Extended Abstract


This study presents the mobile treatment system recently deployed in offshore development activities in Brazil. The system is a specialized two-module treatment of synthetic base mud (SBM) contaminated with wash water and slop water. The modules of the unit are deployable to any drilling environment onshore or offshore platforms. The studied unit treatment process uses a combination of chemical and physical processes such as demulsification, flocculation, settling and filtration to separate SBM and SBM fractions from the slop water into their main components. Laboratorial testing was conducted to ensure that this system would have the capacity to treat SBM-contaminated wastes to comply with the Brazilian Resolutions for Effluents Discharge (Conselho Nacional do Meio Ambiente Resolutions n° 357/05 and 430/11). The tests involved adjusting the system to operate within the limits established by the local legislation, which establish very conservative limits of metals and hydrocarbons, amongst other parameters, that effluents have to meet before being allowed to be discharged in continental or oceanic bodies of water. The study presents the test results which show that the system has produced effluent that complies with all the parameters necessary to allow its discharge at the drilling offshore location in Brazil. The next step to be taken, before operational use of this technology in Brazil, is the agreement of a monitoring plan with the environmental agency. Results have shown that the use of such system is not only economically advantageous, but also environmentally significant as it helps minimize the waste, reuse fluid, increase profit, and improve margins in drilling operations. In Brazil, the use of this technology has an innovative profile and it’s a tool that can contribute to reducing the high volumes of drilling waste that currently are sent onshore for final waste disposal.
Introduction

Considering the current scenario of environmental valuation and continuous advancement in oil exploration and production, contemplating the environmental variable is increasingly a critical issue for the survival of the major oil producing companies that compete and merge in the borderless search for new hydrocarbon reserves (SCHAFFEL, 2002).

The oil and gas exploration and production industry is often perceived as a major polluter of the oceans due to the impact that accidents, such as oil spills, may have to the adjacent ecosystems and those populations that depend on it. Oil and gas is experiencing a period of adaptation/development of new technologies and creation of productive processes more efficient and less harmful to the environment.

Several new drilling fluids have been introduced to the market to meet the new green parameters. However, offshore drilling operations generate solids and liquids waste streams. Contaminated deck drain water and slop water from clean up or displacement operations involving synthetic base mud (SBM) and/or spacer surfactants and solvents cannot be discharged to the sea. In these cases, the correspondent volumes are transported to shore for disposal as dangerous effluents. This procedure, although aimed at reducing the impact to seawater around the drilling units, generates a huge volume of effluents with a high water ratio to be disposed onshore at landfills.

Landfills, although designed to store away dangerous effluents safely, are a liability and subject to leaks or seepages into soil and ground waters. According to Kjeldsen et al, (2002), the use of landfills is the most common alternative to final waste disposal in most countries. However, disposal of effluents in a landfill may contaminate the surface and ground waters, propagated by excess rainwater that percolates the waste layers of the landfill.
Developing a technology capable of reducing the amount of water that goes to a landfill as effluent and permit the reuse and recycle of drilling fluids – waste minimization pyramid – is a challenge drilling operators and petroleum institute face and is assumed to be the key for sustainable future drilling activities.

This study presents a mobile treatment system for drilling effluents, recently deployed in offshore Brazil for testing. In Brazil, since the discharge of SBM to the sea is not allowed, contaminated fluids are considered effluents by the environmental agency (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis - IBAMA). The discharge of effluents is regulated by Conselho Nacional do Meio Ambiente (CONAMA) Resolutions n° 357/05 and 430/11. These resolutions establish very conservative concentrations of metals and hydrocarbons, amongst other parameters, that effluents have to meet before being discharged into bodies of water in order to protect the natural resource.

**Materials and Methods**

Tests were performed in Brazil to understand whether the system would have the capacity to treat SBM contaminated effluents to the point where they are in compliance with the CONAMA Resolutions. Samples from five ongoing operations were adjusted using the system to verify the end product was within the limits established by Brazilian legislation.

- **Slop Definitions**

  Interface, also called slop, is generated when changing from one fluid system to another. For example, WBM-SBM-WBM and vice versa. Operations where drilling fluids are replacement with fresh or salt water also generate an enormous amount of slop, which usually ends up in landfills. Drilling fluids spilled on the drilling unit (rig floor, sack store, shaker house, and mud pump room) and oil contaminated rain water are often washed into the closed drainage system, where drilling fluid and wash water are collected in a slop tank. Additionally, any sediment (barite) contaminated water occurring during tank cleaning would end up in a landfill.
Drilling fluids (WBM and SBM) can also suffer contamination by industrial water or sea water. When this occurs, the fluid can no longer be used and is considered slop fluid. Any SBM contaminated with water be disposed of in landfills as dangerous effluents. To recover water contaminated drilling fluid, use of the mobile effluent treatment unit will separate the contaminant (water) and allow reuse of the fluid.

All the residues listed above can be treated with the mobile effluent treatment unit. However, other waste slop generated in maritime operations, such as hydraulic oil, bilge water, grey water, and brown water, are not suitable for the mobile effluent treatment unit and disposal should be made in accordance with the specific legislation (e.g., International Maritime Organization).

A different tank for each kind of slop waste treated by the mobile effluent treatment units used due to the different treatment methods. Because of this, the mobile effluent treatment unit cannot treat all the types of drilling fluid on all drilling platforms. The amount of space available for tanks will affect the number of different fluids that can be treated. Space is also needed for the rigorous procedures to prevent the mixture of fluids.

- **Treatment Description**

The mobile effluent treatment unit is a modular wastewater and slop water treatment system consisting of two circular tanks for treatment, a flocculation tank, a filtration unit with a twin filter pod, and a filter press (each with four cartridge filters). The treatment uses a combination of chemical and physical processes such as demulsification, flocculation, settling, and filtration to separate slop into its main components for re-use or subsequent disposal.

The first step in the treatment process is based on a patented emulsion breaking process that allows the recovery and reuse of SBM fractions from the slop water. An emulsion breaker is slowly blended into the contaminated drilling fluid in the first two process tanks with a frequency controlled agitator. The whole drilling fluid separates out to the bottom of the tank and the water breaks out at
the top. The water phase includes the emulsion breaking chemicals and is pumped off for further treatment.

The next step uses a specialized water treatment containing specially prepared bentonite based flocculants. The water from the first two separation tanks is pumped off the top into the second treatment tank. In the second tank, chemicals for flocculation are added in order to remove the remaining particles and oil in the water phase. The flocculated particles settle to the bottom and are removed or recovered after the water at the top is pumped through the integrated filtration unit. The flocculated material goes through a filter press for further treated after the water from the top is treated.

After flocculation, the clean water from the top of the second treatment tank is directed to the filtration process, which is a policing/polishing three-step filtration process. The oil remains inside the filter cartridges and is disposed of to be reused in other activities. The water is sampled and analyzed with an oil-analyzer to guarantee the treated water meets all regulatory requirements.

Effluent treated into clean water that is compliant with the local regulatory framework is either discharged or reused in another industrial application on the rig; for example tank cleaning and development of new drilling fluids.

**Results and Discussion**

Slops from five different drilling activities (SBM contaminated deck drain, wash water from surface pits tank cleaning, and slop water interfaces) in Campos Basin, Rio de Janeiro, Brazil, were treated with the mobile effluent treatment unit and are identified in this study as B1, B2, B3 B4 and B5.

A comparison of the results found with the parameters established by CONAMA Resolutions n° 357/05 and 430/11 for effluents discharge revealed that almost all analysis presented results undetectable and/or below the maximum values authorized for discharge into the sea, with the exception of BTEX, Mercury and Copper in B2 and Total Silver in B5.
However it is important to mention that these values do not take in account the immediate dilution that the effluent will suffer immediately after its discharge to the sea. Therefore, it is possible to affirm that the effect of dilution in marine waters will lead the concentrations of these contaminants to levels below those recommended in Brazilian and international legislations.

A total volume of $1.078 \text{ m}^3$ was treated. By treating the slop with the mobile effluent treatment unit, approximately 4% of the excellent SBM and about 83% of clean water were recovered. Most of the volume treated was SBM contaminated deck drain water from cleaning activities (74%), which contributed to the high volume of reclaimed water and low SBM/base oil recovered. The reduction percentage in disposal on landfills (water + solids portion), in the present study was 96%. However, is highlighted that, for the study in question, were not discharges overboard of any effluent treated.

**Conclusion**

The present study presented concepts designed to meet and be compliant with Brazilian environmental legislation requirements of managing SBM contaminated deck drain and slop water interfaces from offshore drilling operations.

So far, the results obtained for tests carried out in Brazil show that, with minor adjustments, the system can treat effluent so that it complies with all parameters necessary for discharge at the drilling location. This prevents significant risks in transport to a landfill destination, as well as the associated costs. Before operational use of this technology in Brazil (to significantly reducing the volume of effluent sent to landfill, with real reduction, reuse, and recycle of effluents) an agreement of a monitoring plan with the environmental agency (IBAMA) is suggested.

**Keywords**

On-board Treatment Unit; Innovation; Offshore Drilling; Fluids.