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How does Eni Norge Risk Management Process align with Norwegian HSE Regulations?

Thesis by

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A truth ceases to be a truth as two people perceive it.

Oscar Wilde

Executive Summary

The oil and gas sector of Norwegian industry is recognized as one of the major petroleum regions in the world. Oil and gas is recovered from these fields using a wide variety of installation designs including entirely subsea completions and manifolds, steel jacket and concrete gravity platforms, floating installations and floating production storage and offloading (FPSO) vessels.

The regulation of health, safety and environmental issues across Norwegian industry is administered by three primary authorities. The Petroleum Safety Authority (PSA) is one of these three authorities and is responsible for all safety aspects of petroleum activities, either offshore or onshore. Primary legislative regulation covering petroleum activities is administered by the Norwegian Petroleum Directorate (NPD) but this is specifically a fiscal authority and all requirements concerning health and safety have been transferred to the PSA.

The Norwegian regulatory and supervisory system is mainly performance based rather than prescriptive based, and laid out so that the operating companies hold total responsibility and accountability for operating in satisfactory manner. The Petroleum Safety Authority (PSA) may occasionally recommend certain practices or solutions, but will not oblige preferred solutions on the companies. In the view of this, operators on the Norwegian Continental Shelf (NCS) are expected to assess, identify and exhibit the best adequate and suitable solutions to a problem or issue. In doing so, it is the sole responsibility of the operators to demonstrate compliance with the laws and regulations.

It is many years since oil was first discovered on the Norwegian Continental Shelf.1969 was a memorable year in that respect, and Eni Norge was there right from the start. Eni Norge was one of the first operators to carry out exploration in the North Sea, the Norwegian Sea and the Barents Sea, and is today an active participant in 56 licenses. Eni Norge's participating interests in fields in production include the Ekofisk Area in the North Sea, and Heidrun, Norne, Urd, Skuld, Åsgard, Mikkel, Morvin, Kristin and Tyrihans fields in the Norwegian Sea (Eni Norge 2016). Eni Norge is the operator of Goliat FPSO that was constructed in South Korea and sailed Goliat field in Barents Sea in 2015. Eni Norge is in the view that the Barents Sea represents an opportunity for the long-term development of the oil and gas industry in Norway. Goliat FPSO is the first in Barnet Sea that makes its operation for Eni Norge so challenging, with no experience in such arctic environment. Eni Norge has never been involved in operations in Norway besides Marulk that is comprised of 2 subsea wells and drilling activities.

This thesis provides a comparison and discussion on selected key elements of the Norwegian HSE regulations and Eni Norge Integrated Management System (ENIMS) with a focus on risk management process. The thesis will identify areas with potential gaps, and suggests recommended actions to address the findings.

Acknowledgement

After an intensive period of 2 years studying and working, writing this note of thanks is the finishing touch on my thesis. It has impacted me not only in the scientific arena, but also on a personal level.

I would first like to appreciate my thesis Supervisor Prof. Preben Hempel Lindøe at University of Stavanger. The door to Preben office was always open whenever I needed or had a question about my research or writing. I am gratefully indebted to him for his very valuable comments on this thesis.

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Last not the least, I must express my very profound gratitude to my spouse, Mahsa for providing me with unfailing support and continuous encouragement throughout study and through the process of researching and writing this thesis.

This achievement would not have been possible without them.

Stavanger, December 2016

Mohammad Bakhshmand Amir

Abbreviations

ALARP: As Low as Practicable

APOS: Advanced Process Oriented Steering

BARID: Barrier ID

BAT: Best Available Technique

BSP: Barrier Status Panel

CMG: Chemical Management Group

CM: Corrective Maintenance

COND: Condition

DSHA: Defined Situations of Hazard and Accident

DU: Dangerous Undetected

DNV: Det Norske Veritas

ENIMS: Eni Norge Integrated Management System

EPA: Emergency Preparedness Analysis

EPC: Engineering, Procurement and Construction

FAR: Fatal Accident Rate

FEED: Front End Engineering and Design

FMECA: Failure Mode Effects and Criticality Analysis

FPSO: Floating, production, storage and offloading

HAZID: Hazard Identification

HRA: Human Reliability Analysis

HSEQ: Health, Safety, Environment & Quality

ICAF: Implied Cost of Averting a Fatality

IEA: International Energy Agency

IRGC: International Risk Governance Council

ISO: International Organization for Standardization

JSA: Job Safety Analysis

KPI: Key Performance Indicator

LTI: Lost Time Injury

MSF: Main Safety Function

MSG: Management System Guidelines

MTO: Man, Technology, Organization

MW: Megawatt

NCS: Norwegian Continental Shelf

NGO: Non-Governmental Organization

NORSOK: Norsk Sokkels Konkurranseposisjon (Design standards)

NPD: Norwegian Petroleum Directorate

NPV: Net Present Value

OIM: Offshore Installation Manager

OLF: Norwegian Oil & Gas Association

OPEX: Operational Expenditure

PDCA: Plan, Do, Check & Action

PEEL: Prepare, Execute, Evaluate & Learn

PM: Preventive Maintenance

PSA: Petroleum Safety Authority

PTW: Permit to Work system

QRA: Qualitative Risk Assessment

RAC: Risk Acceptance Criteria

RMI: Integrated Risk Management

RMP: Risk Management Plan

RR: Risk Register

SAP: Systems, Applications, Products in Data Processing software

SIF: Safety Instrumented Functions

SIL: Safety Integrity Level

SWL: Safe Working Load

WE: Working Environment

WEC: Working Environment Committee

WHRU: Waste Heat Recovery Unit

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1. Introduction

An efficient and effective HSE management system is essential to ensure that business processes are carried out by an organization in a safe, healthy, environmentally and socially responsible manner. The main objective of having an HSE management system is to prevent incidents, injuries, occupational illnesses, pollution and damage to assets. HSE management system is the combination of policies, methods, resources and equipment needed to enable an organization and stakeholders to thrive in a sustainable manner.

There has been an extensive development in the industry both with regards to technology, organization and management system in particular within HSE and risk management. Accidents such as Piper Alpha (Cullen Report 1990) in the North Sea and Deepwater Horizon in the Gulf of Mexico (Report to president 2011) and others brought fundamental shift in the way risk and HSE are managed in the industry over the recent years. Figure 1 shows how safety has developed during the course of the last 150 years (Sutton 2014a).

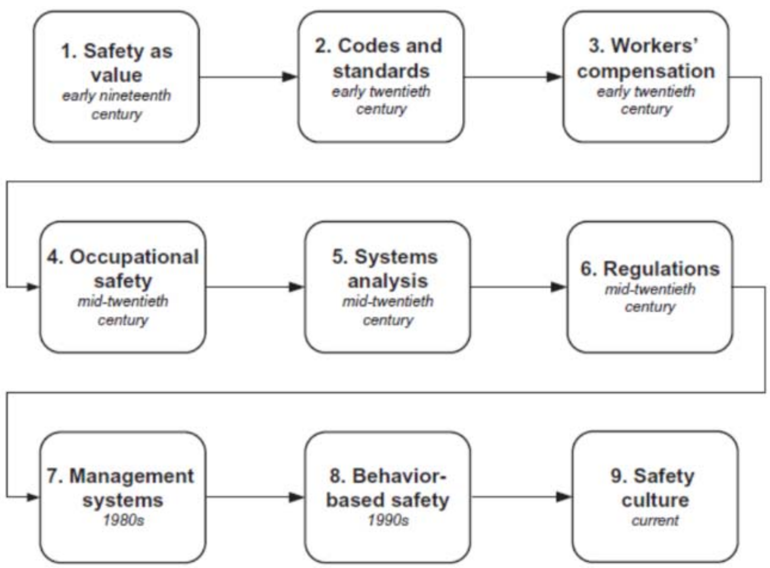


Figure 1 – Developments in Safety Systems

The PSA as the regulatory authority that monitors petroleum activities on the Norwegian Continental Shelf (NCS) as well as petroleum related plants and associated pipelines system, requires all companies operating on the NCS to follow the rules and regulations provided by the authorities known as the HSE regulations, in addition to a number of laws and acts under the PSA area of authority. Within these regulations, risk management is recognized as a key maintaining a high level of safety.

The PSA regulations require operating companies to conduct their activities in accordance with prudent, technical, sound principles and maintain high level of safety with technological developments. It further specifies that practice must accord with sound professional standards (PSA 2010a). The PSA regulations and supervisory system are designed in a way that they bear total responsibility for operating companies, hence companies are free to come up with the best solutions themselves. They are entrusted with their professionalism and understanding of their roles and responsibilities to practice the HSE regulations. This approach makes Norwegian HSE regulations performance-based norms rather than prescriptive functional. As a result of this, they always alter in line with professional developments in the industry, unlike perspective norms that may become obsolete and ineffective over time.

A fundamental element of the Norwegian HSE regulations is the principle of internal control. It denotes that regulations can only be applied and practiced effectively when each operating company accepts and embraces the role of self-control and self-regulation, to ensure its compliance with the regulations.

Figure 2 shows the trends of events with major accident potential, offshore production facilities since 2000 in Norway. Hydrocarbon leaks and well control incidents are important contributor to major accident risk in 2015. Result of barriers show that companies face challenges in meeting certain areas.

Eni Norge is committed to guaranteeing best practice in HSE at all levels of the Company through a standardized management system, based on rules and procedure meaning that the same governing documents, procedures and operating instructions apply regardless of where the activity takes place (PSA 2016a).

1.1 Purpose & Scope

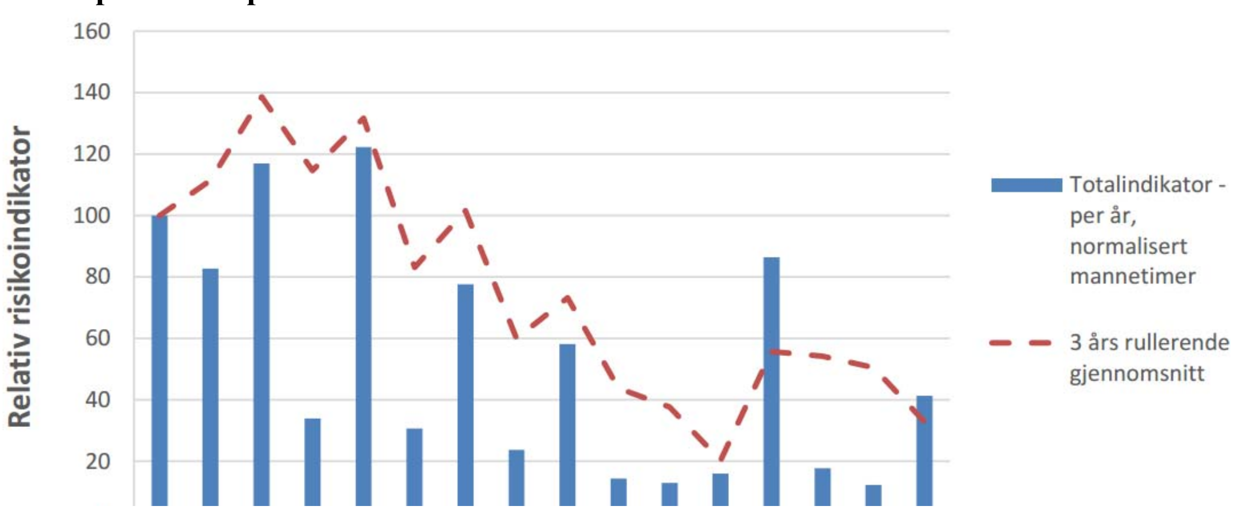


Figure 2 – Overall indicator for major accidents on the NCS

This thesis intends to compare Eni Norge risk management process along with its underlying governing documents, and the Norwegian HSE regulations in order to identify potential gaps and recommend improvement areas to address the potential gaps. In doing so, the following questions should be raised to be replied:

- What is risk management in the view of Eni Norge?
- Is Eni Norge risk management process well designed in accordance with Norwegian regulations?
- Is Eni Norge risk management process well implemented in Goliat operations?

The comparison has been limited to the frameworks concerning the offshore petroleum industry, thus specific requirements for onshore facilities have not been included. Moreover, the HSE risks in design and development phase have not been included in this thesis.

1.2 Terminology

ALARP: (As Low as Reasonable Practicable) expresses that the risk level has been reduced (and documented) to a level where no further measures for risk reduction may be identified, except for those where the cost is grossly disproportionate to the benefits.

BAT: Best Available Technique, that means the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and where that is not practicable, to reduce emissions and the impact on the environment as a whole.

Barrier: Technical, operational and organisational elements which are intended individually or collectively to reduce possibility for a specific error, hazard or accident to occur, or which limit its harm/disadvantages (PSA 2010a).

Black Swan: Surprising extreme event so called as black swan that can be defined as (Aven 2013a):

- A surprising extreme event relative to expected occurrence rate
- An extreme known event with a very low probability
- A surprising extreme event in situation with large uncertainties (unknown known)
- A surprising extreme event entirely unknown to scientific community (unknown unknown)

Defied Hazard Situation of Accidents (DHSA): defined situation of hazard and accident identified by QRA and other relevant studies, that can have major accident potential to personnel or environment, or can impair main safety functions of Goliat FPSO.

Deming Cycle: Known also as The PDCA cycle, is a systematic series of 4-step model for gaining valuable learning and knowledge for the continual improvement of a product or process through plan, do check and review steps.

ENIMS: Eni Norge Integrated Management System is the Eni Norge regulatory system for direction, coordination and control of its own functions.

Governing Document: Eni Norge documentation, available in any form or type of medium, included in the four levels of hierarchy. Governing documents are of mandatory compliance.

Major Accident: A major accident is defined as an acute incident, such as a major discharge / emission or a fire / explosion, which immediately or subsequently causes several serious injuries and / or loss of human life, serious harm to the environment, and / or loss of substantial material assets. Specific areas where the probability of major accidents is the greatest are (PSA 2016b):

1. Hydrocarbon leaks
2. Serious well incidents
3. Damage to load-bearing structures and maritime systems
4. Ships on collision course

MSG: Eni SpA management system is governed by series of process-based documents called MSG (Management System Guidelines).

Performance Requirements: Verifiable requirements related to barrier element properties, to ensure that the barrier is effective. They can include such aspects as capacity, functionality, effectiveness, integrity, reliability, availability, ability to withstand loads, robustness, expertise and mobilisation time.

Process Manager: An individual, appointed by the Eni Norge Managing Director, who is responsible for the suitability of design and implementation of relevant process and its governing documents.

Risk: can be described as the combination of plausible future incidents, their consequences of an activity with the associated uncertainty.

Risk Categorization Matrix: A matrix of severity of risk against its consequences that is used by Eni Norge for all qualitative risk analysis carried out, including risk in projects and operation activities and alert notification, registration for actual and potential consequences of HSE incidents.

Risk Criteria: Risk criteria are the standards used to translate numerical risk estimates (e.g. 10-7 per year) into value judgments (e.g. “negligible risk”), which can be set against other value judgments (e.g. “desirable employment prospects”) in a decision-making process, and presented to justify a decision.

Safety Critical Equipment: Equipment that is critical and required if the barrier is to fulfil its intended function during a hazardous event.

SYNERGI: Software developed by DNV (Det Norske Veritas) for Health and safety management system and incident management.

Winterization: Winterization activities aims to adapt offshore facilities for cold and harsh operating conditions that shall be foreseen during the design and operations in Arctic area, or any other similar area. It ensures that safety critical equipment (detection, notification, isolation, shutdown, etc.) work as intended under all weather conditions

1.3 Methodology

The main intention behind this thesis was to conduct a gap analysis between Eni Norge risk management process and Norwegian HSE regulations. This required an overall understanding of both established terminology and key concepts in risk management principles and framework in petroleum activities in Norway. In that respect, the PSA website, Eni Norge Integrated Management System and Eni Norge Governing Document portal, have been used as the main references. In addition, Eni SpA regulatory system portal has been used for further clarifications. Various literature used in the study program have been utilised, to provide background and basis for discussion in the analysis. Appendix 1 outlines the list of reviewed documents within Eni Norge for the purpose of this thesis.

Moreover, certain individuals were informally interviews on many occasions. Such interviews were casual conversations and one to one discussions with Eni Norge employees, in order to streamline the presented topics with in-depth information and obtain empirical evidence of the practices across Company. In particular, HSE risk management process responsible persons (Safety Manager, HSE Project Manager, Quality Manager) and operations risk management process responsible (Asset Integrity Manager) in order understand the process flows, implementation status and challenges. Also, the topics were discussed with other process users from HSEQ and operations department employees onshore and offshore in order to learn the practice that is being followed and implemented, uncovering where the most valuable Process improvements lie.

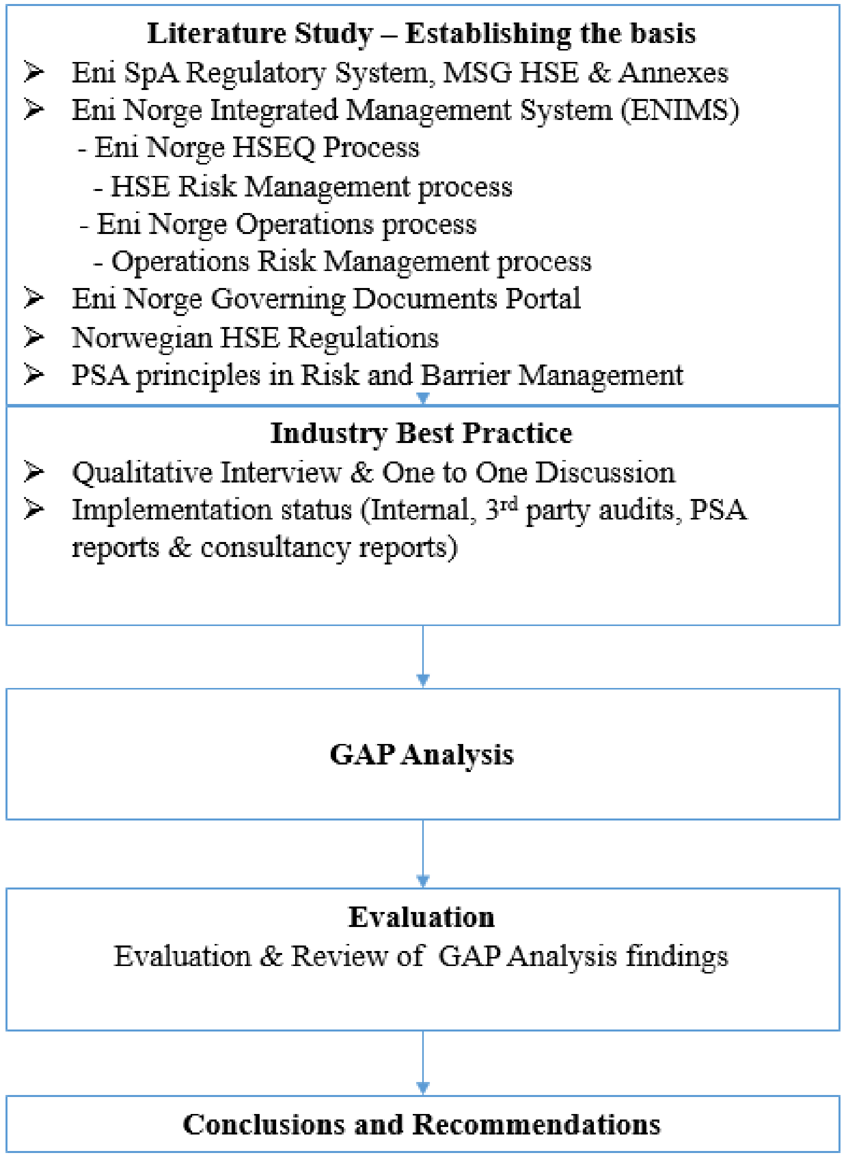


Figure 3 - Methodology Flowchart

1.4 Limitations & Challenges

The major limitation faced in preparing and finalizing this thesis was an ongoing alignment project for Eni Norge Integrated Management System, in order to adopt Eni SpA regulatory system and ensure compliance with Norwegian HSE regulations. In addition, there were some missing process workflows and procedures that were still under construction and / or revision. Furthermore, there were other limiting factors such as:

- Considering the extremely hectic time for Eni Norge during early phase of Goliat operations
- Level of rigidity in a company operating in a difficult situation
- The timeframe available to develop the thesis

These limitations were challenging factors, combined with continuous risk management process and relevant documents that had to be checked and reviewed frequently.

2 Norwegian HSE Regulations

Norwegian HSE regulations have been developed and enhanced over the past decades since its start. During the pioneer years from the mid-1960's, historians have found that the risk of a fatal accident offshore was eight times greater, than in the rest of Norwegian industry (NDP 2016). After Alexander L. Kielland disaster in 1980 when the flotel rig capsized killing 123 persons (Officer of the watch 2016), Norwegian government took the initiative to simplify and enhance the efficiency of petroleum activities operations and importance of being able to establish and maintain a high level of safety with clear regulatory boundaries. NPD initially and later the PSA have led the shift from prescriptive-regulations towards a system of government enforced self-regulations, with risk assessments and principle-based requirements as basic elements (Bang, Thuestad & Kaasen 2014). This opened the path towards more integration and connections between human, technology and organization principle (MTO). This has been achieved by placing emphasis on the significance of tripartite model as such collaboration between employers, unions and government are equally essential. This helped to expend the safety concept openly in a wider supervisory regime for sharing knowledge and expertise. This was consolidated later with introduction of tripartite arenas such as, “The Safety Forum”, “The Regulatory Forum” and “Working Together for Safety” which gave tripartite collaboration greater commitment and wider involvement among all players.

All of this has put Norwegian HSE regulations in a unique position that is essential for progress of HSE, working environment and prudent operations (Hale 2014).

There are five sets of regulations for health, safety and the environment (HSE) in Norway's offshore petroleum sector and at selected petroleum plants on land. These regulations entail risk and performance based HSE requirements for the petroleum industry in an integrated manner. These regulations are as it follows (PSA 2016c):

- The Framework Regulations (apply both offshore and on land)
- The Management Regulations (apply both offshore and on land)

- The Facilities Regulations (apply offshore)
- The Activities Regulations (apply offshore)
- Technical and Operational Regulations (apply on land)

The fundamental HSE regulations are structured around four regulations which shall be read and grasped as one entity (Figure 4). These regulations are in general composed by a set of functional requirements, which indicate what the regulator wish to achieve. The guidelines and interpretations to these regulations need to be complied with, and describe the recommended solution in form of standards (i.e. NORSOK, DNV, OLF, ISO, etc. recognized international or national standards) to meet the requirements however, compliance to standards are not mandatory.

The responsible party is the operator and others participating in operations. The responsible party must ensure compliance with the requirements specified in the HSE legislation. Also Employees must participate in ensuring compliance with the regulations. Norwegian HSE regulations framework is mainly performance based and functional, rather than prescriptive which expresses goal setting requirements and stresses the responsibility resting on the responsible parties for operating companies in an acceptable manner. This is referred to the principle of internal control which as per the PSA view that a regulator cannot "inspect" quality into the Norwegian petroleum sector (PSA 2016d).

It follows up the responsible parties to ensure that they in a systematic and planned way, live up to the expectations given by flexible targets and norms in the framework through constructive collaboration and continuous dialogue.

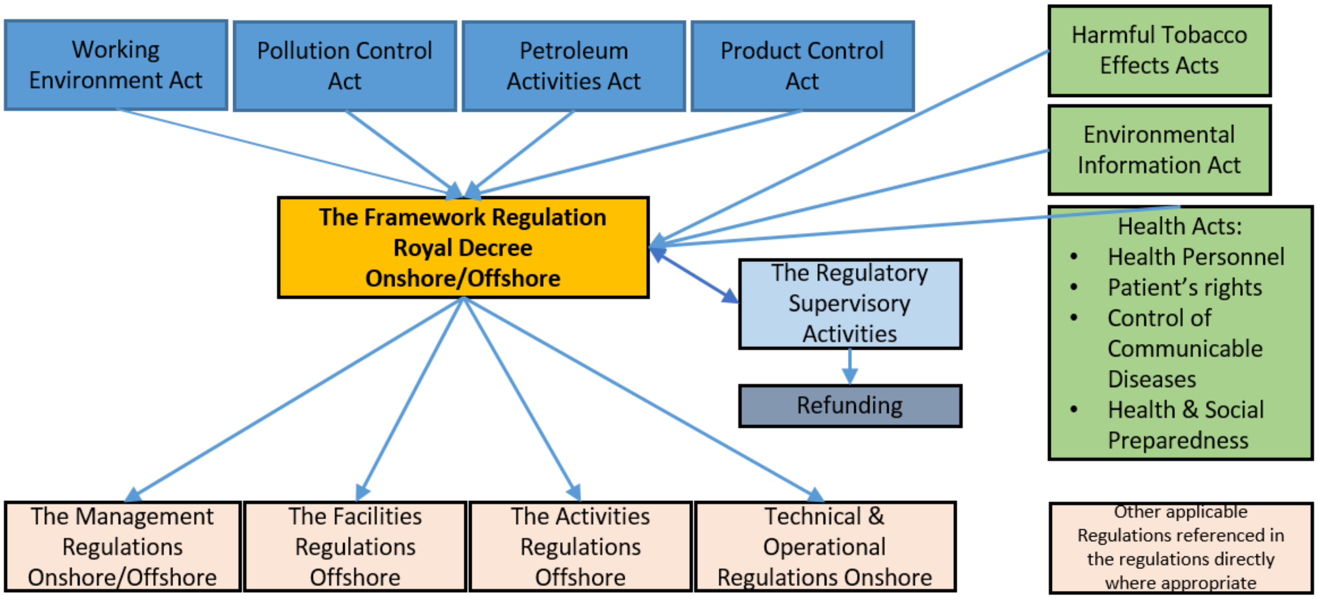


Figure 4 - Primary Norwegian HSE Regulations (www.PSA.no)

Compliance assessment is attained through a process of supervision, which is defined as a combination of audits, verifications, investigations, consents, meetings with industry, surveys, etc. that are carried out by the PSA. The audits are defined as a systematic examination of the management and control systems that the operator has in place. The PSA audits are supported by verifications based on measurements, spot checks, tests and inspections, aimed to ensure that the actual circumstances and practices conform with the regulatory and management system requirements (Ryggvik 2014).

3 Eni Norge

Eni SpA is an Italian multinational Oil and Gas Company headquartered in Rome, Italy. It has operations in over 83 countries with over 80,000 employees, and is currently world's 10th global oil and gas companies based on revenue (132 billion USD in 2015) and 6th largest vertically integrated Oil & Gas Company in the world by market capitalization (Statista 2016). Aside from usual upstream and downstream activities that most of the oil majors engage in, Eni is also a major natural gas and electric utilities Company, and operates in the oilfield services industry, Eni SpA has a geopolitical advantage over many of its competitors, in that it has greater access to the high-yield, though politically risky African and Middle Eastern reserve markets; this can been seen in the distribution of the Company's reserves, as over half of them are concentrated in North and West Africa and the Caspian Sea (Eni 2016).

Eni Norge as an incorporated subsidiary of Eni SpA and a public limited liability Company, started its activity in Norway over 50 years ago since the start of the petroleum activities in Norway, then known as Norsk Agip was founded in 1965 and renamed to Eni Norge in 2003. That same year in 1965, the Company was awarded exploration licenses in area of the North Sea that was later to reveal Norway's first oil field – Ekofisk (Eni Norge 2016). The owner share in Ekofisk positioned Eni SpA among the first wave of participants in the oil and gas industry on the Norwegian Continental Shelf.

Eni Norge was one of the first operators to carry out exploration in the North Sea, the Norwegian Sea and the Barents Sea, and is today an active participant in 56 licenses. Eni Norge is operator in 18 of these (NDP 2016). Eni Norge's participating interests in fields in production include the Ekofisk area in the North Sea, and Heidrun, Norne, Urd, Skuld, Åsgard, Mikkel, Morvin, Kristin and Tyrihans fields in the Norwegian Sea (Eni Norge 2016).

Over the years, Eni Norge has gradually enhanced its skills and expertise in exploring for and producing oil from the Barents Sea, in order to be fully ready to operate its newly built Goliat FPSO. Eni Norge is the operator of Goliat FPSO, that was constructed in South Korea and sailed to Goliat field in Barents Sea in 2015. Eni Norge is in the view that the Barents Sea represents an opportunity for the long-term development of the oil and gas industry in Norway. Goliat FPSO is the first in Barnet Sea which makes its operation for Eni Norge so challenging in such arctic environment with no previous experience. Eni Norge has never been involved in operations in Norway besides Marulk that is comprised of 2 subsea wells and drilling activities.

Eni SpA has an integrated process-based management system with the objective to rationalize and simplify its regulatory system which requires all the subsidiaries to adopt and implement it. Eni SpA management system is governed by a series of process-based governing documents called MSG (Management System Guideline) for every business process. MSG's define for each business process, the guidelines aimed at appropriately managing the process itself and its related risks, also through the implementation of compliance principles. HSEQ process is governed by an MSG and relevant annexes. The organizational model of the HSEQ process operates according to Deming Cycle (Bulsuk 2016) and is structured in different levels of responsibility, starting from Company resources which are closer to the sources of the hazard and are therefore suited to assess their potential impacts and to plan appropriate prevention measures. At the same time, specific HSE structures at a higher level to carry out steering, coordination, support and control activities ensuring the issue and update of guidelines, regulations and best practices, with the aim of continually improving HSE performance. HSEQ process is fundamental for Eni in carrying out its activities, since Eni subsidiaries are allocated within clusters defined on the basis of the HSE risk related to type of activity.

3.1 Goliat FPSO

The demand for energy in the world according to IEA (International Energy Agency) will increase by one third from 2011 to 2035 (IEA 2016). The industry has great interest in the petroleum resources in Arctic areas around the globe. There are only few sources that cite estimates for remaining and undiscovered oil and gas resources throughout the world. Although too optimistic in their view, the estimates prepared by the US Geological Survey indicate that the world's total undiscovered resources are equivalent to 1500 years of the current Norwegian oil and gas production of 4.5 billion barrels a day. It is expected that more than 20 percent of these resources are found north of the Arctic Circle – that is to say, in Arctic and Sub-Arctic areas. This equals nearly 300 years of production from the Norwegian Continental Shelf. More than two-thirds of this volume is probably gas and nearly 85 percent of the resources are expected to be found offshore (Statoil 2010). Therefore, the findings and estimates in the Arctic area seem ever more interesting.

The Goliat field was discovered in 2000 and went on stream in March 2016, with estimated recoverable oil reserves approximately 179 million barrels with 15-year production lifetime (Eni Norge 2016). Goliat field is located in the Barents Sea north west of Hammerfest, at a water depth of about 400 meters. Goliat is the first oil field developed in the Barents Sea, and sets the industry standard as activity moves ever further north. It consists of 8 subsea templates, risers, flow lines, umbilical and 22 wells (12 production, 7 water injector & 3 gas injector). The main stakeholders are Eni Norge with 65% stake as an operator and Statoil with 35% stake. Goliat FPSO is the world's largest and most advanced cylindrical oil platform. It is designed to operate at temperature down to -20 ºC, particularly for environmentally friendly operations as electricity is supplied from onshore. The platform design will lead to new principles for risk management, winterization and accommodate for expected environmental conditions in the Barents Sea. In the design of FPSO maximum efforts were dedicated to tailor it for arctic weather conditions. Goliat FPSO comprises of the following main parts:

- Main steel hull with a storage capacity of 950 000 barrels of oil
- Spread mooring system with 14 mooring lines in 3 directions
- 20 riser / umbilical and 5 cable I-tube slots inside the hull ballast water tanks
- Process Plant capable of producing 100,000 barrels per day
- Flare Tower for safe gas discharge and venting (normally closed not lit flare)
- One hose based crude oil offloading station and associated crude metering
- Utility area with a dual fuel turbine generator set(s) with WHRU
- Shore cable connection for up to 60 MW
- Living quarter for 140 persons (120 beds + 20 turnable beds) with a helideck on top
- Two lifeboat stations with two skid launched free fall lifeboats on each station
- Two offshore cranes (55 tons SWL)

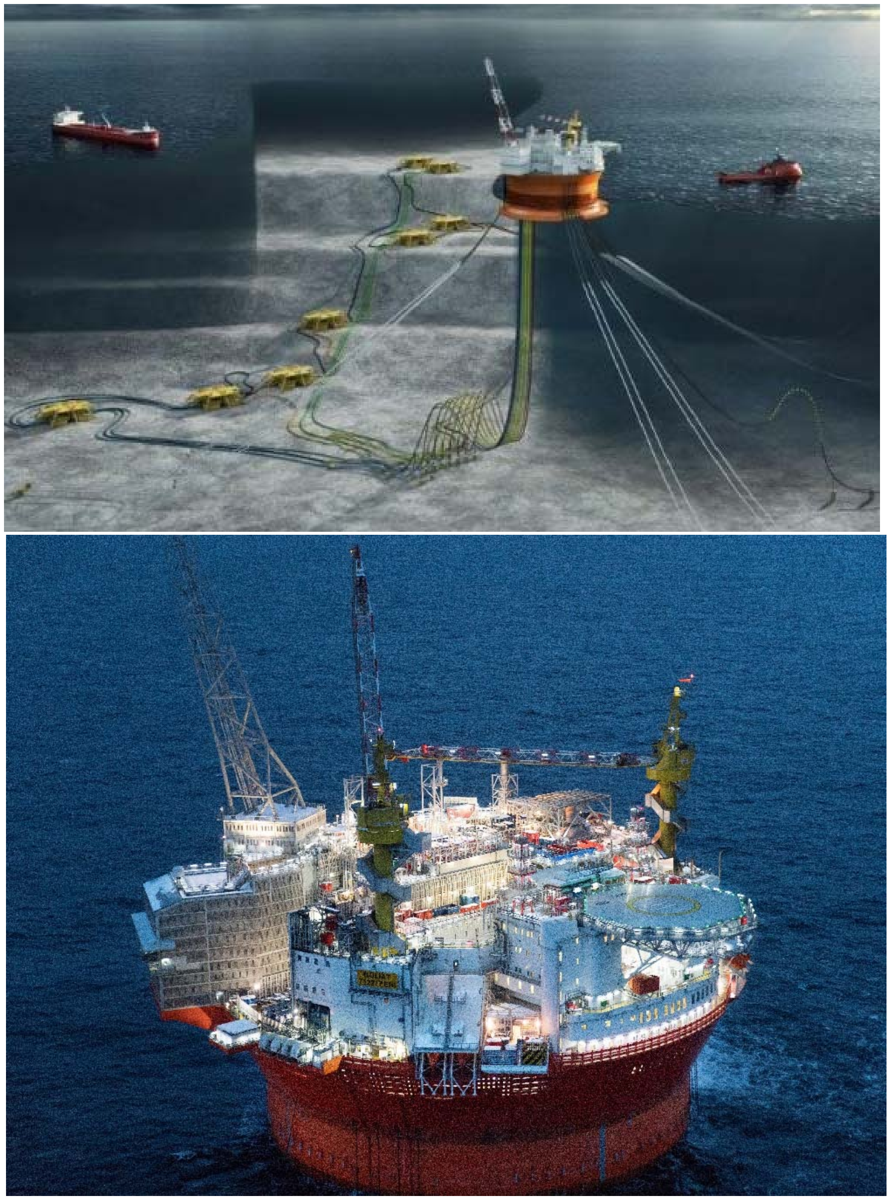


Figure 5 - Goliat FPSO (courtesy of Eirik Helland Urke)

The design life of the topside, utility and process plant, is 20 years, whilst for the steel hull the design life will is 30 years. Goliat FPSO has a full processing facility on board. Stabilized crude oil stored in the cargo tanks is being directly offloaded from the FPSO to shuttle tankers through an offloading system. Goliat FPSO hull is cylindrical and contains 10 cargo tanks, 20 ballast tanks (which have double sides / double bottom, to protect the environment from oil leakage in case of a puncture of the outer hull due to an accidental event), 2 slop tanks, 2 diesel tanks, 4 fresh water tanks and an open drain tank.

Goliat FPSO operates within the arctic region in the Barents Sea and the climatic conditions for this area are therefore cold, harsh and dark. Most of the areas on FPSO are enclosed by winterization walls to ensure personnel and equipment are protected from the cold weather, but still allow sufficient natural ventilation. Also specific winterization requirements are set to system design, equipment design and as discipline requirements that indirectly will influence the overall safety level.

3.2 Eni Norge Integrated Management System (ENIMS)

Eni Norge is obliged to implement Eni SpA regulatory system after conducting a detailed gap analysis to ensure their applicability and compliance with Norwegian laws and regulations. In case, there is a conflict, a request for exemption will be made to Eni SpA.

ENIMS (Eni Norge Integrated Management System) has been designed and developed based on APOS to meet such requirements by Eni Norge around a process-based approach as per Norwegian regulatory requirement (Figure 6).

APOS is the name of method and system that was designed in a project conducted by the Norsk Hydro Produksjon and SoluDyne from 2002 to 2006 with the focus on best practices and working processes, with roles to streamline the management of the business. It provides the user a clear understanding of and participation in what should be done, what requirements exist and what method should be used (The history of APOS 2016).

According to ENIMS the business is process-driven with management support. This is aimed at allowing members of different departments and units within Eni Norge, to collaborate in different processes and contribute in a transversal manner, to reduce duplication of efforts in terms of conduct of their intended business activities and improved risk management.

Eni Norge Integrated Management System has incorporated the requirements laid down by the Norwegian regulations. Table 1 outlines the summary of Norwegian regulations requirements with respect to integrated management system.

Table 1 - Integrated Management System

Regulations to Act relating to petroleum activities	Framework HSE Regulations	Management Regulations - Chapter IV	Eni Norge Integrated Management System (ENIMS)
Chapter 8 Management, System for the petroleum Activities, Section 56 – Management System The main objective of the management system established according to the Act 10-6 in order to ensure compliance the statutory requirements, shall be to contribute to ensuring and furthering the quality of the work carried out in the petroleum activities. The management system shall specify the applicable statutory requirements and shall to the extent necessary include internal requirements to and routines for compliance with statutory requirements. Furthermore the management system shall include internal requirements to and routines for organization, divisions of responsibilities, division of authority in the individual case and between the licenses and other participants in the petroleum activities, competence, resources and work performance in relation to the party establishing the management system according to the first paragraph	**Chapter III Section 17 – Duty to establish, follow up and further develop a management system** The responsible party shall establish, follow up and further develop a management system designed to ensure compliance with requirements in the health, safety and environment legislation. The licensee and owner of an onshore facility shall establish, follow up and further develop a management system to ensure compliance with requirements in the health, safety and environment legislation directed toward licensees and owners of onshore facilities. The employees shall contribute in the establishment, follow-up and further development of management systems.	**Section 12 - Planning** The responsible party shall plan the enterprise's activities in accordance with the stipulated objectives, strategies and requirements so that the plans give due consideration to health, safety and the environment. The resources necessary to carry out the planned activities shall be made available to project and operational organizations. The operator or the party responsible for operating an offshore or onshore facility shall ensure coordination of plans of significance to health, safety and the environment, cf. Section 1 **Management Regulations - Chapter IV Section 13 – Work process** The responsible party shall ensure that the work processes and the resulting products fulfil the requirements related to health, safety and the environment. The interaction between human, technological and organizational factors shall be safeguarded in the work processes. Work processes and associated interfaces of significance to health, safety and the environment shall be described. The level of detail in the description shall be adapted to the importance of the process for health, safety and the environment	Eni Norge integrated management system identifies & adjust the phases, activities, resources information flows and the main controls and statutory/internal requirements that is necessary for proper management of the processes and related risks, their interaction with other business processes in all Eni Norge activities. It disseminates methodologies and criteria in all its activities on/offshore. It also establishes ownership, roles & responsibilities of key functions involved in the process & their required competence. All work processes are supported and detailed when required with operating instructions and procedures. It also facilitates integrated operations efficiently by utilizing new technology and work processes suited for the different operations and tasks. It also ensures all employees contribution and involvement in the establishment, follow-up and revision of management system. It also ensures all company's contribution and involvement in the establishing, follow-up and update of management system.

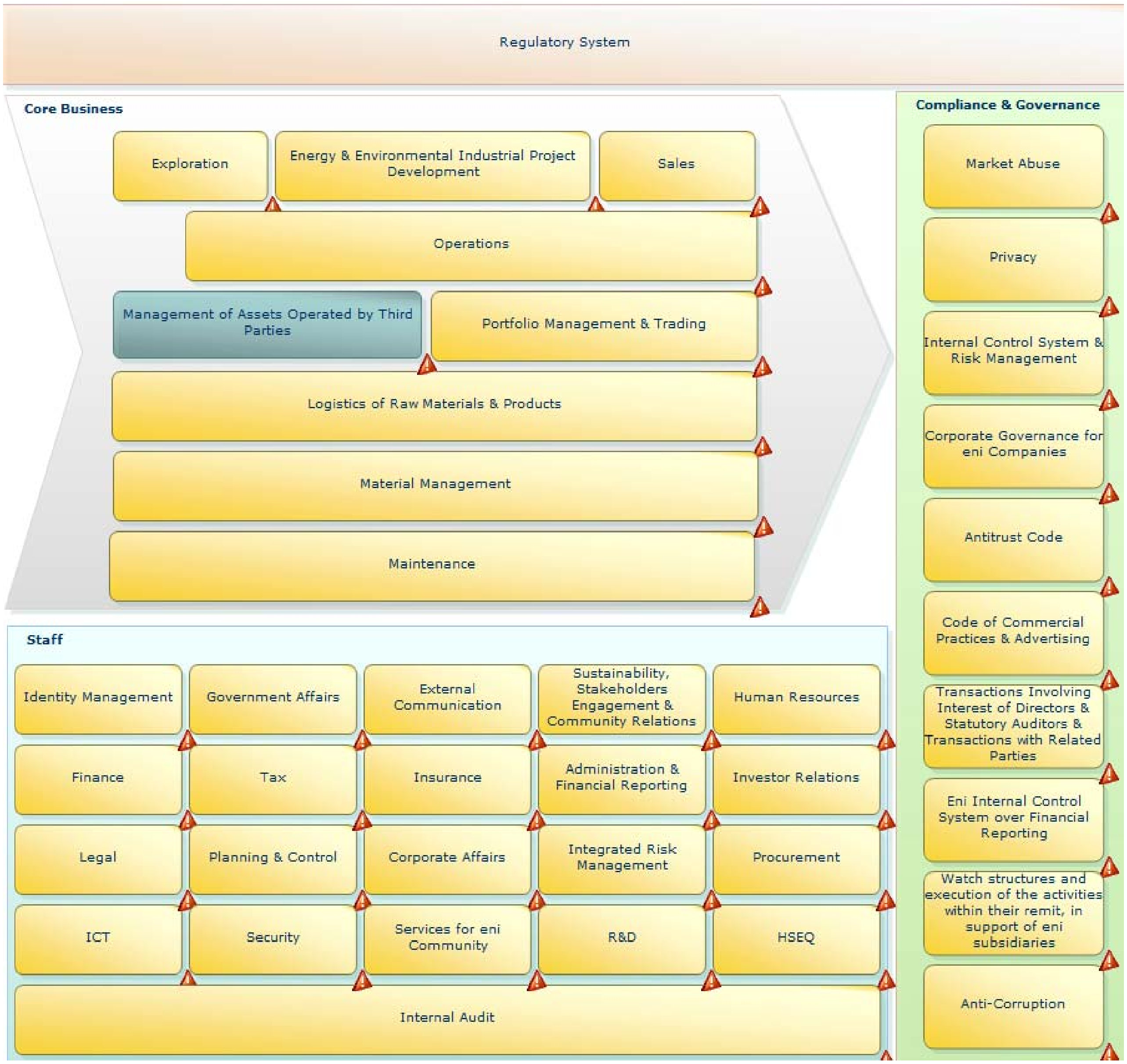


Figure 6 - Eni Norge Integrated Management System (ENIMS)

Eni Norge governing documents are grouped by process and distributed in 4 levels of the architecture of ENIMS, ensuring compliance with Norwegian regulatory requirements, and with the document hierarchy described in Figure 7.

- Policies and MSG's are Eni SpA tools, received and adopted by Eni Norge after a detailed gap analysis carried out by Eni Norge Process Managers, Unions and WEC Representatives.
- Level 3 and 4 documents includes strategies, technical requirements, procedures and operating instructions as regulatory tools specific to Eni Norge.

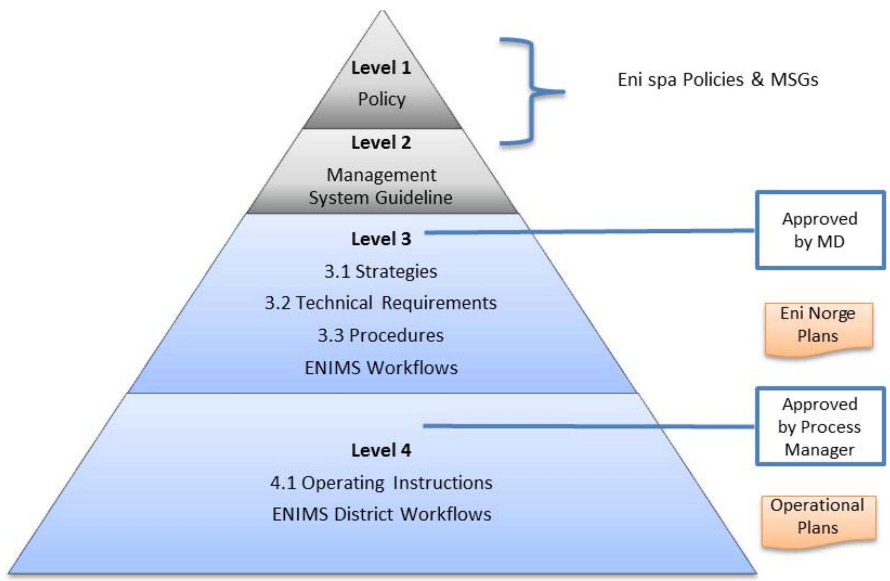


Figure 7 - Eni Norge Governing Structure

3.2.1 Eni Norge HSEQ Prosess

Eni Norge Integrated Management System has a specific process for HSEQ, as illustrated in Figures 8. Goliat operations also has specific HSE workflows, as per Figure 9. Eni Norge has made extensive effort over the previous years prior to start of Goliat operations, to improve HSEQ process in a consistent approach across disciplines, in order to ensure that the business is run and controlled in compliance with Norwegian HSE regulations. Eni Norge HSEQ process provides framework, roles, responsibilities and tools to manage evolving HSEQ issues in conduct of its operations, with main focus on relevant risk and combining diverse evidence for different management areas.

Figure 8 - Eni Norge Base Organization HSEQ Process

Figure 9 - Goliat Operations Process

4 Theoretical Framework

Eni Norge conducts its operations in a relatively centralized manner consisting of various internal and external factors, with various expectations as illustrated in Figure 10. According to IRGC's framework (IRGC 2016), Eni Norge is not alone on managing risk, it is part of an overlapping political and social systems. In order to manage risk, knowledge of decision making in all the systems, their interactions and which one to consider while making decision are required. The role of leadership is tremendously crucial based on realistic and reliable conditions, to ensure prudent operations. With this in mind, MTO perspective has been selected for this thesis, to support and frame the justifications in discussion and conclusion chapters.

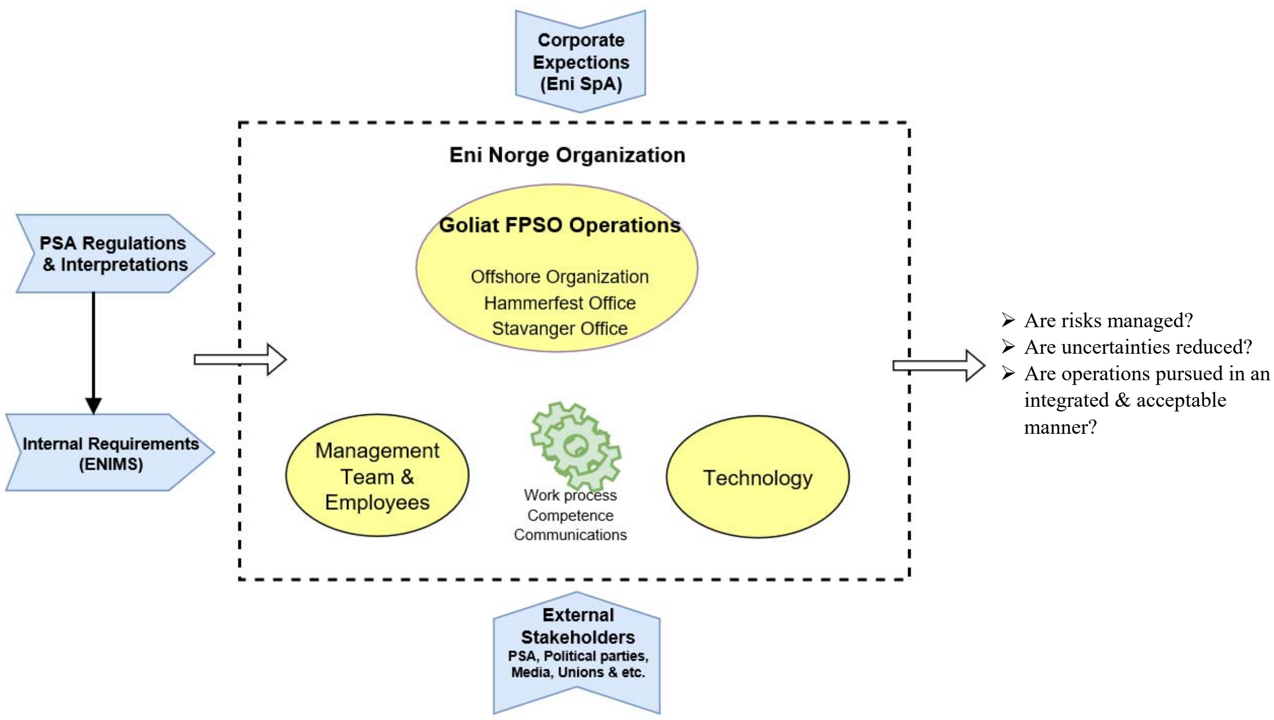


Figure 10 - External & Internal Factors to Eni Norge

4.1 MTO (Man, Technology & Organization perspective)

Human and organizational factors play a key role in the occurrence of accidents. Reason (Reason 1997) provided an excellent illustration of the point, when he demonstrated how latent conditions (organizational and workplace factors) contribute to organizational accidents, in particular, the rare but often catastrophic events that can occur within complex modern technologies. No technical safety system can function without the close involvement of the human and the surrounded organization. Humans are both the cause and the solution as well. As long as human element is not considered to be the most critical component of the socio-technical system, catastrophic events can recur.

Deepwater Horizon accident occurred in the Gulf of Mexico on April 20, 2010. In that accident, failure in well integrity led to a blowout caused by a gas explosion resulting in 11 deaths and 16 injuries, a massive oil spill of 5 million barrels, and billions of dollars of damage. Various investigations after Deepwater revealed that the most significant failure can be traced back to organizational factors and safety culture that failed on account of previous human barrier failures (Report to president 2011 & US Chemical Board Investigation Final Summary Report 2016).

The PSA rightly emphasizes on the significance of understanding of interaction of human, technology and organization correctly as a fundamental element of HSE regulations in petroleum industry (PSA 2016e).

The MTO perspective aims at promoting safety in industrial processes based on an understanding of the interactions and interplay between human, technology and organizational factors to mitigate risk. It also develops a safety culture thinking, that focuses on the entire socio-technical system. The three elements of MTO (Man, Technology and Organization) are like gears turning together to drive an organization towards a risk understanding and managing risk (Figure 11).

Successful risk management is very much dependent on developing systems, methods, tools and safety culture that can identify faults, weaknesses technically, organizationally and the people who use them.

James Reason maintains that culture evolves gradually, based on local conditions, past events, character of leadership, and the dynamics of the workforce (Reason 1998). Developing safety culture is not achievable without a mature organization culture. Organizational culture is the sum of values and rituals, which serve as glue to integrate the member of the organization (Harvard Business Review 2016). Organization culture is rarely static. Tuckman modelled a series of group development that groups go through five key stages in their development; forming, storming, norming, performing and adjourning (Tuckman Theory revisited 2010). These phases are all required and inevitable in order for a group to grow, to face up to challenges, to tackle problems, to find solutions, to plan work, to deliver results. A mature organizational culture can help increase the maturity of safety culture and eventually better risk management.

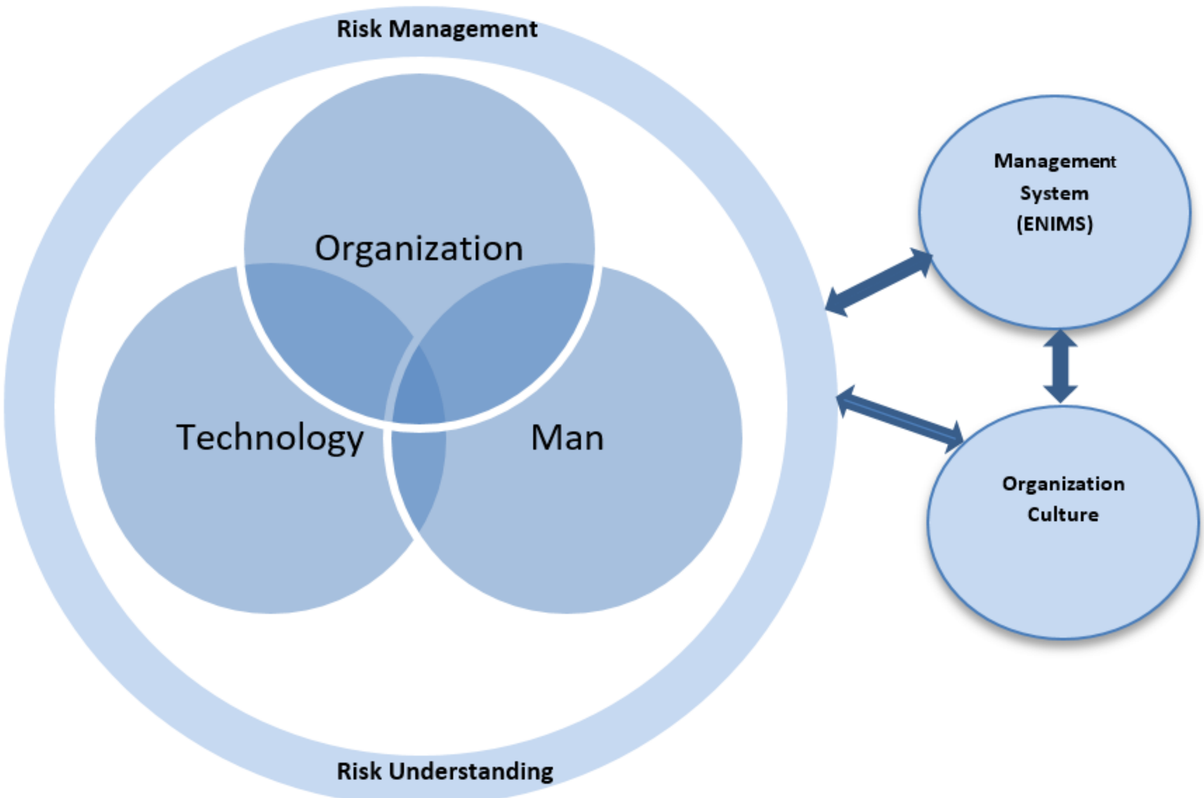


Figure 11 - MTO perspective

5 Industry Best Practice

The risk management process is general and can be applied to all type of risks. However, this thesis focuses on the management of HSE risks during operations. Key aspects of the Norwegian HSE regulations are compared with Eni Norge risk management process in this chapter. This includes underlying standards, guidelines and interpretations to regulations. In addition, certain concepts and definitions are used by the PSA however, they are not mentioned in the regulations, have been taken into account in case of applicability.

5.1 Risk Definition

The basic problem with defining “risk” is that it is used to mean several different things. Some of those uses are very hard to define and often lead to considerable confusion. The English word “risk” has its origin in Latin (riscare) where it meant “to run into danger” or “to dare” (Sutton 2014b).

As per ISO 31000, risk is defined as the "effect of uncertainty on objectives”. The word "effect" may be positive, negative or a deviation from the expected, and that risk is often described by an event, a change in circumstances or a consequence.

In the view of Eni Norge, an HSE risk is associated to the verification of a particular event from which scenarios that are defined as regards probability / frequency of occurrence and as regards consequences for people, assets and the environment follow. This definition is consistent with the established risk perspective and is used largely in risk management standards and frameworks. Eni Norge risk management process considers HSE risks as Company risks, that shall be communicated and escalated to top management. The high level of HSE risks shall be presented to the Managing Director at least every six months and whenever there is a change in the risk profile.

There is no formal definition of risk concept in Norwegian HSE regulations. However, the PSA argues that the traditional way of describing risk is too narrow and limiting, for the ability to understand, administer and manage activities and enterprises. Moreover, certain contexts would require to compare risks, in order to acquire a perspective on their comparative importance in an activity (PSA 2016f).

5.1.1 Risk Acceptance Criteria

Tthe Management Regulations, Section 9, states: “The operator shall set acceptance criteria for major accident risk and environmental risk. Such Acceptance criteria shall be set for:

a) personnel on the offshore or onshore facility as a whole, and for personnel groups exposed to particular risk
b) loss of main safety functions as mentioned in Section 7 of the Facilities Regulations for offshore petroleum activities
c) acute pollution from the offshore or onshore facility
d) damage to third party

The acceptance criteria shall be used when assessing results from risk analyses reference to Section 17 also Section 11 of the Framework Regulations. Moreover, the guidelines following the framework states that these acceptance criteria “shall express and represent an upper limit for what is considered an acceptable risk level”. Additional risk reduction shall always be considered, even if the results of risk analyses or risk assessments indicate a level of risk that is within the acceptance criteria reference to ALARP principle as described in Chapter 5.1.5.

In compliance with Management Regulations Section 9, Eni Norge has defined a set of risk acceptance criteria (RAC) applicable for the company’s activities that are used as the upper limit for acceptable activity as below:

Personnel: The Fatal Accident Rate (FAR) value for personnel as a whole on the facility or activity shall not exceed 5, helicopter transportation included. The FAR value for the most exposed personnel group shall not exceed 15.

Impairing Main Safety Functions: Eni Norge’s risk acceptance criteria relates to loss of any of the five listed main safety functions listed in Facility Regulation Section 7 (Appendix 3), which is more conservative than Norwegian regulatory requirements. The main safety functions shall be available individually and collectively until the installation is evacuated, including search and rescue efforts has been completed. Less frequent than 1 in 10 000 years (Annual frequency < 1·10-4). This time requirement for Goliat FPSO is one hour.

Eni Norge has defined a more conservative risk acceptance criteria related to loss of main safety functions than stipulated in the regulations, reference to impairing main safety functions (loss of any main safety functions shall not exceed the 10^{-4} per year criteria).

Pollution from the facility: The risk acceptance criteria for pollution from the facility, have been developed according to the industry practices on the Norwegian Continental Shelf. The risk acceptance criteria are based on a common understanding throughout the industry for the Norwegian Continental Shelf. The establishment of RAC for pollution is based on the guiding principle that the frequency of harm shall be “insignificant” compared with the consequence of the harm. Insignificant in this context is defined as 5% of the consequences of the harm. This implies that harm to the environment which lasts for instance 0.5 years should only occur every 10th year

(0.5 Years /5%=10 years) for the relevant resource; independent of the Company's activity level. Table 2 illustrates Eni Norge RAC for pollution and damage to the environment.

Generic assessments					Field specific RAC		Facility specific RAC		Activity specific RAC	
Consequence category	Time for Restitution (year)	Average (year)	Regional limit (1 year)	Return period (year)	RAC for pollution	Return period (year)	RAC for pollution	Return period (year)	RAC for pollution	Return period (year)
Minor harm	< 1 year	0,5	1,0 x 10^{-1}	10	2,0 x 10^{-2}	50	1,0 x 10^{-2}	100	1,0 x 10^{-3}	1 000
Moderate harm	1– 3 years	2	2,5 x 10^{-2}	40	5,0 x 10^{-3}	200	2,5 x 10^{-3}	400	2,5 x 10^{-4}	4 000
Significant harm	3 – 10 years	5	1,0 x 10^{-2}	100	2,0 x 10^{-3}	500	1,0 x 10^{-3}	1 000	1,0 x 10^{-4}	10 000
Serious harm	> 10 years	20	2,5 x 10^{-3}	400	5,0 x 10^{-4}	2 000	2,5 x 10^{-4}	4 000	2,5 x 10^{-5}	40 000

Table 2 - Eni Norge Risk Acceptance Criteria for pollution and damage to the environment

RAC for third parties

The risk acceptance criteria for onshore facilities 3rd party risk shall meet the criteria listed below:

Off-site Risk:

Individual (Geographical) Risk

No single residential area or public assembly area off-site should be exposed to fatal exposure levels caused by major accidents at the site of probability greater than 10^{-5} per year. If two or more sites can potentially cause fatalities in the same area, this criterion applies to the combined probability.

Off-site Risk: Societal Risk

The frequency (F) of accidents causing N or more fatalities off-site, should not exceed the value given by the curve in Figure 12 for any N equal to, or larger than 3. The curve (called FN curve) applies to each site, regardless of the number of plants on the site. However, the combined effect of two sites is not to be considered with respect to this criterion.

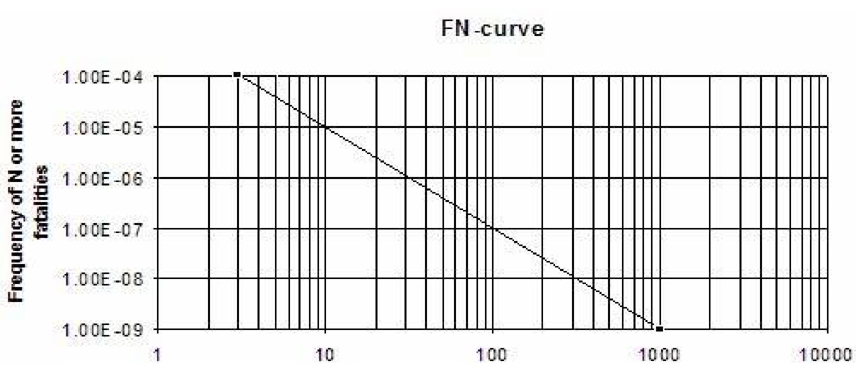


Figure 12 - Social Risk Acceptance Curve

5.1.2 Risk Reduction principles

Framework and Management Regulations identifies risk reduction principles as the foundation for risk management. They require responsible party to select technical, operational and organizational solutions that reduce the likelihood that harm, errors, hazard and accident situations. This includes solutions and barriers that have the greatest risk-reducing effect are chosen, based on individual as well as overall evaluation. Collective protective measures are preferred over protective measures aimed at individuals. According to Framework Regulations, harm or danger of harm to people, the environment or material assets shall be prevented or limited in accordance with the health, safety and environment legislation and internal risk acceptance criteria.

Eni Norge in order to be aligned with Framework and Management Regulation has applied ALARP principle mainly to further reduce the risk to extent possible. Eni Norge risk categorization matrix (Figure 13) describes 3 areas of control level to mitigate risk.

- **Green Area**: The level of risk that requires continuous monitoring to prevent deterioration.
- **Yellow Area**: The level of risk that shall be mandatorily reduced applying suitable corrective measures, provided that is demonstrated that the implementation of such measures is not disproportionate to the benefits (reference to ALARP principle).
- **Red Area**: The level of risk is intolerable and risk reducing measures are required. For operating assets, the risks could be recovered in a maximum one year provided that interim Operational measures are adopted.

Risk reduction principles also refers to best available technology principle (BAT) that is described in Chapter 5.1.6 and Eni Norge has adopted it in risk management process, highlighting that if there are factors that could cause harm or disadvantage to people, environment or asset in its activities shall be replaced by factors that in overall assessment, have less potential for harm or disadvantage.

Eni Norge has established a risk matrix that is used for all qualitative risk analysis carried out within Eni Norge including risk in projects and operation as illustrated in Figure 13 and its explanation sheet in Figure 14. Nevertheless, using the risk matrix requires to distinguish between degrees of uncertainty related to the risk (high, medium and small degree of uncertainty). The consequences of well-known activities have less uncertainty while less familiar activities have greater uncertainty.

Eni Norge Risk management requires a short explanation in using the risk matrix with regards to degree of uncertainty. It recommends taking into account questions such as: What is the uncertainty about, lack of knowledge or information, insufficient understanding, insufficient models, something special with the situations? Is it possible to reduce the uncertainty and should it be reduced?

Appendix 3 summarizes a side by side comparison of the requirements related to risk reduction principles in the Framework and Management Regulations and Eni Norge risk management process.

Consequence							Increasing Frequency →					
							0	A	B	C	D	E
Severity	People	Environment	Asset	Production *(**)*	OPEX *(***)*	Reputation	**Improbable** *Expected to occur more seldom than 1mill years*	**Unlikely** *Expected to occur within 10 000 - 1mill years*	**Rare** *Expected to occur within 1 000 - 10 000 years*	**Credible** *Expected to occur within 10 - 1 000 years*	**Probable** *Likely to occur within 1-10 years*	**Frequent** *Likely to occur once to several times a year*
1	**Slight effect on health/minor injury.** First aid On-site medical treatment In both cases absence from work is limited to the day of the accident.	**Slight Effect** Spill to environment resulting in no or negligible effects on environmental resources.	**Slight Damage** No disruption to operations/business	**Slight Effect:** Insignificant Production Loss.	**Slight Effect:** Insignificant OPEX increase.	**Slight impact:** Known by part of the local population, but did not cause concern.			Continuous improvement			
2	**Minor effect on health Minor injury** < 30 days lost time or restricted work. Reversible health effects.	**Minor effects.** Spill to environment resulting in minor harm (less than one year restitution time) to the environment.	**Minor damage:** Possible short disruption of operation/business. Repair costs < 1 MNOK Production downtime < 1 day	**Minor Effect:** Production loss < 1 day equivalent	**Minor Effect:** OPEX increase 1 - 3% of yearly BDG OPEX	**Minor impact:** Local public and stakeholder concern. Local media coverage.					Risk reduction measures	
3	**Major effect on health Major injury** Multiple LTI. Single LTI with ≥30 days lost time or irreversible effects on health.	**Moderate effects.** Moderate effect on natural resources, with restitution time between 1-3 years.	**Moderate damage:** The unit needs to be repaired/replaced in order to resume operations. Repair cost < 15 MNOK. Production downtime < 1 week.	**Moderate Effect:** Production loss < 1 week equivalent	**Moderate Effect:** OPEX increase 3-7% of yearly BDG OPEX	**Local impact:** Regional public and stakeholder concern. Extensive attention in local media. Slight national interest.						
4	**Permanent Total Disability or 1 fatality.** From incident or occupational exposure .	**Major effects:** Major effect on natural resources, with restitution time between 3-10 years.	**Major damage:** Long time/Major change in order to resume operations. Repair cost < 150 MNOK Production downtime < 3 months.	**Major Effect:** Production loss < 3 months equivalent	**Major Effect:** OPEX increase 7-15% of yearly BDG OPEX	**Major national impact:** National public and stakeholder concern. NGO actions initiated. Possible impact on grant of licences. National lasting damage to Eni Norge's image					Intolerable risk	
5	**Multiple fatalities.** From incident or occupational exposure.	**Extensive effects.** Extensive harm to environmental resources, restitution time more than 10 years.	**Extensive damage:** Total loss of operations. Repair costs > 150 MNOK. Production downtime > 3 months.	**Extensive Effect:** Production loss > 3 months equivalent	**Extensive Effect:** OPEX increase > 15 % of yearly BDG OPEX	**Major international impact:** International public and stakeholder concern. Extensive NGO actions against company. International media coverage. Impact on access to new areas and licences. Potential loss of future national/international business opportunities and / or international lasting						

Figure 13 - Eni Norge Risk Categorization Matrix

Harm to people

1 Slight injury or health effect
o Not affecting work performance or daily life activities
o First aid cases and on-site medical treatment cases
o Exposure to health hazards that give rise to noticeable discomfort, irritation or transient effects reversible after exposure stops
2 Minor injury or health effect
o Medical treatment resulting in less than 30 days lost time or restricted work.
o Reversible health effects
3 Major injury or health effect
o Multiply LTI
o Single LTI with ≥ 30 days lost time
o Irreversible effects on health
4 Permanent Total Disability or One fatality
o Resulting from incident or occupational exposure
5 Multiple fatalities
o Resulting from incident or occupational exposure

Frequency

0 Improbable (Usannsynlig)
Expected to occur less frequently than once in a million years for this operation/activity
Less than 10^{-6} occurrences/year for this operation/activity
Virtually improbable & unrealistic (unforeseen event)

A Unlikely (Lite trolig)
Expected to occur within 10 000 - 1mill years for this operation/activity
Between 10^{-6} - 10^{-4} occurrences/year for this operation/activity
Could happen (or has happened) in exploration and production industry worldwide (risk identified with very low probability)

B Rare (Sjelden)
Expected to occur within 1 000 - 10 000 years for this operation/activity
Between 10^{-4} - 10^{-3} occurrences/year for this operation/activity
Has occurred at least once on the Norwegian Continental Shelf (NCS)

C Credible (Mulig)
Expected to occur within 10 - 1 000 years for this operation/activity
Between 10^{-3} - 10^{-1} occurrences/year for this operation/activity
Has occurred several times on NCS

D Probable (Sannsynlig)
Likely to occur within 1 - 10 years for this operation/activity
Between 10^{-1} - 1 occurrences/year for this operation/activity
Happens several times per year on NCS

E Frequent (Hyppig)
Likely to occur once to several times per year for this operation/activity
Likely to occur several times per year in Eni Norge operations

Asset, Production, OPEX notes

(*) Hazard may cause a damage to the Asset. Prod. Downtime = % Loss of Production * N

(**) Hazard may have an impact on Production. Eq. Days of Prod. Loss = % Loss of Production * N N = number of days with the loss

(***) Hazard may have an impact on OPEX.

If the impact is on more than 1 year, consider the worst impact year in the current 4YP

As for Production and OPEX impacts evaluation, the reference period is the latest 4YP

Harm to assets

1 Slight damage
o No disruption to operations/business
2 Minor damage
o Possible short disruption of operation/business.
o Repair costs < 200,000 USD.
o Production downtime < 1 day..
3 Moderate damage
o The unit needs to be repaired or replaced in order to resume operations.
o Repair cost < 2,5 MUSD.
o Production downtime < 1 week.media.
4 Major damage
o Major change in order to resume operations.
o Repair cost < 25 MUSD.
o Production downtime < 3 months..
5 Extensive damage
o Total loss of operations.
o Repair costs > 25 MUSD.
o Production downtime > 3 months

Environmental Impact

1 Slight Effect
Spill to environment resulting in no or negligible effects on environmental resources.
2 Minor effects
Spill to environment resulting in minor harm (less than one year restitution time) to the environment.
3 Moderate effects
Moderate effect on natural resources, with restitution time between 1-3 years.
4 Major effects
Major effect on natural resources, with restitution time between 3-10 years.
5 Extensive effects
Extensive harm to environmental resources, restitution time more than 10 years.

Oil equivalent calculation scheme Correction factor

Green chemicals 100
Yellow chemicals 10
Crude oil, petroleum products or red chemicals 1
Substance classified according to
Black chemicals 0,1
No environmental classification, ready biodegradable and nonbioaccumulating
100
No environmental classification, while either not ready biodegradable or potentially bioaccumulating
10
Classification R52, R53, R52/53 1
Other chemicals
Classification R50, R50/53, R51/53 0,1
Explanation: Discharge of 100 m3 of green chemicals is the equivalent of 1 m3 of oil, while discharge of 1 m3 black chemicals is the equivalent of 10m3 of oil

Harm to reputation

1 Slight impact
o Known by part of the local population, but did not cause concern
2 Minor impact
o Local public and stakeholder concern.
o Local media coverage.
3 Local impact
o Regional public and stakeholder concern.
o Extensive attention in local media.
o Slight national interest
4 National impact
o National public and stakeholder concern.
o NGO actions initiated.
o Possible impact on grant of licences
o National lasting damage to Eni Norge's image
5 International impact
o International public and stakeholder concern.
o Extensive NGO actions against company.
o International media coverage.
o Impact on access to new areas and licences.
o Potential loss of future national/international business opportunities and / or international lasting damage to eni's image/reputation

Taking into consideration degrees of uncertainty

When using the matrix one should aim to distinguish between degrees of uncertainty related to the identified risk. The consequences of well-known activities have less uncertainty, while less familiar activities have greater uncertainty. Degree of uncertainty should be visible for each identified risk.

- High degree of uncertainty
- Medium degree of uncertainty
- Small degree of uncertainty

High or medium degree of uncertainty requires a short explanation: What is the uncertainty about, lack of knowledge or information, insufficient nderstanding, insufficient models, something special with the situation? Is it possible to reduce the uncertainty, and should it be reduced?

The uncertainty related to the consequences of an activity should hence be visible to decision makers. Greater uncertainty requires increased safety margins, and might also determine whether we are willing to take a certain risk.
-is there sufficient knowledge to take a sound decision?
-how can a sound decision be made considering the uncertainty associated?

Figure 14 - Eni Norge Risk Categorization Matrix Explanation Sheet

5.1.3 ALARP Principle

Framework Regulations Section 9 relating to principles for risk reduction provides guidelines for the companies to establish processes to reduce health, environment and safety risk beyond an estimated minimum level insofar as this is practicable as ALARP (As Low As Practicable) principle. ALARP principle can be characterized as "burden of proof", which means that a measure should be implemented, unless it cannot be demonstrated that there is an unreasonable disparity between costs, disadvantages and benefits (PSA 2016g).

Eni Norge risk management process has incorporated ALARP principle during project phase and operations in line with Framework Regulation Section 9. Eni Norge ALARP principle requires the risk for harm to personnel, environment and loss of material/economical values has to be reduced as far as reasonably practicable, independently of risk acceptance criterial through hazard / risk identification, risk characterization qualitatively or quantitatively and selection of optimal solutions. This is characterised by a clear understanding of what decision process relates to (choice of concepts, equipment and systems) and the knowledge of framework condition of the decision process in a traceable manner.

Eni Norge ALARP principle tries to provide risk management process a greater confidence in order to make the right decisions regardless of solutions, measures and means. It further requires to identify and evaluate risk reducing measures by use of applicable tools (i.e. HAZID, design reviews, consideration of design alternatives, QRA studies, EPA studies & Working Environment studies) and make decision in a traceable and documented manner. It also requires EPC contracts to implement ALARP principle. Any risk reduction measures with a positive overall HSE benefit should be implemented if the cost does not exceed cost limit defined by the project or operating unit. When this is applied for the risk to personnel aspect, all risk reduction measures shall be implemented unless cost per statistical life saved is in gross disproportion to the benefit (i.e. the statistical life saved otherwise shall be considered according to the ALARP principle, for ICAF (Implied Costs of Averting a statistical Fatality) values as per Table 3).

Appendix 3 outlines ALARP recommended decision criteria for the risk to personnel, asset and environment during development and modification phases.

Implied Costs of Averting a statistical Fatality (in NOK)	Assessment
0	**Highly effective**; always implement
100,000	**Effective**; always implement
1,000,000	**Effective**; implement unless individual risk is negligible
10,000,000	**Consider**; effective if individual risk levels are high
100,000,000	**Consider** at high individual risk levels or when there are other benefits
1,000,000,000	**Not socially effective – look at other options**

Table 3 - Eni Norge ICAF Values & Proposed Ass. used for ALARP application of Risk to Asset

5.1.4 BAT principle

Framework and Management Regulations require that the responsible party shall choose the technical, operational, or organizational solutions that offer the best results and ensure continuous improvement. Results from risk assessment shall be applied further in new BAT (Best Available Technique) assessments and potential measure to reduce the environmental risk such as produced water and emissions in particular during development phases.

Eni Norge in reducing the risk requires to choose the technical, operational or organizational solutions that, according to an individual and overall evaluation of the potential harm and present and future use, offer the best results provided the costs are not significantly disproportionate to the risk reduction achieved. If there is insufficient knowledge concerning the effects that the use of technical, operational or organizational solutions can have on health, safety or the environment, solutions as a precautionary principle that will reduce this uncertainty, shall be chosen. This is also incurred in Eni Norge risk reduction principle highlighting that if there are factors that could cause harm or disadvantage to people, environment or asset in its activities shall be replaced by factors that in overall assessment, have less potential for harm or disadvantage reference to Appendix 3 – Risk reduction principles.

5.1.5 Risk Analyses

Management Regulations requires the responsible party to ensure that analyses are carried out in a manner that provide the necessary basis for making decisions to safeguard HSE aspects by utilizing recognized and suitable models, methods and data.

Eni Norge HSE risk management requires that a comprehensive risk analysis shall be carried out throughout all the phases of activities and operating life of an asset demonstrating ALARP principle. It views risk analysis as a systematic approach for describing and / or calculating risk by use of available information to identify hazards and estimate the risk. This involves consideration of the causes and sources of risk, their consequences and likelihood, in addition, taking into account the associated uncertainty in order to avoid a simplified risk picture. Quantitative or qualitative analyses, assessments or comments retailed to this uncertainty, and thereby the risk, must always be viewed in relation to who is conducting the analysis. Uncertainty is somebody's uncertainty about what the consequences will be. The confidence in determining of the level of risk and its sensitivity to preconditions and assumptions, including the degree of uncertainty, should be considered in the analysis, and communicated to the decision maker and other stakeholders. Factors such as different opinions among experts, uncertainty, availability, relevance of information, limitations on modelling also should be stated.

The requirement for risk analysis as per Management Regulations and corresponding ones to Eni Norge risk analysis approach is summarized in Appendix 3. The same appendix shows that the requirements for risk analysis and emergency preparedness analysis follow the same approach.

5.2 Eni Norge Risk Management Process

Eni Norge risk management is governed by the following processes within ENIMS:

a. Operations Risk Management: A sub-process within Operations process aimed to systematically identify, analyse and control risks in terms of asset integrity, production and OPEX impact for asset during operating life of asset.
b. HSE Risk Management: A sub-process within HSEQ process covering all HSE risks from planning to execution of activities including how to establish risk picture and assessment of the potential risk reducing measures.

5.2.1 Operations Risk Management Process

Eni Norge operation risk management process highlights that all development project risks transferred to productions operations, shall involve operations management as soon as the risk has been identified during project development. This includes new risks that will appear, and risks already identified may change over the time in frequency or consequences as per Eni Norge Risk Categorization Matrix (Figure 13). The identified risks are categorized according to risk impact areas. Registered risks are then assigned a risk owner who will plan steps to define the risk control and action plan. These steps shall end with a risk register (RR). Identified risks consequently will be evaluated versus asset level objectives in terms of impact on HSE, asset integrity, production, reputation and OPEX. Probability of occurrence and level of impact can be calculated qualitatively according to Eni Norge Risk Categorization Matrix (Figure 13).

A quantitative risk analysis is normally performed additionally for high risks if needed and risk register gets updated according to the analysis outcomes. Control plan for such evaluated risks are followed, based on risk evaluation and on a cost benefit analysis among four options or combination of them for dealing with risk, which are Avoid, Transfer, Mitigate & Accept. This step results in risk management plan (RMP) defining how risks are managed / controlled, techniques selected and required resources / tools within the asset. It also assigns responsibilities / tasks for managing risks according to the chosen risk control.

Risk management plan will be escalated to the operation level in order to apply the above process at operation level, which ends with an operation risk management plan and risk register. Figure 15 illustrates the Operations risk management process and its steps.

Eni Norge launched the risk management tool in SYNERGI during 2015. This tool is supposed to be utilized for the overall process of identifying, qualifying and mitigating risks in an interactive process. However, this tool has not yet been utilized properly due to lack of clear roles and responsibilities.

Eni Norge has also established the PEEL (Prepare-Execute-Evaluate-Learn) approach based on Deming Cycle for pre-job talks which is a risk-based actions management system aimed at ensuring identifying and managing the risks and hazards linked to Goliat operations, ensuring everyone taking part in the task is also involved in all stages of the PEEL process. Communication, teamwork, and a desire to improve and learn lessons are all key factors. Basically PEEL refers to the following stages in conduct of day to day activities:

Prepare:

- Understand the task and desired end result
- Identify and understand the risks and obstacles
- Comply with requirements and procedures
- Use your own expertise and experience

Execute:

- Execute the task according to plan
- Focus fully to achieve precision
- Take breaks to check for changes
- Revise plans if any changes arise

Evaluate:

- Evaluate the end result
- Evaluate preparation and execution

Learn:

- Learn lessons and share your experiences with others

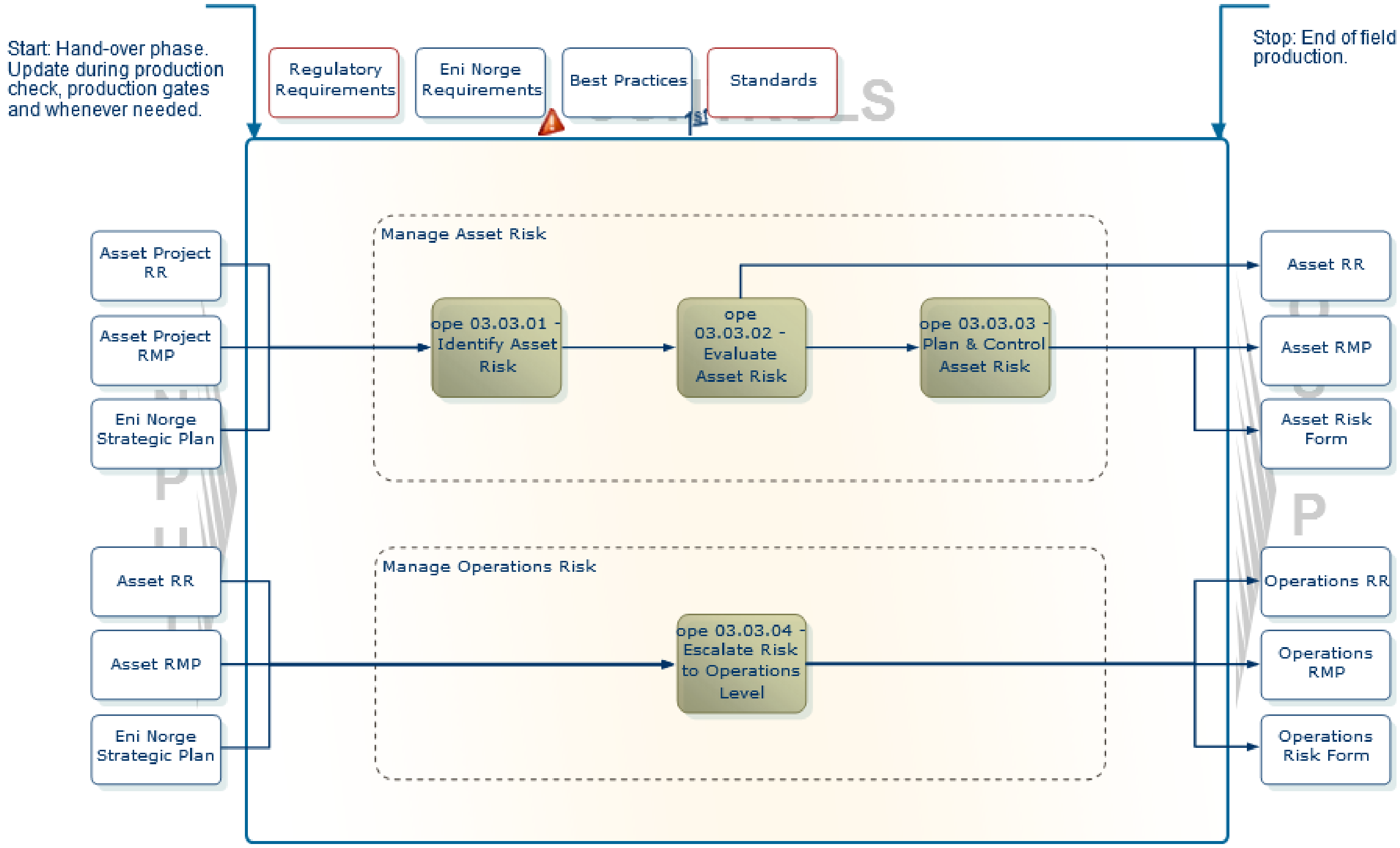


Figure 15 - Operations Risk Management Process

5.2.2 HSE Risk Management Process

Eni Norge HSE risk management has established a generic principle for planning and performing risk assessment, and what assessment shall be taken at which stage in the operating life of asset, as illustrated in Figure 16.

Eni Norge has established generic scope of work as method for the following analysis as applicable within appropriate business processes. Specific scopes are prepared for each analysis with the context of the activity / project being carried out.

- Environmental risk analysis
- QRA / EPA (covering all phases of the petroleum activities)
- Oil Spill related emergency preparedness analysis
- Well specific risk analysis
- Location specific emergency preparedness analysis

- Collision risk analysis
- Legal and Compliance

The process outlines risks from external environment that normally are not under the control of Company, as well as risks from internal environments considered in the risk assessment. This process highlights the significance of communication and consultation with external and internal stockholders, during all stage of the risk management process to ensure all those responsible and accountable for implementing the actions understand the basis for made decisions. The process then requires to establish the context covering all activities carried out and all measures implemented prior to risk assessment process. The context defines system boundaries (i.e. subsystems, components & operations) and objective of the analysis.

Risk and ALARP evaluation is the risk identification and risk evaluation of Eni Norge HSE risk management process as per risk reduction principles. It compares described or calculated risk with specified RAC in order to evaluate if risk is acceptable or no additional risk reducing measures is required, or if a measure should be implemented or not. When all possible measures are considered, the evaluations continue with comparing the risk levels for each solution and the combination of the most significant risk considering total cost, material damage, and loss of operation for the relevant years given a major accident, for scenarios which are relevant to the suggested solutions. It suggests the use of following applicable best practices for Eni Norge:

- Failure Modes, Effects and Criticality Analysis / FMECA
- Fault Tree Analysis
- Even Tree Analysis
- Safe Job Analysis
- Human Reliability Analysis
- Task Analysis

The process begins with a preliminary HAZID (hazard identification includes hazards from hardware, equipment failure, software, systems, human errors, environmental factors, etc.) in order to identify whether or not the source of risk is under control of Eni Norge and potential hazards and accident events that may lead to an accident and rank their severity, possible causes and scenarios with their consequences, required hazard controls and follow-up actions. This is carried out by use of relevant tools, current and background information if feasible. The actual and potential risk analysis of technological system is related to sudden events in practice. The first deviation from "normal" is called accidental event or initiating event. This establishes a risk picture identifying defined situation of hazards and accidents (DSHA) and performance requirements. For instance, Goliat DSHAs are listed in Chapter 5.4.

Such risk picture includes assessment of possible consequences by use of qualitative, quantitative or combination of these depending on the context. Eni Norge Risk Categorization Matrix distinguishes between degree of uncertainty related to the high, medium and small degree of uncertainty. The consequences of well-known activities have less uncertainty, while less familiar activities have greater uncertainty. Once the risk report is completed, reviewed, and agreed by the appropriate parties, then identified risk is communicated to the appropriate risk stakeholders.

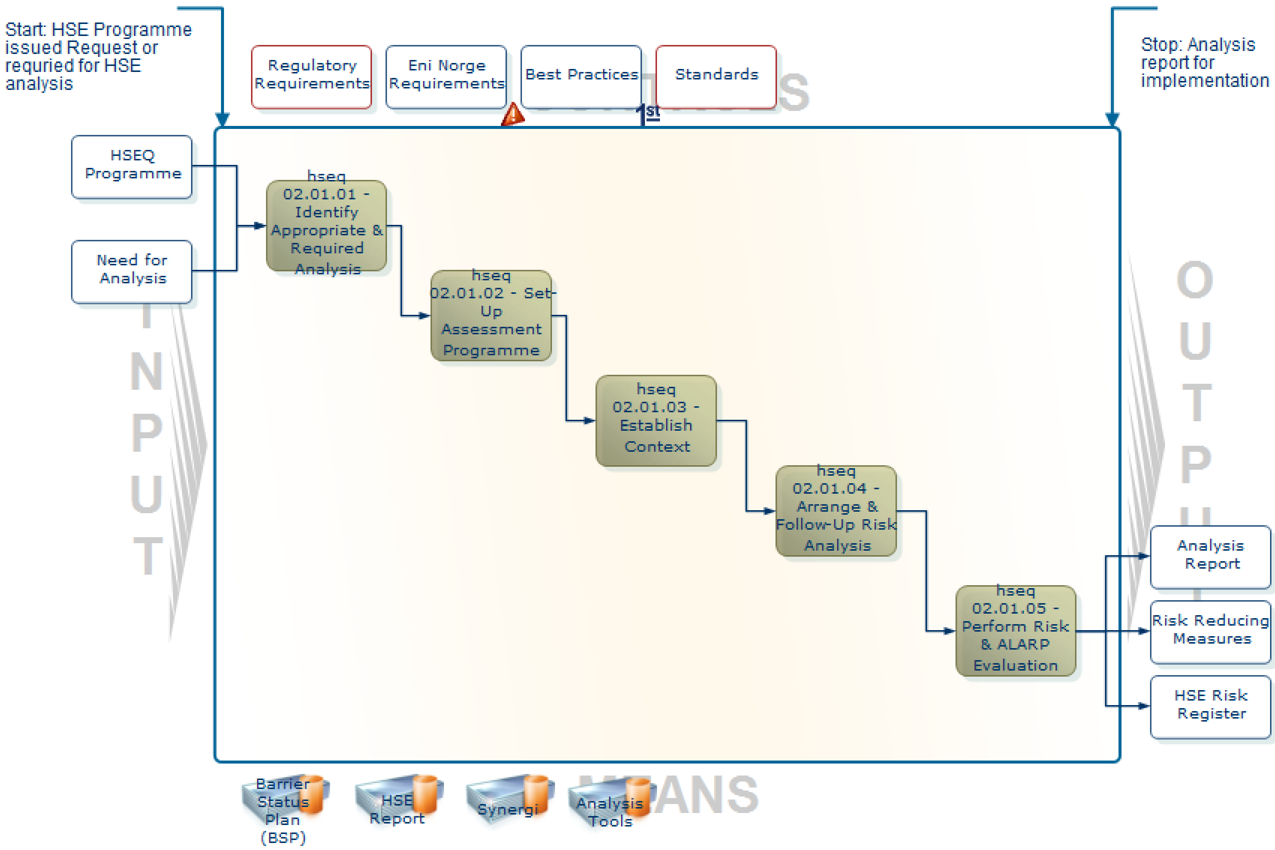


Figure 16 - HSE Risk Management Process

5.3 Barriers and Establishing Barriers

Barrier concept is used largely in oil & gas industry in various contexts with different meanings. Often, there is not a common and unambiguous understanding of the concept.

According to Norwegian regulations, barrier is a technical, operational and organizational element which is intended individually or collectively, to reduce possibility of a specific error, hazard or accident to occur, or which limit its harm and adverse impact on both offshore and land-based installations. Requirements for barrier perspective are embedded in the "energy and barrier" perspective, which demands a separation between hazardous energy and assets such as human life, health, natural environment and material facilities (PSA 2013a). In other words, a barrier is planned measures to regain control, to mitigate development of defined situation of hazard and accident or to mitigate consequences (Figure 17).

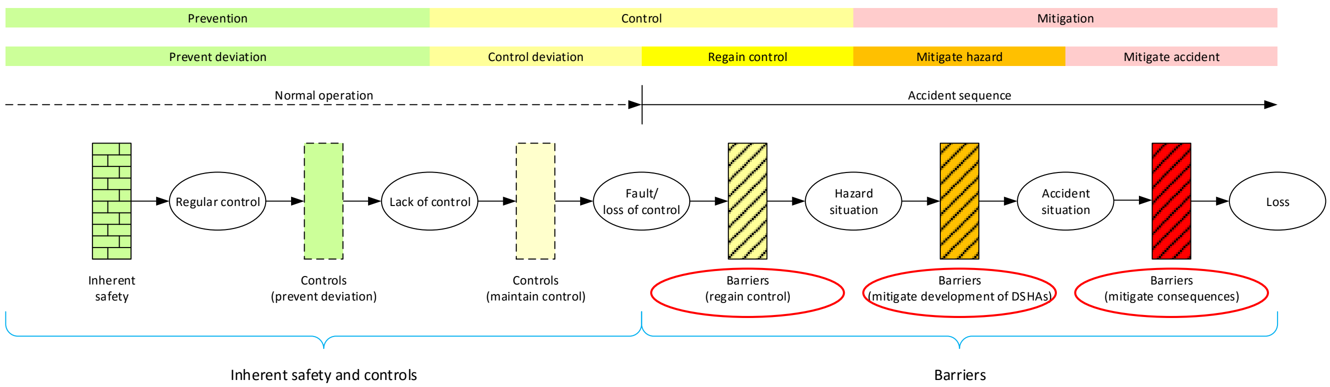


Figure 17 - Barrier Concept

In the view of PSA, barrier management is about ensuring that the various barrier elements possess the requisite properties to provide, in combination, the intended barrier function over time so that risk faced at any time can be handled by preventing an undesirable event from occurring by limiting the consequences should such an incident occur (PSA 2016h). PSA further specifies that personnel, specific equipment and systems are referred to or described not as barriers, but as barrier elements. Thus, performance requirements must be defined for barrier elements (technical, operational and organizational) to realize effectivity of barrier function. Relationship between a barrier and its functions, sub-functions and barrier elements is illustrated in Figures 18 & 19.

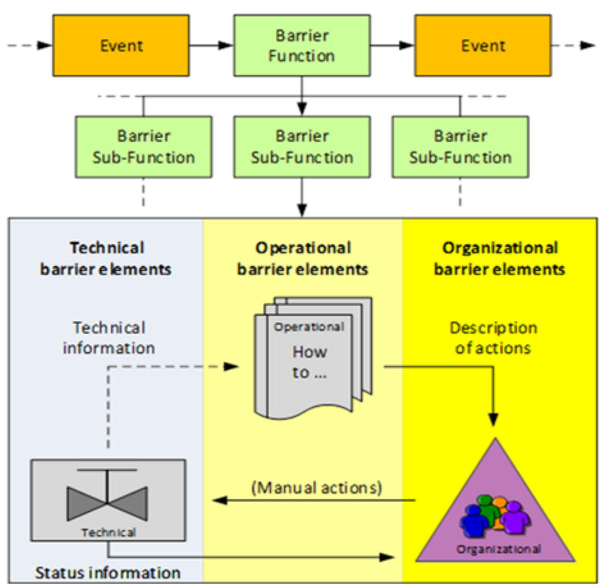


Figure 18 - Barriers

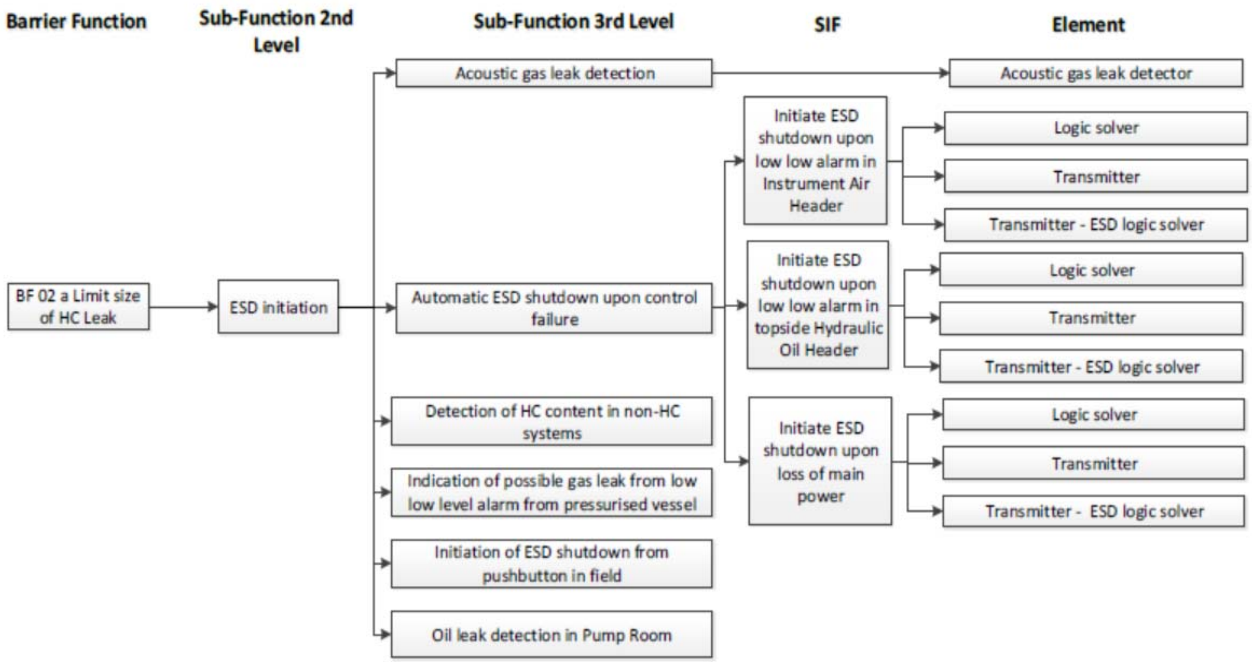


Figure 19 - Relationship between a Barrier and its sub-function with its relevant Barrier elements

As specified in principles for barrier management by PSA in petroleum industry, the main purpose of barrier management is to systematically and continuously ensure that the necessary barriers, and the barrier elements they comprise, are identified and present in order to provide protection in all relevant failure, hazard and accident situations (PSA 2010b).

PSA defines a major accident as; “An acute incident, such as a major discharge / emission or a fire / explosion, which immediately or subsequently causes several serious injuries and / or loss of human life, serious harm to the environment and / or loss of substantial material assets” (PSA 2016i).

Eni Norge has defined the barrier principles and framework in order to be compliance with the Management Regulation Section 5. Eni Norge barriers principles and framework is an integrated part of overall risk management process (Figure 20), referring to the coordinated activities needed in order to establish and maintain controls and barriers, so that they are functional at all times as shown and further described in Goliat operations process as shown Figure 21.

This includes the establishment and maintenance of technical, operational and organizational control and barrier elements that are established to prevent and / or minimize the consequences of Defined Situations of Hazard and Accident (DSHA) with major accident potential. As per Eni Norge Barrier management process, every development project shall identify the list of relevant DSHA’s and barrier established safety and barrier strategy during FEED, relationship between the Defined Situations of Hazard and Accident (DSHA) identified for the facility’s different areas and relevant barrier functions established to prevent, control and mitigate the relevant DSHA's. These shall be revised and updated during detailed engineering through monitoring and verification systems.

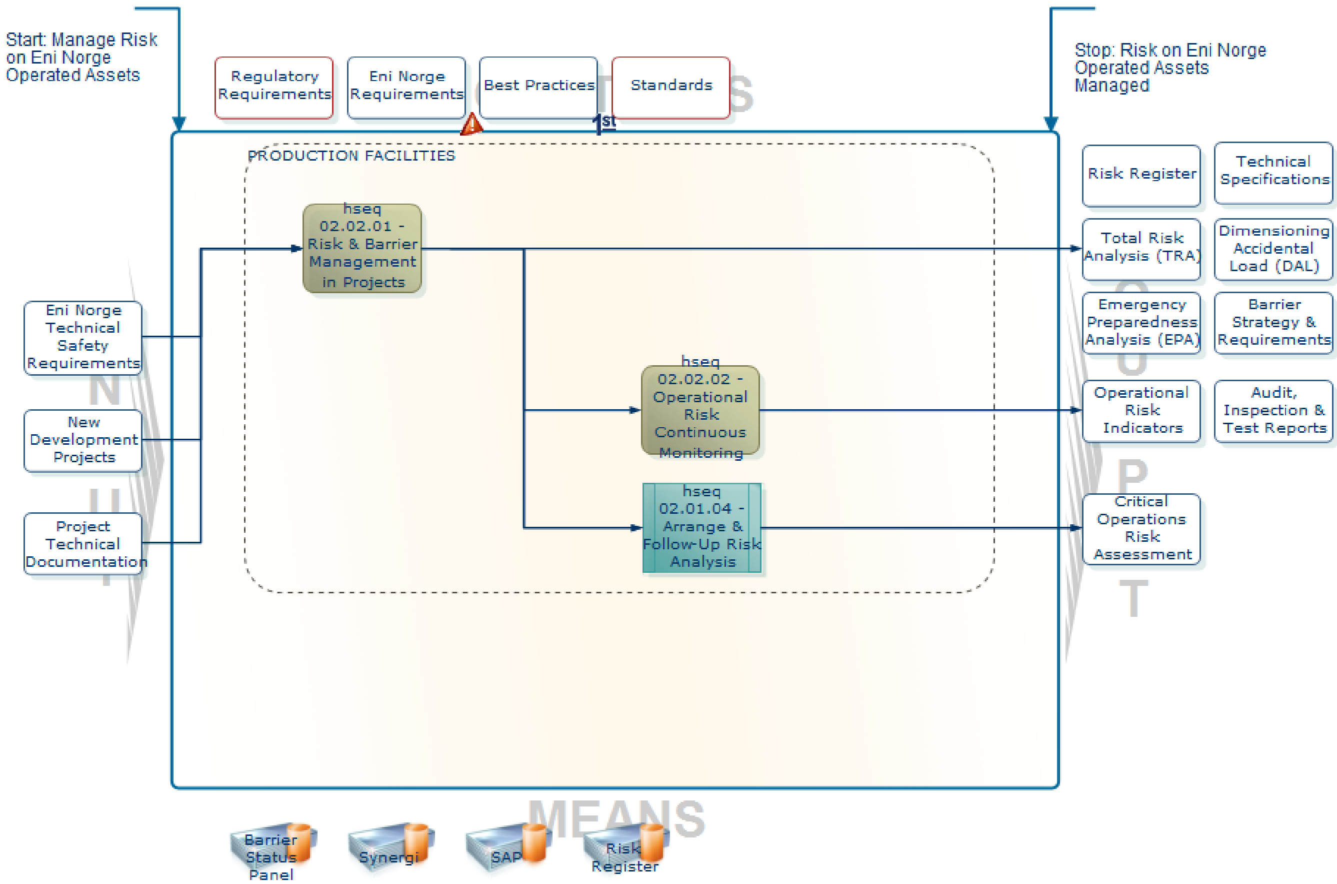


Figure 20 - Eni Norge Barrier Management

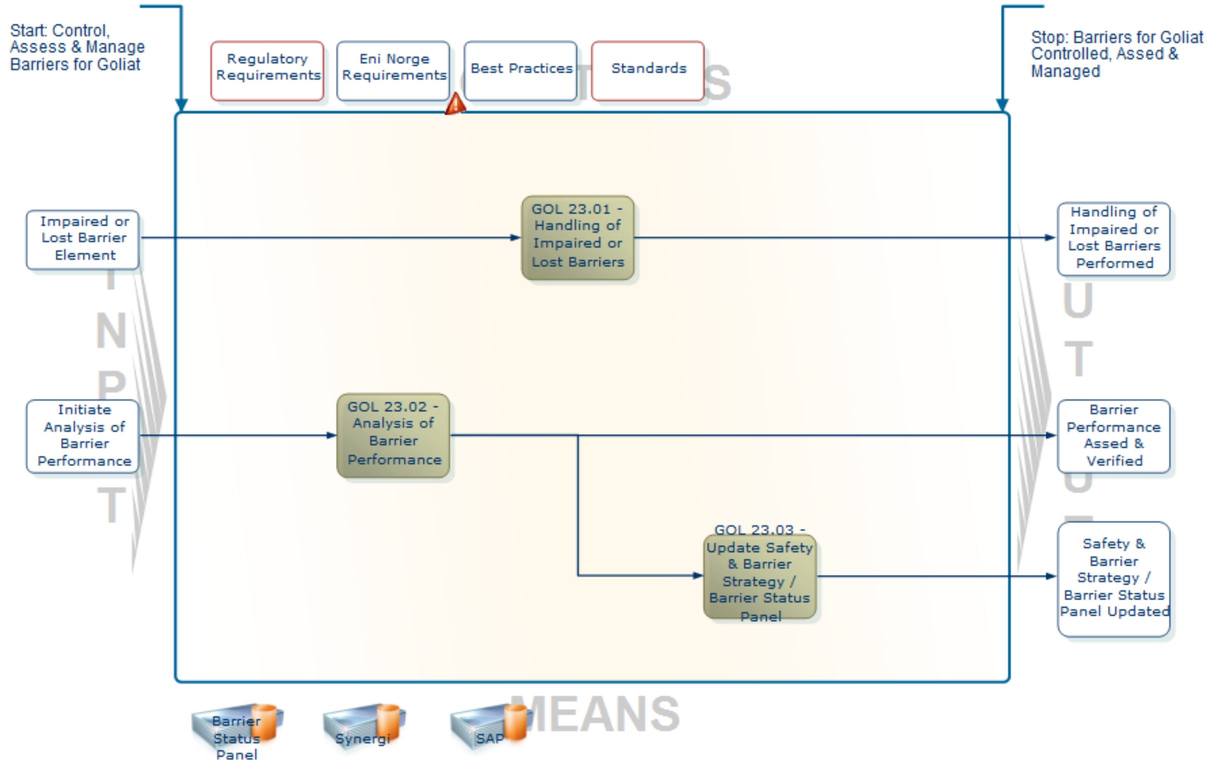


Figure 21 - Barrier Management in Goliat Operations

5.4 Performance Criteria & Barrier Elements

Performance requirements are essential for safe design and following-up safety through barrier management in operations. According to the Management Regulation, Section 5 performance requirements shall be verifiable for barrier elements to ensure that the barrier effectiveness. The performance requirements shall include requirements concerning capacity, functionality, effectiveness, integrity, availability, reliability, load resistance, robustness, expertise and mobilization time.

Eni Norge Barrier principle and framework requires that performance requirements for all technical, operational and organizational barrier elements shall be established. Such performance requirements shall be possible to verify throughout the entire lifetime of the facility on a regular basis. This verification shall, if possible and appropriate, take place at a barrier element or tag level during operations. There shall be monitoring tools, enabling systematic follow-up and verification used actively in operational risk management and decision making. For safety instrumented functions (SIFs) verification should also be performed at a function level. Barrier performance data shall be presented and communicated in a way that provides all relevant roles with adequate information about the conditions of relevant barrier. All significant non-conformities related to barrier performance shall be evaluated in terms of potential consequences for operational decision making and/or initiation of improvements or modifications. In case of permanent technical, operational and organisational modifications, as well as external factors that may significantly influence the performance of the identified barrier functions, the need for updating of the In Service Safety and Barrier strategy and / or performance requirements shall be evaluated. If changes are executed, the barrier monitoring and verification tools also need to be updated accordingly.

5.4.1 Barrier Management in Goliat Operations

Goliat FPSO barrier management is based on the Goliat QRA and provides an overview of all barriers in place to prevent and/or mitigate risk on Goliat FPSO in order to be able to control risk through barrier management in daily operations. It also specifies which barrier functions that require to be present in order to prevent and/or mitigate major accidents risk on Goliat. Barrier Management for Goliat has identified and established the following characteristics:

- Barrier context and area divisions
- Major accident hazards; 18 Goliat FPSO major DHSA's are;
  Hydrocarbon leakage, Fire & Explosion, Acute pollution, dropped objects, Ship on collision course / drifting object, Ship collision, Reduced buoyancy & stability, Loss of position, Helicopter accident at installation, Helicopter accident at sea, Man overboard, Injured personnel, acute illness, Extreme weather, Loss of control with radioactive sources, Terror, threats, criminal act, NGO, Epidemic, Personnel in sea during emergency evacuation, Loss of power (Goliat QRA)
- Barrier functions and sub-functions
- Barrier elements for each barrier (sub)function
- Performance requirements for each barrier element
- Verification activities for the performance requirements of each barrier element

In this regard, all the DSHA's, barrier function, sub-functions, SIF's, control and barrier elements including technical, operational & organizational have been identified. The barrier elements represent the solutions or "materialization" of the sub-functions necessary to realize a barrier function. Technical barriers are made operational and monitored (e.g. how to operate the barrier systems) and organisational responsibility (e.g. who is going to operate the barrier systems; who is authorized to realise a barrier function) are assigned.

Grid technique has been used to show the relationship between identified DSHAs and barrier function for each area. Performance requirements for all barrier and control elements are identified in order to verify their performance during operations. The status of all barriers are monitored and verified through the barrier status panel (BSP) Figure 22 shows a barrier function and its sub-function relationship with its relevant barrier elements as an example.

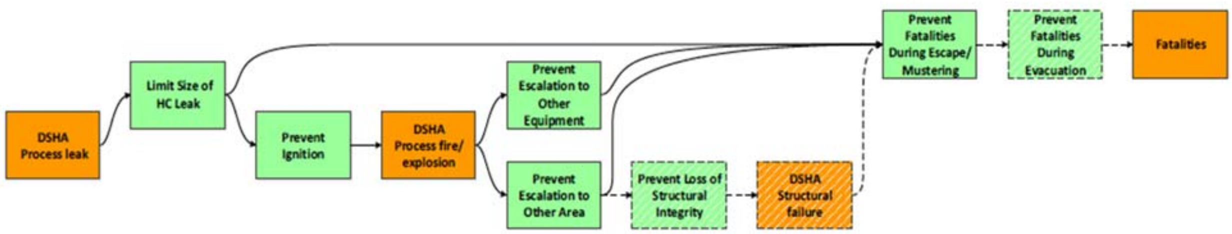


Figure 22 - Relationship between DSHAs and Barrier Functions

Operational and organizational elements in barrier management are related to aspects as it follows: Competency, training and risk-awareness of the personnel performing the identified safety-critical tasks. Deviation status of required courses and training for personnel on-board (from competency matrix). Quality, availability and up-to-dateness of the procedures, other documentation and routines describing the safety critical tasks. Frequency, quality and timeliness of training and drills. Overdue / backlog on the completion of all required trainings and drills according to plans. Quality of the performed safety critical tasks / work (e.g. in the form of adherence to procedures, reporting of deviations, etc.) audit findings, both internal and external. Reported deviations collected from SYNERGI (e.g. related to non-adherence to procedures, inadequate implementation of risk reducing measures, etc.).

Risks are characterized based on how much the accident scenarios (DSHA) contribute to impairment of main safety functions, personnel risk and environment risk (Table 4).

Colour	**Impairment of MSF (portion of risk acceptance criteria)**	**Personnel risk (contribution to total risk)**	**Environmental risk (contribution to total frequency of oil spill)**	**Description**
	> 20 %	> 20 %	> 20 %	Major contribution
	5 – 20 %	5 – 20 %	5 – 20 %	Moderate contribution
	1 – 5 %	1 – 5 %	1 – 5 %	Minor contribution
	< 1 %	< 1 %	< 1 %	Insignificant contribution

Table 4 - Impairment of main safety functions (MSF), personnel risk and environment risk

Eni Norge has established a Barrier Status Panel (BSP) in order to be able to monitor and follow-up the status of all the barrier elements and decision making support tool. Goliat barrier status panel is used for both long and short term planning, in decision making situations, deviation handling and long term follow-up of barriers and controls. Use of the Barrier Status Panel should help to improved risk management and a joint risk awareness/understanding between the offshore and the onshore organizations.

The BSP is based on the "In Service Safety and Barrier Strategy for Goliat FPSO" and shows a health status of all 11,399 tags defined as barrier elements. The health status is based on information from both the ABB Safety and Automation System and from SAP. The following parameters are monitored for each barrier tag:

- **COND (Condition)**
  Fault signal from ABB 800xA indicating alarm on a Condition Monitored system (e.g. from Hart instruments, electro equipment, IT equipment, vibration measurement equipment).
  A condition monitoring alarm = Failure (>=750) will give a red light:
- **DU (Dangerous Undetected)**
  Fault signal from ABB 800xA indicating a safety fault discovered during demand or test. (e.g. Valve not closed as expected).
  Safety fault alarm = failure, will give a red light:
- **FAULTS**
  Miscellaneous faults from ABB 800xA. (e.g. dirty optics, I/O card faults, hardware faults).
  Fault alarm = degraded - will give a yellow light:
- **BLOCK**
  Blockings including Suppress from ABB 800xA.
  Tag manually blocked (i.e. inhibited) or suppressed, will give a red light:
- **CM (Corrective Maintenance [open])**
  Corrective maintenance information from SAP.
  If CM notification open OR overdue, AND priority in SAP= high, then red light:
  If CM notification overdue AND priority in SAP=medium, then yellow light:
- **PM (Preventive Maintenance [overdue])**
  Preventive maintenance information from SAP.
  If PM overdue> 90 days, then red light:
  If 28 days ≤ PM overdue ≤ 90 days, then yellow light

Goliat daily operations requires risk-based decision making on a daily basis. Any decision may have short or long term impact on the risk picture for Goliat FPSO. Monitoring of barriers and safety critical elements on Goliat FPSO are carried out daily through the following means:

- Barrier Status Panel (BSP) is used to navigate and extract information regarding status of the barriers (Figure 24).
- Barrier management tools (such as Area Risk Charts (Figure 23), Barrier Logic Diagrams to support decision-making in daily operation.
- Relevant information from Area Risk Charts (ARC) is extracted to demonstrate an understanding of the implication of this information. Area Risk Charts are summary of risk in specific area from QRA used in PTW, JSA, planning of operations and modifications, assessing the effect of loss of barriers and compensating measures, input to emergency preparedness drills scenarios – Figure 23 is process deck risk area chart as an example.
- Information from Area Risk Charts are combined in order to describe different aspects of a certain risk picture.
- Compensating measures, short and long term deviations generated in the barrier panel.
- Work processes for Handling of Lost or Impaired Barriers & Monitoring, Verification and Evaluation of Barrier Performance as shown in Figure 21.
- PEEL (prepare, execute, evaluate & learn) as described in Chapter 5.2.1

Figure 23 - Goliat FPSO Area Risk Chart for Process Deck Area

Process deck area F10, P10 – P60, EL. 50.000, EL. 60.000 and EL. 69.000

Area overview:

Modules and main equipment:

P10: Production-inlet manifold
P20: Separation module
P30: Gas compression and Fuel gas
P40: Gas re-compression & oil metering
P50: Water and Chemical Injection
P60 & **P70**: Future
Z10: Pipe rack
F10: High and Low Pressure flare and vent system / flare tower
D10: Offloading hose reel

Escape Routes:

Note that it is not possible to escape around the firewall on the west side of the platform. If personnel are located in this corner it is highly recommended to escape down to main deck level.
Escape route network for El. 50.000 shown in figure. Main escape direction is north towards LQ / muster areas via two fire doors through the main fire wall. The stairways access down to the main deck level (EL.44.000) and have H-0 / explosion rated doors when entering down to main deck level. The stairways are not fire or explosion rated internally in the process area.

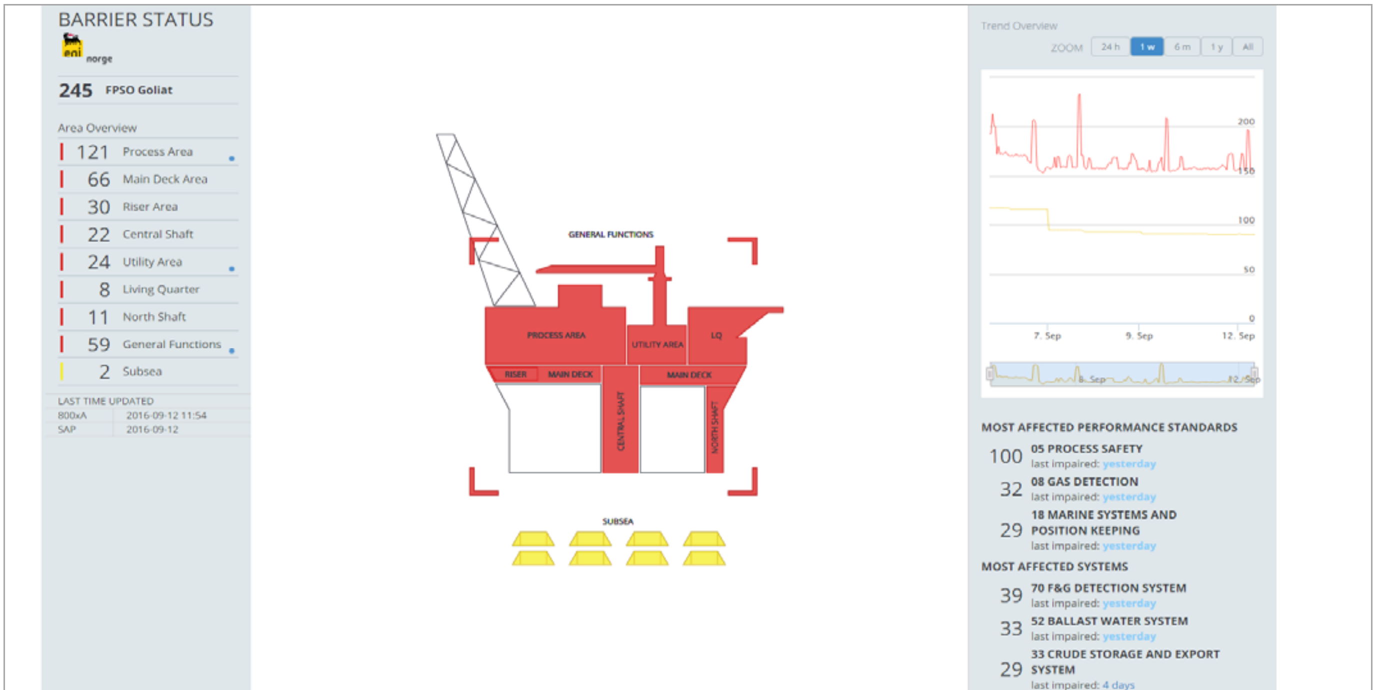
Area risk picture	Defined Situation of Hazard and Accident	Main Safety Function[1]	Personnel Risk	Environmental Risk
	DSHA 1.1: **HC leak process equipment**			
	DSHA 1.3: **HC leak during offloading**			
	DSHA 2.1: **Fire / Explosion due to HC leak**			
	DSHA 04: **Dropped Objects**			
	Overall Risk in Area:			

[1] *MSF (Main Safety Functions; prevent escalation, main load bearing, protection of combat and safe areas & escape routes)*

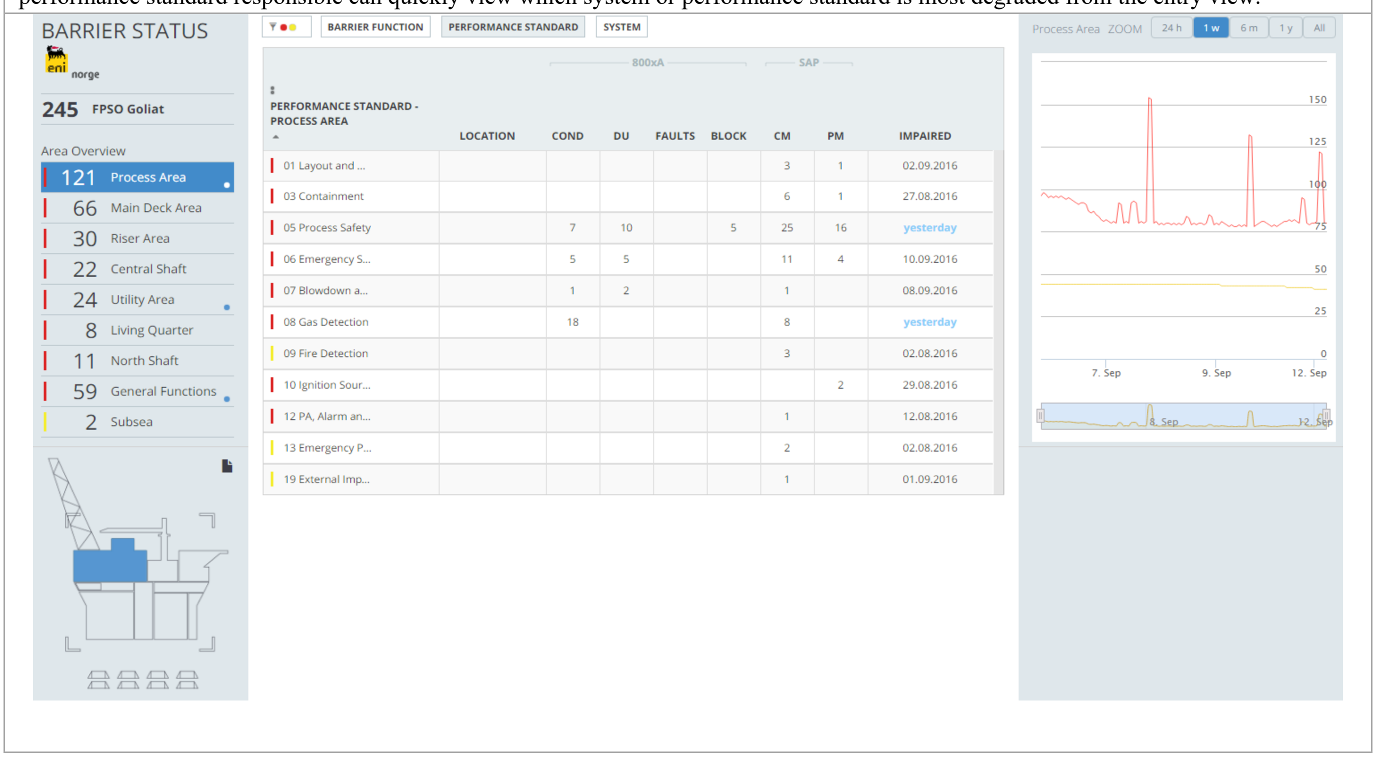
- There is a risk of fires and explosion in the area, the process system has large amounts of hydrocarbon (>400 tons).
- Personnel risk is high due to fires and explosions. Explosions may impact personnel in neighboring areas.
- The following factors increase the explosion risk:
  - weather walls limiting the ventilation and high level of congestion in the area,
  - semi-circular shape of area with fire wall towards utility,
  - large process area where the clouds develop quickly and are slowly ventilated out of the area.
- Low potential for fires and/or explosions hindering escape from other main areas.
- Internal escape from area is critical. Escape from El. 60.000 and El. 69.000 with fires on lower decks might be challenging.
- Smoke from large fires may in unfavorable wind and weather conditions impede the mustering areas.
- Low explosion and fire risk of leaks from offloading line. Major concern is leaks to environment.

Process Risk	Description
Leak frequency	Approximately one leak every other year is expected in this area. A major portion of the leaks are related to intervention and maintenance of equipment, with lower pressures and HC content than normally. 80% of all leaks on the platform occur in this area.
Leak duration gas	The design fire loads durations for large leaks is 10 minutes, and for small leaks it is 30 minutes.
Leak duration liquid	Oil and condensate leaks have potentially long durations (> 60 min), even when the isolation valves are functioning. After the blowdown, the hydrostatic pressure will be the driving force of the leak, and it is this phase with low leak rates that will be prolonged.
Ignition probability	The average ignition probability for all leaks is low (< 1.5 %). Large gas leaks will have a much higher ignition probability (> 5%), as large leaks may develop into large flammable clouds potentially exposing more ignition sources.
Fire consequence	The fires are not likely to escalate out of the area. Smoke and heat radiation exposure to personnel in the area may become fatal. The area is large, and fires at lower levels may expose personnel at higher levels.
Explosion consequence	Explosion loads have the potential to critically damage the fire and explosion walls towards utility, offloading station and process deck. Collapse of the process deck may escalate into a Loss of Main Load Bearing. The development of a large gas cloud is quick, and an explosion within the first minute of the leak is realistic.

Barrier function	Operational Risk Control
HC containment (BF 1a Prevent HC leak)	• Leak prevention during maintenance or operator intervention shall be in focus. Leaks during such operations are major contributors to personnel risk. • After maintenance / operator intervention return system / equipment to safe operation state. • Take notice of changes in the system that may be a sign of reduced technical condition, and investigate further or report to relevant personnel. • Prioritize maintenance on surfaces and CUI to avoid increased leak frequency due to corrosion.
Detection (BF 2a Limit size of HC leak) (BF 3 Prevent Ignition)	• Minimize detector shut-out and inhibit by-pass of gas / fire detectors. • Use of scaffolding shall not block gas or fire detectors. • Follow up any HC leaks or fires that are not detected automatically.
Isolation and depressurization (BF 2a Limit size of HC leak)	• Avoid any actions that may delay or hinder automatic isolation of HC segments upon gas or fire detection. The closing time for ESDV's shall be 1 second per inch, any increase in closing time may result in explosion risks above ENI's accept criteria. Closing time for isolation valves has a significant impact on size of flammable clouds that develop. • Avoid any actions that may delay or hinder automatic depressurization of system. Time to depressurization starts is a critical parameter for effective reduction of gas cloud development and ignition probabilities. It is critical to reduce the pressure in equipment exposed to fire to avoid equipment rupture and consequent escalation of the fire.
Ignition source Control (BF 3 Prevent Ignition)	• Hot work needs to be performed in habitat for the classified area. • Rotating equipment shall be in good technical condition to avoid over-heating. • Ex-rated equipment shall be in good technical condition at all times. Note that such equipment is historically the major contributor to ignition of HC leaks. • No open hot surfaces shall occur. • Do not bring unauthorized equipment into the area that may be an ignition source. • Avoid actions that may delay or hinder automatic isolation of ignition sources. • Consider instantaneous isolation of ignition sources by manual activation upon gas alarm
Prevent escalation (BF 4a Prevent Escalation to Other Equipment) (BF 4b Prevent escalation to other area)	• Keep fire doors closed. • Use of scaffolding or other temporary equipment shall not block gas / flame detectors. • Use of scaffolding or other temporary equipment shall not block or hinder escape. • Do not use temporary weather shields that may reduce the natural ventilation in the area. Poorer ventilation reduces the dispersion and venting out of any flammable gases and increased probability of ignition and explosions may result. • Remove ice / snow that can obstruct ventilation. • Technical condition of Passive Fire Protection shall be good. • Do not introduce equipment / scaffolding or other items that increase the congestion in the area as this may increase the explosion loads. • Do not leave loose or temporary equipment in the area. Smaller equipment (tools, spare parts) can be missiles in an explosion and impact personnel and equipment. Such equipment may also damage process equipment if dropped and cause HC leaks. • Do not block or hinder drainage of spilled liquids. Liquid pools also present an explosion hazard as lighter components will evaporate from the pool.
Lifting activity (BF 4b Prevent escalation to other area)	• No lifts are to be performed above forbidden or restricted areas. • Adhere to the main lifting corridors, as decks below the lifting corridors are more likely to sustain a dropped object. This minimizes the escalation potential. • Do not lift more than four (4) meters above the highest deck to lift over. Excessive lift height increases the likelihood of a dropped object penetrating the impacted deck. • Avoid lifting from temporary laydown areas at high to lower elevations to avoid dropped objects from excessive heights. For instance; for lifts to P40 (south east corner) area, lift directly from supply vessels over P60 area if possible and not from spare storage areas on elevation 76.000. • All lifts shall be containerized and maximum weigh up to 6 tons. For heavy lifts, e.g. such as diesel engines, special procedures apply. • Avoid lifting more than 110 lifts per week, including lifts off the platform (e.g. empty containers). More frequent lifts may result in ENI's accept criteria for escalation not being met.
Manning	• Safe planning and coordination of activities is important to minimize hazardous situations arising. Increased activity and simultaneous operations increases the personnel risk.



The entry view of the barrier status panel is designed to provide users a quick overall overview of the status of barriers and controls on Goliat. The left pane area menu shows aggregated condition for all areas on Goliat, Subsea wells & all global barrier functions. System and performance standard responsible can quickly view which system or performance standard is most degraded from the entry view.



PERFORMANCE STANDARD - PROCESS AREA	LOCATION	COND (800xA)	DU (800xA)	FAULTS (800xA)	BLOCK (800xA)	CM (SAP)	PM (SAP)	IMPAIRED
01 Layout and ...						3	1	02.09.2016
03 Containment						6	1	27.08.2016
05 Process Safety		7	10		5	25	16	yesterday
06 Emergency S...		5	5			11	4	10.09.2016
07 Blowdown a...		1	2			1		08.09.2016
08 Gas Detection		18				8		yesterday
09 Fire Detection						3		02.08.2016
10 Ignition Sour...							2	29.08.2016
12 PA, Alarm an...						1		12.08.2016
13 Emergency P...						2		02.08.2016
19 External Imp...						1		01.09.2016

Figure 24 - Goliat FPSO Barrier Status Panel (BSP)

5.5 Verification & Follow-up

Managing risk cannot be ensured without continuous follow-up and verification activities. Verification and follow-up activities shall monitor and ensure that identified compensating and mitigating measures put in place are robust and effective as intended.

The Framework Regulations, Section 19, states that "The responsible party shall determine the need for and scope of verifications, as well as the verification method and its degree of independence, to document compliance with requirements in the health, safety and environment legislation. When verifications are deemed necessary, they shall be carried out according to a comprehensive and unambiguous verification programme and verification basis. The operator shall establish the verification basis for the overall activities after assessing the scope, method and degree of independence of the verification. The operator shall also carry out an overall assessment of the results of the verifications that have been carried out".

Eni Norge verification & follow-up activities ensures the facility satisfies requirements used for the specific location and method of operations taking into account design, material selection, corrosion protection, integrity, safety and analysis method used. It provides special consideration to the organisation of verification activities in cases which involve a new type of facility, new project execution models or information technology systems. This follow-up will contribute to identify technical, operational or organizational weaknesses, failures and deficiencies. Such activities throughout the hydrocarbon lifecycle of a project consists mainly of the following activities:

a. Supervisory HSEQ Audits:
Audits as management tools and verification activity are planned and carried out to ensure the compliance with Eni Norge requirements and Norwegian HSE regulations. Eni Norge prioritizes them based on risk assessment of its activities, contract criticality, the results of previous audits, the management review's results, the performance of management system against objectives and targets. Eni Norge supervisory audits are planned and carried out annually. They include the following types:

- Internal Audits (focus on HSE topics i.e. health & working environment management, chemical management, PTW, lifting operations & process safety & etc.)
- 2nd Party Audits (contractors and suppliers i.e. contractors in charge of maintenance & modifications)
- 3rd Party Audit (annual assessments by certifying bodies to maintain ISO 14001 and OHSAS 18001 certificates)
- Compliance Audits (verify compliance of ENIMS with Norwegian regulations and internal requirements)

- Technical Audits (verify technical safety i.e. barrier management, emergency organization, offloading, electrical installations, maintenance management, etc.)
- Technical Audits are normally carried out jointly by HSEQ and technical departments.
- Process Safety Audits (verify integrity of process safety system)
- Eni SpA Audits (audits by Eni SpA every second year to verify compliance with Eni SpA regulatory system and Norwegian regulations)
- Inspections (risk based approach inspection and condition to verify technical and operational integrity of the facilities)

b. Statistics, Trends Evaluation & Analysis:

All the data and performance indicators are reviewed and evaluated in order to determine whether there are type of incidents, work processes, activities, systems, equipment, causes of incidents, etc. that require special attention. This also can identify hazards/risk which are not reflected in the KPI´s. The trend evaluation indicates areas which should be analysed in a greater depth. Methods used are MTO, human factors, interviews, surveys, workshops, and data modelling. Some ways of approaching the analysis work include using methods such as analysis of the events leading up to the incident, causal analysis, barrier analysis, organisational analysis, mitigation analysis, etc. For instance, analysis of technical barriers considers causes, equipment and system as well as data from verification activities and maintenance database (e.g. registered non-conformities of critical barriers failures in connection with the testing of equipment). In doing so, Goliat barrier status panel (BSP) are checked for such analysis and follow-up.

Eni Norge verification and follow-up requirements are mainly defined in relation topics where applicable. For instance, follow-up and verification of notifications and work orders for maintenance activities are performed at least once a year, by those who are organizationally independent to the auditee department / unit.

Eni Norge verification and inspection throughout the project development phases are verification plans, considering the criticality of the activities. This includes but may not necessarily be limited to:

- Audits and assurance reviews
- Verification assuring design and technical integrity
- Verification of technology qualifications
- Inspection and test

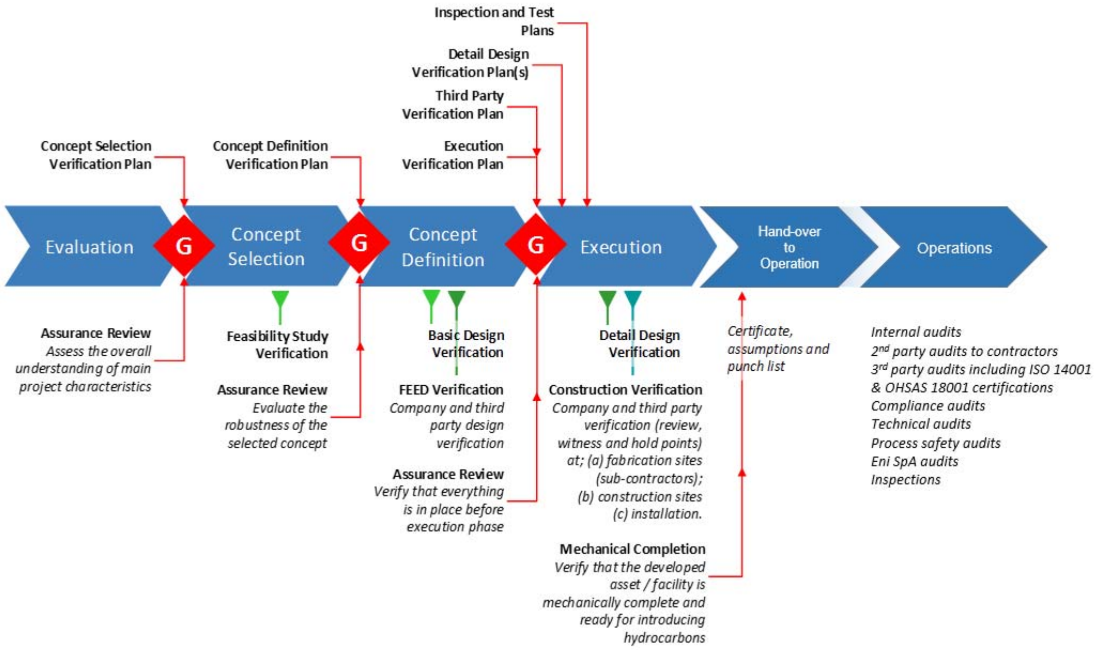


Figure 25 – Eni Norge indication of verification activities throughout hydrocarbon lifecycle of a project

6 Discussion

The purpose of this thesis is to compare Eni Norge risk management process and its underlying governing documents, with the Norwegian HSE Regulations, in order to identify potential gaps and recommend improvement areas to address these potential gaps. This chapter, identified gaps, and focus areas are further assessed, in order to reply the raised questions in thesis scope with regards to the comparisons, consultant's reports, internal & external audit findings and one to one interviews with Eni Norge staff.

6.1 Risk Culture

Eni Norge as an operating Company in Norway operates within a multi-cultural environment. Norwegian and Italian business cultures are not similar. This becomes distinctly prominent when it comes to risk culture. According to the PSA, a sound HSE culture can be observed in enterprises which facilitate continuous, critical and thorough efforts to improve HSE (PSA 2014a). Culture is not an individual quality, it develops through interaction between people and specified pattern of behaviours.

It seems reasonable to assume that people attitude to risk will vary according to deeply held values, beliefs and assumptions that is the foundation of natural cultural differences (Rondmo 2014).

Cultural perspectives are interrelated and integrated as part of risk management. Risk culture in an organization describes values, knowledge and perception about risk shared by employees with a common purpose. The prevailing risk culture within a Company can make it significantly better or worse at managing these risks.

Companies that underestimate such fact might experience costly failures and reputational issues. As a result of this certain individuals or units / team within a Company ignores, overlooks or does not see what is going on. There have been several articles in Norwegian media over the last years indicating how foreign companies ran into serious issues due to lack of Norwegian work culture understanding and poor cross cultural competence (Granli 2012).

In spite of significant measures, improvement, development of processes and procedures for managing the risk within Eni Norge, it is fair to say that there is not a unified perception of risk perspective across various units and departments within Eni Norge.

Findings from internal investigations, PSA audits and review of HSE statistics can also support the issues regarding risk culture and risk understanding in the Company (Appendix A, item 28).

6.2 Understanding Risk and Uncertainties

Both Norwegian HSE regulations and Eni Norge risk management process requires that activities are controlled through a risk-based perspective. Understanding risk is highly dependent on the definition of risk as described in Chapter 5.1 that can form the risk culture and consequently risk interpretations in the Company. The PSA does not have a formal definition of risk and argues that describing risk is too narrow and can limit the ability to see the entire risk and uncertainties.

The human knowledge is always incomplete and selective and thus dependent on uncertain assumptions, assertions and predictions. It is obvious that the modelled probability distributions within a numerical relational system can only represent an approximation of the empirical relational system with which to understand and predict uncertain events. Hence, it seems sensible to include other additional aspects of uncertainty e.g. ignorance or lack of knowledge (Renn 2006). One can define risk, but one can barely define the outer layers of uncertainty. The consequence of well-known activities has less uncertainty than unknown activities, while less familiar activities have greater consequences or in other words, surprises relative to the of knowledge so called “black swans”. This raises the question whether degree of uncertainty is visible, to identified risks with suitable knowledge and information for decision maker.

The concept of risk should allow for different ways of describing the uncertainties, as the PSA rightly argues, that such a simplified perspective is a matter of concern.

The perspective of risk is all probability-based, and several authors have argued that such perspective should be replaced by some broader perspectives. Such perspective should not be linked only to one specific measure of uncertainty namely probability as it is not able to reflect the strength of the knowledge that probabilities are based on, and not that assumptions that the probabilistic analysis is built on could conceal important aspects of uncertainties as shown in Figure 26 (Aven 2013b).

Figure 26 - The New Perspective (Aven 2013b)

Eni Norge Risk Categorization Matrix recommends taking uncertainties into account during risk assessment, that uncertainty regarding consequences of an activity should be visible to decision maker, greater uncertainties requires increased safety margins and might also determine whether certain risks can be taken, or not. High or medium degree of uncertainty requires a short explanation, replying to questions; “What is the uncertainty about? Is it due to lack of knowledge or information? and insufficient understanding, insufficient models or something special with the situation? Is it possible to reduce the uncertainty, and should it be reduced? This is where historical data does not exist or is insufficient by including columns for events classified as “Improbable (expected to occur seldom more than every 1 million-year” and “Unlikely expected to occur within 10,000 to 1 million-year)”.

However, the concern remains how a sound decision should be made considering uncertainties? As pointed out in new risk perspective in Figure 26, the dimension of knowledge, experience transfer and lesson learning with degree of uncertainties, are key factors while performing risk assessment. From what can be said, many performed risk assessments in Eni Norge do not take into account such considerations and definitely, this needs to be improved.

6.3 Risk Management Process Implementation

In spite of great deal of efforts, Eni Norge risk management process still is not properly implemented and used at all Company activities. Some are unable to find the process in ENIMS, or never seen it, and few persons find them deficient (Appendix A, item d). This can be traced back to the fact that there is no Company risk management process in Eni Norge, and as described in Chapter 5.2, there are 2 different processes for risk management in HSEQ and operations process. This is verifiable when the number of hits to risk management process was reviewed in different periods.

Moreover, Eni Norge has adopted ALARP principle in the risk management process, and is committed to utilize it independently of risk acceptance criteria, to reduce the risk as low as reasonable practicable / possible and providing risk management a greater confidence. Eni Norge risk management process requires to establish ALARP register to keep track of options, and documentations for decision making basis in order to document the overview of accepted risk reducing measures, their justification, or their rejection and their cost analysis, along with documentation that risk level after implementation of accepted risk reduction measures is as low as reasonably practicable. Such register does exit neither for Goliat development project, nor during operational phase. However, there are various documentations during project phase indicating that measures were decided and implemented as per ALARP principle, they are not properly documented. There is a challenge to implement and document ALARP process properly particularly when some confuse ALARP principle with continuous improvement. It seems that meeting Eni Norge risk acceptance criteria is adequate in most cases during operational activities.

6.4 Barriers & Barrier Management

Eni Norge is in compliance with Norwegian HSE regulations by defining a barrier principle framework and making it an integral part of risk management process. Technical Barriers and their performance requirements are foreseen from design stage and have been successfully implemented in Goliat FPSO barrier management as described in Chapter 5.4.1. With respect to establishing barriers and barrier management in risk management process, Eni Norge meets the requirements laid down by Norwegian HSE regulations. However, organizational & operational barrier elements are still under development, and not operational while preparing this thesis. Thus they cannot be monitored in the barrier status panel for daily monitoring and activities planning as intended. There is an ongoing project underway to identify and establish a system for monitoring the status of the operational and organizational barriers for Goliat FPSO to be used in barrier status panel, including identifying indicators for degradation of the operational and organizational barriers, in addition to performance requirements and verification activities (e.g. performance indicators and audits).

Moreover, it is also unclear who is in charge of monitoring the barrier status plan, in order to make a decision. There are various teams involved in operations planning, such as Technical Support Group based in Hammerfest office, Operation Support Group based split in Hammerfest office and Stavanger office, Technical Authority & Technical Integrity units based in Stavanger. Their roles and responsibilities against offshore management, with regards to barriers monitoring, is not properly defined and clear (Appendix A item 28d & 29a).

Eni Norge has experienced a few gas leaks during the last project completion and early production phase, while preparing this thesis. Review of their investigations reveals that the technical barriers have worked as intended (Appendix A item 28 a, b, c & d).

6.5 Change Management

Effective change management is interconnected with risk management, in order to minimize risk of failures and undesired consequences during operations. Any change organizationally, technically or operationally, entails risk and requires compensating measures to reduce and mitigate risk. In other words, it can be said that change management is a component of risk management. Eni Norge change management process is not implemented properly during operational phase at all the times hence, there is no traceable records that all organizational and operational changes have gone through the change management process, and consequently their imposed risks are not evaluated and mitigated. To name but a few examples to substantiate this are; company reorganization just after Goliat start-up, while still some commissioning activities were ongoing, early retirement of some key employees without proper experience transfer and capacity building, putting tremendous workload on few key positions during start-up and operations (e.g. maintenance team, unplanned change of key personnel during start-up) and shifting between ICT solutions (Appendix A, item 28). Eni Norge change management process is generic and needs to be improved to identify roles and responsibilities, according to company organization chart.

6.6 Competence Assurance

Eni Norge has put in a place competence management system, in order to ensure regulatory and operational training requirements of its personnel, and competence assurance identifying performance gaps and managing continual improvement. The system is operational, however its efficiency and effectiveness is questionable, for instance there is no training requirement identified yet for risk management. In addition, there are many cases that training requirements are not met, refreshing courses are overdue, or contractors' personnel doing critical tasks on Goliat are excluded from the system, etc. Moreover, safety critical positions are not yet identified in the database, for instance there is no competency requirement yet identified for the barrier technical authority that is surely a safety critical position (Appendix A, item 28d).

6.7 Eni Norge Governing Documentations

Eni Norge governing document structure is well defined in ENIMS. Anyone can request a governing document and workflow through a dedicated portal justifying why such governing document and workflow is required. There is a process for handling requests by relevant process managers. Issued document will be then linked in the relevant process in ENIMS and communicated to the Company.

Theoretically, the above process should include all the necessary documentations such as procedures, instruction, checklist, etc. However, in practice this is not the case, there is another operating support system in Eni Norge called SATOS that contains Goliat operational supporting documents, based on equipment and Goliat systems. This was designed during project development, and contains checklists and procedures for routine and emergency operations. There are many examples that their contents are not maintained and aligned with some governing documents and workflows in ENIMS. It is also unclear who owns the system and who should keep it updated and maintain it. This often leads to confusion where to look for a relevant document in particular on Goliat FPSO (Appendix A, item 28d).

Moreover, Operational barrier elements (procedures, checklists, diagrams, etc.) are still under development, missing, or are in draft. This will become critical constraining factor if there is no single access point and repository for governing document, when it comes to utilizing them in daily operational barrier management as intended.

It seems there is not a common understanding on the concept of what a governing document means, and there are many examples of documents mixing requirements, procedures with "need to know" information and "nice to know" information, with incorrect titles. In addition, clarity of who owns them, quality checks them and where they should be stored is missing.

Review of some of the recent internal accident investigations and SYNERGI cases can reveal that this is an area of concern and should be resolved adequately (Appendix A, item 28 & 29). However, this is a known issue to the Company management, and while preparing this thesis, a project was under definition to resolve the issue.

6.8 Learning the Lessons

Risk is a dynamic and continuous process, many factors contribute to its influencing, developing, understanding and among them learning from accidents are the most significant (PSA 2013b). All the actions raised by incident investigations, audits, etc. are registered in SYNERGI, to be followed-up until fully completed. However, often due to workload and reprioritization of task, critical actions are postponed. Review of the serious investigations after Goliat start-up shows that similar accidents had happened before but one item in the chain of events was not in place (Appendix A, item 28). Learning the lessons from accidents can prevent reoccurrence of them.

7 Conclusion & Recommendations

As described in Chapter 1.1 this thesis intends to compare Eni Norge risk management process and Norwegian HSE regulation. Chapter 6 further described and examined the findings, providing replies to the raised questions by the thesis scope. The following recommendations are the result review of risk management process, internal investigations, internal audits, PSA audits, HSE statistics and carried out interviews.

In conclusion, Eni Norge as the first operator in the Barents Sea and Goliat, as the fourth biggest producing oil felid in Norway, has put itself under "microscopic surveillance". Eni Norge is planning six more wells in Norway in the next couple of years, of which at least half will be in the Barents Sea, and is considering participating in the next licence awards round. Having said that, Goliat operations is still in early phase, but already has stepped up expectations form various internal and external stakeholders, due to many factors that are not topic of this thesis. Risk management has been one of the main causes of these expectations. This does require Eni Norge to appropriately increased focus and review of its risk management process, for effectiveness and proper implementation with a need for tuning and still ongoing commissioning activities. It is visible that Eni Norge risk management process should be improved comprehensively, through enhancing risk awareness and risk culture, integrating work processes, strategy, planning and management. What follows are the main improvement areas, with regards to boundaries of risk management.

7.1 Improvement of Risk Culture & Risk Organization

Eni Norge top management requires to address this issue by replying the following questions:

- What is the current risk culture and risk awareness in the Company and how it can be improved?
- How is it possible to unify the risk perception in the Company?
- What is the objective and how the Company can meet it?
- What will be the consequences of not resolving this issue?

Organizational structure is the framework that holds an organization together and defines the authorities, roles and responsibilities within a Company. Different kind of non-HSE risks associated with Eni Norge activities are foreseen and dealt with organizationally. It means there are dedicated functions with clear roles and responsibilities for instance financial risks has a specific function within Finance and Control department. However, there is no dedicated function in charge of risk management process in place, neither within Operations department nor HSEQ department. It is recommended to establish a risk coordinator function within HSEQ department and Goliat FPSO, to ensure the risk management process is implemented at all Company levels.

This function should ensure implementation of risk management process, and involve all risk owners, to the active use of risk management process and capture new risks and opportunities through participation and interactions with operations, etc.

Moreover, Eni Norge has identified technical authorities for barrier management responsible persons in its organization charts. However, the roles and responsibilities of such positions has not yet been identified in Eni Norge while preparing this thesis. Technical authorities' roles and responsibilities are unclear; they are often involved by request to provide expertise to address critical issues case by case. At the time of preparing this thesis, there were on average 300 impaired barriers identified in barrier status panel. It is not clear if that is safe to operate / risks are acceptable and whose responsibility and authority to evaluate barriers impairments and faults in order to identify whether it is acceptable to continue operations or not. This is unclear whether this falls within the authority of technical authority for barrier management or not. Another similar example of this kind is within well operations department whether there is a function for well integrity coordinator though the person is not involved or part of test and verification of well barriers in barrier status panel, and even has no access to well barrier status in barrier status panel for condition monitoring.

It is recommended that the framework for technical authorities should be established, defining their roles and responsibilities. Work processes to be updated taking into account such roles and responsibilities. Technical authority's functions should be actively involved in handling non-conformities, technical deviations and risk assessments, etc. Also well integrity coordinator function should be involved in condition monitoring of well barriers in barrier status panel.

7.2 Improvement of Risk Management Process

Eni Norge has no company risk management process on the other hand it has a dedicated risk management in operations process and another one in HSEQ process, as described in Chapter 5.2. This has been impedance in the Company, in implementation of risk management process properly.

A risk enablable performance Company requires integrated risk management directly into processes themselves. It is recommended that Eni Norge evaluates these 2 processes and replace them with a single, thorough and comprehensive process as Company risk management, since these processes follow the same risk acceptance criteria and risk categorization matrix. The new process should take into account all associated risks with their impact on people, environment, assets, reputation, quality, schedule, legal, procurement, financial and projects.

Each risk should be linked to at least one process for instance in operations or HSEQ process. If the risk is relevant for more than one process all should be linked. Any of the Eni Norge work processes can be linked to any of the identified risk.
Moreover, review the scattered risk register in operations, HSEQ departments and elsewhere to be registered in SYNERGI risk module for continuous update and follow-up.

7.3 Clarification of Roles & Responsibilities

Implementation of risk management process without clear clarification of roles and responsibilities identifying "who does what" and "when and how does it" is impossible. Having a relatively flatten organization, with 3 level of organization supporting Goliat operations has generated some increased gaps between the management and supervision. There are facility technology and technical integrity units as technical authority function based in Stavanger, technical support groups as systems responsible and operation support groups based in Stavanger and Hammerfest offices. Roles and responsibilities of technical authority function and system responsible versus offshore management should be clarified in the risk management process. Process owners and document owners should be identified. There should be clarity who will be involved in barriers status panel handling and risk evaluations. The coordination among these parties is a key ensuring implementation of risk management process.

7.4 Improvement of Governing Documents Management

Governing documents should be easily accessible, owned and updated. Document owners are responsible to coordinate the quality and update them if required. Also, there should be a reading list identifying who needs to know which document in order to increase the user knowledge of operational documents across the Company. There should be a common, unifying approach and a single point centralised accessibility to operational documents. Technical authority functions and system responsible should be involved in quality check of governing documents. Governing document portal should be used for all scattered and obsolete governing documents and checklists for quality check and registering them.

7.5 Improvement of Verification Activities

Review of verification activities in particular internal audits show that there are many audits postponed, cancelled or on hold due to hectic activities or unexpected events, in fact there are only a few audits carried out in 2016. For instance, there is an internal requirement to carry out process safety audit every second year, but such audit has never been carried out either in 2015 or 2016. On the other hand, over the last year, many actions identified during PSA audits, internal verifications and other internal reports upon review of SYNERGI cases. So many of these actions are pending, or yet to be processed. In fact, there are lots of backlogs on this. There is no value of audits finding if they are not followed-up by top management. Top management should raise the audit process and follow-up the findings all the time, and actions based on their criticality and risk status should be prioritized.

7.6 Improvement of Competence Assurance

The use of Eni Norge competence management system should be improved with reliable and up-to-date data, taking into account all the regulatory, technical and operational requirements for all personnel, including contractors, doing critical tasks on Goliat. Safety critical positions should be identified, in order to determine gaps and address them against regulatory, technical and operational requirements. Safety critical positions competence profile should be available for OIM in order to easily identify high priority, safety critical competencies and to view training events that can be used to close any competency gaps.

7.7 Improvement of Lessons Learning process

Lesson learning from accidents needs to be improved. Investigations finding, recommendations and actions needs to be followed-up for efficiency. Registered actions in SYNERGI should be closely followed-up for implementation, until fully completed by action. It is recommended to add a functionality to the tool, in order to check the effectiveness of closed critical actions (actions with regards to cases with increased risk potentials) after 3 months or 6 months.

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Appendices

Appendix 1 - Reviewed Eni SpA and Eni Norge documents

1. Eni Norge Risk management procedure
2. Eni Norge Barrier management principles and framework procedure
3. Eni Norge process modeling operating instruction
4. Eni Norge ALARP evaluation process requirement operating instruction
5. Eni Norge Incident management procedure
6. Eni Norge management review reports for 2014 & 2015
7. Eni Norge HSE qualitative Four-Year Plan 2015-2018
8. Eni Norge HSE Audit program 2015-2018
9. Eni Norge Strategy for facilities technologies
10. Eni Norge Structure and management of governing documents
11. Eni Norge Registration and follow up of HSEQ data in Synergi
12. Eni Norge Handling governing documents portal operating instruction
13. Eni Norge Chemical management strategy and requirement
14. Eni Norge HSEQ Contractor management strategy
15. Eni Norge Health & Working Environment strategy and requirements
16. Eni SpA Management System Guidelines HSE and its annexes
17. Eni SpA Management System Guidelines Operations
18. Eni SpA Management System Guidelines Maintenance
19. Eni SpA Management System Guidelines Integrated Risk Management
20. Eni SpA Management System Guidelines Energy & Environmental Industrial projects
21. Goliat Quantitative risk assessment
22. Goliat Well Barrier testing operating instruction
23. Goliat Maintenance and Spare Part Strategy
24. Goliat Functional & Design requirements
25. Goliat Operations philosophy
26. Goliat Safety Requirements
27. Goliat Cold climate operation manual
28. Internal incident investigation reports
    a) Gas leak incident 17.04.2016
    b) Gas leak incident 17.06.2016
    c) Gas leak incident 03.08.2016
    d) Power loss incident of 28.08.2016
29. Audit reports
    a) HSE technical & compliance audit 2015
    b) Maintenance & Inspection audit 10.06.2016
    c) ISO 14001 & OHSAS 18001 audits carried out by 3rd party 15.10.2016
30. Other internal documents such as presentations and reports

Appendix 2 – Management System

Regulations to Act relating to petroleum activities **Chapter 8 Management, System for the petroleum Activities, Section 56 – Management System**	**Framework HSE Regulations** **Chapter III Section 17 – Duty to establish, follow up and further develop a management system**	**Management Regulations - Chapter IV** **Section 12 - Planning**	**Eni Norge Integrated Management System (ENIMS)**
The main objective of the management system established according to the Act 10-6 in order to ensure compliance the statutory requirements, shall be to contribute to ensuring and furthering the quality of the work carried out in the petroleum activities. The management system shall specify the applicable statutory requirements and shall to the extent necessary include internal requirements to and routines for compliance with statutory requirements. Furthermore the management system shall include internal requirements to and routines for organization, divisions of responsibilities, division of authority in the individual case and between the licenses and other participants in the petroleum activities, competence, resources and work performance in relation to the party establishing the management system according to the first paragraph.	The responsible party shall establish, follow up and further develop a management system designed to ensure compliance with requirements in the health, safety and environment legislation. The licensee and owner of an onshore facility shall establish, follow up and further develop a management system to ensure compliance with requirements in the health, safety and environment legislation directed toward licensees and owners of onshore facilities. The employees shall contribute in the establishment, follow-up and further development of management systems.	The responsible party shall plan the enterprise's activities in accordance with the stipulated objectives, strategies and requirements so that the plans give due consideration to health, safety and the environment. The resources necessary to carry out the planned activities shall be made available to project and operational organizations. The operator or the party responsible for operating an offshore or onshore facility shall ensure coordination of plans of significance to health, safety and the environment, cf. Section 1 **Management Regulations - Chapter IV Section 13 – Work process** The responsible party shall ensure that the work processes and the resulting products fulfil the requirements related to health, safety and the environment. The interaction between human, technological and organizational factors shall be safeguarded in the work processes. Work processes and associated interfaces of significance to health, safety and the	Eni Norge integrated management system identifies & adjust the phases, activities, resources information flows and the main controls and statutory/internal requirements that is necessary for proper management of the processes and related risks, their interaction with other business processes in all Eni Norge activities. It disseminates methodologies and criteria in all its activities on/offshore. It also establishes ownership, roles & responsibilities of key functions involved in the process & their required competence. All work processes are supported and detailed when required with operating instructions and procedures. It also facilitates integrated operations efficiently by utilizing new technology and work processes suited for the different operations and tasks. It also ensures all employees contribution and involvement in the establishment, follow-up and revision of management system.

		environment shall be described. The level of detail in the description shall be adapted to the importance of the process for health, safety and the environment.	It also ensures all company's contribution and involvement in the establishing, follow-up and update of management system.

Appendix 3 - Risk Reduction Principles

Framework Regulation **Section 11 – Risk reduction principles**	**Management Regulation** **Section 4 – Risk reduction**	**hseq 02.01 – Plan & Perform HSE Risk Assessment** **pro hse 010 Eni Norge r01 - HSE Risk Management** **hseq 02.02 – Risk & Barrier Management**
Harm or danger of harm to people, the environment or material assets shall be prevented or limited in accordance with the health, safety and environment legislation, including internal requirements and acceptance criteria that are of significance for complying with requirements in this legislation. In addition, the risk shall be further reduced to the extent possible. In reducing the risk, the responsible party shall choose the technical, operational or organizational solutions that, according to an individual and overall evaluation of the potential harm and present and future use, offer the best results, provided the costs are not significantly disproportionate to the risk reduction achieved. If there is insufficient knowledge concerning the effects that the use of technical, operational or organizational solutions can have on health, safety or the environment, solutions that will reduce this uncertainty, shall be chosen. Factors that could cause harm or disadvantage to people, the environment or material assets in the petroleum activities, shall be replaced by factors that, in an overall assessment, have less potential for harm or disadvantage. Assessments as mentioned in this section shall be carried out during all phases of the petroleum activities. This provision does not apply to the onshore facilities' management of the external environment.	The responsible party shall select technical, operational and organizational solutions that reduce the probability that harm, errors and hazard and accident situations occur. Furthermore, barriers as mentioned in Section 5 shall be established. The solutions and barriers that have the greatest risk-reducing effect shall be chosen based on an individual as well as an overall evaluation. Collective protective measures shall be preferred over protective measures aimed at individuals	Eni Norge Risk management process sets the requirements for risk reduction principles ensuring the laid down requirements in section 11 of framework regulations and section 4 of management regulations are implemented throughout of lifecycle activities. It also requires BAT principle in reducing the risk to choose the technical, operational or organizational solutions that, according to an individual and overall evaluation of the potential harm and present and future use, offer the best results provided the costs are not significantly disproportionate to the risk reduction achieved. Degree of uncertainties related to the identification risk shall be considered in risk analysis. Eni Norge Barriers management principles and framework procedure sets the requirement ensuring solutions and barriers are established and monitored. Eni Norge ALARP evaluation process operating instruction requires all risk reduction proposals with limited costs shall be implemented for a development and modification project. The following shall be the decision criteria: a) Any risk reduction proposal that has a positive overall HSE benefit shall be implemented without exception if cost does not exceed cost limit defined by the specific project or operating unit. b) The cost limit may be increased if the risk reduction proposal improves the concept robustness against catastrophic events or falls under inherent design umbrella.

		When this is applied for the risk to personnel aspect, all other risk reduction measures to be implemented unless cost per statistical life saved is in gross disproportion to the benefit, i.e. the statistical life saved. The following is the recommended decision principles: c) Risk reduction measures that does not satisfy a) or b) shall be considered according to the ALARP principle, for ICAF (Implied Costs of Averting a statistical Fatality) values as per Table 3. d) Values in Table 3 may be higher for scenarios which may result in catastrophic events, for personnel, environment or assets. The approach in case of risk to assets shall be similar, but no concrete limits are stated.

Appendix 4– Risk Analysis Requirements

Management Regulations	hseq 02.01 - Plan & Perform HSE Risk Assessment pro hse 010 Eni Norge r01 - HSE Risk Management hseq 02.08 - Emergency Preparedness & Response hseq 02.04 - Health & Working Environment
Section 16 – General requirements for risk analyses The responsible party shall ensure that analyses are carried out that provide the necessary basis for making decisions to safeguard health, safety and the environment. Recognized and suitable models, methods and data shall be used when conducting and updating the analyses. The purpose of each risk analysis shall be clear, as well as the conditions, premises and limitations that form its basis. The individual analysis shall be presented such that the target groups receive a balanced and comprehensive presentation of the analysis and the results. Criteria shall be set for carrying out new analyses and/or updating existing analyses as regards changes in conditions, assumptions, knowledge and definitions that, individually or collectively, influence the risk associated with the activities. The operator or the party responsible for operating an offshore or onshore facility shall maintain a comprehensive overview of the analyses that have been carried out and are underway. Necessary consistency shall be ensured between analyses that complement or expand upon each other.	Risk analysis shall be used: ▪ to provide control and the establish the awareness of the risk in operational activities ▪ to meet regulatory requirements ▪ in the design phase: to develop a safe and reliable system ▪ in the operating phase: to improve system safety and reliability A perceived risk is a perception of danger that individuals or groups of individuals can form as a result of various activities or situations in society. This is often also referred to as subjective risk. Risk as expressed in a risk analysis is on the other hand called calculated risk, objective risk or real risk. Perceived risk is important when making decisions about risk, but is not reflected in the risk analysis as such. The following best practices may be applicable for Eni Norge to carry out systematic, multidisciplinary review of systems: Failure Modes, Effect and Criticality Analysis / FMECA, Fault tree analysis, Event tree analysis, Safe job analysis (SJA), Human reliability analysis (HRA), Task analysis. In Eni Norge, HSE Risk Analysis is normally carried out by a consultant, in line with Norsok Z-0013 for the design and construction facilities used in hydrocarbon activities. Eni Norge shall track, monitor, update and follow-up risk analyses closely & consistently and provide information to and communicate with risk stakeholders as appropriate.
Section 17 – Risk analyses and emergency preparedness analyses The responsible party shall carry out risk analyses that provide a balanced and most comprehensive possible picture of the risk associated with the activities. The analyses shall be appropriate as regards providing support for decisions related to the upcoming processes, operations or phases.	There is a multitude of technical, operational and organizational factors in major accidents, and each factor can, alone or in combination, cause accident or affect a possible course of events. The design of facilities and plants, the choice of technical solutions with good inherent safety characteristics (Goliat safety standards) and the choice of effective barriers (Goliat barrier status panel) are included in the measures to prevent undesirable incidents. The barriers include a

Risk analyses shall be carried out to identify and assess what can contribute to major accident risk and environmental risk associated with acute pollution, as well as ascertain the effects various processes, operations and modifications will have on major accident and environmental risk. Necessary assessments shall be carried out of sensitivity and uncertainty. The risk analysis shall: a) identify hazard and accident situations b) identify initiating incidents and ascertain the causes of such incidents c) analyze accident sequences and potential consequences, and d) Identify and analyze risk-reducing measures Risk analyses shall be carried out and form part of the basis for making decisions when e.g.: a) identifying the need for and function of necessary barriers, cf. Sections 4 and 5, b) identifying specific performance requirements of barrier functions and barrier elements, including which accident loads are to be used as a basis for designing and operating the installation/facility, systems and/or equipment, cf. Section 5, c) designing and positioning areas, cf. Section 5 of the Facilities Regulations, d) classifying systems and equipment, cf. Section 46 of the Activities Regulations, e) demonstrating that the main safety functions are safeguarded, f) stipulating operational conditions and restrictions g) selecting defined hazard and accident situations. Emergency preparedness analyses shall be carried out and be part of the basis for making decisions when e.g. a) defining hazard and accident situations, b) stipulating performance requirements for the emergency preparedness, c) selecting and dimensioning emergency preparedness measures.	number of elements that on its own or in combination prevents or mitigates major accidents. A hazard (or threat) is either: ▪ Random (non-planned, accidental); A situation with a potential for human injury, damage to physical assets, damage to the environment, loss of production, or some combinations of these OR ▪ Deliberate (planned, on purpose): A foreign or domestic entity possessing both the capability and the intention to make damage to a system. This may be an individual, an organization, or a nation. Hazards not identified will not be analyzed, they will not be taken into account when managing risk and no emergency response will be in place to reduce consequences. Environmental Hazard identified as significant environmental aspects, i.e. the common sources of environmental hazards. For offshore application a (more or less) standard list of Accidental Events forms the basis for the QRA. Risk analysis regarding barriers, their performance requirements of barrier functions, barrier elements including which accidental loads are to be used as a basis for decision making are described in chapter 5.3 & Appendix 5. A separate Hazard Identification meeting is often arranged where the focus is more on causes, i.e. the hazards. The main purpose is to identify all potential problems. Common sources of hazards are: ▪ Sources and propagation paths of stored energy in electrical, chemical, or mechanical form ▪ Mechanical moving parts ▪ Material or system incompatibilities ▪ Radiation ▪ Electromagnetic radiation (including infra-red, ultra-violet, laser, radar, and radio frequencies) ▪ Collisions and subsequent problems of survival and escape ▪ Fire and explosion ▪ Toxic and corrosive liquids and gases escaping from containers or being generated as a result of other incidents ▪ Deterioration in long-term storage ▪ Noise including sub-sonic and supersonic vibrations ▪ Biological hazards, including bacterial growth in such places as fuel tanks

	▪ Human error in operating, handling, or moving near equipment of the system ▪ Software error that can cause accidents In order to identify the hazards, Eni Norge shall: ▪ Examine similar existing systems ▪ Review previous hazard analyses for similar systems ▪ Review hazard checklists and standards ▪ Consider energy flow through the system ▪ Consider inherently hazardous materials ▪ Consider interactions between system components ▪ Review operation specifications, and consider all environmental factors ▪ Use brainstorming in teams ▪ Consider usage mode changes ▪ Try small scale testing, and theoretical analysis ▪ Think through a worst case what-if analysis ▪ Consider human-machine interface The analysis is carried out to analyze and identify potential causes of initiating events, and to assess the probability/frequency of initiating events occurring. This causal analysis gives best basis for risk management. The initiating event analysis can be either qualitative or quantitative. Establish a useful and understandable synthesis of the risk assessment, with the intention to provide useful and understandable information to the relevant decision makers and users about the risk and the risk assessment performed. To further enhance the risk picture, the Company may require uncertainty analysis, sensitivity analysis and estimation of dimensioning accidental loads. Risk analysis of technological systems is usually related to sudden events in practice, the first significant deviation from normal is called accidental event (or initiating event). The steps of the risk analysis covered by this activity is further described in Norsok Z-013 - Risk and emergency preparedness analysis section 5.2 - Hazard Identification, Section 5.3 - Analysis of initiating event and Section 5.4 - Analysis of Potential Consequences.
Section 18 – Working Environmental Analysis There are also requirements to analyses of the working environment in the Regulations relating to conduct of work (RCW) (in Norwegian only). They relate to:	Risk-based health surveillance shall consist of a targeted, periodic health examination restricted to employees for whom there may be a connection between health issues and risk factors in the working environment. This shall be a continuous process carried out in accordance with Eni Norge's health and working environment management system – hseq 02.04, i.e. "Systematic Follow-Up of Risk Factors in Working Environment", and in compliance with the requirements of Eni

a) use and handling of chemicals, cf. RCW chapter 3, with the exception of sections 3-23, 3-24 and 3-27 as far as offshore petroleum activities are concerned, b) risk of being exposed to biological factors, cf. RCW chapter 6, c) exposure to factors detrimental to reproduction, cf. RWC chapter 7, d) exposure to noise and mechanical vibrations detrimental to health, cf. RCW chapter 14, with the exception of sections 14-1 – 14-7 included, and 14-10, all as far as offshore petroleum activities are concerned, e) exposure to artificial optic radiation, cf. RCW chapter 16, f) conduct of manual work which may imply risk of strain detrimental to health, cf. RCW chapter 23, g) danger of snow slides, cf. RCW chapter 30 Necessary analyses mean e.g. analyses in connection with planning, operation and shutdown of offshore and onshore facilities, in connection with modification of existing offshore and onshore facilities, in connection with procurement or hire of new equipment, when chartering facilities, in connection with signing contracts with contractors and for organizational changes in the activities. To ensure a sound working environment, the various analyses should complement each other so that they cover both hazard and accident situations and exposure to working environment factors. The analyses should include the use of data on a) the personnel's individual or group workload and exposure to working environment factors, as well as data on how the employees experience the physical and psychosocial working environment, b) working environment factors in the respective areas of the offshore or onshore facility, c) work-related illness and work accidents To fulfil the requirements for working environment analyses, the ISO 11064 standard, Part 1, should be used for design and manning of the control room.	Norge's specification and strategic document for health and working environment. Evaluation and risk assessment shall encompass the entire working environment, i.e. its organizational, psycho-social, physical, ergonomic, radiation, chemical and biological aspects. Evaluation of the working environment consists, among other things, of the assessment of: ▪ work processes ▪ equipment and technical devices (workplace design) ▪ exposure to harmful strains and chemicals ▪ use of personal protective equipment ▪ organization of work ▪ work content, including requirements for working and self-regulation of the work situation ▪ working hours Eni Norge shall ensure that hazardous exposure of personnel and environment to chemicals during storage, use, handling and disposal, in operations and during processes giving reaction products, is avoided. Eni Norge will achieve this through; ▪ Identify and evaluate chemical risk ▪ Control and reduce chemical risk A Chemical Management Group (CMG) is established in Eni Norge and is responsible for the chemical application administration in Eni Norge and preparation of competent documentation of assessing and reducing risk of chemical hazards. All chemicals that are intended to be taken in use shall be evaluated/assessed and approved by the Chemical Management Group before being taken in use. To fulfil the approval, the Chemical Management Group must take the following aspects in consideration: ▪ Environmental evaluation/risk assessment ▪ Chemical health risk assessment ▪ General safety assessment ▪ Technical properties ▪ Asset integrity ▪ Substitution Eni Norge Health and Working Environment management system requires the protection regime providing a theoretical barrier against hearing damage based on relatively basic assessments of area noise. In some situations, where noise conditions are more complex, it will be necessary to carry out a detailed risk analysis in which self-generated noise and the frequency distribution of the noise

	shall be taken into account. An example of this is in connection with the use of ultra-high pressure hoses. This analysis will present conclusions as to whether or not the operation can be carried out in the course of a single working day, or as a single job, and whether corrective measures have to be put in place. A detailed noise exposure analysis shall take into account the type of operation, communication requirements, the true efficacy of the hearing protection (as dictated by the frequency distribution), impulse noise, area noise, self-generated noise, as well as noise generated outside working hours which is responsibility of the employer. Measures that may result from such analyses include the introduction of administrative barriers such as mobile noise insulation walls, restrictions on the time spent working in a given area, training, and the type of hearing protection used. Eni Norge Health & Working Environment management system requires that in the event of work in cold weather conditions, it is essential to make an assessment of the following aspects: ▪ wind strength and direction, ▪ temperature ▪ wave height ▪ movement of the installation ▪ precipitation (rain and snow) ▪ risk of falling ice

Appendix 5 - Risk Management & Establish of Barriers Requirements

Management Regulations **Risk Management Section 5 – Barriers**	**hseq 02.02 - Risk & Barrier Management** **GOL23.01 - Handling of Impaired or Lost Barriers** **GOL23.02 - Monitoring, Verification & Evaluation of Barrier Performance** **GOL23.03 - Update of Safety and Barrier Strategy and Barrier Status Panel**
Barriers shall be established that: a) reduce the probability of failures and hazard and accident situations developing, b) limit possible harm and disadvantages. Where more than one barrier is necessary, there shall be sufficient independence between barriers. The operator or the party responsible for operation of an offshore or onshore facility shall stipulate the strategies and principles that form the basis for design, use and maintenance of barriers, so that the barriers' function is safeguarded throughout the offshore or onshore facility's life. Personnel shall be aware of what barriers have been established and which function they are intended to fulfil, as well as what performance requirements have been defined in respect of the technical, operational or organizational elements necessary for the individual barrier to be effective. Personnel shall be aware of which barriers are not functioning or have been impaired. The responsible party shall implement the necessary measures to remedy or compensate for missing or impaired barriers.	Barrier management refers to the coordinated activities needed in order to establish and maintain controls and barriers so that they are functional at all times. This includes the establishment and maintenance of technical, operational and organizational control and barrier elements that are established to prevent and/or minimize the consequences of DSHAs with major accident potential. Barrier management also includes verification and monitoring of barrier performance in operation. Barrier management shall be an integrated part of overall risk management in Eni Norge, and be in compliance with statutory regulations, PSA guidelines, and the framework of ISO 31000. Barrier management in operation includes all activities carried out to ensure the functionality and integrity of all barriers during all operational modes, and is based on the following main principles: 1. The performance of all barriers shall be verified on a regular basis. This verification shall, if possible and appropriate, take place at a barrier element or tag level. For safety instrumented functions (SIFs) verification should also be performed at a function level. 2. Verification of barriers shall be evaluated against the performance requirements set in the project phase. 3. The output from the verification activities shall be monitored and followed up systematically through adequate barrier monitoring and verification tools, presenting the status of all barriers implemented to mitigate risk at the facility. 4. Barrier performance data shall be presented and communicated in a way that provides all relevant roles with adequate information about the condition of relevant barriers. 5. Information from the barrier monitoring and verification tools shall be used actively in operational risk management and decision-making. 6. All significant non-conformities related to barrier performance shall be evaluated in terms of potential consequences for operational decision-making and/or initiation of improvements or modifications. 7. In case of permanent technical, operational and organizational modifications, as well as external factors that may significantly influence the performance of the identified barrier functions, the need for updating of the In Service Safety and Barrier strategy and/or performance requirements shall be evaluated. If changes are executed the barrier monitoring and verification tools also need to be updated accordingly. In order to manage risk over time, barrier performance needs to be monitored and verified. The performance of all barriers shall be continuously monitored and verified throughout operation in order to ensure safe operation and robust barriers throughout the lifecycle of the facility. The verification of barrier performance shall be systematic, and directly linked to the identified performance requirements of each barrier element.

	Monitoring and verification of technical barrier elements shall primarily be covered through the facility's integrity management programs (e.g. testing, inspection and maintenance), as well as systems for condition monitoring. Barrier performance should also be followed up per system and performance standard (PS), and safety instrumented function (SIF). If considered appropriate, other verification activities, such as multi-annual audit programs, could be applied. Monitoring and verification of operational and organizational barriers shall be carried out by means of KPIs considered appropriate for the purpose. These data could be collected from a wide range of information sources with different updating intervals, e.g. competence matrix, document reviews, surveys, and audits. All data from the monitoring and verification process should be gathered and presented in facility specific monitoring and verification tools. The information shall be presented at an adequate level of detail, and be adapted to different user groups and areas of application. In case of an impaired or lost barrier that cannot be handled immediately, the OIM shall assess the situation in terms of criticality. Based on this assessment, the OIM shall evaluate the need for measures to restore the performance of the lost/impaired barrier. Notification of CM actions shall always be written in a situation of a persistent loss or impairment of a technical barrier. Non-conformities regarding operational or organizational barriers should always be reported. In situations where compensating measures are deemed to be necessary but adequate measures are not possible to implement, alternative solutions shall be evaluated. In case of repeating barrier failures and/or negative trends, it should be considered to initiate a system improvement or modification. Eni Norge requires that performance of all barrier systems and performance standards should be monitored on a regular basis to verify if the barrier function performance is satisfactory in terms of current status and trends (positive or negatives). The status and trends of all barrier functions should be evaluated against predefined evaluation criteria (performance requirements and others). This includes assessing situation in terms of criticality. Relevant roles should perform a joint criticality of the non-satisfactory barrier performance. The following checklist could support the criticality assessment of the non-satisfactory barrier performance: ▪ Are there absolute (regulatory or corporate) requirements related to availability of the barrier? ▪ Does the situation represent a violation of the assumptions in the QRA? ▪ Is barrier in question global or limited to one/a few area(s)? ▪ Are there redundant systems or solutions that fulfil the same function as the barrier in question? ▪ Is it possible to implement temporary measures that can compensate for the barrier in question? ▪ How fast will it be possible to bring the barrier into normal function? In case of need for modification, a M2 notification should be created in SAP according to GOL14.01.13 process. Improvement measures should be planned and followed up according to hseq 02.02 process. In practice, the Barrier Status Panel presents information regarding condition for all barriers and controls on Goliat. It shall be used for barrier and control monitoring, long and short term planning, decision-making, deviation handling and long term follow-up of barriers and control.

Comment: Barrier strategy and performance requirements for all the barriers based on the specific risk picture and identification of area hazards and corresponding required barrier functions on the Goliat FPSO are established in order to be able to control risk through barrier management in daily operations. Performance requirements are linked to technical barrier elements for each barrier function. Technical barrier functions are identified by barrier technique grid. Barrier grids are developed for all main areas to show the relationship between the hazard in a specific area and the barrier function needed to prevent or/and mitigate the risks. The technical barrier elements identified, they represent the solutions or "materialization" of the sub-functions necessary to realize a barrier function. Technical barriers are operational (e.g. how to operate the barrier systems) and organizational responsibility are assigned (e.g. who operates the barrier systems; who authorizes to realize a barrier function). Goliat barrier status panel has been developed and is used as a planning & decision support tool during activity planning. It is not a system for handling hazardous situation e.g. during a gas leak or high alarm but is used for condition monitoring, undetected fault signals, faults, blocking by using real time data from safety & automation system and preventive/corrective maintenance plan from SAP. It shows the current status of the barrier functions and impaired barriers and the barrier elements providing off/onshore employees up to date information regarding the barriers health status and to monitor and trend risk and barrier status. It uses barrier grids to show where in sequence of events that barriers are not functioning or degraded. Aggregating rules are set for barrier status information. The following rules are set as traffic light (red, yellow and green) on all the barrier elements. On a barrier element/tag level at least one of these observations can give a red light: • If PM overdue more than 90 days, then red light • If CM notification open or overdue, and priority in SAP is high, then red light • If condition monitoring alarm fails, then red light • If safety fault alarm fails, then red light • If tag manually blocked (i.e. inhibited) or suppressed, then red light On a barrier element/tag level at least one of these observations can give a yellow light: • If PM is overdue more than 28 days and less than 90 days, then yellow light • If CM notification overdue and priority in SAP is medium, then yellow light • If fault alarm degraded, then yellow light If none of the above conditions are present, then barrier element/tag has a green light. All the barrier elements are given traffic light following above rules. Red takes preferences over yellow and yellow takes preference over green.

Management Regulations, Section 9 - Acceptance criteria for major accident risk and environmental risk The operator shall set acceptance criteria for major accident risk and for environmental risk associated with acute pollution. Acceptance criteria shall be set for: a) the personnel on the offshore or onshore facility as a whole, and for personnel groups exposed to particular risk, b) loss of main safety functions as mentioned in Section 7 of the Facilities Regulations for offshore petroleum activities, c) acute pollution from the offshore or onshore facility, d) damage to third party.	Essential functions to ensure personnel safety and minimize pollution are defined in barrier management. Preventing escalation include: ▪ Fire/explosion barriers ▪ Integrity of support structure ▪ Integrity of equipment ▪ Decks protecting from dropped objects Main load-bearing structure: ▪ Structure supporting process modules / LQ and FPSO stability Safe areas: LQ (living quarter) and helideck & Muster areas and lifeboat stations, Escape routes & CCR

The acceptance criteria shall be used when assessing results from risk analyses, cf. Section 17. Cf. also Section 11 of the Framework Regulations.	
Comment: The process area is large and the winterization enclosure gives challenges with respect to high explosion loads. The Eni Norge acceptance criteria for this main safety functions are met. There is a concern for the ballast system availability and independency. Both ballast pumps locate in the cargo pump room, adjacent to sea. Flooding of the room may results in ballast system failure which might lead to an accident escalation. Flooding will cause an increased trim of 0.6 meters, which is not critical but ballasting will not be possible. Modifications on this is ongoing while preparing this thesis. The requirements for this main safety function has been met with a good margin on sufficient capacity of load-bearing structures for the facilities evacuation time.	

Facilities Regulations - Chapter II General provisions **Section 7 – Main Safety functions**	hseq 01.01 - Establish HSE Requirements **hseq 01.01 - Establish HSE requirements** **pro hse 010 Eni Norge r01 - HSE risk management**
The main safety functions shall be defined in a clear manner for each individual facility so that personnel safety is ensured and pollution is limited for permanently manned facilities, the following main safety functions shall be maintained in the event of an accident situation: a) preventing escalation of accident situations so that personnel outside the immediate accident area is not injured b) maintaining the capacity of load-bearing structures until the facility has been evacuated c) protecting rooms of significance to combating accidents so that they remain operative until the facility has been evacuated d) protecting the facility's secure areas so that they remain intact until the facility has been evacuated e) Maintaining at least one escape route from every area where personnel are found until evacuation to the facility's safe areas and rescue of personnel have been completed. **Section 8 – Safety functions** Facilities shall be equipped with necessary safety functions that can at all times: a) detect abnormal conditions b) prevent abnormal conditions from developing into hazard and accident situations, c) Limit the damage caused by accidents. Requirements shall be stipulated for the performance of safety functions. The status of active safety functions shall be available in the central control room.	It shall be verified that relevant safety measures have been established for the identified hazards, meeting Facilities Regulations requirements, in particular: ▪ probability of ignition, explosion, spread of flammable liquids or gases is minimized ▪ barriers have been installed to detect, control, combat and mitigate the effects of major accidents identified in Goliat QRA ▪ fire resistance of load-bearing structures and aluminum stair and ladders in aluminum is suitable for given evacuation period of time ▪ non-hazardous areas separated from hazardous areas ▪ arrangement of escape and evacuation is adequate ▪ consequence of fire, explosion or collision is minimized Measures for preventing escalation of accident situations so that personnel outside the immediate accident area are not injured. Sufficient capacity of load-bearing structures for the facilities evacuation time. Safety critical rooms are identified e.g. control rooms, temporary refuge, muster areas, fire water pump generator, emergency power sources are separated by distance, protected by fire and blast resistant division from equipment handling hydrocarbons and, where required, secured in fire rated boundaries. Control rooms are mechanically ventilated with overpressure (50Pa). Rooms with internal ignition source are under pressurized. Protection of the facility secured area, so that they remain intact until the facility has been evacuated. The time requirement on Goliat is one hour. Escape routes availability ensuring at least one escape route is available to escape to the muster areas in both medium to large jet fires and medium to large pool fires. Goliat FPSO has safety functions with capabilities to detect abnormal conditions in time as defined in safety requirement specifications. Prevention functions are realized and controlled through ESD&BD, PSD, F&G, HVAC, PAGA, emergency power and lighting systems in order to limit the damage caused by accidents.

Section 11 - Loads/actions, load/action effects and resistance	
The design loads/actions that will form the basis for design and operation of installations, systems and equipment, shall be determined. When determining design loads/actions, the requirement to robust solutions, cf. Section 5, and the requirement to risk reduction, cf. the Framework Regulations Section 11, shall form the basis. The design loads/actions shall ensure that installations, systems or equipment will be designed such that relevant accidental loads/actions that can occur, do not result in unacceptable consequences, and shall, as a minimum, always withstand the dimensioning accidental load/action. When determining design loads/actions, the effects of fire water shall not be considered. This applies to both fire loads/actions and explosive loads/actions. Installations, systems and equipment that are included as elements in the realization of main safety functions, cf. Section 7, shall as a minimum de designed such that dimensioning accidental loads/actions or dimensioning environmental loads/actions with an annual likelihood greater than or equal to 1x10-4, shall not result in loss of a main safety function. When determining loads/actions, the effects of seabed subsidence over, or in connection with the reservoir, shall be considered. Functional and environmental loads/actions shall be combined in the most unfavorable manner. Facilities or parts of facilities shall be able to withstand the design loads/actions and probable combinations of these loads/actions at all times.	DALs (most severe accidental load that the function or system shall be able to withstand during a required period of time, in order to meet the defined risk acceptance criteria) are initially established in early project phases, based on QRA. The modelling may at that time be somewhat coarse and details concerning, layout, systems, equipment, etc., may not be available. The following apply: a) the establishment of dimensioning accidental loads shall start with the completion of a risk analysis and the comparison of calculated risk with RAC b) the risk analysis shall establish sets of accidental events and associated accidental loads, and possibly also associated probabilities. The dimensioning accidental loads are chosen from these sets, such that the RAC are complied with c) it may be difficult to define the accidental load in relation to some types of accidental events, for instance in relation to filling of buoyancy compartments that may lead to instability of topside equipment, impact of escape routes, personnel panic, capsizing or loss of buoyancy. In these cases, the basis of dimensioning is given by the DAEs d) The selection of dimensioning accidental loads shall take considerations described in c) into account, and provide sufficient margins in order to avoid inadequate dimensioning accidental loads at a later stage e) tolerable damage or required functionality shall be defined in such a way that the criteria for dimensioning are unambiguous. The term ‘withstand’ in the definition may be explained as the ability to function as required during and after the influence of an accidental load, and may involve aspects such as 1) the equipment has to be in place, i.e. it may be tolerable that some equipment is damaged and does not function and that minor pipes and cables may be ruptured. This may be relevant for electrical motors and mechanical equipment, 2) the equipment has to be functional, i.e. minor damage may be acceptable provided that the planned function is maintained. This may be relevant for ESVs, deluge systems, escape routes, main structural support system, etc. f) the equipment has to be gas tight. This may be relevant for hydrocarbon containing equipment. The final establishment of the design accidental loads will be decided based on a consideration of the DALs but also a consideration of other factors, e.g. risk reducing measures, design safety factor etc. For modification of existing facilities, it is important to identify possible new dimensioning accidental loads. Equipment and structures shall be designed in accordance with the relevant DALs specification for the existing facility.

Section 34 – Process Safety System Facilities outfitted with or attached to process facilities, shall have a process safety system. The system shall be able to perform the intended functions independently of other systems. The process safety system shall be designed such that it enters or maintains a safe condition if a fault occurs that can prevent the system from functioning. The process safety system shall be designed with two independent levels of safety to protect.	Eni Norge Goliat process safety requirements define that the process safety function is the barrier designed to protect the system against violation of the process safety limits. Failure of the barriers to function may lead to leaks or unnecessary flaring. The barriers are typically PSD, PSV and local instrumented safety functions (e.g. HIPPS (High Integrity Pressure Protection System), which initiates the necessary actions to protect the system against conditions, which may exceed the design limits. The safety system including ESD, Fire and Gas detection and process safety functions shall provide minimum two independent levels of protection to prevent or minimize the consequences of an equipment failure within the process. The two levels of protection shall be independent of, and in addition to, the control devices used in normal process operation. PSD functions shall be fully operational whenever the installation is 'live' with hydrocarbons, and appropriate testing of the system shall be possible. Reliability and safety unavailability requirements for PSD functions shall be documented and maintained throughout the life cycle of the PSD system. Heat tracing shall be provided where considered necessary. The process safety function shall provide a reliable and fast detection of process upsets. PSD valves shall prevent a process upset to develop normally by stopping the process flow. PSD valves shall be separate from process control valves. Alarms shall support operator decision-making during upsets and accidental situations. Actions shall be initiated automatically when process or equipment protection limits are exceeded with maximum response time as per safety requirements specification datasheet.
Activities Regulations Section 26 – Safety Systems The measures and restrictions that are necessary for maintaining the safety systems' barrier functions in the event of overbridging, disconnection or other impairment, shall be set in advance. The compensatory measures shall be implemented as rapidly as possible when such impairment occurs. The status of all safety systems shall be known by and available for relevant personnel at all times.	Eni Norge should ensure that there is sufficient accountability, authority and competence to conduct barrier management, including implementation and maintenance of the barrier management process in all levels of the organization. Monitoring and verification of technical barrier elements shall primarily be covered through the facility's integrity management programs (e.g. testing, inspection and maintenance), as well as systems for condition monitoring. All active compensating measures shall be visualized in adequate monitoring and verification tools as long as the compensating measure is active. Backlog of corrective maintenance related to a barrier shall also be visualized in the monitoring and verification tools. The barrier functions shall be able to function at any time. The technical part of the barrier functions shall be secured by maintaining the barrier elements to be in a state in which they comply with performance requirements The technical barriers management

	is an integral part of the maintenance management system. In order to give special attention to the technical barrier elements, the following actions shall be performed: • Technical barrier elements shall be identified and highlighted in CMMS. • Acceptance criteria for the barriers shall be defined and made easily available • Execution of maintenance work orders on barriers shall not be delayed, unless assessment of consequences has been performed • Execution of CM work orders on barriers shall have highest priority Supply of spare parts shall be specified and prioritized to ensure availability of barriers.

Section 46 - Classification
Facilities' systems and equipment shall be classified as regards the health, safety and environment consequences of potential functional failures.
For functional failures that can lead to serious consequences, the responsible party shall identify the various fault modes with associated failure causes and failure mechanisms, and predict the likelihood of failure for the individual fault mode.
The classification shall be used as a basis in choosing maintenance activities and maintenance frequencies, in prioritizing between different maintenance activities and in evaluating the need for spare parts.
 	
Section 45 – Maintenance
The responsible party shall ensure that facilities or parts thereof are maintained, so that they are capable of carrying out their intended functions in all phases of their lifetime.
 	
Section 47 – Maintenance Program
Fault modes that may constitute a health, safety or environment risk, cf. Section 46, shall be systematically prevented through a maintenance program.
This program shall include activities for monitoring performance and technical condition, which ensure identification and correction of fault modes that are under development or have occurred.
The program shall also contain activities for monitoring and control of failure mechanisms that can lead to such fault modes.
	Eni Norge has classified Goliat FPSO as HSE consequences. The classification has been the basis an established maintenance management system consisting of consisting of:
	
	▪ Facility breakdown structure (hierarchy) addressing the complete Goliat FPSO
	▪ Definition of functions and Consequence classification
	▪ FMEA Failure mode analysis
	▪ Risk assessment of failure
	▪ Definition of Integrity control activities
	  - Condition monitoring
	  - Inspections
	  - Preventive maintenance
	▪ Assessment of residual risk
	▪ Assessment of Maintainability
	▪ Setting up Maintenance & Inspection (M&I)
	▪ program packages
	▪ Uploading of requirements to CMMS/Inspection management system
	Preventive maintenance contains activities for monitoring performance and technical condition which ensure identification and correction of fault modes that are under development or have occurred.
	
	In cases where functional failures can lead to unacceptable consequences, preventive activities shall be developed applying a risk based maintenance approach (RCM/RBI). When developing the PM activities, condition monitoring activities (to enable condition based maintenance) shall be preferred as long as they are proven to be cost effective. The monitoring of technical condition is applicable as long as it provides sufficient time to correct the state of condition before a fault is real, or before its

	function is demanded. In cases where failure of equipment leads to acceptable consequences to HSE, production or cost, such equipment will normally be operated until a fault occurs. Corrective maintenance activities are then executed as planned (deferred) maintenance. Exceptions are preventive maintenance actions (greasing, change of oil, etc.) which are regarded as being cost effective (saving break-down/repair/replacement cost). When corrective maintenance is required on equipment where a fault has occurred/will soon result in an unacceptable condition, and such fault is leading to a hazardous situation, the corrective maintenance activities shall take place as immediate corrective maintenance.
Activities Regulations, Section 85 – Well Barriers During drilling and well activities, there shall be tested well barriers with sufficient independence, cf. also Section 48 of the Facilities Regulations. If a barrier fails, activities shall not be carried out in the well other than those intended to restore the barrier. There shall be pumping and fluid capacity available on the facility or on vessels in the event of heavy well intervention. The need for pumping and fluid capacity in the event of light well intervention shall be included in the activity-specific risk assessment. When handing over wells, the barrier status shall be tested, verified and documented.	As per ope 04 - Well Integrity & Delivery process, Well Barriers are envelopes of one or several dependent WBE's (Well Barrier Elements) preventing fluids and gases from flowing unintentionally from one geological formation into another, or to the surface. All well barriers must be defined prior to commencement of an activity or operation, by identifying the required well barrier element) to be in place and their specific well barrier element acceptance criteria. In all stages of a well's life-cycle, the correct number and type of barriers must be in place and tested in order to avoid leakage of fluids. For detailed information on well barriers, well barrier element, their construction principles and testing requirements, reference should be made to NORSOK D-010 standard. During well planning, well construction, well operations, well interventions, well suspensions & well abandonment operations, well barriers are required to be installed and tested, to verify the well barrier's function and performance. Well barrier schematics These must be generated, for each stage of the well life-cycle relating to each operation performed, to demonstrate and illustrate the presence of the defined primary and secondary well barriers in the well. For well activities that is not possible to establish two independent well barriers. When a common well barrier element exists, a risk analysis shall be performed and risk reducing measures applied. This shall include additional precautions and acceptance criteria when qualifying and monitoring the common well barrier element. Well barrier element acceptance criteria shall be in place for all well barrier elements used. General technical and operational requirements and guidelines relating to well barrier element are collated in the elements acceptance criteria tables included in Section 15 of the NORSOK D-010 Standard, which shall be applicable for all types of activities and operations. A new element acceptance criteria Table shall be developed in cases

	where an elements acceptance criteria Table does not exist for a specific well barrier element. The level of detail shall be defined by the user. The described acceptance criteria and listed references in the tables are for selection and installation purposes and do not replace the technical and functional requirements that standards or the Company specify for the equipment. There must be pumping and fluid capacity available on the facility or on vessels in the event of heavy well intervention. The need for pumping and fluid capacity in the event of light well intervention shall be included in the activity-specific risk assessment.