this criterion as it involves employees in addition to HSE statistics in its efforts to mitigate risk. All achieve criterion five. Criterion six is something the risk community has been adamant about; risk contains both negatives and positives. The PSA address this adequately, but both operator and supplier fail to have a system which can utilise the positives. The PSA achieves criterion six, while both operator and supplier fail. Lastly, both the PSA and operator fail to properly implement risk modelling to their approach, while the supplier does to some extent. This criterion is only partially achieved, if at all. In total, all documents and organisations have something to improve on, whether including functional and correct definitions of risk or to better utilise positive opportunities when they present themselves.

While evaluating standards and organisations one by one yielded results which the respective organisation can use to improve their adherence to being risk-based. As the analysis showed deficiencies severe enough to not warrant a risk-based title to almost all the elements evaluated, as 2.3 says that all criteria must be fulfilled to be considered risk-based. The dissertation has shown more nuances and ambiguities than first thought in concluding whether a criterion is met. Even one by one, the organisations can be partially considered risk-based. While looking at documents and organisations, one by one has yielded results themselves can use to evaluate whether audits done on PSV valves, as an example, throughout their life-cycle are risk-based or not; a holistic evaluation was deemed necessary.

The holistic analysis found that no single level of the industry is fully risk-based as they all fail to fulfil at least one criterion. Moreover, it was found that while the different levels function as a type of barrier to avoid major incidents, the system of which these barriers exist is fragile. This might be a result of the conceptual understanding of fundamental concepts across the industry being contended. While the industry as a whole is considered more adequately resilient towards such incidents than the organisations alone, experienced-based learning seemed to be a pervasive issue. Considering this, the industry can only be considered partially risk-based when compared to risk management theory. However, it is important to note that theoretical frameworks often work under the presumption of ideal conditions, which is most often not realistic in real-life situations.

7 Recommendations

Considering the findings of this dissertation it is clear that further research on the topic of the implementation of risk-based approaches in audits in the offshore industry is needed. First and foremost, this dissertation found that the ambiguity related to the risk concept itself may have a negative effect on the successful implementation of a risk-based approach to audits. To remedy this, this dissertation recommends that a more integrated and clearer definition is implemented to the industry through the universal frameworks. While it would be prudent to develop a fully functional framework for the implementation of such an approach, this falls outside the scope of this dissertation. It is recommended that a large-scale research project to map and assess all operators, as well as the supplier chains and safety authorities is conducted to gain a holistic and in-depth understanding of the risks related to conceptual confusion between the different levels. Moreover, the results from such a project should in turn be used to develop a fully functional framework including a glossary with conceptual clarification. While this dissertation has provided a list of seven criteria for assessing whether an organisation can be considered to successfully have implemented a risk-based approach, it is important to note that practical application may differ from theoretically founded practices. Considering this, more research is also recommended on the practical application of such criteria.

Based on the findings of this dissertation it is recommended for the offshore industry on all level to continue to assess their procedures on a regular basis to ensure the continuous safety on NCS operations. Moreover, it seems prudent to recommend that safety authorities, in cooperation with the operators and suppliers, develop a functional definition of the concept of risk-based approaches, what this entails, and how this should be done. If this is not done future endeavours to emphasise the implementation of such approaches seem futile as there seems to be an underlying confusion related to this on all levels of the industry.

Lastly, the findings of this dissertation indicate that the standards applied within the industry cannot fully be considered risk-based, thus it is recommended that the industry re-evaluate and revise these standards so that they better reflect the desired level of safety on NCS.

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Appendix 1. Information letter

Are you interested in taking part in the research project:

An Evaluation of the Framework for Risk-Based Audits on Safety Valves in the Offshore Industry.

This is an inquiry about participation in a research project **where the main purpose is to evaluate the use of the concept of «risk-based approaches» in the petroleum industry, which is emphasised by the safety authorities. In this letter we will give you information about the purpose of the project and what your participation will involve.**

Purpose of the project

The purpose of this dissertation is to evaluate the contemporary standard performed on safety valve audits to explore whether a risk-based approach has been applied to these audits or not. *The aim is to compare how audits are performed both internally and externally, and whether this is in line with academic risk management.*

Who is responsible for the research project?

The University of Stavanger is responsible for this research project.

Why are you being asked to participate?

For the purpose of this project, we have chosen to interview experts on audits, both related to active petroleum operations, national authorities, and safety valve specialists. You are being asked to participate in this project due to your position and expertise within your organisation.

What does participation involve for you?

The method applied for this project is qualitative interviews with experts on their fields. For the duration of the interview, we wish to record and make notes. If you choose to participate in this project, we would like to perform a face-to-face or video-interview. The interview will take approximately 1 hour and will include questions about what your background is, how your organisation defines risk-related concepts, and how your organisation performs risk-based audits. Your answers will be recorded electronically. As this project will be in English, any transcribes made in Norwegian will be translated.

Participation is voluntary

Participation in the project is voluntary. If you chose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you chose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data

We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act). The information shared with us will only be available to the students in charge of this project and relevant professors contributing on this project. All participants will be anonymised in the publication. This means that names and ages will be redacted, but your occupation will be disclosed.

What will happen to your personal data at the end of the research project?

The project is scheduled to end 15. June 2022 and recordings and notes from the interviews will be deleted.

Your rights

So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
- send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?

We will process your personal data based on your consent.

Based on an agreement with *the University of Stavanger*, Data Protection Services has assessed that the processing of personal data in this project is in accordance with data protection legislation.

Where can I find out more?

If you have questions about the project, or want to exercise your rights, contact:

- *The University of Stavanger* via *Frederic Emmanuel Bouder*, frederic.bouder@uis.no
- *The University of Stavanger* via *Jørgen Arntzen*, 261278@uis.no
- *The University of Stavanger* via *Linn Steensrud*, linnsteensrud@hotmail.com
- Our Data Protection Officer: *Elena Sikveland*, 51834516, elena.sikveland@uis.no
- Data Protection Services, by email: (personverntjenester@sikt.no) or by telephone: +4753211500.

Yours sincerely,

Frederic Emmanuel Boudier

(Researcher/supervisor)

Jørgen Arntzen & Linn Steensrud

(Students)

Consent form

I have received and understood information about the project *An Evaluation of the Framework for Risk-Based Audits on Safety Valves in the Offshore Industry* and have been given the opportunity to ask questions. I give consent:

to participate in *an interview*)

I give consent for my personal data to be processed until the end date of the project.

(Signed by participant, date)

Appendix 2. Interview guide.

An evaluation of the framework for risk-based audits on safety valves in the offshore industry.

Interview guide – Master dissertation

Introduction

This dissertation is a research project aimed to explore the uncertainties related to the concept of a risk-based approach which has been emphasised by audit authorities. Through informal conversation with individuals working in the Norwegian energy sector the uncertainty surrounding what warrants a risk-based approach, what this means for operators, and the lack of best practice protocols was emphasised. The main purpose of this project is to evaluate and advise a framework for risk-based approaches in the Norwegian energy sector with an emphasis on risk-based audits on safety valves in the offshore industry. Considering this, this research project aims to answer the topic question of:

How are audits implemented internally and externally with regards to safety valves on offshore installations, and is this in line with academic risk management?

Background

1. What is your background?
2. What is your role in your organisation?
3. How is your role related to risk-based audits within the organisation?

Risk

1. How would you describe risk?
 - a. [Does this definition fluctuate according to changing challenges, if so, how?]
 - b. [How would you define uncertainty?]

Risk-based approach

1. What are the goals of your organisation?
2. How are these goals defined?
3. How would you describe a risk-based approach?
 - a. [Are the audits your organisation performs risk-based?]
4. How is this implemented throughout your organisation?
 - a. [How does your organisation consider positive opportunities that may occur, and how is your organisation prepared to utilise these?]

Audits

1. How do you perform an audit?
 - a. [What standards and principles do you apply when conducting an audit?]
2. Do you think audits are influenced by risk perception, if so, how?
3. What are the goals set concerning the audits?
4. How is this practice performed when a faulty PSV valve is detected?