WESTPORT TECHNOLOGY CENTER INTERNATIONAL

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Mr. E. C. Haynes, Jr.
Thuslick Incorporated
10200 Old Katy Road, Ste 200
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Dear Mr. Haynes,

The enclosed document is the final report of our evaluation of Thuslick. The thrust of the evaluation was centered around lubricity, filtration control, and formation damage. The Westport Laboratory has put your product through an extensive, on occasion harsh, series of evaluation protocols. The product has shown a positive effect in all the areas of concern, and was superior, overall, to the additives included in the evaluation.

We appreciate the opportunity to be of service to Thuslick Incorporated and look forward to assisting you in your future endevors.

Regards,

David B. Young
Manager of Research
Westport Laboratory
IIT Research Institute

DETERMINATION OF THE EFFECTIVENESS OF THUSLICK IN WATER-BASED AND OIL-BASED DRILLING FLUID SYSTEMS

INTRODUCTION

A new drilling fluid additive was brought to the Westport laboratories for extensive testing of its basic properties and for comparative testing versus some industry standard lubricants. This was a massive undertaking, particularly the lubricity testing, involving a variety of mud testing devices and protocols never before attempted in the industry. The product, Thuslick, from Thuslick Incorporated, a division of PEP LTD., is a micronized, siliconized natural graphite. It was given to Westport by the manufacturer and, except for general guidelines, left up to Westport to develop the test protocols. These independent test results are presented in this report..

Lubricity is one of the more important properties of a drilling fluid, especially in deep wells, extended reach drilling, and horizontal holes to minimize torque and drag. Lubricants are also important for longer bit life and to mitigate casing wear. The lubricating properties of a mud are highly dependent on the type of mud (air, water, oil) as well as the additives in the mud. This is evidenced by the lubricity coefficient of the mud. In general, lubricity coefficients may range from greater than 0.5 for air, about 0.4 for water, and about 0.1 for diesel oil (Chillingar, 1983, pg. 530).

The measured lubricity coefficient, however, is highly dependent on the equipment used to measure it. The most common laboratory tester is the Baroid Lubricity Tester which uses a constant speed and constant force on a metal-to-metal contact to determine the lubricity coefficient. The Westport laboratories can determine "real-world" lubricity coefficients with the IITRI/M-I HLT Lubricity Tester. This is a state-of-the-art tester capable of determining mud coefficients of friction on metal-to-metal, metal-to-sandstone, metal-to-shale, or metal-to-filter cake contact. Fluids can be tested from ambient to 350 °F with pressures up to 1000 psi. The HLT tester can use a permeable test surface, typically 200mD Berea sandstone, to achieve differential pressures up to 500 psi, so that filter cake testing is accomplished. In addition, test results from the HLT tester are directly correctable to field torque measurements.

The Thuslick sample was mixed into muds prepared by Westport laboratory personnel and all testing was done by Westport personnel. Westport personnel also selected the other products used in the comparative lubricity testing phase. Various protocols were developed for the testing which used seven different muds and five lubricants in addition to the Thuslick. In addition to the extensive HLT lubricity testing, at ambient and at elevated temperatures, all muds were tested for routine API properties and selected muds were tested for dynamic fluid losses by both the ALKC0 stirred tester and the FANN Model 90 radial flow, concentric cylinder tester. Selected samples were also tested for formation damage characteristics by return permeability measurements.

Sample Identification

Due to the comparative nature of these tests, Westport elected not to identify the lubricants used in this project, with the following exceptions; the base mud (Sample A, in all tables and graphs), and Thuslick (Sample F, in all tables and graphs). The drilling fluids used in this project included both laboratory-prepared and field muds. Most of the products used in the laboratory-prepared muds were supplied by major drilling fluid companies. Field muds were obtained from a mixing plant in South Louisiana.

TESTING PROCEDURES

Drilling Fluids

Two types of water-based muds were used in this project. The first was a lab-prepared PHPA/seawater drilling fluid, weighing 13.0 lb/gal. The second was an unweighted, high-temperature PHPA/SPA drilling fluid. Each base drilling fluid was mixed in four gallon batches using standard laboratory procedures and equipment. After mixing, all fluids were hot-rolled for 16 hours at 150 °F prior to testing.

Five types of oil-based muds were used in this project. Field muds obtained for testing included a mineral oil-based mud, a diesel oil-based mud, and a synthetic-based mud. Lab-prepared oil-based muds included an 11.2 lb/gal mineral oil-based mud and a 13.2 lb/gal synthetic-based fluid. All of the oil-based fluids were hot-rolled for 16 hours at 150 °F prior to testing.

After cooling to room temperature, each mud sample was recombined into five gallon buckets and remixed. After mixing, each fluid was divided into 16 lab-barrel aliquots (5,600 ml) and treated with one of the test lubricants. While mixing, the pH of the sample was adjusted with caustic soda, if needed. After mixing, the sample was again hot-rolled for 16 hours at 150 °F prior to testing.

After again cooling to room temperature, each sample was remixed. A sufficient amount of fluid was removed for fluid property testing. The remaining fluid was placed into a two-gallon bucket, labeled, and prepared for testing on the IITRI/M-I HLT Lubricity Tester.

Sample Testing

All of the samples used in this project were tested in the following manner:

Basic Tests
1. Initial rheologies at 120 °F, pH, API fluid loss, HTHP fluid loss at 300 °F (water-based fluids)
2. Initial rheologies at 120 °F, electrical stability, HTHP fluid loss at 300 °F (oil-based fluids)
3. HLT Lubricity Testing (metal-to-metal contact, metal-to-sandstone contact, room temperature, 150 rpm, 125 lbf)

In addition to the above tests, many of the samples were also tested in the following manner:

1. Dynamic filtration (Fann Model 90 radial flow and ALKCO Services HTHP Dynamic Fluid Loss Tester)
2. Additional HLT Lubricity Testing (metal-to-metal contact, metal-to-sandstone contact, elevated temperature testing of up to 250 °F)
3. Return permeability testing
4. Surface tension measurements

HLT Lubricity Testing Procedure

Experimental Apparatus

The IITRI/M-I HLT Lubricity Tester is a sophisticated, computer-controlled device capable of testing drilling fluids and lubricants under a variety of simulated downhole pressure and temperature conditions. It is a multi-functional machine capable of measuring the coefficient of friction on a wide variety of surfaces, such as metal/casing, metal/formation, metal/shale and metal/filter-cake. Drilling fluids can be tested from atmospheric pressure to 1000 psi (500 psi differential pressure across a permeable test surface), as well as temperatures from ambient to 350 °F. Other variables that are controlled with this machine include rotational speed (50 to 380 rpm) and contact forces (25 to 200 lbf). The machine can be run manually or by computer control, with an IBM computer/Keithley DAS system. The computer controls, monitors, and records the testing parameters and results, storing the test information in an ASCII file for retrieval into a spreadsheet program. Computer control also oversees the safety systems built into the machine for temperature, pressure, load, and rpm values.

HLT Lubricity Testing Procedure, cont.

The following is a description of the test methods and set-up procedures used for running the HLT Lubricity Tester.

A. Metal Insert Test Set-up

1. Place a metal bob onto the drive shaft and the casing test surface holder plate in the L-shaped arm holder. Epoxy the N-80 casing test sample to the holder plate, allowing the epoxy to harden overnight. Place 50 lb-force on the test surface/bob while the epoxy hardens to properly align the two surfaces.

2. After the epoxy has hardened, coat the metal bob with coarse grinding compound, set bob rotation at 150 rpm, and grind the casing test surface for approximately five minutes with 50 lb-force, mating the two surfaces together.

3. After mating the test surfaces, remove all of the grinding material with a clean rag. Clean the metal bob and the casing surface with isopropyl alcohol.

B. Metal-to-Metal Test Procedure

1. Clean the metal bob and casing insert with isopropyl alcohol.

2. Replace the set-up bob with the metal bob to be tested. After attaching the metal bob to the shaft, re-clean the metal bob and metal insert with isopropyl alcohol. Attach the fluid sample container to the HLT Tester. Attach the tubing pump to the inlet and outlet of the sample container. Fill the sample container with fresh water and begin pumping at 1.5 gallons/minute.

3. After entering the test parameters into the computer program, begin the test. Monitor the coefficient of friction display on the computer terminal during the test. For fresh water, 150 rpm and 125 lbf, the average coefficient of friction of metal-to-metal contact will be 0.31 to 0.35. (Test parameters include bob speed rpm, contact force during the test, and number of subtests for the run. Each subtest (nine) is composed of fifty data points, with each data point being an average of 25 torque readings. For a complete run of nine subtests, a total of 11,250 data points are measured).

4. After verifying that metal-to-metal coefficient of friction values are between 0.31 and 0.35, clean up the HLT machine. Mix the fluid sample to be tested on a dispersator for 10 minutes. Repeat the machine setup and computer parameters. Fill the machine with the test fluid and begin the test.