

Laboratory Testing of Drilling Fluids

API RECOMMENDED PRACTICE 13I
NINTH EDITION, DECEMBER 2020

ADDENDUM 1, JANUARY 2023



American
Petroleum
Institute

Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to ensure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be used. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

All rights reserved. No part of this work may be reproduced, translated, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001-5571.

Foreword

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

The verbal forms used to express the provisions in this document are as follows.

Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the standard.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the standard.

May: As used in a standard, “may” denotes a course of action permissible within the limits of a standard.

Can: As used in a standard, “can” denotes a statement of possibility or capability.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001.

Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001, standards@api.org.

Currently in preview, click buy full version

Contents

| | Page |
|--|------|
| 1 Scope..... | 1 |
| 1.1 Objective..... | 1 |
| 1.2 Conditions of Applicability..... | 1 |
| 2 Normative References..... | 1 |
| 3 Terms, Definitions, Abbreviations, and Symbols..... | 2 |
| 3.1 Terms and Definitions..... | 2 |
| 3.2 Abbreviations..... | 2 |
| 3.3 Symbols..... | 3 |
| 4 Abrasivity of Weighting Materials..... | 5 |
| 4.1 Principle..... | 5 |
| 4.2 Reagents and Apparatus..... | 5 |
| 4.3 Determination of Abrasivity of Weighting Materials..... | 6 |
| 4.4 Calculation—Determination of Abrasivity of Weighting Materials..... | 7 |
| 5 Filtration-control Agents..... | 7 |
| 5.1 Principle..... | 7 |
| 5.2 Reagents and Apparatus..... | 8 |
| 5.3 General Instructions for Preparation of Base Drilling Fluids..... | 9 |
| 5.4 Salt-saturated, Drilling Fluid Preparation for Filtration Testing..... | 10 |
| 5.5 High-hardness, Salt-saturated Drilling Fluid Preparation for Filtration Testing..... | 10 |
| 5.6 10 % Potassium Chloride (KCl) Drilling Fluid Preparation for Filtration Testing..... | 11 |
| 5.7 Pre-hydrated Bentonite Slurry Preparation for Filtration Testing..... | 11 |
| 5.8 Modified Seawater Drilling Fluid Preparation for Filtration Testing..... | 12 |
| 5.9 Low-salinity Drilling Fluid Preparation for Filtration Testing..... | 12 |
| 5.10 Lime-treated Drilling Fluid Preparation for Filtration Testing..... | 13 |
| 5.11 Low Solids, Non-dispersed Drilling Fluid Preparation for Filtration Testing..... | 13 |
| 5.12 Freshwater Lignosulfonate Drilling Fluid Preparation for Filtration Testing..... | 14 |
| 5.13 Initial Performance Filtration Test..... | 14 |
| 5.14 Low-temperature Filtration Performance Testing after Heat Aging..... | 15 |
| 5.15 HTHP Testing after Heat Aging..... | 15 |
| 6 Methylene Blue Capacity of Drilled Solids and Commercial Bentonite..... | 16 |
| 6.1 Methylene Blue Capacity of Drill Solids..... | 16 |
| 6.2 Methylene Blue Capacity of Commercial Bentonite..... | 18 |
| 6.3 Equations to Calculate Drill Solids Content from Methylene Blue Capacity Results..... | 20 |
| 7 Deflocculation Test for Thinner Evaluation..... | 21 |
| 7.1 Principle..... | 21 |
| 7.2 Reagents and Apparatus..... | 21 |
| 7.3 Determination of Moisture Content of Calcium Bentonite..... | 23 |
| 7.4 Preparation of Drilling Fluid Base for Calcium Bentonite Test..... | 23 |
| 7.5 Calculation of Solids Content of Calcium Bentonite in Drilling Fluid..... | 24 |
| 7.6 Determination of Rheological Properties of Calcium Bentonite Drilling Fluid Sample..... | 24 |
| 7.7 Calculation of Thinner Efficiency..... | 26 |
| 8 Potassium Ion Content—Ion-selective Electrode (ISE) Method..... | 26 |
| 8.1 Principle..... | 26 |
| 8.2 Reagents and Apparatus..... | 27 |

Contents

| | Page |
|-------|--|
| 8.3 | Preparation of Electrodes 28 |
| 8.4 | Operational Check of Electrode System 28 |
| 8.5 | Measurements Using a Meter with Direct Concentration-readout Capability 28 |
| 8.6 | Measurements with Instruments Providing Readout in Millivolts 29 |
| 9 | Calcium Ion Content—Ion-selective Electrode (ISE) Method 30 |
| 9.1 | Principle 30 |
| 9.2 | Reagents and Apparatus 30 |
| 9.3 | Preparation of Electrodes 31 |
| 9.4 | Operational Check of Electrode System 32 |
| 9.5 | Measurements using a Meter with a Direct Concentration-readout Capability 32 |
| 9.6 | Measurements with Instruments Providing Readout in Millivolts 32 |
| 10 | Sodium Ion Content—Ion-selective Electrode (ISE) Method 33 |
| 10.1 | Principle 33 |
| 10.2 | Reagents and Apparatus 34 |
| 10.3 | Preparation and Operational Check of the Electrode System 35 |
| 10.4 | Measurements using a Meter with a Direct Concentration-readout Capability 35 |
| 10.5 | Measurements with Instruments Providing Readout in Millivolts 36 |
| 11 | Preparation and Evaluation of Non-aqueous Fluids (NAFs) 37 |
| 11.1 | Principle 37 |
| 11.2 | Reagents and Apparatus 37 |
| 11.3 | Mixing of the Initial Drilling Fluid 38 |
| 11.4 | Testing the Properties of the Initial Drilling Fluid 39 |
| 11.5 | Preparation of the Sample Contaminated by Seawater 39 |
| 11.6 | Preparation of the Sample Contaminated by Standard Evaluation Base Clay (SEBC) 39 |
| 11.7 | Preparation of the Sample Contaminated by Mixed salt Brine 40 |
| 11.8 | Procedure for Hot-rolling 40 |
| 11.9 | Procedure for Static Aging 41 |
| 11.10 | Procedure for Testing after Heat Aging 41 |
| 12 | Testing Base Fluid Properties for Non-aqueous Fluids (NAFs) 41 |
| 12.1 | General 41 |
| 12.2 | Reagents and Apparatus 42 |
| 12.3 | Density, Relative Density (Specific Gravity), or API Gravity—Hydrometer Method 42 |
| 12.4 | Density and Relative Density of Liquids Using a Digital Density-meter 42 |
| 12.5 | Kinematic Viscosity of Transparent and Opaque Oils—Calibrated Capillary Tube Method 42 |
| 12.6 | Distillation 43 |
| 12.7 | Aniline Point and Mixed Aniline Point 43 |
| 12.8 | Pour Point 44 |
| 12.9 | Flash Point by Pensky-Martens Closed Tester 44 |
| 12.10 | Aromatics Content 44 |
| 13 | Testing Particle Size Distribution (PSD) in Drilling Fluids 45 |
| 13.1 | General 45 |
| 13.2 | Dry, Granular-solid Drilling Fluid Particulates 45 |
| 13.3 | PSD in a Non-aqueous Drilling Fluids 46 |
| 14 | Aging of Water-based Drilling Fluids 46 |
| 14.1 | Principle 46 |

Contents

| | Page |
|---|------|
| 14.2 Practices Common to the Preparation, Handling, and Testing at all Temperature Ranges | 46 |
| 14.3 Metal Aging Cells | 47 |
| 14.4 Drilling Fluid Sample Preparation and Aging at Ambient Temperature | 50 |
| 14.5 Drilling Fluid Sample Preparation and Aging at Moderate Temperatures [Ambient to 65 °C (150 °F)]..... | 51 |
| 14.6 Water-based Drilling Fluid Sample Preparation and Aging at Elevated Temperatures [over 65 °C (150 °F)]..... | 52 |
| 14.7 Contrast between Drilling Fluid Material Performance in Laboratory Testing and Field Environments | 53 |
| 15 Aging of Non-aqueous Drilling Fluids | 53 |
| 15.1 Principle | 53 |
| 15.2 Apparatus | 54 |
| 15.3 Metal Aging Cells | 54 |
| 15.4 Ovens | 57 |
| 15.5 Practices Common to the Preparation, Handling, and Testing at all Temperature Ranges | 57 |
| 15.6 Non-aqueous Drilling Fluid Aging at Ambient Temperatures..... | 58 |
| 15.7 Non-aqueous Drilling Fluid Aging at Moderate Temperatures [Ambient to 65 °C (150 °F)]..... | 58 |
| 15.8 Non-aqueous Drilling Fluid Aging at Elevated Temperatures [over 65 °C (150 °F)] | 59 |
| 15.9 Contrast Between Drilling Fluid Material Performance in Laboratory Testing and Field Environments..... | 59 |
| 16 Shale-particle Disintegration Test by Hot-rolling | 59 |
| 16.1 Principle | 59 |
| 16.2 Reagents and Apparatus | 60 |
| 16.3 Procedure | 61 |
| 16.4 Calculation—Shale Disintegration by Hot-rolling | 62 |
| 17 Measurement of Shear Strength using Shearometer Tube | 62 |
| 17.1 Principle | 62 |
| 17.2 Apparatus | 62 |
| 17.3 Procedure | 63 |
| 17.4 Calculation | 63 |
| Annex A (informative) HTHP Filtration Testing of Drilling Fluids using the Permeability-plugging Apparatus (PPA) ... | 64 |
| Annex B (normative) Particle Size Distribution (PSD) Measurement in a Non-aqueous Drilling Fluid using a Laser Diffraction Instrument..... | 74 |
| Bibliography..... | 81 |
| | |
| Figures | |
| 1 Spot Tests for End point of Methylene Blue Titration | 18 |
| E.1 Immiscible Mud Clumps form when Alkane-based Mud is Mixed in IPA..... | 77 |
| E.2 Miscible Olefin-based Mud Fully Dispersed in IPA..... | 77 |
| B.3 PSD Curves of 70/30 (olefin/water) Mud at Different Flow Rates..... | 78 |
| B.4 PSD Curves of 70/30 (olefin/water) Mud at Different Flow Rates after 60 s Sonication..... | 78 |
| B.5 PSD Curves of 70/30 (olefin/water) Mud at 50 % and 75 % Flow Rate after Sonication..... | 79 |
| B.6 PSD Curves of 70/30 (olefin/water) Mud with Different Duration of Sonication at 100 % Power and the Corresponding d_{50} Values..... | 79 |

Contents

| | Page |
|---|------|
| B.7 Artifact Peaks Induced by Sonication Disappear over Time | 80 |

Tables

| | |
|--|----|
| A.1 API Ceramic Disk Designation and Mean Pore Throat Diameter | 67 |
| A.2 Recommended Minimum Cell Heat-up Pressure and Back-pressure | 70 |
| B.1 Average Refractive Index Value of Mineral Components in Drilling Fluids | 76 |

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 regulation 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).

Currently in preview, click buy full version

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.