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SUPPLYING CHEMISTRIES TO THE OILFIELD-A SUSTAINABLE APPROACH?

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Abstract

Demonstrating a commitment to the environment, to society and to the local economies in which we all participate is perhaps one of the greatest enduring challenges faced by companies today. On the environmental front, this is indeed true when it comes to the chemistries that are a mainstay of our business. Still, the most successful driver of new development is a changing regulatory landscape. This is also the most likely driver of operator policy, although without regulatory boundaries in place, the operator has to use internal policy to determine what practices are and are not acceptable. The industry as a whole has made great strides to develop and share best practices for operation. Greater demands for transparency have driven the development of global minimum standards for many corporations, for example governing discharges of drilling fluids on cuttings.

The service industry can take an influential role in the pursuit of sustainable business practices and the use of environmentally responsible technologies that demonstrate commitment to the communities and local environments in which the industry operates.

Already, highly biodegradable, low toxicity chemicals are available in the market place, but "doing the right thing" as far as environmentally sustainable technology R&D is concerned is often not sufficient to drive the market to adopt the technology. Late adoption or total lack of adoption of more sustainable technologies may be due to many reasons. Examples are higher per barrel product cost, lack of local familiarity with new technologies or extreme technical requirements. However, against this downside, early adoption of more environmentally responsible chemistries may minimize HSE risks, avoid future cleanup costs and even reduce the regulatory burden if the industry demonstrates use of best practice and self government. This paper will discuss the work within a large multinational service company in developing and offering to the market a range of environmentally sustainable oilfield chemicals and the successes obtained as a result of adoption of these technologies.

1. Introduction

We are all connected. As individuals and as citizens of the global business community we are conscious of the role we play in shaping our common destiny. We must understand our responsibilities as an industry and as individual companies, not only to our employees, our customers and our shareholders, but also to the wider community and the lives we touch.

Corporate sustainability and sustainable development, for the most part, are defined by who we are as an industry. To give back to the environment, the oil and gas industry must manage the investments it has made in existing wells as efficiently as possible and invest in alternative approaches to development alongside pursuing development of alternative energies. The role of the service company is to research, develop and offer alternative approaches in terms of chemistries. Halliburton continues to invest its research dollars into developing more environmentally friendly, higher performance drilling fluids and minimizing drill cuttings disposal.

2. Commitment to Local Communities

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With the introduction of new forms of communication technology, like the Internet, the world is more interwoven than ever. The industry must respond to the concerns and values of all its neighbors in a respectful and accepting manner according to the needs of each country in which it operates. However, global corporations increasingly are held to high global standards irrespective of the environmental regulations in place by the host government.

When an operator goes to area without environmental regulations, the flexible boundaries for acceptable behavior may put that operator at risk for future liabilities. In these areas, it may be best to use global minimum standards or guidelines such as those promulgated by the International Oil and Gas Producers Association (OGP), World Bank, or the International Finance Corporation (IFC).

Service companies play a vital role for the operator in terms of how they are perceived by local communities and host governments because often they are the people on the ground representing the project to the community, especially in emerging markets that may not have regulations in place. With each project, there is a unique opportunity to give back to the local communities and environment. Sustainability must be evident economically, socially and environmentally. Empowering locally inspired solutions develops and encourages a corporation to learn and innovate. Acknowledging and promoting cultural bias into solutions promotes acceptance of cultures.

Halliburton’s policies and procedures involving environmental stewardship become interwoven with the overall impact of each project. Operating companies already ask for third party governance, the evidence of best practice and ownership of our performance. Our commitment to alternative technologies plays directly to their need to show responsibility to their clients.

3. Environmental Impact

Perhaps the most effective driver of alternative technology development is environmental regulations.

Economic offshore drilling operations often necessitate discharge of drilled cuttings with associated fluids. This activity faces regulatory control, including those in the most active offshore oil and gas basins. Where there is a high level of activity or operations are conducted close to shore, especially in shallower waters, there may be potential or perceived conflicts with other stakeholders in the area (e.g., tourism and fisheries).

Frequently, regulators have established government agencies that in turn devise a system of control to help ensure that the potentially negative long-term impacts of these drilling and well construction discharges are minimized.

Environmental impact of discharged cuttings introduces a difference in approach to sustainability and environmental stewardship. The assumption could be made that it is better to not dispose of cuttings offshore, but the safety risks and the environmental emissions and land fill associated with transporting cuttings to shore and to a disposal site provide a better perspective of overall value of offshore disposal of clean cuttings.

Application of science to a regulatory situation may lead to a different outcome of analysis than expected. A good example of this is the US EPA consideration of support of use of Non-Aqueous Fluids (NAF) in place of water-based fluids (WBF) or oil-based fluids (OBF). The reasons the EPA gave for their support was that the NAF would give better performance than the WBF with a reduction in non-water quality pollutants (including energy requirements). They also considered that NAF would lead to reduced rig requirements due to improved availability of extended reach drilling. Thus, NAF were favorable over OBF due to their lower toxicity, better biodegradability and lower Polycyclic Aromatic Hydrocarbon (PAH) content, which is a good advantage given that PAH are considered priority pollutants by the EPA.

A zero discharge approach for NAF also was considered. However, EPA recognized that operators would move away from synthetic-based fluids (SBF) to WBF and OBF. Such a move was considered a negative aspect, as EPA determined that increased WBF would lead to unacceptable non-water quality impacts and greater pollutant loadings to the ocean. The use of OBF was considered undesirable due to the increased requirement for shipping of cuttings to shore and associated non-water quality impacts such as fuel usage, air emissions and land disposal of the OBF cuttings. EPA also recognized that shipping cuttings to shore carries an associated risk of cuttings spills and an increase of fluid and cuttings toxicity if operators switched to OBF. The EPA recognized that offshore operations could potentially impact the environment, specifically in the GOM, where it estimated that the number of wells drilled per year in shallow water totaled 1,047 and 138 in deepwater.

The zero discharge option was rejected by EPA. Discharge of SBF is regulated using New Source Performance Standards and Best Available Technology (BAT) limitations (Table 1). Therefore, what is discharged is controlled and reported. EPA considered that controlled discharge of SBF would lead to the least ocean, air and land pollution.

Table 1. Summary of US synthetic-based drilling fluid standards

	Fluids meeting Ester Standard	**Fluids meeting Internal Olefin Standard**
Percentage Base Fluid Retention on Cuttings	Cuttings must retain equal to or less than 9.4% wet weight base fluid measured every 500 ft. at least once per day, but no more than 3 samples/day. If BMP plan is used extent of monitoring is reduced.	Cuttings must retain equal to or less than 6.9% wet weight base fluid measured every 500 ft. at least once per day, but no more than 3 samples/day. If BMP plan is used extent of monitoring is reduced.
Base Fluid Biodegradation	Equal to or better than a C8 or C12-C14 2-ethyl hexanol/palm oil ester in a 275 day test. Tested once per year.	Equal to or better than a 65:35 blend of C16 C18 Internal Olefin in a 275 day test. Tested once per year.
Leptocheirus Base Fluid Toxicity	10 day Leptocheirus LC50 must be equal to or less toxic than a C8 or C12-C14 2-ethyl hexanol/palm oil ester. Tested at least annually.	10 day Leptocheirus LC50 must be equal to or less toxic than a 65:35 blend of C16 C18 Internal Olefin. Tested at least annually.
Field Mud Static Sheen	Test weekly as per existing permit.	Test weekly as per existing permit.
Mysid Field Mud Toxicity testing	30,000 ppm 96hr LC50 SPP Mysid as per existing permit (monthly).	30,000 ppm 96hr LC50 SPP Mysid Test as existing permit (monthly).
Leptocheirus Field Mud Toxicity testing	Leptocheirus 96hr LC50 must be equal to or less toxic than standard IO lab mud. Once per well at end of drilling.	Leptocheirus 96hr LC50 must be equal to or less toxic than standard IO lab mud. Test monthly sample and at end of drilling.
Heavy Metal Content of Barite	Total Hg must be less than or equal to 1 mg/kg and Cd must be less than or equal to 3mg/kg using 40 CFR 435, Subpart A.	Total Hg must be less than or equal to 1 mg/kg and Cd must be less than or equal to 3mg/kg using 40 CFR 435, Subpart A.
PAH Content of Base Fluid	10ppm or 0.001% PAH (as Phenanthrene) content by HPLC/UV- EPA Method 1654.	10ppm or 0.001% PAH (as Phenanthrene) content by HPLC/UV- EPA Method 1654.
Crude/PAH Content (Prior to drilling)	GC/MS test per batch of fluid to be tested before being shipped offshore. Must contain <1% Crude oil.	GC/MS test per batch of fluid to be tested before being shipped offshore. Must contain <1% Crude oil.
Crude/PAH Content (Field Mud testing).	Weekly using a Reverse Phase Extraction method. If a fluid fails by containing a suspected >1%, a sample should shipped to shore and tested using GC/MS. Test run weekly.	Weekly using a Reverse Phase Extraction method. If a fluid fails by containing a suspected >1%, a sample should shipped to shore and tested using GC/MS. Test run weekly.

4. Developing New Technologies

One of the greatest challenges for sustainability is to understand the holistic cost and value argument for the approaches we rely upon and the new chemistries available on the market and those being developed. Many approaches taken in isolation may appear to offer the best 'value', but we sometimes have to weigh up overall cost or value. Development of new technologies to meet or exceed environmental regulations is possible if the service companies and operators form a partnership to ease the fully-burdened cost involved.

While environmental regulations may differ among regions and countries (i.e., the North Sea and the Gulf of Mexico), they can provide a forced emphasis on alternative approaches, and may hasten uptake of new chemicals as the industry is forced to collectively meet new targets that will help to offset some of the more common barriers to adoption.

However, there is anecdotal evidence from the field that environmentally friendly chemicals are often perceived as being less effective than their traditional counterparts, even though the redesign of field chemicals to accommodate changes in regulatory requirements may present opportunities to improve technical performance.

A good example of redesign for environmental reasons resulting in performance improvement was a product that was designed for wellbore clean-ups, pit cleaning and, when diluted, washing down the rig. The challenge was to develop a new product with an enhanced environmental rating that is capable of matching or exceeding the performance of existing materials.

The existing material achieved a "red" classification in Norway, and the new material achieved a "yellow" rating. This difference in rating was due to the difference in biodegradability of the organic component of a key component of the product. The significance of the change in rating was that operators could use the new product without making a special case to the regulators. Not only was there better biodegradability of the new product (Figure 1), but lab testing indicated an increase in performance (Figure 2).

Figure 1: New cleaning material improved biodegradability performance compared to existing product.

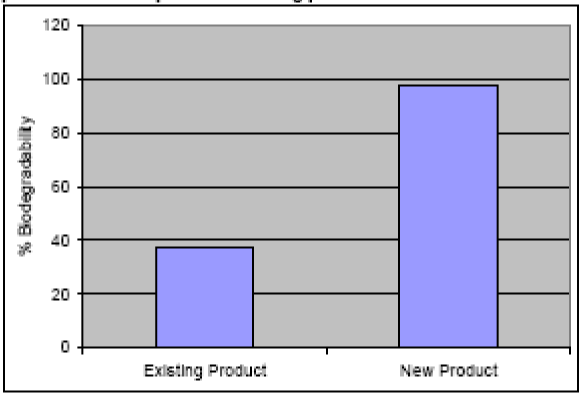
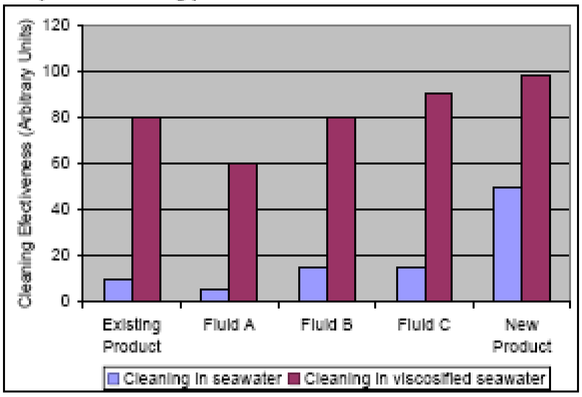


Figure 2: New cleaning material laboratory performance compared to existing product and other available materials.



With the establishment of specific biodegradation requirements as a principal component of the regulatory philosophy, key cement dispersants and cement fluid loss additives were found to have biodegradability values below 20% in 28 days, which placed them in the "red" classification in Norway. The difficulty in developing polymer materials that can achieve both greater than 20% biodegradability and provide performance required for cementing oil and gas wells in the North Sea operational environment is difficult understated. In fact, the development of polymer materials in all operational areas (i.e., cementing, drilling, completion, fracturing, acidizing and sand control) that satisfy both the regulatory requirements and product performance requirements is no doubt the most difficult chemical challenge in the environmental arena.

Over a five year period, with intense efforts focused on the synthesis and testing of several new polymers, new cement dispersants and fluid loss additives were developed to move from a 'red" to a "yellow" classification in Norway (Table 2). The performance of the cement dispersants and fluid loss additives has improved with each new generation of materials with new polymer technologies. However, to date, the performance of these environmentally compliant materials falls short of the performance of the original dispersant and fluid loss additives; thus development in these areas continues.

Table 2: Evolution of cement dispersant and cement fluid loss additive

Additive Type	**Year Developed**	**Biodegradability**	**Norway Classification**	**Product Functional Performance**
Cement Dispersant 1	2000	<20%	Red	Excellent

Cement Dispersant 2	2001	>20%	PLONOR	Poor
Cement Dispersant 3	2005	>20%	Yellow	Very Good
Fluids Loss Additive 1	2000	<20	Red	Excellent
Fluid Loss Additive 2	2001	>20%	Yellow	Poor
Fluid Loss Additive 3	2002	>20%	Yellow	Medium
Fluid Loss Additive 4	2005	>20%	Yellow	Good

As wells in the North Sea have increased in both depths and temperatures, the development and use of higher performance acid corrosion inhibitors, which are in compliance with the ever increasing environmental compliance demands, has presented a very tough challenge. For example, designing a corrosion inhibitor to function at 400ºF in 28% HCl for 16 hours of pumping, is at odds with the environmental requirements of being biodegradable at room temperature and having low toxicity.

The best performing corrosion inhibitors in existence prior to the establishment of environmental compliance regulations in the North Sea had biodegradability values less than 20% and toxicities, EC/LC50, less than 10 mg/l, which put them in the “Black” classification in Norway. A number of Acid Corrosion Inhibitors (ACI) generations have been introduced in the North Sea as a result of the focused efforts to develop new ACIs that were able to meet the compliance regulations and performance requirements. Table 3 shows that the evolution of ACIs to achieve the best environmental classification and product performance is a long and tedious effort with challenges still ahead for improvement.

Table 3: Evolution of Acid Corrosion Inhibitors (ACIs)

Additive Type	Year Developed	Biodegrad-ability	Toxicity EC/LC50 mg/L	Norway Classification	Product Functional Performance	Comments
ACI 1	2000	<20%	<10	Black	Excellent	
ACI 2	2001	<60%	<10	Red	Fair	
ACI 3	2003	<60%	<10	Red	Medium	Three components were

						“red” classification
ACI 4	2004	<60	<10	Red	Medium	Two components were “red” classification

Lab testing plays an important role in developing and adapting environmentally compliant materials. Even though some service companies have reliable testing equipment, operators are slow to adopt these new environmentally friendly chemicals. For example, an operator may desire a new drilling fluid technology for deep Gulf of Mexico shelf drilling, which requires fluids that can withstand bottomhole temperatures of 600°F and pressure up to 30,000 psi. Development of such fluids is not only expensive, but the service company also requires lab equipment to test these high-pressure / high-temperature (HPHT) fluids.

For example, Halliburton Fluid Systems has been using the FANN i77 Extreme HTHP rheometer, which cost over $300,000 to develop and over a year of development time to produce (Figure 3), to test fluids up to 600°F. The rush now is on for other service companies to develop their own specialized testing equipment. However, even though service companies are delivering the necessary testing equipment, operators are slow to drill in these HPHT environments. In fact, less than five deep gas wells have been drilled, and operators are not sharing data from these wells.

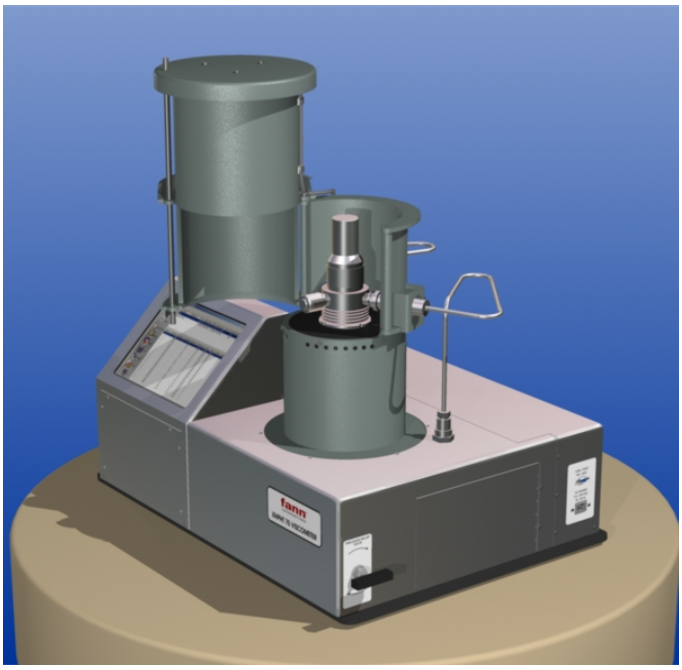


Figure 3. New FANN Model i77 Extreme HTHP Rheometer, 600°F, 30,000 psi

Reasons why the industry may delay in adopting the new technology include:

- May not work. Service companies must prove its effectiveness in controlled field and lab trials.
- Familiarity with existing product. Service companies must demonstrate the new technology’s value / effectiveness and how it mitigates risk to operations.
- Lack of training. Service companies and operators need to do knowledge sharing.

- Misconception of green does not equal performance effectiveness.

However, the benefits the industry may reap from adopting this new technology early include:

- Less impact on the environment and eco-systems potentially both short and long term.
- Less employee HSE risk – more evident as we educate each other to consider usage of such alternatives from a holistic standpoint.
- More efficient operations.
- Stakeholder engagement. A viable opportunity to illustrate a commitment and investment in the future.
- Technical advances improves industry image.
- Competitive advantage for early adopters (less cost per barrel).

5. Working Together for Our Future

As an industry, we have a huge amount of knowledge. The more we work together, the more powerful we can be. Business for business sake will no longer suffice. To sustain a corporation, it must perform fiscally in a competitive global market, but also do the right thing environmentally, socially and economically. The industry must think beyond the immediate future and develop clean renewable energies.

If a company is to be effective in its pursuit to be sustainable for the long term and a leading contributor to the future success of the oil and gas industry, it must focus and develop technologies and services for maximizing existing reservoir value.

7. Acknowledgements

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8. References

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