

Laboratory Testing of Drilling Fluids

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Introduction

This standard, which establishes testing methodologies for drilling fluid materials, formulations, and various properties, is based on API 13I, Eighth Edition. This standard was developed in response to a demand for more exacting testing methodologies. The tests contained herein were developed over several years by a group of industry experts and were identified as being those which can yield reproducible and accurate results. The tests are anticipated to be performed in a laboratory setting but can be applicable in a field situation with more a rigorous apparatus and conditions than normally found in a drilling fluid field-test kit.

These tests are designed to assist in the evaluation of certain parameters for drilling fluids, with these properties not necessarily used for the maintenance of a drilling fluid in field use. The tests provide either more precision or different properties than those given in the field-testing standards API 13B-1 and API 13B-2.

It is necessary that users of this standard be aware that further or differing requirements can be needed for individual applications. This Standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for individual applications. This may be particularly appropriate where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this standard and provide details.

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

This standard contains footnotes giving examples of apparatus, reagents and sometimes the supplier(s) of those materials that are available commercially. This information is given for the convenience of users of this standard and does not constitute an endorsement by API of the products named. Equivalent products may be used if they can be shown to lead to the same results.

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 values associated with the different 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*, November 2017. This numbering format is different than that used in API 13I, Eighth 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).

Laboratory Testing of Drilling Fluids

1 Scope

1.1 Objective

This standard provides procedures for the laboratory testing of both drilling fluid materials and drilling fluid physical, chemical, and performance properties.

1.2 Conditions of Applicability

This document is applicable to both water-based and non-aqueous drilling fluids, as well as the base or make-up fluid.

It is not applicable as a detailed manual on drilling fluid control procedures. Recommendations regarding agitation and testing temperature are presented because the agitation history and temperature have a profound effect on drilling fluid properties.

NOTE 1 This document does not include procedures related to testing barite specifications. These procedures are presented in API 13A.

NOTE 2 This document does not include procedures related to testing barite for mercury, cadmium, and arsenic. These procedures are presented in API 13K.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API 13A, *Specification for Drilling Fluids Materials*

API Recommended Practice 13B-1, *Recommended Practice for Field Testing Water-based Drilling Fluids*

API Recommended Practice 13B-2, *Recommended Practice for Field Testing Oil-based Drilling Fluids*

ASTM D86 ¹, *Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure*

ASTM D93, *Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester*

ASTM D97, *Petroleum Product—Determination of Pour Point*

ASTM D287-12b, *Standard Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)*

ASTM D445, *Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)*

ASTM D611, *Standard Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents*

ASTM D1141, *Standard Practice for the Preparation of Substitute Ocean Water*

¹ ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, www.astm.org.

ASTM D1298-12b, *Standard Test Method for Density, Relative Density (Specific Gravity) or API Gravity of Crude Petroleum and Petroleum Products by Hydrometer Method*

ASTM D4052, *Standard Test Method for Density and Relative Density of Liquids by Digital Density Meter*

ASTM D5186, *Standard Test Method for Determination of Aromatic Content and Polynuclear Aromatic Content of Diesel Fuels and Aviation Turbine Fuels by Supercritical Fluid Chromatography*

Energy Institute, IP 391 ², *Petroleum products—Determination of aromatic hydrocarbon types in middle distillates—High performance liquid chromatography method with refractive index detection*

EPA 1654 ³, *PAH Content of Oil by HPLC/UV*

3 Terms, Definitions, Abbreviations, and Symbols

3.1 Terms and Definitions

3.1.1

ACS reagent grade

Chemical which meets purity standards as specified by the American Chemical Society (ACS).

3.1.2

autoclave

A pressurized steam-heated vessel.

3.1.3

base oil

Water-free hydrocarbon oil, used for preparation, and dilution, or both, of a non-aqueous drilling or completion fluid.

NOTE Commonly used base oils are often termed as mineral oils, solvent oils or absorber oils. Base oils also include diesel oils, linear paraffin, internal or linear olefins as some synthetic base oils.

3.1.4

carboy

A rigid container used for transporting liquids.

NOTE Typical capacity of 20 L to 60 L (5 gal to 15 gal).

3.1.5

d_{50}

The size (dimension) at which 50 % of the particulates in a measured population are either larger or smaller than the reported dimension.

3.1.6

spurt loss

Volume of fluid that passes through the filtration medium before a filter cake is formed.

3.2 Abbreviations

ACS American Chemical Society ⁴

ASTM ASTM International

² Energy Institute (Institute of Petroleum), 61 New Cavendish Street, London, W1G7AR, UK, www.energyinst.org.

³ U.S. Environmental Protection Agency, 1200 Pennsylvania Ave NW, Washington, DC 20004, USA, www.epa.org.

⁴ American Chemical Society, 1155 Sixteenth Street, NW Washington DC 20036, www.acs.org.

CAS	Chemical Abstracts Service
EI-IP	Energy Institute (formerly, Institute of Petroleum)
EPA	U.S. Environmental Protection Agency
HPLC	high performance liquid chromatography
HTHP	high-temperature, high-pressure
IPA	isopropanol
ISA	ionic strength adjuster
ISE	ion-selective electrode
ISO	International Organization for Standardization ⁵
LTLP	low-temperature, low-pressure
NAF	non-aqueous fluid
PAH	polynuclear aromatic hydrocarbon
PPA	permeability plugging apparatus
PPT	permeability plugging test
PSA	particle size analysis
PSD	particle size distribution
PTFE	polytetrafluoroethylene
SEBC	standard evaluation base clay
TC	to contain
TD	to deliver
UV	ultraviolet
psi	pound-force per square inch

3.3 Symbols

<i>a</i>	abrasion, expressed in milligrams per minute
$C_{MBT-AVE}$	average methylene blue capacity for all low-gravity solids, expressed in milliequivalents per hundred grams (meq/100 g)
C_{MBT-B}	methylene blue capacity of commercial bentonite, expressed in milliequivalents per hundred grams (meq/100 g)
C_{MBT-BS}	methylene blue capacity of drill solids, expressed in milliequivalents per hundred grams (meq/100 g)
$c_{B,SI}$	concentration of bentonite, expressed in kilograms per cubic meter
$c_{B,USC}$	concentration of bentonite, expressed in pounds per barrel
$c_{DS,SI}$	concentration of drilled solids, expressed in kilograms per cubic meter
$c_{DS,USC}$	concentration of drilled solids, expressed in pounds per barrel
$c_{LG,SI}$	concentration of low-gravity solids, expressed in kilograms per cubic meter
$c_{LG,USC}$	concentration of low-gravity solids, expressed in pounds per barrel

⁵ International Organization for Standardization, BIBC II, chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland; www.iso.org.

c_X	concentration of component “X” in a solution, expressed in grams per liter or as per its molarity M (moles per liter)
d_{50}	particle mean diameter, expressed in microns
e	thinner efficiency, expressed in percent
$E_{BE,SI}$	bentonite equivalent, expressed in kilograms per cubic meter
$E_{BE,USC}$	bentonite equivalent, expressed in pounds per barrel
l	submerged length of the shear tube, expressed in centimeters (inches)
m_B	mass of a commercial bentonite sample, expressed in grams
m_b	initial blade mass, expressed in milligrams
m_{C1}	initial weight of cuttings sample, expressed in grams
m_{C2}	final dry sample weight, expressed in grams
m_{DS}	mass of drill solids sample, expressed in grams
m_d	mass of dry sample, expressed in grams
m_{dmb}	mass of dry methylene blue powder, 1.00 g sample, expressed in grams
m_f	final blade mass, expressed in milligrams
m_h	mass of water required for solids adjustment, expressed in grams
m_L	specified mass of the suspension, expressed in grams
m_{mb}	corrected mass of methylene blue powder to prepare methylene blue solution, expressed in grams
m_o	mass of original sample, expressed in grams
m_r	mass of residue, expressed in grams
m_s	mass of sample, expressed in grams
m_{st}	mass of the shear tube, expressed in grams
m_{tot}	total shear mass (sum of platform mass and mass of weights), expressed in grams
R	test precision interlab between-laboratories reproducibility, expressed in milligrams per minute
r	test precision intralab, within-laboratory repeatability expressed in milligrams per minute
P_{df}	phenolphthalein alkalinity of the drilling fluid (see API 13B-1)
p_r	performance of reference thinner, for example yield point or gel strength as determined in accordance with API 13B-1
p_s	performance of test sample, for example yield point or gel strength as determined in accordance with API 13B-1
t	time, expressed in minutes
t_1	time at the initial reading, expressed in minutes
t_2	time at the final reading, expressed in minutes
V	volume of methylene blue solution used in titration, expressed in milliliters
V_{PPT}	permeability plugging test (PPT) volume, expressed in milliliters



V_{sl}	spurt loss, expressed in milliliters
V_1	filtrate volume after time t_1 , expressed in milliliters
V_2	filtrate volume after time t_2 , expressed in milliliters
$V_{7.5}$	filtrate volume after 7.5 min, expressed in milliliters
V_{30}	filtrate volume after 30 min, expressed in milliliters
v_{sf}	static filtration rate (velocity of flow), expressed in milliliters per minute
w_{hB}	moisture content of calcium bentonite, expressed as percent mass fraction
w_{hC}	initial moisture content of cuttings sample, expressed as percent mass fraction
w_r	mass recovery (mass residue), expressed as percent mass fraction
w_s	mass fraction of solids, expressed as percent mass fraction
ρ	density, expressed in grams per milliliter
γ	shear strength of the drilling fluid, expressed in pascals (lbf/100 ft ²)

4 Abrasivity of Weighting Materials

4.1 Principle

4.1.1 Drilling fluid weighting materials can vary considerably in relative abrasivity. This laboratory test is designed to measure and evaluate this relative abrasivity.

4.1.2 The test is performed using an abrasion test blade (see [4.2.8](#)) attached to a high-speed mixer to mix a base drilling fluid containing the weighting material. The mass loss of the blade is used to calculate the abrasivity of the weighting material in milligrams per minute (mg/min).

4.1.3 This test is intended to give only a relative index of wear for weighting materials. It should not be used to infer whether or not these materials can cause abrasion problems in a field drilling fluid system.

4.2 Reagents and Apparatus

4.2.1 Reference (Calibration) Bentonite

Reference (calibration) bentonite can be acquired from various suppliers. Accuracy of results from the use of this material is strictly the responsibility of the laboratory using it. See API Specification 13A for a description of the required properties of reference (calibration) bentonite and for details on API Reference Material Program.

4.2.2 Detergent.

4.2.3 Deionized or distilled water, in accordance with ISO 3696, or prepared by passing tap water through a series of cation and anion exchange resins.

Use deionized or distilled water for preparation of all reagents and calibration standards and as dilution water.

4.2.4 Mixer, capable of operation at 11,500 r/min $\pm$ 300 r/min under load, with single, corrugated impeller. The impeller shall be replaced with an abrasion test blade in accordance with [4.2.8](#).

4.2.5 Mixing container, approximately 180 mm (7 ¹/₈ in.) deep, $d = 97$ mm (3 ³/₄ in.) at top and 70 mm (2 ³/₄ in.) at bottom. A standard mixer cup generally conforms to these specifications.

4.2.6 Balance, accuracy ± 0.0001 g (i.e. 0.1 mg).

4.2.7 Balance, of capacity 500 g and accuracy ± 0.1 g.

4.2.8 Blade, for abrasion test, steel, of diameter 36.5 mm (1.4 in.); flat side of thickness 1.4 mm (0.05 in.); Rockwell hardness of 16; four waves of depth 6.4 mm (0.25 in.) and width 15.3 mm (0.6 in.); center hole of diameter 7.1 mm (0.28 in.), and a G-90 coating with a mass of approximately 12 g.

Each blade may be used up to a cumulative mass loss of 200 mg (approximately four runs).

4.2.9 Screw, round-head machine screw, M5–0.8 $\times$ 15 mm [size 10–32 (32 threads/in.) $\times$ 0.5 in.], to fasten the abrasion test blade securely onto the shaft of the abrasion mixer.

4.2.10 Tachometer, optical, magnetic induction or equivalent, capable of reading 11,000 r/min ± 50 r/min.

4.2.11 Cylinder, graduated, TD, 500 mL ± 2.5 mL.

4.2.12 Viscometer, direct indicating, shall be in accordance with API 13B-1.

4.2.13 Timer, digital or mechanical, accuracy ± 5 seconds per hour.

4.2.14 Small brush.

4.3 Determination of Abrasivity of Weighting Materials

The following procedure shall be used to determine abrasivity of weighting materials:

- a) Prepare a base suspension by adding 15.0 g ± 0.1 g reference (calibration) bentonite to 350 mL ± 2.5 mL deionized or distilled water in a mixing container while stirring on the base suspension mixer. At least two of these suspensions are needed for the test.
- b) After 5 min ± 5 s stirring time on the mixer, remove the mixing container from the mixer and scrape its sides with the spatula to remove or dislodge any reference bentonite adhering to the container. Be sure that all bentonite clinging to the spatula is incorporated into the suspension.
- c) Replace the mixing container on the mixer and continue stirring for 15 min ± 15 s. The container should be removed from the mixer and the sides scraped to dislodge any bentonite clinging to the container walls at 5 min intervals. Total stirring time after adding the reference bentonite shall be 20 min ± 20 s.
- d) Pour the base suspension into the cup provided with the direct-indicating viscometer. Note the dial reading at the 600 r/min rotor-speed setting when it reaches a constant value. The 600 r/min dial reading shall not exceed 10 at a test temperature of 25 °C ± 2 °C (77 °F ± 3 °F). If necessary, the 600 r/min dial reading of the base suspension can be lowered by adding a small amount of deionized water.
- e) Pour 300 mL ± 2.5 mL of base suspension into the mixing container (use 280 mL ± 2.5 mL when testing barite).
- f) Add 300.0 g ± 0.1 g of weighting materials into the base suspension in the test container.
- g) Immediately prior to use, clean the blade by washing with detergent and a small brush. Rinse thoroughly and dry. Weigh a freshly cleaned and dried abrasion test blade to the nearest 0.1 mg. Record as m_b , in milligrams.

Blades should be polished after manufacture to remove rough edges. Only non-corroded blades should be used.

- h) Disconnect the mixer power cord to avoid accidental operation during blade installation. Center and fasten the abrasion test blade, with the waves in the downward position, onto the abrasion mixer spindle with the lock washer and screw.

- i) With the mixer off, place the mixing container into position on the mixer, such that the rim engages with the trip switch. Start the mixer using a series of quick on-off flips of the switch to bring the spindle up to speed gently.

NOTE An abrupt start can sling some suspension out of the cup.

- j) Run the test for 20 min $\pm$ 5 s.
- k) Turn the mixer off, disconnect the power cord, remove the mixing container and the abrasion test blade.
- l) Clean and dry the abrasion test blade and weigh to the nearest 0.1 mg. Record as m_f in milligrams.

4.4 Calculation—Determination of Abrasivity of Weighting Materials

4.4.1 Calculate, a , the abrasion, expressed in milligrams per minute, as given in Equation (1):

$$a = \frac{m_b - m_f}{t} \quad (1)$$

where

- m_b is the initial blade mass, expressed in milligrams;
- m_f is the final blade mass, expressed in milligrams;
- t is the time, expressed in minutes (20 min in this procedure).

4.4.2 The test precision for this procedure has been determined to be as follows:

- Intralab precision, $r = \pm 0.45 \text{ mg/min}$
- Interlab precision, $R = \pm 0.78 \text{ mg/min}$

where

- r is the intralab, within-laboratory repeatability, the maximum expected difference between two test results on the same sample by the same laboratory at the 95 % confidence level;
- R is the interlab, between-laboratories reproducibility; the maximum expected difference between test results by two different laboratories on the same sample at the 95 % confidence level.

Because this test is not an absolute measurement, test results should be evaluated cautiously. Best evaluations are obtained by comparing test results of a sample to test results of a weighting material of proven performance, rather than using the test-result value obtained as an absolute.

5 Filtration-control Agents

5.1 Principle

5.1.1 Organic filtration-control agents can vary greatly in chemical composition and performance characteristics in different drilling fluid environments. Judgments are made by comparing the performance of test filtration control materials to that of known materials that have been accepted for field use.

5.1.2 In specific cases, comparisons may be made in the actual field drilling fluid in which the material will be used, but in general, evaluations are performed in laboratory-prepared drilling fluids.

5.1.3 It is recommended that filtration-control materials considered for broad applications be screened in different drilling fluid systems. While filtration control is the property being evaluated, the effect of the test material on rheological properties, pH or other properties can be of concern.

5.2 Reagents and Apparatus

5.2.1 Calcium chloride, CaCl_2 (CAS No. 10043-52-4), ACS reagent grade.

5.2.2 Magnesium chloride, MgCl_2 (CAS No. 7786-30-3), ACS reagent grade.

5.2.3 Potassium chloride, KCl (CAS No. 7447-40-7), ACS reagent grade.

5.2.4 Xanthan gum, drilling fluid grade dry powder, material specifications shall be in accordance with API 13A.

5.2.5 Attapulgate, material specifications shall be in accordance with API 13A.

5.2.6 Simulated drilled solids, for example standard evaluation base clay (SEBC). Material specification shall be in accordance with API 13A.

5.2.7 Reference (calibration) bentonite. If fluid loss properties are not obtained within the specified range, replace the reference bentonite. Material specifications shall be in accordance with API 13A.

5.2.8 Salt, stock solution No. 1, shall be in accordance with ASTM D1141:

555.60 g ± 0.05 g magnesium chloride hexahydrate [$\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ (CAS No. 7791-18-6)], 57.90 g ± 0.05 g anhydrous calcium chloride [CaCl_2 (CAS No. 10043-52-4)] and 2.10 g ± 0.05 g strontium chloride hexahydrate [$\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$ (CAS No. 10025-70-4)] diluted to 1 L with deionized or distilled water.

5.2.9 Salt, stock solution No. 2, shall be in accordance with ASTM D1141:

69.50 g ± 0.05 g potassium chloride [KCl (CAS No. 7447-40-7)], 20.10 g ± 0.05 g sodium bicarbonate [NaHCO_3 (CAS No. 144-55-8)], 10.00 g ± 0.05 g potassium bromide [KBr (CAS No. 7758-02-3)], 2.70 g ± 0.05 g boric acid [H_3BO_3 (CAS No. 10043-35-3)] and 0.30 g ± 0.01 g sodium fluoride [NaF (CAS No. 7681-49-4)], diluted to 1 L with deionized water or distilled.

5.2.10 Sodium hydroxide, (NaOH) i.e. caustic soda (CAS No. 1310-73-2), standardized solutions, $c_{\text{NaOH}} = 10$ mol/L (10 N) and $c_{\text{NaOH}} = 0.1$ mol/L (0.1 N).

5.2.11 Lignosulfonate (chrome or ferrochrome), drilling fluid grade.

5.2.12 Lime, (CAS No. 1305-78-8), drilling grade lime, assay $>85\%$ as $\text{Ca}(\text{OH})_2$ or better.

5.2.13 Sodium chloride (CAS No. 7647-14-5), ACS reagent grade.

5.2.14 Sodium sulfate, anhydrous (CAS No. 7757-82-6), ACS reagent grade.

5.2.15 Deionized or distilled water, in accordance with ISO 3696, or prepared by passing tap water through a series of cation and anion exchange resins.

Use deionized or distilled water for preparation of all reagents and calibration standards and as dilution water.

5.2.16 Defoamer.

NOTE For example octyl alcohol.

5.2.17 Balance, accuracy ± 0.01 g.

5.2.18 Mixer, capable of operation at 11,500 r/min $\pm$ 300 r/min under load, with a single, corrugated impeller approximately 25.4 mm (1.0 in.) in diameter.

The impeller shall be replaced when a mass loss of approximately 10 % occurs. The original blade mass is approximately 5.5 g and should have been recorded when the impeller was placed in service.

All mixing referenced in [Section 5](#) shall be conducted at 11,500 r/min $\pm$ 300 r/min.

5.2.19 Mixing container, approximately 180 mm (7 $\frac{1}{8}$ in.) deep, $d = 97$ mm (3 $\frac{3}{4}$ in.) at top and 70 mm (2 $\frac{3}{4}$ in.) at bottom. A standard mixer cup generally conforms to these specifications.

5.2.20 Timer, direct-reading counter with an accuracy within $\pm$ 5 seconds per hour.

5.2.21 Sealable container, appropriate to volume of fluid to be prepared.

5.2.22 Spatula.

5.2.23 Filter press, low-temperature, low-pressure (LTLP), shall be in accordance with API 13B-1, having a filter area of 45.2 cm² to 46.4 cm² (diameter of 75.9 mm to 76.9 mm) [filter area of 6.97 in.² to 7.17 in.² (diameter of 2.98 in. to 3.02 in.)].

The filter-press gasket is the determining factor for the filter area. It is recommended that the filter-press gasket used be tested by a conical gauge having the maximum [76.86 mm (3.02 in.)] and the minimum [75.86 mm (2.98 in.)] allowed diameter dimensions marked on it. Any filter press gasket diameter measuring outside this range should be discarded.

5.2.24 Viscometer, direct-reading, shall be in accordance with API 13B-1.

5.2.25 Roller oven, regulated to maintain a temperature of 65 °C $\pm$ 3 °C (150 °F $\pm$ 5 °F).

5.2.26 pH meter, shall be in accordance with API 13B-1.

5.2.27 Jar, small and covered, e.g. 0.5 L glass jar with screw-type lid.

5.2.28 Oven, regulated to maintain a temperature of 105 °C $\pm$ 3 °C (220 °F $\pm$ 5 °F).

5.2.29 Aging cells, in accordance with [14.3](#) of this document.

5.2.30 Filter press, high-temperature, high-pressure (HTHP), shall be in accordance with API 13B-1.

5.2.31 Flasks, volumetric, class A, 1 L to contain (TC).

5.2.32 Graduated cylinders, 10 mL, 25 mL, 250 mL to deliver (TD).

5.2.33 Syringes, disposable, 3 mL capacity.

5.3 General Instructions for Preparation of Base Drilling Fluids

5.3.1 Prepare a sufficient quantity of base drilling fluid for a series of tests. This can be achieved by preparing a large batch or by combining small batches for uniformity prior to aging.

5.3.2 Composition, order of addition, mixing time, shear, and aging time shall be consistent from batch-to-batch.

5.3.3 Stir all base drilling fluids prior to testing to ensure uniformity.

5.3.4 Test a sample of the untreated base drilling fluid each time a new series of tests is begun. Subject a sample of the untreated base drilling fluid to the same amount of stirring, heat aging, and testing as the treated drilling fluids.

All quantities given are for the preparation of a single laboratory barrel (350 mL).

5.4 Salt-saturated, Drilling Fluid Preparation for Filtration Testing

The following procedure shall be used to prepare a salt-saturated, drilling fluid sample for filtration testing.

- a) For the purpose of testing (see [5.13](#)), the mass equivalent for this sample is 439 g per 350 mL. Prepare saturated saltwater by adding 400 g $\pm$ 1g of sodium chloride to sufficient deionized water to yield 1 L (this will exceed the solubility of sodium chloride in water at room temperature).
- b) Mix for 30 min $\pm$ 30 s, age overnight (16 h $\pm$ 2 h) at room temperature and decant into a large covered carboy (approximately 4 L).
- c) Prepare a suspension of attapulgite clay and simulated drilled solids using 8.00 g $\pm$ 0.05 g of attapulgite and 30.00 g $\pm$ 0.05 g of simulated drilled solids in 338 mL (401.00 g $\pm$ 0.05 g) saturated saltwater in a container. Sift the clay and drill solids into the water while stirring with the mixer. This yields one laboratory barrel.
- d) After 5 min $\pm$ 5 s, remove the container from the mixer and scrape the sides to dislodge any clay and solids adhering to the container.
- e) Replace on the mixer and continue stirring for an additional 25 min $\pm$ 25 s (for a total mixing time of 30 min $\pm$ 30 s).
- f) Store the suspension for 24 h $\pm$ 2 h in a sealed container at room temperature.
- g) Stir the suspension for 5 min $\pm$ 5 s on the mixer.
- h) Measure the filtrate volume using a LTLP filter press. Measurement procedure shall be in accordance with API 13B-1. The filtrate volume should be 90 mL to 105 mL. If not, prepare a new sample for testing.

5.5 High-hardness, Salt-saturated Drilling Fluid Preparation for Filtration Testing

The following procedure shall be used to prepare salt-saturated drilling fluid sample for filtration testing.

For the purpose of testing (see [5.13](#)), the mass equivalent for this sample is 467 g per 350 mL.

- a) Prepare a high-hardness brine by adding 125.00 g $\pm$ 0.05 g calcium chloride and 22.00 g $\pm$ 0.05 g magnesium chloride to sufficient saturated salt solution, as prepared in [5.4](#), item a) to yield 1 L total volume.
- b) Mix for 30 min $\pm$ 30 s, age overnight (16 h $\pm$ 2 h) at room temperature 24 °C $\pm$ 3 °C (75 °F $\pm$ 5 °F) and decant into a large covered carboy.
- c) Prepare a suspension of attapulgite clay and simulated drilled solids using 8.00 g $\pm$ 0.05 g of attapulgite and 30.00 g $\pm$ 0.05 g of simulated drilled solids in 338 mL (429.00 g $\pm$ 0.05 g) of high-hardness, salt-saturated drilling fluid in a mixing container. Sift the clay and drill solids into the water while stirring with the mixer.
- d) After 5 min $\pm$ 5 s, remove the mixing container from the mixer and scrape the sides to dislodge any clay and solids adhering to the container.
- e) Replace on the mixer and continue stirring for an additional 25 min $\pm$ 25 s (for a total mixing time of 30 min $\pm$ 30 s).
- f) Store the suspension for 24 h $\pm$ 2 h in a sealed container at room temperature.

- g) Stir the suspension for 5 min $\pm$ 5 s on the mixer.
- h) Measure the filtrate volume using a LTLP filter press. Measurement procedure shall be in accordance with API 13B-1. The filtrate volume should be 90 mL to 105 mL. If not, prepare a new sample for testing.

5.6 10 % Potassium Chloride (KCl) Drilling Fluid Preparation for Filtration Testing

The following procedure shall be used to prepare salt-saturated drilling fluid sample for filtration testing.

For the purpose of testing (see [5.13](#)), the mass equivalent for this sample is 391 g per 350 mL.

- a) Prepare a 10 % potassium chloride (KCl) solution by adding 111.00 g $\pm$ 0.05 g of KCl to a flask and diluting with water to 1 L.
- b) Sift 1.00 g $\pm$ 0.01 g of xanthan gum slowly into 360.00 g $\pm$ 0.05 g (340 mL) of the 10 % KCl solution in a mixing container while stirring on a mixer.
- c) After 5 min $\pm$ 5 s, remove the mixing container from the mixer and scrape the sides to dislodge any polymer adhering to the container.
- d) Replace on the mixer and continue stirring for an additional 10 min $\pm$ 10 s (total mixing time 15 min $\pm$ 15 s).
- e) Add 30.00 g $\pm$ 0.05 g of simulated drilled solids while continuing to stir with the mixer.
- f) After 5 min $\pm$ 5 s, remove the container from the mixer and scrape the sides to dislodge any solids adhering to the container.
- g) Replace the container on the mixer and continue stirring for an additional 10 min $\pm$ 10 s (for a total mixing time of 30 min $\pm$ 30 s).
- h) Measure the rheological properties using the viscometer. Measurement procedure shall be in accordance with API 13B-1. If properties are as follows, continue to the next step in the testing procedure. If they are not, prepare a new sample for testing:

plastic viscosity: 3 cP (mPa•s) to 7 cP (mPa•s);

yield point: 6 lbf/100 ft² to 10 lbf/100 ft² (2.9 Pa to 4.8 Pa);

10 s gel: 2 lbf/100 ft² to 4 lbf/100 ft² (0.96 Pa to 1.92 Pa);

10 min gel: 3 lbf/100 ft² to 5 lbf/100 ft² (1.4 Pa to 2.4 Pa).

- i) Measure the filtrate volume using a LTLP filter press. Measurement procedure shall be in accordance with API 13B-1. The filtrate volume should be 30 mL to 50 mL, if not, prepare a new sample for testing.

5.7 Pre-hydrated Bentonite Slurry Preparation for Filtration Testing

The following procedure shall be used to prepare pre-hydrated bentonite slurry for filtration testing.

- a) For procedures requiring pre-hydrated bentonite in a base drilling fluid, prepare and age the bentonite in advance.
- b) Prepare a suspension of the bentonite using 25.00 g $\pm$ 0.05 g bentonite (as received) in 350 mL deionized water (6.67 % mass fraction solids) in a mixing container for each sample being tested. Sift the clay into the water while stirring with the mixer.

- c) After 5 min $\pm$ 5 s, remove the container from the mixer and scrape the sides to dislodge any bentonite adhering to the container.
- d) Replace on the mixer and continue stirring for an additional 10 min $\pm$ 10 s (for a total mixing time of 15 min $\pm$ 15 s).
- e) Store the suspension overnight (16 h $\pm$ 2 h) in a sealed container at room temperature.
- f) Stir the suspension for 5 min $\pm$ 5 s on a mixer before using.

5.8 Modified Seawater Drilling Fluid Preparation for Filtration Testing

The following procedure shall be used to prepare modified seawater drilling fluid sample for filtration testing.

For the purpose of testing (see [5.13](#)), the mass equivalent for this sample is 382 g per 350 mL fluid.

- a) Prepare simulated seawater by adding 24.50 g $\pm$ 0.05 g sodium chloride and 4.10 g $\pm$ 0.05 g anhydrous sodium sulfate to a 1 L flask with 800 mL deionized or distilled water. Pour 20.0 mL stock salt solution No. 1 and 10.0 mL of stock salt solution No. 2 into the flask and dilute to 1 L with deionized water while stirring. Adjust pH to 8.2 with 0.1 mol/L sodium hydroxide solution.
- b) Prepare a suspension of bentonite clay using 150.0 g $\pm$ 0.1 g (144 mL) of pre-hydrated bentonite slurry in a mixing container, as prepared in [5.7](#). Add 193 mL of simulated seawater, as prepared in [5.8](#), item a), while stirring on the mixer.
- c) Continue stirring while adding 2.5 mL of 10 mol/L NaOH and sifting in 30.00 g $\pm$ 0.05 g of simulated drilled solids.
- d) After 5 min $\pm$ 5 s, remove the container from the mixer and scrape the sides to dislodge any clay and solids adhering to the container.
- e) Replace on the mixer and continue stirring for an additional 10 min $\pm$ 10 s (for a total mixing time of 15 min $\pm$ 15 s).
- f) Store the suspension for 24 h $\pm$ 2 h in a sealed container at room temperature.
- g) Stir the suspension for 5 min $\pm$ 5 s on the mixer.
- h) Measure the filtrate volume using a LTLP filter press. Measurement procedure shall be in accordance with API 13B-1. The filtrate volume should be 60 mL to 70 mL. If not, prepare a new sample for testing.

5.9 Low-salinity Drilling Fluid Preparation for Filtration Testing

The following procedure shall be used to prepare low-salinity drilling fluid sample for filtration testing.

For the purpose of testing (see [5.13](#)), the mass equivalent for this sample is 382 g per 350 mL fluid.

- a) Prepare a low-salinity solution by weighing 42.00 g $\pm$ 0.05 g sodium chloride into a flask and diluting to 1 L with water, resulting in 4 % sodium chloride brine.
- b) Prepare a suspension of bentonite clay using 150.00 g $\pm$ 0.05 g (144 mL) of pre-hydrated bentonite slurry as prepared in [5.7](#), in a mixing container. Add 193 mL of low-salinity solution to the suspension of bentonite while stirring with the mixer.
- c) Continue stirring while adding 2.5 mL of 10 mol/L NaOH and sifting in 30.00 g $\pm$ 0.05 g of simulated drilled solids.

- d) After 5 min $\pm$ 5 s, remove the container from the mixer and scrape the sides to dislodge any clay and solids adhering to the container.
- e) Replace on the mixer and continue stirring for an additional 10 min $\pm$ 10 s (for a total mixing time of 15 min $\pm$ 15 s).
- f) Store the suspension for 24 h $\pm$ 2 h in a sealed container at room temperature.
- g) Stir the suspension for 5 min $\pm$ 5 s on the mixer.
- h) Measure the filtrate volume using a LTLP filter press. Measurement procedure shall be in accordance with API 13B-1. The filtrate volume should be 35 mL to 45 mL. If not, prepare a new sample for testing.

5.10 Lime-treated Drilling Fluid Preparation for Filtration Testing

The following procedure shall be used to prepare lime-treated drilling fluid sample for filtration testing.

For the purpose of testing (see [5.13](#)), the mass equivalent for this sample is 373 g per 350 mL fluid.

- a) Prepare a suspension of bentonite clay using 260.00 g $\pm$ 0.05 g (250 mL) of pre-hydrated bentonite slurry as prepared in [5.7](#), in a mixing container. Add 73 mL of deionized water, 4.00 g $\pm$ 0.05 g of chrome lignosulfonate and 2.5 mL of 10 mol/L NaOH while stirring on the mixer.
- b) Stir for 30 min $\pm$ 5 s.
- c) Continue stirring and sift in 3.00 g $\pm$ 0.05 g of lime and 30.00 g $\pm$ 0.05 g of simulated drilled solids.
- d) After 5 min $\pm$ 5 s, remove the container from the mixer and scrape the sides to dislodge any clay and solids adhering to the container.
- e) Replace on the mixer and continue stirring for an additional 10 min $\pm$ 10 s (for a total mixing time of 45 min $\pm$ 30 s).
- f) Roll the suspension for 16 h $\pm$ 30 min in a sealed container in an oven set at 65 °C (150 °F).
- g) Cool and stir the suspension for 5 min $\pm$ 5 s on the mixer.
- h) Measure the filtrate volume using a LTLP filter press. Measurement procedure shall be in accordance with API 13B-1. The filtrate volume should be 12 mL to 20 mL. If not, prepare a new sample for testing.
- i) Measure the phenolphthalein alkalinity, P_{df} , of the drilling fluid. The procedure to measure P_{df} of the drilling fluid shall be in accordance with API 13B-1. The P_{df} of the drilling fluid should be 10 mL to 20 mL; if less than 10 mL, adjust with lime, if greater than 20 mL, prepare a new sample for testing.

5.11 Low Solids, Non-dispersed Drilling Fluid Preparation for Filtration Testing

The following procedure shall be used to prepare low solids, non-dispersed drilling fluid sample for filtration testing.

For the purpose of testing (see [5.13](#)), the mass equivalent for this sample is 365 g per 350 mL fluid.

- a) Prepare a suspension of bentonite clay using 150.00 g $\pm$ 0.05 g (144 mL) of pre-hydrated bentonite slurry in a mixing container, as prepared in [5.7](#). Add 200 mL of water and 15.00 g $\pm$ 0.05 g of simulated drilled solids while stirring with the mixer.

- b) After 5 min $\pm$ 5 s, remove the container from the mixer and scrape the sides to dislodge any clay and solids adhering to the container.
- c) Replace the container on the mixer and continue stirring for an additional 10 min $\pm$ 10 s (for a total mixing time of 15 min $\pm$ 15 s).
- d) Store the suspension for 24 h $\pm$ 2 h in a sealed container at room temperature.
- e) Stir the suspension for 5 min $\pm$ 5 s on the mixer.
- f) Measure the filtrate volume using a LTLP filter press. Measurement procedure shall be in accordance with API 13B-1. The filtrate volume should be 20 mL to 30 mL. If not, prepare a new sample for testing.

5.12 Freshwater Lignosulfonate Drilling Fluid Preparation for Filtration Testing

The following procedure shall be used to prepare freshwater lignosulfonate drilling fluid sample for filtration testing.

For the purpose of testing (see [5.13](#)), the mass equivalent for this sample is 369 g per 350 mL fluid.

- a) Prepare a suspension of bentonite clay using 225.00 g $\pm$ 0.05 g (216 mL) of pre-hydrated bentonite slurry as prepared in [5.7](#), in a mixing container. Add 127 mL of water, 15.00 g $\pm$ 0.05 g of simulated drilled solids, 1.00 g $\pm$ 0.01 g of chrome lignosulfonate and 1.2 mL of 10 mol/L NaOH while stirring with the mixer.
- b) After 5 min $\pm$ 5 s, remove the mixing container from the mixer and scrape the sides to dislodge any clay and solids adhering to the container.
- c) Replace on the mixer and continue stirring for an additional 10 min $\pm$ 10 s (for a total mixing time of 15 min $\pm$ 15 s).
- d) Store the suspension for 24 h $\pm$ 2 h in a sealed container at room temperature.
- e) Stir the suspension for 5 min $\pm$ 5 s on the mixer.
- f) Measure the filtrate volume using a LTLP filter press. Measurement procedure shall be in accordance with API 13B-1. The filtrate volume should be 9 mL to 15 mL. If not, prepare a new sample for testing.
- g) Measure the pH of the suspension using a pH meter. Measurement procedure shall be in accordance with API 13B-1. The pH should be 9.5 to 10.5. Adjust, if necessary, with 10 mol/L NaOH if below 9.5; if above 10.5, prepare a new sample for testing.

5.13 Initial Performance Filtration Test

To perform a "Performance Filtration Test" on a sample of prepared drilling fluid according to [Section 5](#), the following procedure shall be used:

- a) Select the concentrations of filtration control agent to cover a wide range (e.g. 0.1 g/350 mL, 0.5 g/350 mL, 1.0 g/350 mL, 3.0 g/350 mL, and 5.0 g/350 mL). Include an untreated sample of the base drilling fluid.

If comparison to a known field-accepted material is being made, performance tests should be run on an equivalent range of known field-accepted material concentrations.

- b) Weigh into each of several mixing containers the mass equivalent of 350 mL of the desired base drilling fluid. Place the containers on the mixer and mix to uniformity. Measure the pH of the base drilling fluid and record.
- c) Weigh out the desired amounts of filtration-control agents and add uniformly over a period of 30 s $\pm$ 5 s while stirring on the mixer.

- d) Mix for 30 min $\pm$ 30 s, removing the containers twice during mixing to scrape the sides to dislodge any clay and simulated drill solids adhering to the container. If foaming occurs while stirring and remains when the sample is removed from the mixer, attempt to remove the entrained air by stirring slowly with a spatula. Add a defoamer if necessary; however, additions of a defoamer can change filtration results. Record the amount of defoamer added.
- e) Measure the pH of the suspensions using a pH meter, in accordance with API 13B-1. If the pH is lower than the untreated test drilling fluid by more than 0.5 pH units, adjust the pH to that of the untreated test drilling fluid with 10 mol/L NaOH. If the pH is higher than the untreated test drilling fluid, record the pH, but do not make any adjustment.
- f) Determine the LTLP filtrate volume, in accordance with API 13B-1. Record the filtrate volume, cake thickness, and cake consistency.

The filtrate volume should be determined immediately after preparation.

5.14 Low-temperature Filtration Performance Testing after Heat Aging

To perform low-temperature performance filtration test on a sample after heat aging, the following procedure shall be used.

- a) Dynamically age the samples prepared and tested in [5.13](#) by rolling or rotating in sealed jars for at least 16 h $\pm$ 30 min in a roller oven set at 65 °C (150 °F).
- b) Cool to room temperature.
- c) Measure the pH of the suspensions and adjust the pH with 10 mol/L NaOH to the initial pH as described in [5.13](#), item e).
- d) Stir for 10 min $\pm$ 5 s on the mixer.
- e) Determine the LTLP filtrate volume. Then record the filtrate volume, cake thickness, and cake consistency.

5.15 HTHP Testing after Heat Aging

If an indication of the high-temperature stability is desired, the following procedure shall be followed.

- a) Age the suspensions either statically or dynamically at the higher temperature in a suitable test container. See [14.3](#) for further details on metal aging cells. The manufacturers' instructions shall be followed for all aspects of using metal high-temperature aging cells, including safe fill volume and pressurization.

WARNING — Improper use of metal high-temperature aging cells can result in catastrophic cell failure and cause bodily injury.

- b) Cool to room temperature. Stir for 5 min $\pm$ 5 s on the mixer.
- c) Determine the HTHP filtrate volume; the procedure shall be in accordance with API 13B-1. Then record the filtrate volume, cake thickness, and cake consistency.

6 Methylene Blue Capacity of Drilled Solids and Commercial Bentonite

6.1 Methylene Blue Capacity of Drill Solids

6.1.1 Principle

6.1.1.1 The methylene blue capacity of drill solids can be determined by a procedure that is similar to that used for the drilling fluid (see API 13 B-1). The methylene blue capacity is an estimate of the cation-exchange capacity of drill solids and bentonite. The true cation-exchange capacity of the drill solids and bentonite will probably be somewhat higher than the methylene blue capacity.

6.1.1.2 Methylene blue solution is used to titrate a sample of drill solids or commercial bentonite that has been dried, ground to a powder and treated with a strong dispersant and an oxidizing agent. The dispersed sample is titrated with methylene blue solution until a faint blue or turquoise ring or halo appears around a drop of dyed solids on filter paper.

NOTE Methylene blue capacity is commonly known in the industry by the abbreviation MBT.

6.1.2 Reagents and Apparatus

6.1.2.1 Methylene blue solution, 3.20 g $\pm$ 0.01 g reagent grade methylene blue ($C_{16}H_{18}N_3SCl$) (CAS No. 61-73-4) diluted to 1 L [1 mL $\equiv$ 0.01 milliequivalent (meq)].

If the solution is prepared in the laboratory, the moisture content of reagent grade methylene blue shall be determined each time the solution is prepared. Dry a 1.00 g $\pm$ 0.01 g portion of methylene blue to constant mass at 93 °C $\pm$ 3 °C (200 °F $\pm$ 5 °F). Make the appropriate correction in the mass, m_{mb} , of methylene blue powder taken to prepare the solution as shown in Equation (2):

$$m_{mb} = \frac{3.20}{m_{dmb}} \quad (2)$$

where

m_{dmb} is the mass of dry methylene blue powder, 1.00 g sample, in grams.

6.1.2.2 Tetrasodium pyrophosphate, (CAS No. 7722-88-5) 2 % solution (20.00 g $\pm$ 0.01 g of tetrasodium pyrophosphate diluted to 1 L).

6.1.2.3 Hydrogen peroxide, 3 % solution (CAS No. 7722-84-1).

6.1.2.4 Sulfuric acid, dilute, $c_{H_2SO_4} = 2.5$ mol/L (5 N).

6.1.2.5 Deionized or distilled water, in accordance with ISO 3696, or prepared by passing tap water through a series of cation and anion exchange resins.

Use deionized or distilled water for preparation of all reagents and calibration standards and as dilution water.

6.1.2.6 Conical flask (Erlenmeyer), of capacity 250 mL.

6.1.2.7 Burette, 10 mL; micropipette 0.5 mL or graduated pipette 1 mL.

6.1.2.8 Graduated cylinder, 50 mL (TD).

6.1.2.9 Stirring rod.

6.1.2.10 Hot plate.

6.1.2.11 Magnetic stirrer and coated stirring bar.

6.1.2.12 Filter paper⁶, qualitative, standard cellulose, grade 1, medium retention and flow rate, 125 mm disk diameter.

6.1.2.13 Drying oven, capable of being maintained at 105 °C ±3 °C (220 °F ±5 °F).

6.1.2.14 Mortar and pestle.

6.1.2.15 Sieve, 75 µm (0.0029 in.—U.S. sieve No. 200).

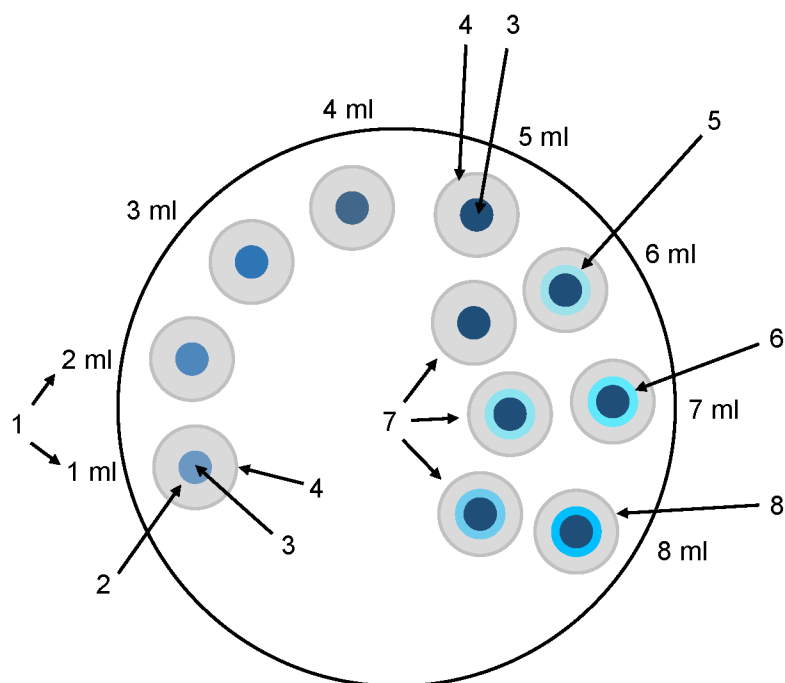
6.1.2.16 Balance, accuracy ±0.01 g.

6.1.3 Methylene Blue Capacity Testing—Procedure for Drill Solids

The following procedure shall be used to determine methylene blue capacity of drill solids.

- a) Clean all traces of drilling fluid from the drill solids sample and dry at 105 °C ±3 °C (220 °F ±5 °F) for 2 h ±2 min.
- b) Grind the drill solids to a fine powder using the mortar and pestle and pass through the 75 µm sieve (U.S. sieve No. 200).
- c) Weigh 1.0 g ±0.1g of the drill solids of size less than 75 µm and add to the Erlenmeyer flask containing 25 mL of 2 % tetrasodium pyrophosphate.
- d) Mix well and boil gently for 10 min. Do not boil to dryness.
- e) Add 15 mL hydrogen peroxide and 1 mL sulfuric acid. Boil gently for an additional 10 min. Cool to room temperature and dilute with water to a volume greater than 50 mL.
- f) Add methylene blue solution to the flask in increments of 0.5 mL while stirring on the magnetic stirrer. If the approximate amount of methylene blue solution necessary to reach the end point is known from previous tests, somewhat larger increments (1 mL to 2 mL) can be used at the beginning of the titration. After each addition of the methylene blue solution, swirl the contents of the flask for 30 s. While the drill solids are still suspended, use the stirring rod to remove one drop of suspension and place it on the filter paper. The initial end point of the titration is reached when unadsorbed dye appears as a faint blue/turquoise ring or halo surrounding the dyed solids, as shown in [Figure 1](#), key item 5 (6 mL addition).
- g) When the initial end point is detected, shake the flask for an additional 2 min and place another drop on the test paper adjacent to the previous drop. If the blue ring is again evident, the 2 min end point has been reached, as shown in [Figure 1](#), key item 7 for the 7 mL addition. If the faint blue ring or halo does not appear, such as in [Figure 1](#) key item 7 for the 6 mL addition, continue as described in [6.1.3](#), item f) until the second drop taken after 2 min still shows the faint blue ring or halo. Free (unadsorbed) dye detected immediately after adding methylene blue solution which is adsorbed after 2 min indicates that the end point has not quite been reached.
- h) After the 2 min end point has been reached, continue stirring an additional 10 min and place another drop on the test paper. If the faint blue ring or halo is again evident, the final end point has been reached. If the faint blue ring does not appear, continue as described in [6.1.3](#), item f) and [6.1.3](#), item g) until a drop taken after stirring 2 min and 10 min still shows the faint blue ring or halo, indicating unadsorbed excess dye. The 8 mL test is indicative of the end point being exceeded.

⁶ This standard cellulose grade 1 filter paper is designed for medium retention and flow. The filter paper has the following typical properties that may vary by manufacturer: medium filtration rate; particle retention in liquid: 11 µm (at 98 % efficiency); ash content: <0.06 % by weight; and thickness: 0.180 mm (0.0071 in.).



Key

- | | | | |
|---|---|---|---|
| 1 | volume of methylene blue solution added | 5 | free unadsorbed dye ring |
| 2 | no free unadsorbed dye present | 6 | endpoint reached initial |
| 3 | dyed drilling fluid solids
(no free dye present) | 7 | endpoint retest after additional
2 min |
| 4 | moisture, no color | 8 | endpoint exceeded |

NOTE 10 min retest spot not shown.

Figure 1—Spot Tests for End point of Methylene Blue Titration

6.1.4 Calculation—Methylene Blue Capacity of Drill Solids

The methylene blue capacity of the drill solids, C_{MBT-DS} , expressed in milliequivalents per 100 g (meq/100 g), is given by Equation (3).

$$C_{MBT-DS} = \frac{V}{m_{DS}} \quad (3)$$

where

V is the volume of methylene blue solution used in titration, in milliliters;

m_{DS} is the mass of drill solids sample, in grams (1 g in the procedure).

6.2 Methylene Blue Capacity of Commercial Bentonite

6.2.1 Principle

The methylene blue capacity of commercial bentonite can be determined using a procedure similar to that used for the drill solids. The methylene blue capacity is an estimate of the cation exchange capacity of the bentonite. The true cation exchange capacity of the bentonite will probably be higher than the methylene blue capacity. A