



Performance Fluids Management: A New Work Method for Achieving Performance Excellence

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This paper was prepared for presentation at the AADE 2004 Drilling Fluids Conference, held at the Radisson Astrodome in Houston, Texas, April 6-7, 2004. This conference was sponsored by the Houston Chapter of the American Association of Drilling Engineers. The information presented in this paper does not reflect any position, claim or endorsement made or implied by the American Association of Drilling Engineers, their officers or members. Questions concerning the content of this paper should be directed to the individuals listed as author/s of this work.

Abstract

Performance excellence in the fluids management business is one of the major challenges faced by operators around the world. The performance fluids management (PFM) process in place at BP has been used successfully on a global basis for two years to help ensure quality delivery at the end of each project.

The PFM work method encompasses contract procedures, personnel, performance, well construction, and the use of common tools. Well construction planning and evaluation requires the acquisition of offset data, analysis of anticipated hole problems, generation of the basis for a design document containing a risk analysis, and the alignment of different reporting systems under a common process.

Personnel assessment helps ensure that each project is supported by well-trained people who are located at the appropriate sites. The assessment tool used in this case is based on a standard format and can be applied to both office and field personnel.

Fluids and waste management performance is captured using a scorecard system that addresses performance in multiple areas, including cost, safety and environmental compliance, nonproductive time, and value added to the project.

Each of the key areas of concern described above is covered in the scope of the PFM contracts tendered at BP. The objective is to have a consistent global contract for PFM that allows work to be awarded based on performance.

This paper describes the different tools used currently by BP in conjunction with major service suppliers to successfully implement the new work method. Numerous examples of its application in various areas are discussed.

Introduction

Performance fluids management, or PFM, is a management system that integrates drilling fluids, cementing, completion fluids, solids control, waste management, and waste disposal. PFM is a quality management system for fluids and is aligned with BP's global quality management systems and the management system used by a major oilfield service provider.

The main areas of the PFM process include:

- Contract
- People
- Performance measures (GWSI-Scorecard)
- Well construction
- Common tools

More than a bundling of services, the PFM process integrates total fluid services into the goals of the total project. The purposes of the PFM system are to provide a culture of continuous improvement and to award work-share based on performance. These goals are achieved through cooperation with the service companies to implement a suite of tools that align closely with BP's Initiatives while remaining specific to the fluids service lines.

The PFM system implemented in each area is focused on reducing nonproductive time (NPT), improving drilling performance, decreasing days/10K, and minimizing the amount of waste generated onsite. Since its implementation in the Gulf of Mexico (GOM), Trinidad, and the North Sea, the PFM system reduced the total fluids-related and NPT costs in 2003 by \$15 MM. This benefit does not take into account improvements in drilling performance and well productivity. The productivity gain estimated for 2003 was at least 30 mbo/d.

This paper explains the structure of the work method and the different tools used to implement it, and also provides an example of a well drilled in a deepwater operation in the GOM.

Structure of the Work Method

The PFM work method focuses on five key areas: the contract, the people, performance measures, well construction, and common tools.

Contract

The contract controls the quality of the work and provides the mechanism for an operator to lay down the company's technical and commercial expectations. The PFM contract covers drilling fluids, completion fluids and waste management equipment, products, engineering, and services, and is linked to performance using a

scorecard system. The objective of the contract management is to award the PFM work based on performance, helping to ensure that the best performer will have the majority of the work. If a good database is established and performance is defined and tracked accurately, a risk/reward contract can be implemented where the PFM service company can benefit from the savings.

The contract strategy is to establish consistency in contractual requirements and remuneration methods across the company. New standards require that the systems of work are used and specify the performance management system. Taking a common approach to the commercial aspects makes cost performance become more obvious.

People

When new personnel are introduced to the project, they receive safety, environmental, and technical training. They also have the opportunity to review the *PFM Guidebook*, which captures all the standard procedures and documentation for the project, all lessons learned, and all historical data.

All PFM personnel involved in the project are expected to complete a self-assessment and submit it before the project begins. This skill assessment was developed in collaboration with the three major drilling fluid companies for all office and field personnel. The core competencies are common across the regions, but project-specific elements are introduced in collaboration with the operations teams to meet specific project needs.

The primary purpose is to identify training gaps and agree on a plan to close those gaps. A training matrix is designed to track the training schedule and timeline. The self-assessment has four main areas: experience, personal, business, and technical.

Performance Measures

The well objectives are identified after the analysis of the offset information, current project needs, and global or local expectations. Key performance indicators (KPIs) are used to measure these objectives, and at the end of each well or project, they are compared with the planned performance.

Most common objectives are set to reduce costs, improve the safety record, achieve environmental compliance, etc. These objectives are agreed upon by the PFM service companies and the operations team before the spud date. The KPIs are monitored through the life of the well using a PFM report, which is presented periodically to the operations team and is used to manage the performance of the PFM services through the life of the well. The operator has a global system to evaluate the PFM service.

Well Construction

Although teamwork between the operator and service

supplier is crucial, at the end of the day, the PFM system should be a process that resides within the service company. However, to be implemented properly, the system also requires support and understanding from the operator. Local management commitment is another requirement. Although PFM will ultimately help reduce project costs, the initial implementation may require additional funding and reassignment of duties.

Key areas where drilling fluids can affect the performance of the drilling operation are drilling rates, hole cleaning, rheological properties, lost circulation, wellbore stability, drilling practices, and formation damage. These elements, combined with cuttings handling and cleaning of the rig and boats, comprise the normal scope of services provided under a PFM contract. The well construction process can be summarized in the following seven steps:

1. Expectations
2. Data and cost analysis
3. Benchmark and data model
4. Setting goals and targets
5. Planning
6. Execution
7. Review

Expectations

Understanding and communicating the operator's expectations is the key to successfully implementing PFM. The operator may have different expectations in the short and long term. These expectations are normally related to drilling cost reductions, environmental compliance, drilling waste reduction, new technology implementation, and the safety and health of employees.

Some expectations are shared by most, if not all, operators. These include spill prevention, avoiding lost-time incidents, increasing safety participation at the rigsite, achieving environmental compliance, reducing whole fluid losses at surface and downhole, controlling wellbore stability, and minimizing drilling waste.

Most operators also have a strong interest in incorporating new drilling fluid technology that may mitigate critical hole problems during the project. Operator expectations vary according to the conditions and requirements of each well and region.

Data and Cost Analysis

The collection of offset data, including formations drilled, laboratory studies, mud weights, pore pressure/fracture gradient windows, downhole tools, well complexity, drilling waste management, costs, days/10K ft, HSE statistics, and the percentage of nonproductive time, is essential to improving the planning and execution of upcoming projects. Access to this type of information can save money and time.

The main problems in each area of operation can be identified with thorough analysis of the offset data

collected. Examples of these problems can be severe mud losses, wellbore stability problems, hole-cleaning issues, improper drilling practices, differential sticking, formation damage, waste management options, and even logistical issues.

Sources of Information

The primary sources of information for preparing a PFM program are records retrieved from both service company and operator databases.

Using its database software, the service company can provide drilling fluid and waste management recaps containing information related to drilling fluid costs, volumes, mud lost, and lessons learned from wellbore conditions or general hole problems experienced in the offset wells. The software also generates mud reports and a valuable summary of the drilling fluid properties, fluid volumes, and drilling parameters used in the operation.

The operator also uses database programs to record all drilling parameters, NPT, costs, and daily rig activities. The service company representatives assigned to the project are trained to extract the information needed for the upcoming project, analyze the information for the current project, and provide recommendations.

A review of invoicing or reports generated by the operator or the accounting system managed by the service company allows the evaluator to obtain more accurate information from third-party services like waste disposal costs, volumes of waste, and boat cleaning.

Benchmark and Data Model

This step of the well construction process is a statistical analysis used to evaluate the historical or offset information collected. Key performance indicators are set up for PFM services and are related to the areas identified to improve the operation.

The operator uses a model (spreadsheet with offset information) to generate estimated drilling fluid and waste management costs, cuttings and fluid volumes, well performance expectations, and HSE information when key parameters of the new well are entered.

The quality of the output data depends on the quality and reliability of the data entered to create the model. Periodically updating the model with new wells is essential to its usefulness. Wells that are not representative of the actual operational conditions can be eliminated. Building a model for each area or type of operation (e.g., development, exploratory, or production well) is strongly recommended.

The following list contains some of the commonly used benchmarks within the PFM system:

- Number of spills caused by PFM personnel
- Number of LTIs involving PFM personnel
- PFM cost/day and/or PFM cost/ft

- Percentage of NPT related to PFM services
- Mud cost/bbl, mud cost/ft
- Waste management cost/day
- Mud losses/well/area
- Days/10K ft
- Volume of waste generated/bbl of rock drilled
- Volume of waste disposed/bbl of rock drilled
- Solids control equipment cost
- Cuttings handling equipment cost
- Waste water generated and discharge
- Drilling fluid recovered and reused

Setting Goals and Targets

Setting appropriate goals requires knowledge of the difficulty of the project, the capabilities of the rig, the waste management method to be used, logistics, and the basis of design. The basis of design concept is explained in more detail in the planning step.

The service company's goals should be aligned with the operator's expectations and should be measurable, specific, obtainable, evaluated, updated, and advertised.

Typical PFM targets are usually measured and reported as a percentage of reduction, as follows:

- LTIs/spills caused by PFM personnel
- Drilling fluid cost
- Waste management cost
- Downhole mud losses
- Surface mud losses
- Volume of mud discharge or disposed of
- NPT related to PFM services
- Days per 10K ft (well objective)
- Base fluid retained on cuttings

The targets are used for evaluation of the PFM service provided. Actual performance against targets will determine the efficiency of the PFM company and also indicate the areas for improvement in subsequent projects.

Planning

Before the planning step in the well construction process begins, valuable information about the specific project is recorded in the basis of the design (BOD) document. The BOD is a living document that is updated as changes or additional risks are identified further into the project. The BOD contains the following basic information:

- Well-specific HSE issues
- Performance target data set
- Project overview, including assumptions and boundaries common to the entire well
- Field and well data
- Casing/liner schematic
- Fault predictions
- Well trajectory plot

- Pressure profile prediction
- Lithological column
- Rig audit
- Wellbore stability modeling
- Hydraulic modeling
- Porosity and K offset data
- Drill cuttings and fluids processing
- Discussion by interval
- Objectives
- Assumptions and boundaries
- Identified risks/mitigation
- Technical evaluation
- Identified solutions
- Environmental evaluation
- Financial solution
- Preferred solution

When the BOD document is created and agreed upon by the drilling engineer/project leader, the PFM service company sets a technical meeting with key personnel to review the BOD content and make changes as identified. The final BOD document is reviewed and signed off by responsible operator and PFM company personnel.

Technical BOD Meeting

The technical BOD meeting is critical and should be attended by the drilling supervisor(s), fluid engineers, waste management coordinator, drilling engineer(s), geologists, directional driller(s), and the team project leader. These key personnel review and evaluate the following issues:

- Main environmental and safety issues
- Subsurface information
- Casing design and directional profile
- PFM and waste management issues, including equipment and processes
- Wellbore stability control
- Pore/fracture pressures and ECD management
- Hole cleaning practices
- Drilling/tripping practices—action plan
- Mud loss issues and contingency plans
- Identification and assignment of tasks
- Training required to achieve project expectations (as identified by the skill assessment)

PFM Program

When the BOD for the project is defined, reviewed, and approved, the PFM program is written. The basis of design provides the key information of the project to build this PFM program. This program should include but is not limited to the following content:

- Clear and detailed operational guidelines and procedures to be followed for the drilling fluid, waste management, solids-control equipment

operation, and safety and environmental aspects and regulations applied to the project

- Estimated costs, fluid volumes, and equipment
- Potential problems and mitigation actions
- Project-specific training plan (skills assessment)
- Scorecard initiation (Set objectives and plan costs for the project.)
- Contingency plans (mud losses, well control, spills, safety, hole cleaning, fluid contamination, fluid/chemicals inventory, stuck pipe, lost-circulation decision tree, etc.)

Execution

The steps in the well construction process outlined in the previous sections are intended to improve the project execution and help participants achieve its goals and expectations. Execution of the project should include the following actions:

- Follow the proposed plan.
- Adjust or improve the plan according to actual project conditions. Consider the changes and new risks identified while executing the project and obtain buy-in and approval of affected parties.
- Communicate any changes to the key personnel.

Throughout the execution of the project, the tools described later in this paper are used to collect and analyze the information.

Daily PFM and Drilling Fluid Reports

The PFM report contains information about solids-control and waste management equipment, benchmarks, fluid performance parameters, cuttings-handling equipment, volumes of fluids discharged or disposed of, drilled cuttings discharged or disposed of, waste management costs, environmental parameters, HSE parameters, well performance indicators, and PFM performance indicators. Summary reports in graphical format are generated periodically during the execution of the project to summarize PFM performance compared with the targets set.

Lessons Learned

The lessons learned during the project should contain enough information to allow the PFM team to make timely decisions while the project is ongoing. Lessons learned after each project are useful for planning the next project (e.g., specific data about tools, products, processes, and procedures).

Drilling Practices

Successful project execution depends on the application of all the drilling practices planned for the project. Drilling practices that can affect the PFM

performance are hole cleaning, tripping procedures, lost-circulation procedures, well control, ECD management (PWD interpretation), waste management, and HSE compliance.

Engineering Tools

Because narrow pore-pressure and fracture-gradient windows exist on many wells, accurate ECD management is critical for successful drilling in today's operations. After the casing design, directional profile, and drillstring geometry are established, the ECD should be optimized. The operator can achieve optimization by selecting the best fluid rheology and flow rate to guarantee good hole cleaning while minimizing ECD.

Review

The review is the final step of the well construction process and is designed to evaluate the project performance by comparing actual results with the goals and expectations initially agreed upon. This evaluation improves the well construction process for the next project and shares the lessons learned with others for continuous improvement. Typically the review will cover the following aspects: technical analysis, ECD management, audit review, and PFM guidebook.

Technical Analysis

Project results are analyzed and compared with planned goals (e.g., procedures, processes, well problems, NPT, incremental benefit, innovations, new technology results, lessons learned, waste management issues, recommendations). The comparison can be presented in a table showing goals and results side by side.

ECD Management

The relationship between recommended hole-cleaning practices and ECD optimization is evaluated to determine whether practices are being executed according to the plan. The evaluation also helps to make corrections for future improvement.

Audit Review

An audit review is recommended at the beginning of the well, during the execution, and at the end of the project to help ensure that the personnel understand the seven steps of the well construction process. The audit is carried out at the rig for the field personnel.

PFM Guidebook

The *PFM Guidebook* contains all standard procedures and documentation for each project, all lessons learned, and all historical data. It is a living document that is updated every time the scope of work changes or a new standard is set for the project.

All the standard documentation should be included in

the guidebook so that the actual mud program for any well will be smaller and will focus on the main activities of the well. The guidebook authority is the drilling engineer, but the responsibility of maintaining updates resides with the PFM company.

Use of Common Tools

The use of standardized tools to successfully implement the PFM work method allows the project team to maintain consistency in the learning process. The following tools are standard in the Gulf of Mexico operation managed by BP:

- **Fluids Delivery Capability Audit**—Determines whether the fluids contractor is capable of delivering sustained and high-value work for BP on budget and with minimal “Consequential NPT.” The audit also determines whether BP understands its part in the delivery of the service and is fulfilling its role. The areas reviewed by this audit are: contract, HSE, people, facilities, systems of work, assurance, and corporate knowledge.
- **Skill Assessment Form**—Provides a format to evaluate the competency of the PFM personnel selected for the project and helps identify training needs.
- **PFM Model Database**—Generates estimated drilling fluid and waste management costs, cuttings and fluid volumes, well performance, and HSE information when key parameters of the new well are entered.
- **Basis of Design Document**—Living document, provides comprehensive, detailed description of the well/project and serves as the key document for communicating and approving changes.
- **PFM Biweekly Report**—Summarizes the PFM performance of a well in easily understood graphs showing HSE information, general well performance data like days/10K ft, and NPT for the well. Also shown, related to PFM services, are mud losses, performance, retention of base fluid on cuttings, PFM costs, and days spent in the operation.
- **Daily PFM Report**—Contains the daily waste management and drilling fluids costs, volumes and performance indicators. Presented in a daily basis to the drilling foreman and to the drilling engineer who leads the project.
- **PFM Guidebook**—Living document, contains all the lessons learned and offset well data for each project or area of operation.

PFM Case History: Deepwater Gulf of Mexico

The benefits obtained from using the PFM work method on a deepwater GOM location are described in

the following sections. The time dedicated to the planning stage and the proactive work ethic of both the operator and service company were essential to the success of this project.

Significant Hole Mud Loss Reduction

Effective ECD management and the introduction of a clay-free synthetic-based fluid (SBF) system with a flat rheological profile over a wide range of temperatures achieved savings of \$500,000 to 1,000,000 USD per well. Downhole mud losses were reduced by 80% (Fig. 1).

Reduction in Days/10K ft

Drilling and casing running times were reduced because the best practices from the offset wells were implemented and the project risk analysis was considered.

Drilling rates were optimized by the use of a power-driver steerable assembly, PDC bits, ECD management based on PWD data and highly accurate hydraulics modeling software, and the management of the fluid rheology (Fig. 2).

Reduction in SBF Discharge

The SBF discharges (bbl/ft) were reduced by the use of the cuttings dryer technology and the close supervision of the total fluids management (TFM) supervisors assigned to the project. Proactive maintenance work was performed to help ensure that all equipment ran properly. The selection of screen sizes was based on formation drilled, flow rate, and ROP. The SBF discharge was reduced from an average of 0.06 bbl/ft obtained in 2002 to 0.02 bbl/ft for the project (Fig. 3).

Reduced Retention of SBF on Cuttings

The oil-on-cuttings (OOC) value was reduced to an average of 3.7%, significantly lower than the 6.9% allowed by the environmental authorities in the Gulf of Mexico for the type of fluids used in the project. Screen selection, cuttings dryer performance, TFM supervision, and careful planning when drilling in certain formations (i.e., salt) were key elements in achieving this reduction.

Fig. 4 shows the daily tracking of the SBF retention on cuttings for one of the wells.

Nonproductive Time

NPT associated with the fluid was an average of less than 1% of the total time.

Reduced Materials Handling and Mixing

The number of pallets and tote tanks containing drilling fluid additives and products indicates that the clay-free SBF system used on the project required 38% fewer crane lifts than the systems used before in the area. Fewer lifts translated into a positive impact on

workboat crews, crane personnel, and drilling contractor crews dealing with material handling and chemical mixing.

An excellent data-tracking system was maintained with offset information and numerous lessons learned on a well-by-well basis. A weekly PFM report summarizing costs, volumes, PFM performance indicators, equipment description, etc., (Fig. 5) was presented to the operator.

Conclusions

Based upon the case history information, the following conclusions can be reached:

- The application of the PFM system of work was a key factor in achieving cost savings, drilling performance, and environmental compliance.
- The use of common tools (e.g., reports, evaluation systems) to gather information, execute, and evaluate the PFM services is fundamental to maintaining consistency in contractual requirements and remuneration methods.
- Team communication is enhanced while applying the PFM work method through the use of common tools.
- The PFM guidebook is a valuable document that contains all historical information about the project and should be updated periodically to facilitate learning about the project or area of operation.

Acknowledgments

The authors thank the management of BP and Baroid product service line, Halliburton, for permission to present this paper and for the support provided.

Nomenclature

BOD—Basis of design
 DFG—Drilling fluids graphics
 ECD, lb/gal—equivalent circulation density
 GOM—Gulf of Mexico
 GWSI—Global well service initiative
 HSE—Health, safety and environment
 LTIs—Lost time incidents
 NPT, days or %—Nonproductive time
 PFM—Performance fluids management
 PWD—Pressure while drilling
 ROC—Retention on cuttings
 ROP, ft/hr—drilling rate of penetration
 SVD—Small volume discharge
 TFM—Total fluids management

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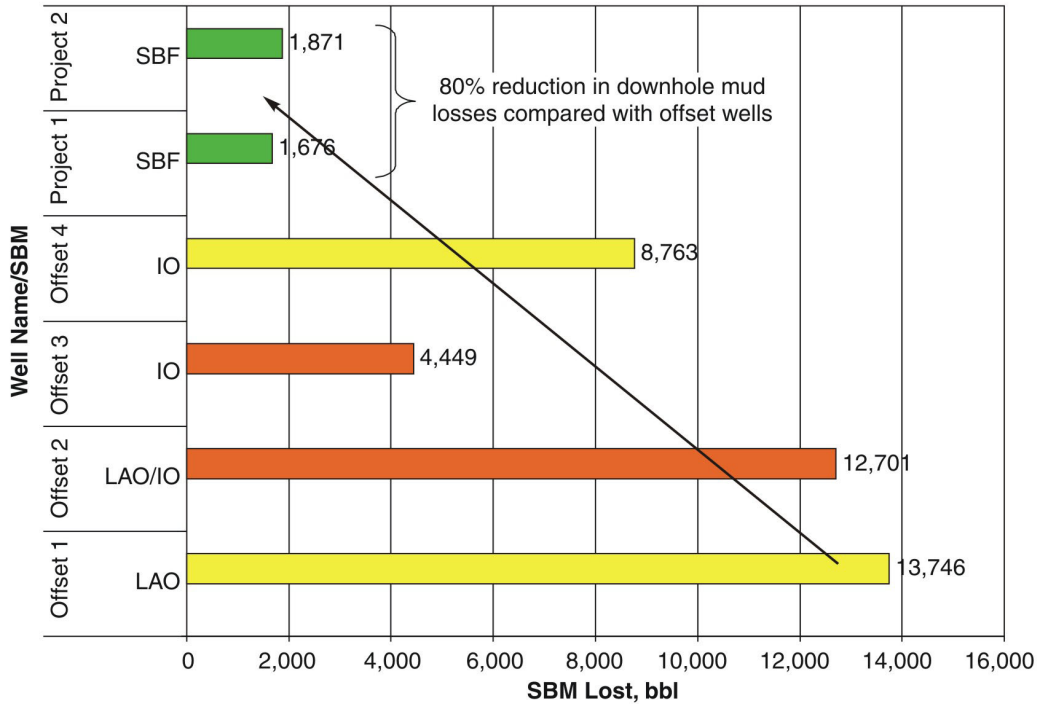


Fig. 1—Reduction in downhole SBM losses per well

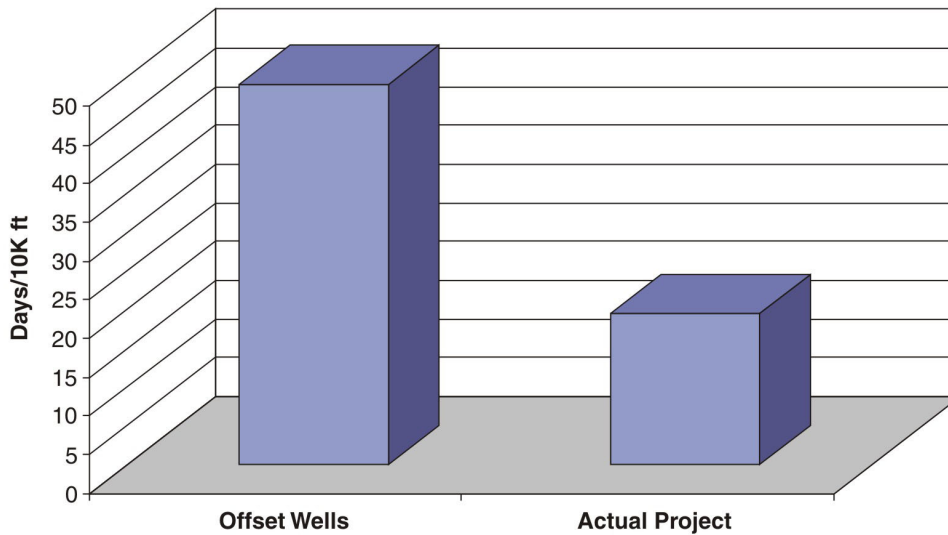


Fig. 2—Drilling time reduction in days/10K ft

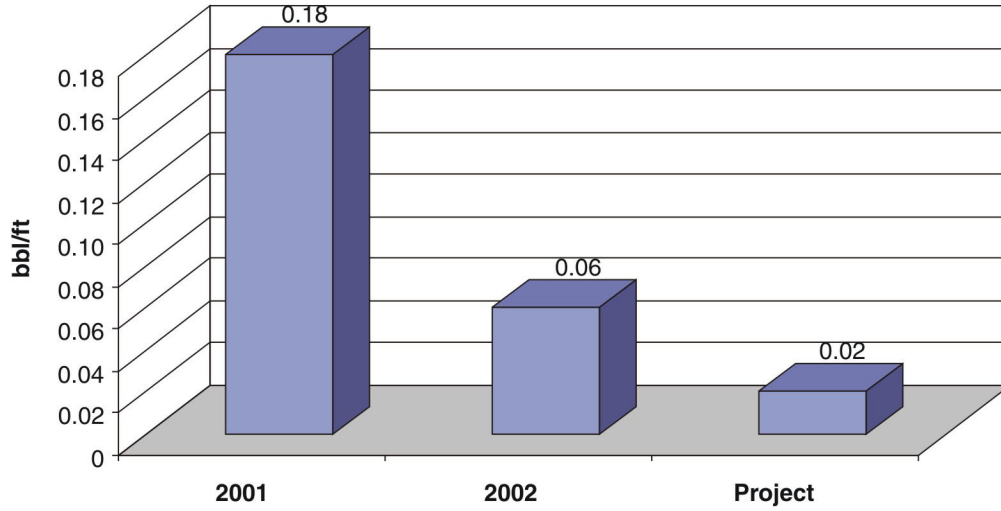


Fig. 3—Reduced SBM discharged in bbl/ft

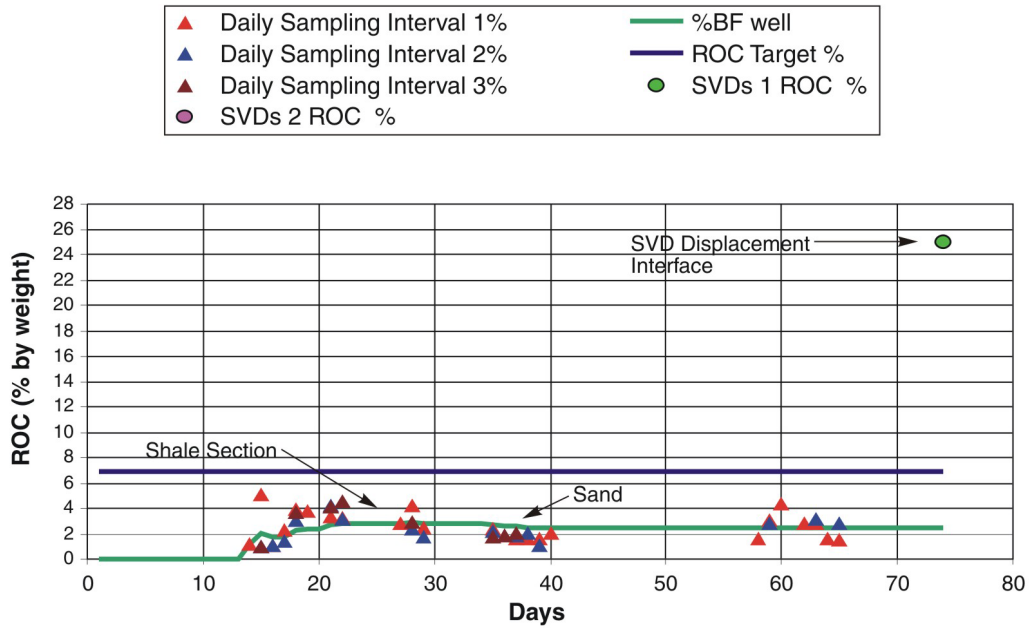


Fig. 4—Daily tracking of retention of SBM on cuttings in % w/w

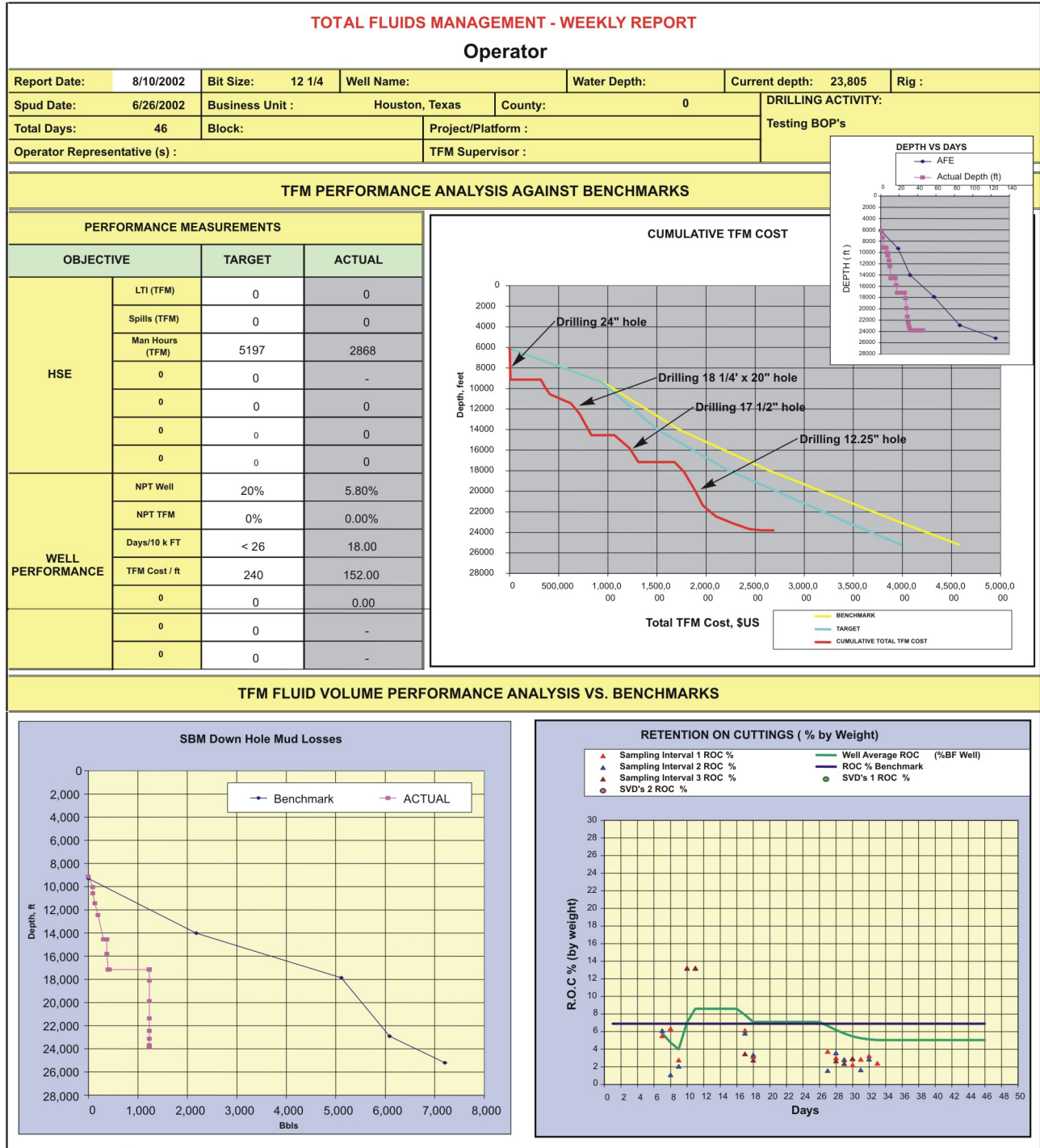


Fig. 5—Performance fluids management report form