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PSA Audits Review

Oselvar Decommissioning Project

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Contents

1 Introduction and Purpose

The Oselvar field was shut down in 2018 and all wells are temporarily suspended. DNO is planning to permanently plug and abandon the field in 2021 and the decommissioning must be completed by the end of 2022.

The purpose of this document is to learn from the results from the Petroleum Safety Authority's (PSA) audits of several operators on NCS and their PP&A operations, and then apply that knowledge to DNO's planned PP&A operation to decrease the risk and increase the chances of a successful operation of the Oselvar PP&A project. It should be noted that there is a big difference in sheer plugging volume between Oselvar's 3 wells and the 20-30 wells that were plugged/planned plugged by the other operators.

2 Summary

Six audits from PSA has been reviewed. They were performed between 2016-2019 with audited operators Statoil, Repsol, Conoco Phillips, AkerBP and Point Resources. Some of the wells are dated as far back as 1974 and others around 2000, while the Oselvar wells were completed 2011/2012.

In the recent years, due to the sheer volume of wells to be plugged on the NCS, PSA notes that an increasing number of large operators choose to deviate from standard practices or recommended guidelines when it comes to establishing permanent barriers and the subsequent verification, to save time and money.

PSA found deviations from NORSOK D-010 Rev.4 in 5 of the 6 performed audits, mostly related to unqualified/verified barriers for PP&A.

3 HSE Challenges related to PP&A

The Norwegian Environment Agency (NEA) together with PSA conducted a study in 2018 to get a better understanding of HSE challenges related to PP&A of wells, with special focus on H_2S and CO. This was initiated as NEA registered several discharges of mud containing H_2S or CO from old wells. Circulating out mud and pumping it to sea have been common practice to avoid exposure to personnel when these gases are detected.

Drilling mud categorized as black or red shall be circulated up to rig and sent to shore for further treatment. NEA has normally granted permissions to discharge to sea from wells drilled with fluids categorized as green or yellow. Discharge of black or red fluids are only accepted if measures have been executed and the risk is acceptable.

Operators must have focus on potential presence of H_2S and CO when planning PP&A operations as H_2S gas can evolve in both drilling fluids and reservoirs, and it is hard to detect the gas before circulating out. It appears that there is an increased chance of H_2S if the well is drilled with water-based mud.

An H_2S emergency preparedness plan should be prepared for each PP&A operation. According to the NEA report, most companies contract Maersk H_2S Safety Services to assist in the planning and operation phase where it is risk of encountering H_2S. The following measures have resulted in less discharges of drilling mud containing H_2S:

- Establishment of Red zones
- Remote reading of H_2S levels using video cameras
- H_2S remover/wash out in mud on MODU and wellhead through booster line
- Reduce circulation rate or stop circulation if H_2S is detected

Although NORSOK-D-010 does not describe requirements related to handling of toxic gases, most companies have internal requirements related to H_2S- and CO sensors (fixed and mobile), breathing apparatus, camera surveillance and PPE.

When transporting the mud to shore many vessels require 0 ppm H_2S. Dependent on the vessel, it might have capacity to store an H_2S inhibitor. Vessels shall also have an emergency preparedness plan to handle H_2S.

The PSA audits did not focus directly on handling of toxic gases. Working environment have however been in focus and the audits aimed to ensure that the operator identifies risks related to well integrity activities. An example of a finding is that the operator does not include all service companies. These companies thereby take the largest risks. Based on audits it is suggested to have the following in place for the Oselvar PP&A operation

- Internal requirement for handling toxic gases
- Knowledge about the drilling fluids chemical composition
- Knowledge about exposure and exposure levels if hazardous chemicals are used
- How and when personnel can be exposed to hazardous components (casing, CO, H_2S, chemicals etc.)
- Solutions to reduce the risk of exposure
- How personnel are involved and informed about the risks they may be exposed to and training related to exposure.
- Risk assessment

NEA audits have focused on the operator's practices to reduce intentional discharges to sea during P&A operations. Measures to reduce exposure of H_2S and thereby requirement to discharge the mud was identified as findings. It is suggested to have knowledge about the following from an environmental point of view:

- What is defined as a "large" discharge?
- Consequences of discharge of hazardous components
- Handling of returned drilling fluids on MODU, boat and shore
- Challenges related to injection on other fields/wells
- Return of volumes, potential discharged volumes, measure to reduce the discharge
- Applied volumes in case of H_2S or CO detection, reporting routines.
- Environmental focus in planning phase
- Alternative technologies
- Best Practice in other companies (i.e. Equinor)
- Change in relevant regulations

4 Results

Report #	Well(s)/Field	Operator at the time	Audit Date	Production start	No. of wells	PSA Findings	Risk/opportunity in project	Comments
1	Huldra	Statoil	14.09. - 11.11.2016	2001	6	• Not significant, but PSA raised the question whether one double barrier was sufficient despite identifying more zones with the potential of flowing. • Though not registered as a deviation, Statoil had a somewhat lacking understanding of the ALARP principle, which means that a company must reason in detail why a certain method/solution is not implemented, in this case using 1 plug instead of 2.	• 1 double barrier was utilized to save time, despite identifying multiple zones with flow potential.	• Statoil could prove through simulations and suspected flow paths that 1 double barrier was sufficient. • A thorough risk analysis was performed and accepted with regards to the use of 1 double barrier.

Report #	Well(s)/Field	Operator at the time	Audit Date	Production start	No. of wells	PSA Findings	Risk/opportunity in project	Comments
2	Gyda	Repsol	07.-08.10.2019	1990	32	• Use of 1 long cement barrier for 2 potential flow zones (res + Forties fm). • According to internal requirements Repsol only qualified the top barrier element of the long cement plug (should be tested separately). • Repsol deemed it necessary to only verify barriers for the first 3 wells and the barrier verification for the remaining 28 was planned to be excluded if they followed an internal job matrix. • Unqualified personnel interpreting CBL logs to verify cement. • Interviewed personnel lacked knowledge of own internal P&A requirements (e.g. 30m min. length cmt barrier). • Insufficient barrier verification of surface plug inside casing and annulus (tagging and P/T). • Lacked internal deviation registration for the above points.	• Isolate 2 zones (res + Forties fm.) in one continuous cement plug and only verify the top of the second plug, to save time. • Log, verify and qualify barriers for the first 3 Gyda wells and skip that step for the remainder if the cement operation was a success, to save time.	• NORSOK D-010 Rev. 4 15.22 D2a) states that qualified personnel must interpret logs, but what defines "qualified"? • NORSOK D-010 Rev. 4 15.24G states that when using common well barriers, the cement must be dressed off, but does not state if a separate verification of the lowest plug is needed when 2 plugs are set on top of each other, as one. If the reservoir and the flow potential zone can be considered as one reservoir, then NORSOK D-010 Rev. 4 allows for 1 long continuous barrier. • NORSOK D-010 Rev. 4 15.22D2b) states that it is acceptable to forego the barrier verification (csg. cmt) given successful log in similar cement jobs.

Report #	Well(s)/Field	Operator at the time	Audit Date	Production start	No. of wells	PSA Findings	Risk/opportunity in project	Comments
3	Kvitebjørn	Statoil	02.-23.11.2017	2004	Up to 16	• Deviation from internal guidelines and NORSOK stating that 4 double barriers were needed to plug sufficiently but used only 2 barriers. • Uncertainties regarding the determination of flow potential zones in addition to fluid type, density, and testing, was not detailed clearly. • The process surrounding the "flow potential determination" testing was unclear as to what determines and approves if there is a risk of flow or not. • Insufficient qualification of Hordaland fm. as barrier, through formation leakage testing. • CBL logs proved only 10m qualified 13 3/8" casing cement, not 30m as NORSOK states. • Old filing system resulting in information and lessons from Kvitebjørn PP&A being hard to locate for future plugging. • Only one pressure test was performed to verify the use of Hordaland as a barrier element outside 13 3/8" casing and in addition it was not over a longer interval (30m) so there were uncertainties attached to the length of the barrier.	• Lean P&A - reduced no. of barriers.	• Statoil could prove through simulations and studies that the flow potential in the overburden would not demand additional barriers and that 2 were sufficient for the whole well. However, there were a lot of uncertainties related to determining fluid type, density, and formation permeability in these flow simulations.

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4	Ekofisk 2/4 Alpha	Conoco Phillips	07.-08.06.2017	1974	23	• Barriers in 18 of 23 wells inadequately documented and not verified in alignment with governing regulations. • Barriers against reservoir not set deep enough due to technical restrictions (age, tectonic movements, long production time, injection, etc.), resulting in lower formation strength in the formation used as a permanent WBE. • Barriers not verified against the permeable Miocene fm.		• PSA states that ConocoPhillips knew about access restrictions in the old wells, but still opted for lighter/ cheaper equipment/ solutions compared to more robust solutions (LWI vs rig and drillpipe).

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5	Valhall DP	AkerBP	20.11.2019	1982		• AkerBP has established a barrier verification and status document for each well, and deviations from these results in MoC. However, the MoC created reflected poorly the change in barrier status for each well, but was more general and did not always reflect the latest information. • The above-mentioned established system does not sufficiently highlight the necessary requirements for documentation (e.g. matters concerning HSE). • A large sand zone, referred to as DP7 and the cap rock, Seal 7 was part of AkerBP's barrier strategy was not adequately documented in relation to size, leakage from below, volume, HSE and pressure build-up from a permanent perspective.		• Ensure MoC document is tailored to the specific case, not being general, including latest information and barrier status.

Report #	Well(s)/Field	Operator at the time	Audit Date	Production start	No. of wells	PSA Findings	Risk/opportunity in project	Comments
6	Jotun B	Point Resources	22.03.2018	1999	up to 32	• Deviation from NORSOK related to the verification of barriers when common well barriers are in use. • The company lacked internal governing documents containing rules of barrier verification when using 9 5/8" csg. cmt as a common WBE. • A FIT was used to verify 9 5/8" casing cement as a permanent barrier.	• Successful cement jobs and subsequent cement bond logs in reference wells can, according to NORSOK, count as verification for the actual well, if the cement job is similar. (In this case, the reference wells could boast good volume control, centralized casing, thorough cement calculations and good CBL logs).	• NORSOK D-010 15.22 G states that casing cement used as both primary and secondary barrier counts as critical cement and shall be tested/verified as such. When using common WBE, the cement plug shall be dressed off and casing cement shall be logged. • NORSOK D-010 15.22 D1 states that the cement sealing capability can be verified through an FIT, but can ONLY be used as a WBE for next section drilling and never be used as verification for permanent abandonment (ref. NORSOK D-010 15.22 D2c).

5 Conclusions

H_2S and CO does not seem to be a problem in general on NCS. Circumstances where mud has been discharged seems to be due to poor planning and routines. Procedures on how to handle the toxic gases are more common now and NEA have seen a reduction in number of discharges the past years. Radioactive equipment is also a challenge in PP&A operations but have not been in focus.

After studying the reports, the focus areas of PSA/NEA, which should be taken into consideration for the Oselvar PP&A project, are:

- Internal requirements for P&A operations
- DNO's ability to foresee risks and plan for appropriate contingencies
- Verification of suitable barriers and internal requirements for qualification
- How DNO report and register deviations from internal guidelines
- Available resources and competence of personnel (e.g interpretation of CBL logs)
- Include service companies in risk assessments

A general reference is made to the Basis of Abandonment Design document where most challenges for Oselvar are addressed.
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