AN4/EA/CP-97553

# Innovative Regulatory Approach for Synthetic-Based Muds

RECEIVED
SEP 28 1999
OSTI

John A. Veil
Argonne National Laboratory
Washington, DC

and
Joseph Daly
U.S. Environmental Protection Agency
Washington, DC

to be presented at:
5th International Petroleum Environmental Conference
Albuquerque, NM
October 20-23, 1998

The submitted manuscript has been created by the University of Chicago as Operator of Argonne National Laboratory ("Argonne") under Contract No. W-31-109-ENG-38 with the U.S. Department of Energy. The U.S. Government retains for itself, and others acting on its behalf, a paid-up, nonexclusive, irrevocable worldwide license in said article to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on behalf of the Government.

## DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

# Innovative Regulatory Approach for Synthetic-Based Muds

John A. Veil
Argonne National Laboratory

Joseph M. Daly
U.S. Environmental Protection Agency

# ABSTRACT

The oil and gas industry has historically used water-based muds (WBMs) and oil-based muds (OBMs) in offshore drilling operations. WBMs are less expensive and are widely used. Both the WBMs and the associated drill cuttings may be discharged from the platform to the sea provided that U.S. Environmental Protection Agency (EPA) discharge limitations are met. In some wells, however, difficult drilling conditions may force a switch from a WBM to an OBM. Neither the OBM nor the associated drill cuttings may be discharged. The OBM is hauled to shore, where it is processed for reuse, while the associated cuttings are injected in a disposal well at the platform or hauled to shore to a disposal facility. Both of these options are expensive. Synthetic-based muds (SBMs) are drilling fluids that use synthetic organic chemicals as base fluids. SBMs were developed to replace OBMs in difficult drilling situations. SBMs are more expensive than OBMs; however, they have superior environmental properties that may permit the cuttings to be discharged on-site. Like OBMs, SBMs are hauled ashore for processing and reuse after the well is drilled.

The existing national effluent limitations guidelines (ELGs) for the offshore industry do not include requirements for SBM-cuttings since SBMs were not commonly in use at the time the ELGs were adopted. In late 1997, EPA announced that it would modify the offshore ELGs to include requirements for discharges of cuttings drilled with SBMs. For the first time in the history of the ELG program, EPA is following an innovative presumptive rulemaking process that will lead to development of draft regulations in one year rather than the 4- to 6-year period usually needed. With direction from the federal government to stakeholders concerning information needs for the regulatory development, the industry has established several working groups to collect new scientific information on SBMs. This paper describes the presumptive rulemaking process and summarizes the findings of the workgroups to date.

# INTRODUCTION

The process of drilling oil and gas wells generates two types of drilling wastes – drilling fluids and drill cuttings. The term "drilling fluids" (or "drilling muds") generally applies to fluids used to help maintain well control and remove drill cuttings (particles from underground geological formations) from holes drilled in the earth. Drilling fluids are an essential technology for oil and gas development.

Historically, the drilling industry used primarily water-based muds (WBMs) for offshore drilling. WBMs are inexpensive, and the mud and cuttings from wells drilled with WBMs can be discharged from offshore platforms as long as they meet current effluent limitations guidelines (ELGs) discharge standards. However, for difficult drilling situations, such as deep wells and horizontal and extended reach wells, WBMs do not offer consistently good drilling performance. Until recently, the industry has relied on traditional oil-based muds (OBMs), based on diesel and mineral oil, for these more difficult drilling situations. OBMs perform well, but they are harmful to the environment when discharged to the sea. Consequently, the EPA prohibited any discharge of OBMs or their cuttings.

Over the past decade, the drilling industry has developed a new family of fluids using various synthetic organic chemicals as the base fluid. The are known as synthetic-based muds (SBMs). In general, SBMs share the desirable drilling properties of OBMs but have lower toxicity, faster biodegradability, lower bioaccumulation potential and only trace concentrations of polynuclear aromatic hydrocarbons. For these reasons, SBM cuttings are less likely than OBM cuttings to cause adverse sea floor impact. EPA has identified that this product substitution approach is an excellent example of pollution prevention that can be accomplished by the oil and gas industry. SBMs drill a cleaner hole than WBMs, with less sloughing, and generate a lower volume of drill cuttings. SBMs are recycled to the extent possible, while WBMs are discharged to the sea. The industry has been eager to use SBMs, particularly in the Gulf of Mexico, where drilling has moved into deep water. However, the current federal regulatory requirements do not adequately address the issue of discharge of cuttings generated while using SBMs.

Several categories of SBMs, distinguished by the base fluid material used, are commonly available today. The base fluids include linear alpha-olefins (LAOs), poly-alpha-olefins (PAOs), internal olefins (IOs), fatty acid esters, and a host of others.

# FEDERAL REGULATORY REQUIREMENTS

Two tiers of Federal regulatory requirements govern the discharge of drilling fluids and drill cuttings – the ELGs and discharge permits. EPA headquarters has developed national ELGs for many major industrial categories, including offshore oil and gas and coastal oil and gas. The offshore ELGs (58 FR 12454; March 4, 1993) specify that facilities located up to 3 miles from shore, except those in Alaska, may not discharge drilling fluids and drill cuttings. Facilities located more than 3 miles from shore and all
Alaskan facilities may discharge drilling fluids and drill cuttings but must meet the following restrictions:

- no discharge of free oil or diesel oil is allowed (this effectively prohibits the discharge of oil-based fluids and cuttings);

- the 96-hour LC50 (the concentration at which one half of the test organisms die during a 96-hour toxicity bioassay test) of the suspended particulate phase must be at least 30,000 parts per million using mysid shrimp as the test organism; and

- the concentration of the barite component used to make the drilling fluid must not exceed 1 mg/kg mercury and 3 mg/kg cadmium.

The coastal ELGs (61 FR 66086; December 16, 1996) do not allow discharge of drilling fluids and drill cuttings, except for facilities in Cook Inlet, Alaska, which are subject to the same standards used for offshore wells.

The Clean Water Act requires that all discharges of wastewater be authorized through a National Pollutant Discharge Elimination System (NPDES) permit. Several of the EPA regional offices (Regions 4, 6, 9, and 10) have developed general NPDES permits that cover offshore or coastal oil and gas discharges. These general permits cover numerous oil and gas facilities. The permit limits must be at least as strict as the national ELGs, and permits may impose additional restrictions, such as prohibitions on discharge of drilling fluids made up as inverse emulsions.

SBMs have been used little, if at all, in Alaska or California. The primary region in which operators have wanted to use SBMs is the Gulf of Mexico, and particularly in the Western Gulf of Mexico, for which Region 6 has jurisdiction. Neither the offshore ELGs nor the current round of permits from Region 6 mention SBMs, because SBMs were not widely available at the time the permits and ELGs were written. In the absence of definitions for SBMs, permit restrictions on discharges of OBMs and cuttings and inverse emulsions were unintentionally providing a barrier to the discharge of SBM cuttings, even though those cuttings were passing the ELG tests set up for WBMs. Operators sought legal opinions from Region 6 but were not given clear approval to discharge cuttings from wells drilled with SBMs. Some operators have elected to use SBMs for drilling in the Western Gulf of Mexico and discharge the resulting cuttings. Other operators have either not used SBMs at all or have collected the cuttings and hauled them to shore for disposal because of the uncertainty about the legality of discharging the cuttings.

# EFFORTS TO RESOLVE THE REGULATORY BARRIER

In 1995, the U.S. Department of Energy (DOE) funded Argonne National Laboratory to prepare a report summarizing the advantages offered by SBMs and identifying the regulatory barriers that were impeding widespread use of an innovative and pollution-preventing technology (1). Following release of the Argonne report, DOE established an informal synthetic fluids discussion group. The discussion group included representatives from EPA, DOE, the U.S. Minerals Management Service (MMS), drilling service companies, and oil and gas operators. The objective of the discussion group was to clearly communicate

to EPA the advantages of SBMs and the difficulties experienced by the operators in getting approval to discharge SBMs, and to find a solution to the problem. Historically, there has often been an adversarial relationship between EPA and the industries it regulates. Early on, the discussion group had to overcome that negative relationship and move toward building trust. EPA used the discussion group to present its information needs for developing SBM regulations. EPA's motivation was to properly control the waste stream while promoting this pollution prevention technology.

Initially, EPA planned to develop detailed guidance and language that could be used by EPA regional permit writers to address SBM and cuttings discharges. In its December 1996 coastal ELGs rulemaking, EPA added several pages of discussion about SBMs to the preamble that, while not authorizing the discharge of SBMs and their cuttings, at least kept the door open for further consideration of the issue. The coastal ELGs included a definition for SBMs that distinguished them from WBMs and OBMs. The coastal ELGs also noted that the current discharge requirements were not sufficient to control SBM discharges. The static sheen test, used to check for crude oil contamination in WBM discharges, was not relevant for SBMs because the synthetic fluids could dissolve the crude oil and carry it to the sea floor without creating any sheen. The toxicity test used for WBMs is not applicable to SBMs because it uses the suspended particulate phase of a sample, while SBMs are found in the sediment phase. EPA provided guidance to permit writers recommending the use of gas chromatograph (GC) as a confirmation tool to assure the absence of crude oil contamination, and indicated that tests such as benthic toxicity conducted on the synthetic material prior to use or whole SBMs prior to discharge may be useful in controlling the discharge of cuttings contaminated with SBM. EPA also stated its intentions of evaluating test methods and results of bioaccumulation and biodegradation as indicators of the rate of recovery of the cuttings piles on the sea floor.

# PRESUMPTIVE RULEMAKING

Each year, EPA is required to identify several industrial categories for which new ELGs will be developed or existing ELGs will be revised. In December 1997, EPA announced that it had selected SBMs for the offshore oil and gas industry as one of three ELG categories it would work on for Fiscal Year 98. Normally, development of an ELG is a slow, lengthy process. EPA collects extensive data and, without any external discussions or advice, prepares a proposed regulation. All external parties are given several months to review the proposed ELGs and their supporting documents and offer comments. EPA takes those comments into consideration and develops a final regulation. The process often takes 4-6 years.

EPA recognized the industry's need to resolve the SBM discharge issue much sooner than 4-6 years. EPA also recognized the environmental benefits that could result from wider use of SBMs. For these reasons, EPA decided to take a "fast-track" approach known as "presumptive rulemaking" that would lead to a final regulation in less than 3 years. After starting in December 1997, EPA plans to publish proposed regulations in December 1998. EPA recognizes the possibility of publishing a notice of data availability or a supplemental proposal on or around September 1999. Final regulations are scheduled for promulgation by December 2000.

To meet such a streamlined schedule, EPA had to significantly modify its standard ELG development procedures, under which it collects information without significant review and input from external sources. Under the presumptive rulemaking process, EPA will rely on industry to supply data in an iterative manner and will maintain some level of communication with external parties throughout the process. Periodically, industry and other stakeholders will lay their favored options on the table and see how far apart they are. The Synthetic Fluids Discussion Group was restructured to form a Steering Group that includes representatives from EPA, DOE, MMS, industry, and a non-governmental organization. Industry representatives established four technical work groups that respond to EPA's needs for technical information. The next several sections describe the four technical work groups, what they hope to accomplish, and the progress they have made through September 1998.

# TECHNICAL WORK GROUPS

The four technical work groups are:

- Analytical Work Group
- Retention on Cuttings Work Group
- Toxicity Work Group
- Environmental Effects Work Group.

## Analytical Work Group

The existing method used for testing WBMs, the static sheen test, was deemed unreliable for SBMs. The Analytical Work Group tested samples of WBMs and SBMs using the static sheen test and reported that crude oil was found at about 1% (volume-to-volume basis) for the majority of WBMs tested, while for SBMs, crude was not detected even at a 20% level (2).

The primary goal of the analytical work group was to identify analytical methods to determine the presence of crude oil or other oils in samples of SBM. Ideal methods would be quick and inexpensive to perform and accurate. A secondary goal was to estimate the frequency of detection at different concentrations of crude oil contamination.

In spring 1998, the work group provided EPA with a draft reverse phase extraction (RPE) method in which extracts of SBMs are filtered through small filter cartridges and the cartridges are then examined under ultraviolet fluorescent lighting. This method is inexpensive and can be done quickly on the platforms. The RPE method gives a pass/fail result. The work group also evaluated gas chromatograph/mass spectrometer (GC/MS) analysis to be conducted onshore to provide baseline information and to verify any noncompliant RPE test results. Currently, the work group has begun a long-term program to validate the fluorescence method and to determine the frequency of SBM samples that contain measurable crude contamination.

## Retention on Cuttings Work Group

Operators attempt to collect all SBMs for recycling, but some portion of the SBMs remains adhered to cuttings particles. The goals of the Retention on Cuttings Work Group are to define methods that could be used to monitor the percentage of SBMs retained on cuttings, or the quantity of SBM discharged, as a potential compliance measure and to determine the cost and performance of various solids separation devices.

In 1997, the work group conducted a study that examined the types of mud recovery devices used in the Gulf of Mexico for wells drilled using SBMs (3). The study showed that primary and secondary shale shakers were the predominant devices being used. The performance of the shale shakers averaged about 12% SBMs on cuttings, with a range from 4% to 25%. The work group was unable to find any statistically valid relationship between percent retention and the type of device used or the properties used.

In the summer of 1998, the work group developed a retort analytical procedure to measure the percentage of SBMs and water in a sample (4). The results of the retort analysis are combined with a mass balance analysis for comparison in a new spreadsheet designed to calculate the volume and mass of SBMs discharged and lost downhole to the formation. As of September 1998, the spreadsheet was still under review by EPA. When the spreadsheet is approved, the work group plans to begin collecting data from wells being drilled with SBMs to validate the procedure. EPA plans to use these data to develop a relationship between the mass or volume of SBMs discharged per volume or length of the well segment drilled with SBMs. This relationship may be incorporated into the ELGs.

The work group also plans to collect and verify cost and performance information from vendors of other types of solids control equipment. In February 1998, one field trial was made using the MUD-10 (Mud Recovery Systems, Ltd.) vibrating centrifuge solids separator on a deepwater floating drill ship. The cuttings from the primary shale shakers were diverted to the MUD-10 before discharge. The SBM recovered from the MUD-10 was low in fines and could be reintroduced directly into the active mud system. The report describing this demonstration of the MUD-10 has not yet been released.

## Toxicity Work Group

Proponents of SBMs have touted the muds' low toxicity. When tested using the bioassay procedure specified for WBMs, most SBMs demonstrate very low toxicity. To some extent this result is attributable to the fact that SBMs do not disperse in water as do WBMs. WBMs tend to concentrate in the suspended particulate phase of the sample, while SBMs concentrate in a sediment phase. If bioassay tests are run on the suspended particulate phase of an SBM sample, the test organisms will not be exposed to the contaminants in the SBMs.

The goal of the Toxicity Work Group is to identify a toxicity bioassay procedure that will measure the toxicity of SBMs and can be used as a discharge monitoring test. The leading candidates were sediment toxicity tests. Sediment tests are typically run for 10 days or longer, which is longer than the 96-hour (4-day) test used for testing WBMs. Therefore, the sediment tests are more costly and less convenient as a compliance measure because

offshore operators do not have adequate space to store muds and cuttings for 10 days or more while a sediment toxicity test is being run.

After evaluating a variety of potential test methods, the work group hired a contractor to test six types of SBMs using four types of toxicity tests. As of September 1998, the first two rounds of test results were made available; no one test clearly stood out as the best performer. The work group plans to continue testing until early 1999.

EPA plans to conduct independent research on the sediment toxicity of the base fluids and on the effect of drilling fluid composition (barite content, emulsifier package, aqueous phase composition) and crude oil contamination. For a drilling fluid of a particular base fluid, if toxicity is affected more by crude contamination than by the formulation variations, then crude oil contamination could be used as an indicator pollutant for sediment toxicity at the point of discharge. Thus, it may be unnecessary to perform sediment toxicity tests at the point of discharge. Instead, toxicity may be controlled through the base fluid and controls on crude oil contamination. EPA will use a 10-day sediment toxicity test with natural sediments.

## Environmental Effects Work Group

The literature contains information about the effects of discharges of WBMs and cuttings and OBM cuttings on the water column and the seabed. Generally, WBMs have short-term, minor impacts on the seabed, while OBM cuttings have long-term, more severe impacts. Neither type of fluid is believed to cause any water column impacts of notable duration. Little has been published in the literature on the environmental effects of SBM cuttings discharges, however.

The goal of the Environmental Effects Work Group is to design a multi-year survey to examine the extent and longevity of impacts of SBM cuttings discharge piles on seabed abundance and diversity. The results of the survey will be used by EPA in its Environmental Assessment report that accompanies the ELGs. For offshore NPDES permits, it can also serve as the basis for the ocean discharge criteria evaluation required by Clean Water Act Section 403(c), Ocean Discharge Criteria, as codified at 40 CFR 125, subpart M.

In August 1997, EPA provided the work group with a week of time on its research vessel. Samples were collected around three platforms in the Gulf of Mexico where SBMs had been used and the cuttings discharged. Industry is preparing a preliminary data report, which will be sent to EPA in the fall of 1998. EPA kept samples of sediments collected during the cruise and agreed to analyze the benthic abundance and diversity data. EPA's results are expected to be available during the fall of 1998. The work group plans to submit a study plan for a comprehensive seabed survey to EPA during the fall of 1998 and will soon select a contractor to conduct the survey.

# REGULATORY OPTIONS UNDER CONSIDERATION BY EPA

To publish a proposed regulation by December 1998, EPA has had to develop a series of options for regulating discharges of SBMs and their cuttings. Because the current practice for handling used SBMs is to collect them and return them to shore for reuse, EPA is likely to propose zero discharge of the synthetic fluids themselves.

For cuttings derived from SBMs, EPA is evaluating several factors. EPA is likely to propose stock limitations on the base synthetic fluids that would be used to formulate SBMs. This action may include limits on the polynuclear aromatic hydrocarbon content, the rate of biodegradation, the potential for bioaccumulation, and the sediment toxicity. EPA is likely to propose discharge limitations on drill cuttings. These limitations may involve the quantity of SBMs discharged with cuttings, the presence of crude oil, the likelihood of sheen formation, and sediment or aquatic toxicity. The current industry practice is to use shale shakers or screens. EPA may propose that these represent the best available technology (BAT), or the agency may propose some other technology, such as a vibrating centrifuges, as BAT. EPA will evaluate the costs and non-water quality environmental impacts associated with discharging the cuttings or requiring zero discharge. If the final rule specifies zero discharge of SBM-derived cuttings, operators will need to haul the cuttings to shore or dispose of them through underground injection.

# CONCLUSIONS

SBMs are an innovative technology that is cost-effective and believed to be environmentally friendly. EPA recognized that its current regulations and permits do not adequately address discharges of SBMs and their cuttings. Through participation in the Synthetic Fluids Discussion Group, EPA has moved forward to resolve a regulatory barrier and has agreed to formally modify its offshore ELGs to provide specific requirements for SBMs. EPA has elected to follow a streamlined presumptive rulemaking approach that provides for regular input from and communication with industry and other stakeholders. This process should have a win/win/win result. Industry wins because it will gain regulatory certainty over requirements to use and discharge a material desirable to the industry. EPA wins because it will have demonstrated its willingness and ability to overcome a regulatory barrier in a timely manner. Finally, the environment wins because operators can use more environmentally friendly drilling fluids.

# ACKNOWLEDGMENTS

Mr. Veil's contribution to this paper was funded by DOE's Office of Fossil Energy under Contract W-31-109-Eng-38. Robert C. Ayers, Jr. provided useful comments to the authors.

# REFERENCES

1. Burke, C.J., and J.A.Veil,1995, "Potential Environmental Benefits from Regulatory Consideration of Synthetic Drilling Muds," ANL/EAD/TM-43, Argonne National Laboratory, Argonne, IL, February.

2. Weintritt Consulting Services, 1997, "Bench Scale Evaluation of Static Sheen Test for Water-based Muds, Synthetic-based Muds and Enhanced Mineral Oil-based Muds," draft, August 28.

3. Annis, M.R., 1997, "Retention of Synthetic-Based Drilling Material on Cuttings Discharged to the Gulf of Mexico," prepared for the American Petroleum Institute, August 29.

4. Annis, M.R., 1998, "Procedures for Sampling and Testing Cuttings Discharged While Drilling with Synthetic-Based Muds," prepared for the American Petroleum Institute, draft, August 19.