Executive Summary

Critical Review of Produced Water Sampling, Analysis and Reporting Procedures: Danish Offshore Operations

Maersk Oil Denmark

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Lloyd's Register

LIFE MATTERS

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1.1 Introduction

During December 2010, Maersk Oil Denmark was subject to allegations published in the Danish newspaper, *Politiken*, regarding the integrity of their produced water management processes, including Oil-in-Water (OiW) analysis and reporting. Maersk Oil Denmark engaged Lloyd's Register EMEA to conduct an independent review of the associated environmental processes and procedures (including implementation). Initial reviews of the Tyra production unit were conducted by Nick Jackson and Amy Annand of Lloyd's Register EMEA, and Stig Stangeland of Lloyd's Register Scandpower. Subsequent reviews of the DUC operations were conducted by Per Christofferson of Lloyd's Register Scandpower and Linda Murray of Lloyd's Register EMEA; they were also supported onshore (Esbjerg) by Amy Annand and Nick Jackson.

1.2 Scope of Work

Lloyd's Register EMEA reviewed and determined the degree to which Maersk Oil Denmark's produced water sampling, analysis and reporting (i.e. specifically Oil-in-Water/OiW) processes truly reflected accepted industry practice. The review evaluated existing documented processes and procedures, and compared their implementation onshore and offshore to recognised industry practice, best laboratory practice, and also compliance with the current OiW discharge permits for operating in the Danish sector of the North Sea. The review also included a series of interviews with workforce representatives who developed and used these processes and procedures. Additionally, the review verified a number of samples of reported concentrations, following the path along data transfer points.

The LR EMEA review teams visited:

- Tyra West.
- Tyra East.
- Dan.
- Halfdan.
- Gorm (including Skjold).
- Harald.
- Esbjerg offices.

1.3 Findings

1.3.1 Commendations

- Maersk Oil Denmark has established appropriate procedures (specifically OPM 2B Part 3 Rev 9) and associated guidance documents and initiatives which enable operations to meet expectations of the discharge permits associated with the Danish production units. It is noted that in response to the recent changes to the discharge permit, Maersk Oil Denmark has already commenced a review and revision of the OiW procedures and practices.

- Processes are established for employee engagement in procedural change (i.e. the updated Rev 9 of the OiW procedure and Rev 10 that is a work in progress).

- Feedback indicated that the response and reporting culture relating to discharge concentrations greater than 20 mg/l appears to be supportive and reflective of good practice.

- The action level for OiW is 20 mg/l, although the permit defines average monthly discharge limit of 30mg/l. This means that corrective action is often applied before a permit breach occurs. It is also noted that Maersk Oil Denmark has stipulated various internal KPIs, some as low as 5 mg/l for specified discharge points.

- As part of their continual improvement processes, Maersk Oil Denmark has implemented a number of initiatives to improve the efficiency of produced water treatment on board. These have included increasing heating capacity in order to improve separation efficiency, improving flow and skimming properties of the de-gasser, relocating the injection points for the water clarifier, and reducing flow throughput fluctuations.

- Evidence indicated that further improvements to the produced water treatment processes will be introduced. These include exploring the use of online OiW monitoring and investigating the accuracy of overboard flow metering systems.

- Daily production checks are conducted on individual produced water process trains. These checks include levels, pressures and temperatures of specific treatment equipment and processes. This data is then used to troubleshoot and define corrective actions if the 20 mg/l limit is exceeded. Some platforms have also implemented in-line continuous OiW monitoring processes to enhance process control and troubleshooting.

- Evidence obtained from offshore conversations confirmed that employees (e.g. the CCR) are empowered to shut down wells/operations and have done so when necessary.

- Communication with regard to OiW appears to be open and honest, and the workforce is actively encouraged to report on any observed undesired emissions and process deviations. The "eyes and ears" of the workforce were seen to be an important tool in monitoring OiW treatment.

- It is clear that some sound practices have been established and individuals know how to respond and troubleshoot when OiW KPIs are exceeded.

- It is clear that the overwhelming majority of the workforce has great pride in working for Maersk Oil Denmark and cares deeply about their responsibilities. People reported that they did not understand what prompted the newspaper allegations, which they believed did not represent the Maersk Oil organisation that they work for, or the reality of OiW management.

1.3.2 Areas for Improvement

The critical OiW review identified six areas of potential improvement, which are summarised below.

1.3.2.1 OiW procedure

The OiW Sampling, Analysis and Reporting procedure (OPM 2B, Part 3, Rev 9) enables operations to meet the expectations of the discharge permits. However, the clarity and structure of the procedure can be strengthened. Visibility and understanding of the overall OiW sample collection, analysis and reporting process within the procedure could be improved through the use of Process Mapping.

It is noted that the OiW procedure differs slightly from the reference (OSPAR) method, with examples highlighted below:

- Sample and reagent volumes.
- Sample gas release.
- Sample clean-up.
- Emulsification of sample.
- Blank samples.

The review of the OiW procedure also identified an inconsistent approach to the level of detail contained within the asset specific sections of the procedure. There should be a standardised minimum amount of platform specific data included in all asset specific sections of the procedure. Additionally, there is a lack of platform specific information relating to (where applicable):

- Expectations relating to communication, and how knowledge or data is transferred.
- Details related to the use of in-line and/or continuous monitoring equipment to supplement OiW management.
- Sampling (including when samples should and should not be taken), labelling, packaging, protection, storage and transporting (i.e. sample custody and integrity).
- Determining total volume of re-injected produced water and total volume of overboard produced water.
- Post analysis reporting (i.e. cross-referencing workbooks, production logs and OiW database).

1.3.2.2 Integrity of data

The Lloyd's Register EMEA reviews could find no evidence that the OiW data had been falsified. However, the lack of robust and transparent sample and data management means that Maersk Oil Denmark is exposed to the potential for error and misconduct. Identified examples of these exposures include the following:

- Existing sample custody practices introduce the potential for samples to be tampered with or to be misplaced; however, there was no evidence that this had taken place.
- Critical data is sometimes verbally transferred.
- There is a lack of written Laboratory Logbooks (denoting sample times, analytical results, anomalies, changes, errors, comments etc.).
- There is a lack of security of data contained within platform specific Excel workbooks.
- When changes are made to data contained within the workbook, there is no record of the original data or documented reason for the change.
- Sense checks (conducted onshore) of reported concentrations did not consistently capture noted data anomalies.
- The first point of verification (using existing practices) is the Excel spreadsheet workbook. This is an issue because the spreadsheet is populated at an advanced stage of the OiW sampling, analytical and reporting process.

1.3.2.3 Lack of robust verification

The overall process for OiW management should be underpinned by robust verification and Quality Assurance. The review revealed a number of areas where Maersk Oil Denmark did not demonstrate structured processes to assure data quality and compliance with best practice. Examples of these areas include:

- Lack of structured supervisory Quality Assurance.
- Lack of robust verification of On-the-Job training.
- No QC samples analysed to provide assurance of accuracy of results. NB: this is not aligned with good laboratory practice.
- Lack of robust internal audits in order to scrutinise OiW processes.
- The limit of the scope of the Force Technology Audits (i.e. only sampling and laboratory practices and OSPAR correlation) did not enable complete verification of OiW processes.

1.3.2.4 Degree of variability of reported concentrations

The uncertainty (standard deviation) of reported concentrations and overboard oil volumes is not fully quantified. Variability levels will be associated with:

- The sensitivity of Wilkes Analyzer at lower concentrations (NB: Maersk Oil Denmark has determined the Limit of Detection to be approximately 4mg/l).
- Individual pieces of laboratory equipment (e.g. balances, volumetric flasks, measuring cylinders etc.).
- Differing approaches by individuals with regard to sample collection, storage, extraction and clean-up.
- The OSPAR correlation method.
- Accuracy of overboard flow meters.

The cumulative variability with the aforementioned elements creates an unknown level of uncertainty for the method. Understanding the lower limits of detection is particularly

important for reporting lower concentrations, especially those concentrations related to OiW KPIs.

1.3.2.5 Competency assurance processes

Maersk Oil Denmark is currently establishing a structure for offshore workforce training programmes which includes: training needs analysis, job descriptions, technical training programmes, On-the-Job training programmes etc. This is documented and managed onshore via the Learning Management System (LMS). This framework is still under development and therefore is not fully implemented.

The offshore workforce's individual training programmes are documented in the LMS. It is the expectation that employees will be trained by experienced team members based on tailored role specific training programmes.

1.3.2.6 Tyra East specific improvements

Some participants on board Tyra East described strong feelings of mistrust towards management both on and offshore. This was supported by perceptions of exclusion and lack of involvement, which are further compounded by stated beliefs that communications between offshore and onshore are ineffective.

1.4 Conclusions and Recommendations

1.4.1 OiW procedure

In line with our findings, the OiW procedure (OPM 2B, Part 3, Rev 9) requires a significant update to meet the requirements of the new discharge permit. This upgrade should also address the expectations of OSPAR and strengthen the clarity and structure of the procedure. The platform specific information (e.g. platforms without laboratory facilities, platforms that re-inject produced water etc.) should also undergo a critical review to ensure adequacy. This will enable consistent understanding and application of the overall OiW sample collection, analysis and reporting process.

1.4.2 Integrity of data

The findings indicate that there is a lack of robust and transparent sample and data management meaning that Maersk Oil Denmark is exposed to the potential for error and misconduct. It is therefore recommended that Maersk Oil Denmark implements a number of data integrity control measures in order to reduce the risks associated with inaccurate OiW reporting. These measures include:

- The platform specific instructions should be developed to include a documented sampling plan and procedure.
- Formally document and log verbal transfer of critical information.
- Establish 'Good Laboratory Practice' with the use of written Laboratory Logbooks.
- Introduce data security controls within platform specific workbooks.
- Formalise onshore based sense checks to capture noted data anomalies.

- Introduce robust verification processes that would verify the data trail from sample collection to reporting.

1.4.3 Lack of robust verification

The overall process for OiW management should be underpinned by robust verification and Quality Assurance. The review revealed a number of areas where Maersk Oil Denmark did not demonstrate structured processes to assure data quality and compliance with best practice. These processes should include:

- Structured supervisory Quality Assurance.
- Robust verification of On-the-Job training.
- Analyse QC samples to provide assurance of accuracy of results.
- Robust internal audits.
- Third party audits.
- Update procedures: ensure that the verification processes add value, and are aligned with revised OiW procedures.

1.4.4 Degree of variability of reported concentrations

Inevitably sample collection, custody, analysis and reporting processes will introduce some degree of variability in reported OiW concentrations. The Limit of Detection is likely to be important when the data is utilised for the setting and achieving of internal KPIs, where these are at levels lower than those that can be reasonably detected. It is therefore recommended Maersk Oil Denmark attempts to quantify the lower Limit of Detection for the OiW method and recognises it when setting internal OiW KPIs.

1.4.5 Competency assurance processes

Maersk Oil Denmark is currently establishing a structure for offshore workforce training programmes. They must formalise arrangements to ensure that:

- Existing and new Laboratory Technicians should either complete the newly developed OiW training programme, or verify competency levels of existing Laboratory Technicians against the programme requirements.
- All relevant job descriptions are cohesive and complete. They must accurately reflect produced water management tasks and responsibilities.
- Training programmes are implemented as per identified needs.
- On-the-Job training is formalised, including verification.

1.4.6 Tyra East specific improvements

Critical review findings relating to the Tyra East installation differ from the other DUC assets. Specific recommendations pertaining to this asset are:

- Maersk Oil Denmark has processes to enable individuals to report concerns. It is important that these processes are not only established, but are fully supported and

people are encouraged to use them. While recognising that this process is supported by Maersk Oil Denmark, it is clear that some individuals on Tyra East elected to choose a different vehicle to communicate concerns. In support of this recommendation, a culture of openness in reporting and communicating should be further nurtured and embraced within the organisation.

- Maersk Oil Denmark should carefully consider the internal communication and management actions to be taken in the aftermath of these events. This would include communication (i.e. internal/external announcements, lessons learned, and individual response actions) to the workforce and relevant stakeholders. This should clearly define the expectations of onshore and offshore management, and those actively involved in the OiW processes.