

Field Testing Nonaqueous-based Drilling Fluids

API RECOMMENDED PRACTICE 13B-2
SIXTH EDITION, JULY 2023



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. The use of API publications is voluntary. In some cases, third parties or authorities having jurisdiction may choose to incorporate API standards by reference and may mandate compliance.

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 utilized. 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.

Copyright © 2023 American Petroleum Institute

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.

Contents

1	Scope.....	1
2	Normative References	2
3	Terms and Definitions	2
4	Symbols, Acronyms, and Abbreviations.....	3
4.1	Symbols	3
4.2	Acronyms and Abbreviations	10
5	Determination of Drilling Fluid Density (Mud Weight)	11
5.1	Principle	11
5.2	Apparatus	11
5.3	Mud Balance Procedure	12
5.4	Calculations.....	12
6	Determination of Drilling Fluid Density—Pressurized Balance Method	14
6.1	Principle	14
6.2	Apparatus	15
6.3	Pressurized Mud Balance Procedure.....	15
6.4	Calculation.....	16
7	Viscosity and Gel Strength	16
7.1	Principle	16
7.2	Determination of Viscosity Using the Marsh Funnel.....	17
7.3	Determination of Viscosity and Gel Strengths Using a Direct-indicating Viscometer	17
8	Static Filtration	21
8.1	Principle	21
8.2	HTHP Static Filtration, Test up to 175 °C (350 °F).....	22
8.3	HTHP Static Filtration Test from 175 °C (350 °F) up to and Including 230 °C (450 °F).....	25
9	Retort Test for NAF, Water, and Solids Concentrations	29
9.1	Principle	29
9.2	Apparatus	29
9.3	Procedure—Volumetric Method	30
9.4	Calculation—Volumetric Method.....	32
9.5	Procedure—Gravimetric Method.....	33
9.6	Gravimetric Method Calculation—Mass Balance	35
9.7	Gravimetric Method Calculation—Volume Fractions of NAF, Water, and Solids.....	36
10	Chemical Analysis of NADF	38
10.1	Principle	38
10.2	Reagents and Apparatus.....	39
10.3	Base Alkalinity Demand (BAD, V_B)	40
10.4	Whole-NADF Alkalinity (V_K).....	41
10.5	Whole-NADF Chloride Concentration	43
10.6	Whole-NADF Calcium Concentration.....	44
11	Electrical Stability Test.....	45
11.1	Principle	45
11.2	Apparatus	45
11.3	Equipment Calibration/Performance Test	46
11.4	Procedure	47
12	Lime, Salinity, and Solids Calculations	47
12.1	Principle	47
12.2	Apparatus	48

12.3	Whole-NADF Calculations.....	48
12.4	Aqueous-phase Calculations.....	51
12.5	Whole-NADF Soluble and Insoluble Sodium Chloride Calculations	56
12.6	Calculation—Solids in the Whole-NADF.....	58
13	Sand Content.....	62
13.1	Principle	62
13.2	Apparatus	62
13.3	Procedure	62
13.4	Calculation.....	63
14	HTHP Filtration Testing of NADF Using the Permeability Plugging Apparatus.....	63
14.1	Principle	63
14.2	Safety Considerations	64
14.3	Apparatus—PPA	66
14.4	Procedure for HTHP Filtration Test Using the PPA.....	69
14.5	PPA Test Reports.....	74
Annex A (informative) Measurement of Shear Strength Using Shearometer Tube.....		76
Annex B (informative) Determination of Nonaqueous Fluid Retained on Cuttings.....		79
Annex C (informative) Determination of Activity of Emulsified Water Using an Electro-hygrometer... ..		85
Annex D (informative) Determination of Aniline-point Temperature of Base Nonaqueous Fluids		89
Annex E (informative) Lime, Salinity, and Solids Calculations.....		92
Annex F (informative) Sampling, Inspection, and Rejection of Drilling Materials		105
Annex G (informative) Rig-site Sampling.....		107
Annex H (informative) Determination of Cuttings Activity by the Chenevert Method.....		110
Annex I (informative) Chemical Analysis of Active Sulfides by the Garrett Gas Train Method		114
Annex J (normative) Calibration and Verification of Glassware, Thermometers, Viscometers, Retort Kit Cup, and Drilling Fluid Balances		119
Annex K (informative) Compatibility of Elastomeric Materials with Nonaqueous Drilling Fluids		126
Annex L (informative) Identification and Monitoring of Weight-material Sag		130
Annex M (informative) Example Nonaqueous-based Drilling Fluid Daily Report		152
Figures		
1	Maximum Concentrations of NaCl in CaCl ₂ Brine at 25 °C (77 °F).....	53
2	Typical Permeability Plugging Apparatus	68
G.1	Side-stream Sampling Device.....	108
G.2	Sample Scoop	109
L.1	Example of Surface Density Variation with Temperature (NADF)	132
L.2	Example Surface Profile Based on Bottoms-up Data	133
L.3	Downhole Density Changes Measured While Running the Drill String in the Hole.....	136
L.4	Weight-material Sag Occurrence During Dynamic Conditions.....	137
L.5	Effect of Changes in Drill Pipe Rotational Speed on Downhole Pressure.....	138
L.6	ECD Fingerprinting for Three Flow Rates and Four Drill String Rotation Speeds.....	139
L.7	Distribution of Fluid Viscosity Across the Annular Gap Caused by Drill String Rotation in a Noncirculating Drilling Fluid.....	141
L.8	Key Equipment for VSST Method.....	142
L.9	Published “Sag Window” for Drilling Fluids Versus Shear Rate	148
L.10	Predicted Dynamic Sag as a Function of Calculated Values of Wall Shear Stress, τ_{wi}	151

Tables

1	Conversion of Density Units	13
2	Density Equivalents	14
3	Recommended Minimum Back-pressure	23
4	Precision of Liquid Receiver	30
5	Commonly Used Densities	61
6	Ceramic Discs—API Designation and Mean Pore Throat Diameter	67
7	Recommended Minimum Cell Heat-up Pressure and Back-pressure	72
B.1	Precision of Liquid Receiver	80
C.1	Standard Saturated Salt Solutions	86
E.1	Physical and Chemical Properties of Examples of Nonaqueous Drilling Fluids	92
H.1	Saturated Salt Solutions	110
I.1	Dräger H₂S Analysis Tubes	115
I.2	Dräger Tube (or Equivalent) Identification, Sample Volume, and Tube Factors to Be Used for Various Sulfide Concentration Ranges	117
J.1	Density of Water, ρ_W, as a Function of Temperature	121
L.1	Sample Trip-out Sag Reporting Sheet	134
L.2	Matrix for Fingerprinting Drill String Rotation Effects on Downhole Density	139

Field Testing Nonaqueous-based Drilling Fluids

1 Scope

This recommended practice provides standard procedures for determining the following characteristics of nonaqueous drilling fluids (NADFs):

- a) drilling fluid density (mud weight);
- b) viscosity and gel strength;
- c) filtration;
- d) nonaqueous fluid (NAF), water, and solids concentrations;
- e) alkalinity, chloride concentration, and calcium concentration;
- f) electrical stability (ES);
- g) lime and calcium concentrations, calcium chloride, and sodium chloride concentrations;
- h) low-gravity solids and weighting material concentrations;
- i) sand content;
- j) high-temperature, high-pressure (HTHP) filtration using the permeability plugging apparatus (PPA).

Calibration and verification methods for glassware, thermometers, viscometers, retort kit cups, and drilling fluid balances shall be required for the application of recommended test methods; procedures are provided in Annex J.

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

- shear strength (see Annex A);
- NAF retained on cuttings (see Annex B);
- drilling fluid activity (see Annex C);
- aniline point (see Annex D);
- example of lime, salinity, and solids concentration calculations (see Annex E);
- sampling, inspection, and rejection of drilling fluids materials (see Annex F);
- rig-site sampling (see Annex G);
- cuttings activity (see Annex H);
- active sulfides (see Annex I);
- elastomer compatibility with NADF (see Annex K);
- identification and monitoring of weight-material sag (see Annex L);
- NADF daily report form (see Annex M).