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Environmental Advances in Drilling Fluid Operations Applying a Total Fluid Management Concept

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Abstract

This paper presents a drilling and well fluids management concept short named TFM. It was intentionally designed to meet the requirements of sustainable business management compliant with current and amended environmental legislation. Key elements of the concept are continuous learning cycles requiring best available technology integration, waste minimization programs, benchmarking and contractual incentives for recycling of materials. Presented data substantiate that profitable returns like cost savings for the operator, increased profit for the drilling fluid supplier and reduction in environmental loads have resulted from the implementation of this concept.

Prior to implementation of TFM in 1999 realistic target operational cost cuts were estimated to ten per cent. Results show higher returns than expected. Reduction in water based drilling fluids consumption is reported to be thirty four per cent. In general less waste material being discharged, lost or spilled followed the intensive reuse of drilling fluids. Slop waters were treated and materials were recycled, resulting in less costly waste disposal and less need for new chemicals entering the consumption chain. Trend analyses show that chemical consumption in drilling operations was significantly reduced, measured as total consumption and chemical spent per volume of drill cuttings excavated.

A most apparent change during the contract period was that the drilling fluid supplier conducted housekeeping of chemicals more diligently than ever. This positive change in attitude was attributed to the recycling incentive formulated in the contracts.

Vendors selling chemicals to the drilling industry and waste treatment companies seem to be the ones that suffer by the consequences of the aggressive waste minimization strategy. Their profits were sacrificed to the benefit of the total environmental burden.

Introduction

Traditionally drilling fluid remnants and drill cuttings from offshore operations has been regarded as drilling wastes and treated accordingly[1]. Historically much effort has been invested in exploring waste minimization opportunities[2-4]. Fairly recently a new trend has gained increased support. This trend is the holistic approach to solving both drilling and waste problems[5, 6]. The essence of this philosophy is that one has to design input chemicals that are used for drilling purposes bearing in mind that none of the chemicals should compromise a recycling solution. Prioritized waste minimization efforts are described by the famous 5R waste minimization hierarchy, where the top R's; reduction at source, reuse and recycling of material are believed to produce rewarding returns. Some will argue that this is *resource management* as opposed to a risk based waste disposal decision strategy, as the ultimate goal of waste minimization is to avoid deposition of waste.

Sørbye[7] originally described reuse of water based drilling fluids as a cost effective fluid handling method. He suggested that reuse be performed beneficially both for the drilling fluid supplier and for the operating company. In a field trial Statoil[8] demonstrated the viable economical benefit, along with reduced discharges to the environment.

Waste minimization of drill cuttings may be pursued to its full extent by treating the drill cuttings and separating useful constituents for recycling included the cuttings itself. Current dispositions of the treated cuttings are predominantly land applications, like municipal landfill cover material[9]. Other treatment options for the drill cuttings include land farming, composting, bioreacting, solidification, washing, thermal desorption and incineration.

Historically, in Norway, the relations between operators and drilling and well fluid suppliers were characterized by the operators being heavy consumer of chemicals while the suppliers made their profit by selling the chemicals. This was not a sustainable arrangement for the operator and steps were taken within Statoil to counteract this practice[10]. Handling, treatment and disposal of drilling waste have always been cost driving. As well production profiles and cost margins became tighter on the Norwegian Continental Shelf (NCS) and environmental regulations became stricter in the 1990s, new management systems were required[10].

To counterbalance the non-sustainable practice in drilling operations Statoil developed the “Total Fluid Management” (TFM) contracts. In these contracts, the suppliers are compensated a fixed price for drilling fluid volumes independent of content. In principle there is no applicable profit to be gained from this sales. To make sure the drilling fluid has the correct properties, the supplier is awarded for good drilling progress that deliver in compliance with, or better than the drilling plans. Finally, left over material from the well is sold back to the supplier for a reduced price. The used drilling fluid can be re-sold to the operator for full price. Optimum profit for the supplier is achieved by effective drilling performance using as much used drilling fluid as possible. The TFM contracts have been reported to contribute significantly to reduced cost per meter drilled, increased drilling rate and reduced drilling waste generation[5, 11].

In light of the commitment outlined in the Norwegian White Paper 58[12] the challenge ahead for drilling operations at the NCS is to comply with a zero discharge requirement by 2005.

The data to follow broaden our understanding of the positive impacts of enforcing waste minimization while sharing the profitable returns with the co-operating service companies. It is strongly maintained that the recycling driven planning is a beneficial and sustainable practice for a drilling operator, in line with the future requirement of sustainable drilling practice.

Major findings

The Statoil drilling operations stretch across a large distance from the south to the north of Norway. Coast bases spread accordingly service these operations. Drilling wastes are therefore taken to shore at four different locations, all of them located along the southern coastline of Norway.

Volumes of slop water treated at different locations are outlined in Table 1. A total of 9915 m^3 of slop waters has been treated at treatment plants, so called EnviroCenters. Outline of treatment principles is shown in Fig. 1. In total there has been produced more slop at Statoil operations than received at these centers, but these treatment plants were erected for the specific purpose of treatment/recycling of drilling wastes. The smooth co-operation with treatment at the EnviroCenters and the drilling fluid supply was beneficial for the improved recycling efforts. As mentioned elsewhere there was a cost-benefit attached to the reuse of fluids.

A major waste volume reduction was achieved by treating the slop waters. This waste had previously been disposed of as hazardous waste owing to the high content of hydrocarbons. The previous practice was accordingly cost driving for Statoil. In average the fraction of waste recycled was 78%. The figures in Table 1 accounting for volume reduction are equal the volumes disposed of as hazardous waste prior to the new contracts. The cost benefit of this recycling practice is thus dependent on the cost for treatment and getting rid of the residue (hazardous fraction) and the savings accounted for by reuse of material contrasting buying new material for building fluids. As shown in Table 2 average percents reuse of oil based and water based drilling fluids are 63% and 34%. The trends during the period show a continuous improvement for most of the measured parameters. The beneficial consequence of this recycling becomes obvious when we look at the decrease in consumption of chemicals, with reference to meters drilled. For typical drilling fluid components the numbers are:

Barite	35% reduction
Viscosifiers	37% reduction
Base oil	0% reduction
Glycol	16% reduction
KCl Brine	20% reduction

A substantial reduction in consumed volumes of fluids and components is thus attributed to the recycling practice. Also, these numbers are indirect proof of the success of the theory that lies behind the TFM. Base oil in drilling fluids has always been recycled owing to its value. Therefore no reduction in base oil consumption was measured. Calculations showed that the average reduction in cost per meter drilled was around 10%. The recycled fluids account for a large fraction of this.

Drill cuttings usually ferry a relative large amount of water based and oil based drilling fluids. Base oil is an expensive component of the drilling fluid formulation and is therefore attractive for reuse. The current technology in Norway, thermal desorption units, is not developed to the extent that it fully aids extensive reuse of the base oil reclaimed from cuttings. Several issues need to be addressed before improved recycling can apply for the base oil carried on the cuttings and the cuttings material itself.

The experience with the TFM contracts has shown that there is a need for close collaboration between drilling fluid companies and waste handlers in order to establish a viable practice with profitable returns. This aspect was taken seriously in Statoil and resources were allocated to develop key performance indicators that stretched across the total line of services, to facilitate alignment of all parties towards the common goal of waste minimization. The increased focus on best available technology that sustain recycling push forward new modes of cooperation between suppliers. Large investments are required to establish right technology and no single company is likely to bear the economical risk alone. Apparently the preferred solution is to develop alliances.

Discussion

In general the *recycling of resources attitude* in drilling waste disposition appears as an effective management principle. The positive results shown here undoubtedly verify this statement. However, the principle has limitations that cannot be neglected. Within the frames of sustainable development different aspects need to be taken into consideration when best environmental practice is in question. Therefore recycling cannot be taken to its full extent in all cases or at any location in the world. Compared to depositing as a waste disposition, secondary emissions and treatment costs must always be balanced with the benefits of recycling. Also, it is true that relative large drilling waste streams must exist before it can sustain profitable returns in operation of a treatment plant. Investments in the order of minimum 10 MNOK per EnviroCenter was needed to support the waste minimization and recycling requirements. Each plant typically service 3 – 4 offshore drilling rigs or other offshore installations.

In terms of liability connected to waste, recycling to the full extent seems to be the solution that can turn liabilities into assets. Again, this is dependent on the technology available. The principle itself, which can contribute to develop new treatment technologies and change yesterday's practices into better solutions, benefits all stakeholders. However, the concept of designing drilling fluids that contain compounds that aid degradation of harmful substances in the drilling waste should be given critical thought[13]. The overall issue is to reduce the input of chemicals.

The successful recycling of water based drilling fluids is an example of how things can change when the recycling principle is implemented as a management perspective. Drilling waste with large volumes of water based drilling fluids attached used to be discharged, in compliance with discharge permits. Now it is proven that the prevalent attitude can be changed with rewarding benefits. This also illustrates that operators must be proactive in developing sustainable solutions. Performing in compliance with regulations does not always sustain the most cost-effective or sustainable practice.

Conclusions

- An important consequence of applying the TFM principle was that large fractions of the drilling waste were reclaimed as resources.
- Waste minimization by intensive reuse and recycling of drilling waste material proved to be cost-effective and beneficial to the environment; 78% of the slop water waste was recycled.
- The concept is regarded as a step forward in managing sustainable drilling practice.

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Table 1. Waste volumes treated and fractions reclaimed for recycling. Waste refers to cleaned water discharged compliant to permit levels, and a residue; hazardous waste. Volume reduction; this volume was previously disposed of as hazardous waste.

		Waste split - volume reduction phases (m^3)				Waste					
Coast base	**Received**	**Water**	**Brine**	**Base Oil**	**OBM**	**Water disch.**	**Residue**	**Waste reduction**	**% Waste reduction**	**Volume reduction**	**% Reduced**
Kristiansund	5239	1291	205	0	1632	1494	611	3134	60	4628	89
Stavanger	3652	1965	0	0	1551	0	155	3497	96	3497	96
Florø	682	205	0	0	168	0	296	386	57	386	57
Bergen	342	80	0	0	262	0	0	342	100	342	100
	9915	**3541**	**205**	**0**	**3613**	**1494**	**1062**	**7359**	**78**	**8853**	**89**

Table 2. Trend analysis of key parameters in drilling fluid recycling. Period from last quarter of 1999 to January 1st. 2002.

	Q4 99	**2000**	**2001**	***mean***
Reuse WBDF	22 %	25 %	44 %	34 %
Reuse OBDF	57 %	66 %	57 %	63 %
Consumption WBDF, m^3/m^3	8,41	6,89	6,13	6,60
Consumption OBDF, m^3/m^3	4,26	4,37	3,79	4,22
Discharge WBDF, m^3/m^3	5,86	4,54	4,29	4,49
WBDF return to shore, m^3	1070	14408	21344	36822

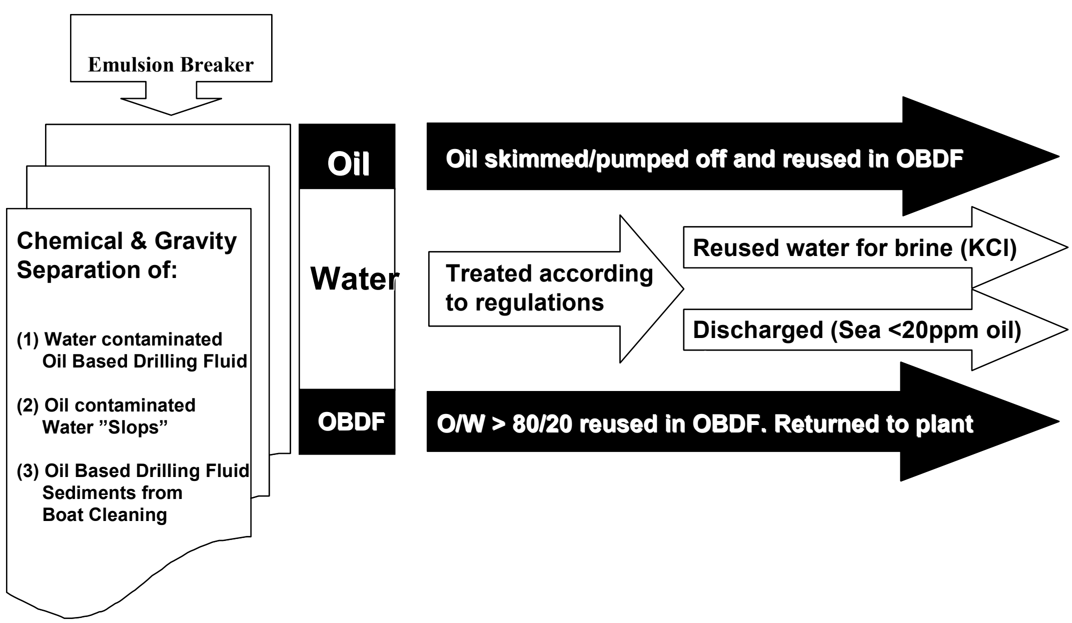

Fig. 1. Schematics of treatment of drilling waste (slop water).