Recommended Practice for Field Testing Oil-based Drilling Fluids

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Addendum 1

Pages 18 to 24: Section 8, Sub-sections 8.1, 8.2, and 8.3, and Table 3 shall be replaced by the following:

8 Static Filtration

8.1 Principle

8.1.1 Measurement of the filtration behavior and the filter cake characteristics of an oil-based drilling fluid are fundamental to the treatment and control of a drilling fluid, as are the characteristics of the filtrate, such as the oil, aqueous phase, or emulsion concentration.

8.1.2 Filtration characteristics of an oil-based drilling fluid are affected by the quantity, type and size of solid particles and emulsified aqueous phase in the drilling fluid, and by properties of the liquid phase. Interactions of these various components can be influenced by temperature and pressure.

8.1.3 Filtration tests are performed at high-temperature/high pressure static conditions. Field static high-temperature/high-pressure filtration tests are conducted using a differential pressure of 3450 kPa (500 psi). Two filtration procedures are given: one for testing up to 175 °C (350 °F) and one for testing from 175 °C (350 °F) to 230 °C (450 °F). Use only the filtration equipment and procedure specified for the temperature required.

NOTE No low-temperature filtration test procedure for oil-based drilling fluids is specified herein, but it can be performed much like the water-based drilling fluid test provided in API 13B-1.

8.1.4 The 175 ml, 250 ml, or 500 ml unit may be used for static filtration testing up to and including 175 °C (350 °F).

8.1.5 For testing above 175 °C (350 °F), only the 500 ml unit shall be used. It is recommended that the cell be equipped with a thermocouple in direct contact with the fluid contained in the cell to more accurately measure the temperature.

8.2 High-temperature/High-pressure Test up to 175 °C (350 °F)

8.2.1 Apparatus

8.2.1.1 High-temperature/high-pressure filter press, consisting of:

a) filter cell, to contain working pressures up to 9000 kPa (1300 psi) at temperature;

b) pressurized gas source, such as carbon dioxide or nitrogen, with regulators;

NOTE Nitrogen is preferred.

c) heating system with temperature controller or thermostat, to heat to 175 °C (350 °F);

d) high-pressure filtrate collection vessel, maintained at proper back-pressure (see Table 3) to avoid flashing or evaporation of the filtrate;

e) filter cell containing a thermometer well or thermocouple in direct contact with the fluid near the center of the cell, fitted with a removable end, a filter-media support and with oil-resistant seals.

NOTE Valve stems on each end of the cell can be opened or closed during the test.

WARNING—Not all manufacturers' equipment can be used above 150 °C (300 °F). Failure to know the pressure/temperature rating of equipment in use can result in serious injury. Testing at high temperature and high pressure calls for added safety precautions. Strict adherence to manufacturer's recommendations as to sample volumes, equipment temperatures and pressures, O-ring material selection and inspection, and other operating instructions is essential. Using appropriate personal protective equipment and safety barriers is recommended when operating HTHP equipment. Failure to follow these precautions could result in serious injury.

Do not use nitrous oxide cartridges as pressure sources for HTHP filtration. Under temperature and pressure, nitrous oxide can detonate in the presence of grease, oil, or carbonaceous materials. Nitrous oxide cartridges shall be used only for Garrett gas train carbonate analysis, in accordance with API 13B-1.

Table 3—Recommended Minimum Back-pressure

Test Temperature		Vapor Pressure		Minimum Back-pressure	
°C	°F	kPa	lbf/in.^{2}	kPa	lbf/in.^{2}
95–149	200–299	84–462	12.1–67	700	100
150–189	300–374	462–1269	67–184	1400	200
190–199	375–399	1269–1704	184–247	1900	275
200–219	400–424	1704–2245	247–326	2500	350
220–230	425–450	2245–2912	326–422	3100	450

8.2.1.2 Filter medium: Hardened, low-ash grade filter paper[2], for temperatures up to 200 °C (400 °F) a new paper is required for each test.

8.2.1.3 Mechanical or electronic timer, with at least a 30 min interval.

8.2.1.4 Thermometer, with a range up to 260 °C (500 °F), and with a 12.5 cm (5 in.) or longer stem, or a thermocouple with a range up to 260 °C (500 °F), preferred.

8.2.1.5 Graduated cylinder (TC), long, slender glass tube, with a capacity of 10 ml or 20 ml.

8.2.1.6 Graduated cylinder (TC), optional, with a capacity of 25 ml.

8.2.1.7 Field mixer, cup type, to operate at 10,000 r/min to 15,000 r/min.

8.2.1.8 Ruler, graduated in millimeters ($^1/_{32}$ in.), to measure filter cake thickness.

[2] This filter paper is a calendered, hardened, qualitative, low-ash filter paper made from cotton linters. The filter paper has the following typical properties which may vary slightly by manufacturer: Slow filtration rate: 2685 Herzbergs; Particle retention in liquid: 2-5 µm; Ash Content: 0.015% by weight; Basis weight: 92 g/m2; Diameter: 63.5 mm (2.5 in.); Thickness: 0.137 mm

8.2.2 Procedure

In order to conduct a HTHP filtration test on a sample of drilling fluid up to 175 °C (350 °F) using a differential pressure of 3450 kPa (500 psi), the following procedure shall be used.

8.2.2.1 Place the thermometer in the well of the heating jacket. Preheat the jacket to approximately 6 °C (10 °F) above the desired test temperature. Adjust the thermostat to maintain this temperature.

WARNING—The outside of the jacket can get hot enough to cause burns.

If the filtration unit is equipped with a thermocouple in direct contact with the drilling fluid, then that temperature should be monitored and reported during the filtration test. Under the “Comments” section, record if the results were based on fluid temperature measured with a direct contact thermocouple or using the 30 min heat-up time (after the cell wall reaches test temperature).

8.2.2.2 Stir the drilling fluid sample for 10 min using the field mixer set at the 10,000 r/min speed. Install and close the upper valve stem on the test cell. Pour the fluid sample into the filter cell, leaving at least a 2.5 cm (1 in.) space in the cell to allow for fluid expansion. Install the filtration media.

8.2.2.3 Ensuring that all O-rings are in place, install the lower end cap, with the valve stem open, above the filtration media and secure. Close the lower valve stem.

8.2.2.4 Complete the assembly of the filter cell and place it in the preheated heating jacket with the filter media on the bottom. Rotate the cell to lock it in place with the pin inside the heating jacket. If the filtration unit is not equipped with a thermocouple in direct contact with the drilling fluid, insert a thermometer into the well of the filter cell wall.

8.2.2.5 Ensure that the filtrate collection vessel is completely free of water or oil. Connect the regulated-pressure filtrate collection vessel assembly onto the lower valve stem and lock it in place. Connect the regulated-pressure assembly to the upper valve and lock it in place.

8.2.2.6 Keeping the two valve stems closed, adjust the pressure on the upper and lower pressure regulators to 700 kPa (100 psi) for temperatures below 150 °C (300 °F) or 1400 kPa (200 psi) for temperatures between 150 °C (300 °F) and 175 °C (350 °F). Open the upper valve stem and readjust the upper pressure regulator to maintain this pressure. Maintain these pressures with the upper valve open during the heat-up time. If the filtration unit is equipped with a thermocouple in direct contact with the drilling fluid, proceed to step 8.2.2.7 when the thermocouple temperature reaches the test temperature. If the filtration unit is not equipped with a thermocouple in direct contact with the drilling fluid, wait 30 min after the filter cell wall reaches the test temperature before proceeding to step 8.2.2.7.

NOTE If the total time required to begin the test exceeds 1 h, the heater might be defective, and the validity of the test is questionable.

8.2.2.7 When the sample reaches the selected test temperature, as indicated by the thermocouple or after the 30 min heat-up time, ensure that the lower pressure regulator is at 700 kPa (100 psi) for temperatures below 150 °C (300 °F) or 1400 kPa (200 psi) for temperatures between 150 °C (300 °F) and 175 °C (350 °F). Open the lower valve stem and immediately increase the pressure on the upper regulator to 4150 kPa (600 psi) for temperatures below 150 °C (300 °F) or 4850 kPa (700 psi) for temperatures between 150 °C (300 °F) and 175 °C (350 °F). This will start the filtration process. Start the timer. Maintain the test temperature to within ±3 °C (±5 °F) during the test, as indicated by the thermocouple or thermometer in the filter cell wall. Maintain these pressures with both valves open during the test, if the back pressure rises above the selected back pressure, cautiously draw off and collect a portion of the filtrate to reduce the back pressure.

WARNING—Filtrate will be hot, and steam may escape if the valve is left open too long.

8.2.2.8 Collect the filtrate in the graduated cylinder. Record the total volume of filtrate collected during the 30 min test, in milliliters. Correct the filtrate volume, V_F, to a filter area of 45.8 cm^2 (7.1 $in.^2$). For example, if the filter area is 22.6 cm^2 (3.5 $in.^2$), double the filtrate volume reported. Also note the presence of, or volumes of, any solids, water, or emulsions, if present.

8.2.2.9 Immediately after collecting the 30 min filtrate, close the lower, then the upper valve stems. Switch off the heating jacket and unplug from the electrical power source. Following the manufacturer's detailed instructions, bleed pressure off the regulators and hoses, and then carefully disconnect the pressurization system.

WARNING—Cell and heating jacket are still hot!

8.2.2.10 Using appropriate personal protective equipment, carefully remove the cell from the heating jacket and allow cell to cool to below 50 °C (125 °F). Keep the cell upright during cooling, depressurization, and disassembly.

WARNING—The filter cell may still be pressurized even after the cell is cooled. To avoid possible serious injury, keep cell upright and cool to room temperature, and then bleed pressure from cell before disassembling.

8.2.2.11 After cooling the cell, bleed pressure from the filter cell by slowly opening the upper valve stem. Avoid spraying drilling fluid as gas exits the stem. Ensure that pressure is fully released before removing the cap. Carefully disassemble the cell.

NOTE If there is resistance when loosening the cap, pressure may still be inside the cell. Ensure that all pressure is released before attempting to remove the end cap.

8.2.2.12 Pour the liquid from the cell.

8.2.2.13 Remove the filter cake with the filtration medium. Measure the filter cake thickness, at its center, to the nearest millimeter ($^1/_{32}$ in.).

8.2.2.14 Settling of solids onto the filter cake may have occurred during the test. Observe indications of this, such as an abnormally thick cake or coarse texture. Record these cake characteristics under the "Comments" on the Mud Report Form. To minimize settling, the times for heat-up and cool-down should be minimized, and the cake should be recovered and examined promptly.

8.2.3 Calculation

8.2.3.1 The filtrate volume, V_F, should be corrected to a filter area of 45.8 cm^2 (7.1 $in.^2$). HTHP filter cells usually have half the standard filter area 22.6 cm^2 (3.5 $in.^2$), thus double the observed volume before reporting.

8.2.3.2 Report the cake thickness to the nearest millimeter ($^1/_{32}$ in.), its texture and the presence of any emulsion or water in the filtrate.

8.3 High-temperature/High-pressure Test from 175 °C (350 °F) up to and Including 230 °C (450 °F)

8.3.1 Apparatus

8.3.1.1 High-temperature/high-pressure filter press, consisting of the following components:

a) 500 ml volume cell, only;

NOTE For safety reasons, it is advisable that only the 500 ml cell be used for testing up to and above 230 °C (450 °F).

b) filter cell, to contain working pressures up to 15,500 kPa (2250 psi) at a temperature of 230 °C (450 °F);

c) pressurized gas source, nitrogen with regulators (preferred);

d) heating system with temperature controller or thermostat, to heat to 260 °C (500 °F);

e) high-pressure filtrate collection vessel, maintained at proper back pressure (see Table 3), to avoid flashing or evaporation of the filtrate;

NOTE For temperatures >190 °C (>375 °F) the back-pressure gauge of the high-pressure filtrate collection vessel will need to be capable of measuring pressures above 1400 kPa (200 psi).

f) filter cell containing a thermometer well or thermocouple in direct contact with the fluid near the center of the cell, fitted with a removable end, a filter-media support and with oil-resistant seals.

NOTE Valve stems on each end of the cell can be opened or closed during a test.

WARNING—Not all manufacturers' equipment can be used above 150 °C (300 °F). Failure to know the pressure/temperature rating of equipment in use can result in serious injury. Testing at high temperature and high pressure calls for added safety precautions. The 175 ml and 250 ml filtration cells are not recommended for use at these higher temperatures and pressures. Strict adherence to manufacturer's recommendations as to sample volumes, equipment temperatures and pressures, O-ring material selection and inspection, and other operating instructions is essential. High temperature O-rings and elastomer seals are required for high temperatures. Equipment manufacturers often recommend replacement or inspection after every test. Inspection should include making sure the O-rings and elastomer seals are pliable with no permanent deformations, nicks, or cuts, etc. A loss of pressure during a test may be an indication of an O-ring or elastomer seal failure and should be corrected. Using appropriate personal protective equipment and safety barriers is recommended when operating HTHP equipment. Failure to follow these precautions could result in serious injury.

WARNING—Do not use nitrous oxide cartridges as pressure sources for HTHP filtration. Under temperature and pressure, nitrous oxide can detonate in the presence of grease, oil, or carbonaceous materials. Nitrous oxide cartridges shall be used only for Garrett gas train carbonate analysis, in accordance with API 13B-1.

8.3.1.2 Filter medium;

a) Hardened, low-ash grade filter paper[3] and glass fiber backing disk[3] for temperatures up to 200 °C (400 °F) a new paper is required for each test;

b) Porous sintered stainless-steel disc, Dynalloy X-5, for temperatures above 200 °C (400 °F): a new disc is required for each test.

8.3.1.3 Mechanical or electronic timer, with at least a 30 min interval.

8.3.1.4 Thermometer, with a range up to 260 °C (500 °F), and with a 12.5 cm (5 in.) or longer stem, or a thermocouple with a range up to 260 °C (500 °F), preferred.

8.3.1.5 Graduated cylinder (TC), long, slender with a volume of 10 ml or 20 ml.

8.3.1.6 Graduated cylinder (TC), optional, with a volume of 25 ml.

8.3.1.7 Field mixer, cup type, to operate at 10,000 r/min to 15,000 r/min.

8.3.1.8 Ruler, graduated in millimeters ($^1/_{32}$ in.), to measure filter cake thickness.

8.3.2 Procedure

In order to conduct a HTHP test at 175 °C (350 °F) up to and including 230 °C (450 °F) test using a differential pressure of 3450 kPa (500 psi), the following procedure shall be used.

8.3.2.1 Place the thermometer in the well of the heating jacket. Preheat the jacket to approximately 6 °C (10 °F) above the desired test temperature. Adjust the thermostat to maintain this temperature.

[3] Glass fiber backing disks are required for testing between 175 °C (350 °F) up to 200 °C (400 °F). These backing disks are a separate item and are inserted between the filter paper and the filter-media support of the filter cell.

WARNING—The outside of the jacket can get hot enough to cause burns.

If the filtration unit is equipped with a thermocouple in direct contact with the drilling fluid, then that temperature should be monitored and reported during the filtration test. Under the “Comments” section, record if the results were based on fluid temperature measured with a direct contact thermocouple or using the 30 min of heat-up time (after the cell wall reaches test temperature).

8.3.2.2 Stir the drilling fluid sample for 10 min using the field mixer set at the 10,000 r/min speed. Install and close the upper valve stem on the test cell. Pour the fluid sample into the filter cell, leaving at least a 5.0 cm (2 in.) space in the cell to allow for fluid expansion. Install the filtration media.

8.3.2.3 Ensuring that all O-rings are in place, install the lower end cap, with the valve stem open, above the filtration media and secure. Close the lower valve stem.

8.3.2.4 Complete the assembly of the filter cell and place it in the preheated heating jacket with the filter media on the bottom. Rotate the cell to lock it in place with the pin inside the heating jacket. If the filtration unit is not equipped with a thermocouple in direct contact with the drilling fluid, insert a thermometer into the well of the filter cell wall.

8.3.2.5 Ensure that the filtrate collection vessel is completely free of water or oil. Connect the regulated-pressure filtrate collection vessel assembly onto the lower valve stem and lock it in place. Connect the regulated pressurized gas source to the upper valve and lock in place.

8.3.2.6 Keeping the two valve stems closed, adjust the pressure on the upper and lower pressure regulators to the minimum back-pressure for the test temperature as shown in Table 3. Open the upper valve stem and readjust the upper pressure regulator to the minimum back-pressure temperature. Maintain these pressures with the upper valve open during the heat-up time. If the filtration unit is equipped with a thermocouple in direct contact with the drilling fluid, proceed to 8.3.2.7 when the thermocouple temperature reaches the test temperature. If the filtration unit is not equipped with a thermocouple in direct contact with the drilling fluid, wait 30 min after the filter cell wall reaches the test temperature before proceeding to 8.3.2.7.

NOTE If the total time required to begin the test exceeds 1 h, the heater might be defective, and the validity of the test is questionable.

8.3.2.7 When the sample reaches the selected test temperature, as indicated by the thermocouple or after the 30 min heat-up time, ensure that the lower pressure regulator is at the minimum back-pressure for the test temperature as shown in Table 3. Open the lower valve stem and immediately increase the pressure on the upper regulator to a value 3450 kPa (500 psi) higher than the back-pressure. This will start the filtration process. Start the timer. Maintain the test temperature to within ±3 °C (±5 °F) during the test, as indicated by the thermocouple or thermometer in the filter cell wall. Maintain these pressures with both valves open during the test, if the back pressure rises above the selected back pressure, cautiously draw off and collect a portion of the filtrate to reduce the back pressure.

WARNING—Filtrate will be hot, and steam may escape if the valve is left open too long.

8.3.2.8 Collect the filtrate in the graduated cylinder. Record the total volume of filtrate collected during the 30 min test, in milliliters. Correct the filtrate volume, V_F, to a filter area of 45.8 cm^2 (7.1 $in.^2$). For example, if the filter area is 22.6 cm^2 (3.5 $in.^2$), double the filtrate volume reported. Also note the presence of, or volumes of, any solids, water, or emulsions, if present.

8.3.2.9 Immediately after collecting the 30 min filtrate, close the lower, then the upper valve stems. Switch off the heating jacket and unplug from the electrical power source. Following the manufacturer’s detailed instructions, bleed pressure off the regulators and hoses, and then carefully disconnect the pressurization system.

WARNING—Cell and heating jacket are still hot!

8.3.2.10 Using appropriate personal protective equipment, carefully remove the cell from the heating jacket and allow cell to cool to below 50 °C (125 °F). Keep the cell upright during cooling, depressurization, and disassembly.

WARNING—The filter cell may still be pressurized even after the cell is cooled. To avoid possible serious injury, keep cell upright and cool to room temperature, and then bleed pressure from cell before

disassembling.

8.3.2.11 After cooling the cell, bleed pressure from the filter cell by slowly opening the upper valve stem. Avoid spraying drilling fluid as gas exits the stem. Ensure that pressure is fully released before removing the cap. Carefully disassemble the cell.

NOTE If there is resistance when loosening the cap, pressure may still be inside the cell. Ensure that all pressure is released before attempting to remove the end cap.

8.3.2.12 Pour the liquid from the cell.

8.3.2.13 Remove the filter cake with the filtration medium. Measure the filter cake thickness, at its center, to the nearest millimeter ($^1/_{32}$ in.).

8.3.2.14 Settling of solids onto the filter cake may have occurred during the test. Observe indications of this, such as an abnormally thick cake or coarse texture. Record these cake characteristics under the “Comments” on the Mud Report Form. To minimize settling, the times for heat-up and cool-down should be minimized, and the cake should be recovered and examined promptly.

8.3.3 Calculation

8.3.3.1 The filtrate volume, V_F, should be corrected to a filter area of 45.8 cm^2 (7.1 $in.^2$). HTHP filter cells usually have half the standard filter area 22.6 cm^2 (3.5 $in.^2$), thus double the observed volume before reporting.

8.3.3.2 Report the cake thickness to the nearest millimeter ($^1/_{32}$ in.), its texture and the presence of any emulsion or water in the filtrate.

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This standard replaces the Fourth Edition of API Recommended Practice 13B-2.

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Introduction

This standard is based on API Recommended Practice 13B-2, *Recommended Practice for Field Testing of Oil-based Drilling Fluids*, Fourth Edition.

As with any laboratory procedure requiring the use of potentially hazardous chemicals and equipment, the user is expected to have received proper training and knowledge in the use and disposal of these potentially hazardous materials. The user is responsible for compliance with all applicable local, regional, and national requirements for worker and local health, safety, and environmental liability.

In this standard, quantities expressed in the international System of Units (SI) are also, where practical, expressed in U.S. customary units (USC) in parentheses for information. The units do not necessarily represent a direct conversion of SI units to USC units, or USC units to SI units. Consideration has been given to the precision of the instrument making the measurement. For example, thermometers are typically marked in one degree increments, thus temperature values have been rounded to the nearest degree.

Calibrating an instrument refers to ensuring the accuracy of the measurement. Accuracy is the degree of conformity of a measurement of a quantity to its actual or true value. Accuracy is related to precision, or reproducibility, of a measurement. Precision is the degree to which further measurements or calculations will show the same or similar results. Precision is characterized in terms of the standard deviation of the measurement. The results of calculations or a measurement can be accurate but not precise, precise but not accurate, neither accurate nor precise, or both accurate and precise. A result is valid if it is both accurate and precise.

This document uses a format for numbers which follows the examples given in *API Document Format and Style Manual*, First Edition, June 2007 (Editorial Revision, January 2009). This numbering format is different than that used in API 13B-2, Fourth Edition. In this document the decimal mark is a period and separates the whole part from the fractional part of a number. No spaces are used in the numbering format. The thousands separator is a comma and is only used for numbers greater than 10,000 (i.e. 5000 items, 12,500 bags).

Recommended Practice for Field Testing Oil-Based Drilling Fluids

1 Scope

This recommended practice provides standard procedures for determining the following characteristics of oil-based drilling fluids:

a) drilling fluid density (mud weight);

b) viscosity and gel strength;

c) filtration;

d) oil, water, and solids concentrations;

e) alkalinity, chloride concentration, and calcium concentration;

f) electrical stability;

g) lime and calcium concentrations, calcium chloride, and sodium chloride concentrations;

h) low-gravity solids and weighting material concentrations.

The annexes provide additional test methods or examples that can optionally be used for the determination of:

— shear strength (Annex A);

— oil and water concentrations from cuttings (Annex B);

— drilling fluid activity (Annex C);

— aniline point (Annex D);

— lime, salinity, and solids concentration (Annex E);

— sampling, inspection and rejection (Annex F);

— rig-site sampling (Annex G);

— cuttings activity (Annex H);

— active sulfide (Annex I);

— calibration and verification of glassware, thermometers, viscometers, retort kit cups, and drilling fluid balances (Annex J);

— high-temperature/high-pressure filtration using the permeability-plugging apparatus (PPA) (Annex K);

— elastomer compatibility (Annex L);

— sand content of oil-based fluid (Annex M);

— identification and monitoring of weight-material sag (Annex N);

— oil-based drilling fluid test report form (Annex O).