

Petroleum and natural gas industries — Drilling fluid materials — Specifications and tests

ICS 75.180.10

National foreword

This British Standard is the UK implementation of EN ISO 13500:2008+A1:2010. It is identical to ISO 13500:2008, incorporating amendment 1:2010 and corrigendum July 2009. It supersedes BS EN ISO 13500:2008 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to ISO text carry the number of the ISO amendment. For example, text altered by ISO amendment 1 is indicated by **A1** **A1**.

The UK participation in its preparation was entrusted to Technical Committee PSE/17/-/3, Drilling and completion fluids and well cements.

A list of organizations represented on this committee can be obtained on request to its secretary.

Hazard warning (clause 12 - Attapulгите)

Attapulгите fibres bear similarities to asbestos fibres, which present a potential health risk. As a result, some countries and various operators have banned attapulгите from their drilling operations. However, although the most commonly encountered forms of attapulгите are fibrous, some are granular. If attapulгите is to be used in drilling operations, then appropriate health and safety precautions should be employed for its handling, usage and disposal.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Amendments/corrigenda issued since publication

Date	Comments
31 December 2009	Implementation of ISO corrigendum July 2009, calculation in C.2.3 replaced
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Specifications and tests (ISO 13500:2008)

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13500:2008)

Erdöl- und Erdgasindustrie - Bohrspülungen -
Spezifikationen und Prüfungen (ISO 13500:2008)

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Foreword

This document (EN ISO 13500:2008) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum and natural gas industries" in collaboration with Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2009, and conflicting national standards shall be withdrawn at the latest by May 2009.

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Endorsement notice

The text of ISO 13500:2008 has been approved by CEN as a EN ISO 13500:2008 without any modification.

Foreword to amendment A1

This document (EN ISO 13500:2008/A1:2010) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" in collaboration with Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" the secretariat of which is held by AFNOR.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 13500 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 3, *Drilling and completion fluids, and well cements*.

This third edition cancels and replaces the second edition (ISO 13500:2006), subclauses 7.1.2/Table 2, 7.3.1, 8.5.2, 8.6.5, 8.13.4, 10.2.5, 11.4, 14.4.3, and 15.4.3 of which have been technically revised. Clause 17 on low-viscosity polyanionic cellulose, Clause 18 on high-viscosity polyanionic cellulose, and Clause 19 on drilling-grade xanthan gum have been added.

Introduction

This International Standard covers materials that are in common usage in petroleum and natural-gas drilling fluids. These materials are used in bulk quantities, can be purchased from multiple sources and are available as commodity products. No single-source or limited-source products are included, nor are speciality products.

International Standards are published to facilitate communication between purchasers and manufacturers, to provide interchangeability between similar equipment and materials purchased from different manufacturers and/or at different times and to provide an adequate level of safety when the equipment or materials are utilized in the manner and for the purposes intended. This International Standard provides minimum requirements and is not intended to inhibit anyone from purchasing or producing materials to other standards.

This International Standard is substantially based on API Spec 13A, 16th Edition, February 1, 2004. The purpose of this International Standard is to provide product specifications for barite, haematite, bentonite, nontreated bentonite, Oil Companies' Materials Association (OCMA) grade bentonite, attapulgite, sepiolite, technical-grade low-viscosity carboxymethylcellulose (CMC-LVT), technical-grade high-viscosity carboxymethylcellulose (CMC-HVT), starch, low-viscosity polyanionic cellulose, high-viscosity polyanionic cellulose and drilling-grade *Xanthomaonas campestris*.

The intent of the document is to incorporate all International Standards for drilling fluid materials into an ISO-formatted document. A survey of the industry found that only the American Petroleum Institute (API) issued testing procedures and specification standards for these materials.

Reference to OCMA materials has been included in API work, as the OCMA and subsequent holding committees were declared defunct, and all specifications were submitted to API in 1983.

Annex A (informative) lists the mineral impurities in barite, Annex B (informative) provides the test precision and Annex C (informative) details examples of calculations.

Petroleum and natural gas industries — Drilling fluid materials — Specifications and tests

1 Scope

This International Standard covers physical properties and test procedures for materials manufactured for use in oil- and gas-well drilling fluids. The materials covered are barite, haematite, bentonite, nontreated bentonite, OCMA-grade bentonite, attapulgite, sepiolite, technical-grade low-viscosity carboxymethylcellulose (CMC-LVT), technical-grade high-viscosity carboxymethylcellulose (CMC-HVT), starch, low-viscosity polyanionic cellulose (PAC-LV), high-viscosity polyanionic cellulose (PAC-HV) and drilling-grade *Xanthomonas campestris* (Xanthan gum). This International Standard is intended for the use of manufacturers of named products.

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.

ISO 6780, *Flat pallets for intercontinental materials handling — Principal dimensions and tolerances*

ISO 10414-1:2008, *Petroleum and natural gas industries — Field testing of drilling fluids — Part 1: Water-based fluids*

ASTM D422, *Standard Test Method for Particle-Size Analysis of Soils*

ASTM E11, *Standard Specification for Wire Cloth and Sieves for Testing Purposes*

ASTM E161, *Standard Specification for Precision Electroformed Sieves*

ASTM E77, *Standard Test Method for Inspection and Verification of Thermometers*

ASTM E177, *Standard Practice for Use of the Terms Precision and Bias in ASTM Test Methods*

NIST (NBS) Monograph 150, *Liquid-In-Glass Thermometry*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

ACS reagent grade

chemicals that meet purity standards as specified by the American Chemical Society (ACS)

3.1.2

flash side

side containing residue (“flash”) from stamping, or the side with concave indentation

3.2 Symbols and abbreviations

ACS	American Chemical Society
API	American Petroleum Institute
APME	Association of Plastic Manufacturers in Europe
ASTM	American Society for Testing and Materials
EDTA	Ethylenediaminetetraacetic acid
CAS	Chemical Abstracts Service
CMC-HVT	Carboxymethylcellulose — High-viscosity, technical-grade
CMC-LVT	Carboxymethylcellulose — Low-viscosity, technical-grade
OCMA	Oil Companies' Materials Association
NBS	National Bureau of Standards
NIST	National Institute of Standards and Technology
TC	to contain
TD	to deliver
B_c	hydrometer correction curve intercept
b	yield point/plastic viscosity ratio
D_1	equivalent particle diameter immediately greater than 6 µm, determined in Equation (9)
D_2	equivalent particle diameter immediately less than 6 µm, determined in Equation (9)
D_e	equivalent spherical diameter, expressed in micrometres
C_c	calibration correction
C_m	40 times the EDTA volume, expressed in millilitres
K_S	sample constant
L	effective depth, expressed in centimetres
$\log(\eta_{20}/\eta_\theta)$	correction for temperature variance
M_c	hydrometer correction curve slope
m	sample mass, expressed in grams
m_2	residue mass, expressed in grams
m_3	mass of the 425 µm sieve, expressed in grams
m_4	mass of 425 µm sieve and sample retained, expressed in grams
m_5	mass passing through a 425 µm sieve, expressed in grams
m_6	mass of the bottom receiver, expressed in grams
m_7	mass of the bottom receiver and sample content, expressed in grams
m_8	mass of sample passing through a 75 µm sieve, expressed in grams

R	hydrometer reading
R_1	average hydrometer reading at lower temperature
R_2	average hydrometer reading at higher temperature
R_{600}	viscometer dial reading at 600 r/min
R_{300}	viscometer dial reading at 300 r/min
S_s	sample test value
t	time, expressed in minutes
V	total filtrate volume, expressed in millilitres
V_c	filtrate volume, expressed in millilitres, collected between 7,5 min and 30 min
V_1	initial volume, expressed in millilitres
V_2	final volume, expressed in millilitres
V_3	volume EDTA used, expressed in millilitres
V_4	volume of filtrate used, expressed in millilitres
w_1	mass fraction residue of particles greater than 75 μm , expressed in percent
w_2	cumulative percent for point immediately greater than 6 μm
w_3	cumulative percent for point immediately less than 6 μm
w_4	cumulative percent less than 6 μm
w_5	mass fraction residue of particles greater than 45 μm , expressed in percent (see 8.9.6)
w_6	mass fraction moisture, expressed in percent
w_a	cumulative percent finer
w_{AEM}	soluble alkaline earth metals as calcium, expressed in milligrams per kilogram
w_{75}	mass fraction of sample passing through a 75 μm sieve, expressed in percent
w_{425}	mass fraction passing through a 425 μm sieve, expressed in percent
ρ	sample density, expressed in grams per millilitre
θ	temperature, expressed in degrees Celsius or degrees Fahrenheit
θ_1	average temperature reading at lower temperature
θ_2	average temperature reading at higher temperature
η_A	apparent viscosity, expressed in centipoise
η	viscosity of water, expressed in millipascal seconds
η_{20}	1,002, is the viscosity of water at 20 °C (68 °F)
η_θ	viscosity at desired temperature (see Table 3)
η_P	plastic viscosity, expressed in millipascal-seconds
η_Y	yield point, expressed in pounds per 100 ft ²

4 Requirements

4.1 Quality control instructions

All quality control work shall be controlled by manufacturer's documented instructions, which include appropriate methodology and quantitative or qualitative acceptance criteria.

4.2 Use of test calibration materials in checking testing procedures

4.2.1 Test calibration barite and test calibration bentonite can be obtained by contacting the API¹⁾. The calibration test materials are shipped in a 7,6 l (2 gal) plastic container.

4.2.2 The API office forwards the request to the designated custodian for further handling. The test calibration products are furnished with a certificate of calibration giving the established values for each property and the confidence limits within which a laboratory's results shall fall.

4.2.3 The custodian shall furnish a certificate of analysis for each sample.

4.2.4 For calibration requirements of API test calibration materials, refer to 5.2.11 and 5.3.10.

4.2.5 API standard evaluation base clay (formerly OCMA base clay; not OCMA grade bentonite): stocks of API standard evaluation base clay have been set aside and can be ordered through the API.

4.3 Records retention

All records specified in this International Standard shall be maintained for a minimum of five years from the date of preparation.

5 Calibration

5.1 Coverage

5.1.1 Clause 5 covers calibration procedures and calibration intervals for laboratory equipment and reagents specified. For laboratory items not listed, the manufacturer shall develop procedures where deemed appropriate.

5.1.2 The manufacturer shall control, calibrate, verify and maintain the laboratory equipment and reagents used in this International Standard for measuring product conformance to International Standard requirements.

5.1.3 The manufacturer shall maintain and use laboratory equipment and reagents in a manner such that measurement uncertainty is known and meets required measurement capability.

5.1.4 The manufacturer shall document and maintain calibration procedures, including details of laboratory equipment and reagent type, identification number, frequency of checks, acceptance criteria and corrective action that shall be taken when results are unsatisfactory.

5.1.5 The manufacturer shall establish and document responsibility for administration of the calibration program, and responsibility for corrective action.

5.1.6 The manufacturer shall document and maintain calibration records for laboratory equipment and reagents; shall periodically review these records for trends, sudden shifts or other signals of approaching malfunction; and shall identify each item with a suitable indicator or approved identification record to show calibration status.

1) American Petroleum Institute, 1220 L Street NW, Washington, D.C. 20005-4070, USA.

5.2 Equipment requiring calibration

5.2.1 Volumetric glassware

Laboratory volumetric glassware used for final acceptance, including Le Chatelier flasks, pipettes, and burettes, are usually calibrated by the supplier. Manufacturers of products to this International Standard shall document evidence of glassware calibration prior to use. Supplier certification is acceptable. Calibration may be checked gravimetrically. Periodic recalibration is not required.

5.2.2 Laboratory thermometers

5.2.2.1 The manufacturer shall calibrate all laboratory thermometers used in measuring product conformance to standards against a secondary reference thermometer. The secondary reference thermometer shall show evidence of calibration as performed against NIST-certified master instruments, in accordance with the procedures specified by ASTM E77 and NIST (NBS) Monograph 150.

5.2.2.2 Calibration — Thermometers

5.2.2.2.1 Place the thermometer being calibrated side by side with a secondary reference thermometer into a constant-temperature water bath (or suitable container of 4 l or more, filled with water, on a counter in a constant-temperature room) and allow to equilibrate for at least 1 h.

5.2.2.2.2 Read both thermometers and record readings.

5.2.2.2.3 Repeat readings throughout at least a 1 h interval to obtain a minimum of four readings.

5.2.2.2.4 Calculate the average and the range of readings for each thermometer. The difference between the range of readings for each thermometer shall not exceed $\pm 0,1\text{ }^{\circ}\text{C}$ ($\pm 0,2\text{ }^{\circ}\text{F}$), or the smallest scale division on the thermometer being calibrated.

5.2.2.2.5 Calculate the average deviation of the thermometer reading from the secondary reference thermometer reading. Calculate and document the correction for each thermometer.

5.2.3 Laboratory balances

5.2.3.1 The manufacturer shall calibrate the laboratory balances periodically in the range of use with NIST class P, grade 3, or better weights.

5.2.3.2 The manufacturer shall service and adjust balances whenever calibration indicates a problem.

5.2.4 Sieves

Sieves shall be in accordance with ASTM E11 and ASTM E161 and have approximate dimensions of 76 mm (3 in) in diameter and 69 mm (2,75 in) from top of frame to wire cloth.

5.2.5 Hydrometer

5.2.5.1 The manufacturer shall calibrate each hydrometer with the dispersant solution used in the sedimentation procedure.

5.2.5.2 Calibration — Hydrometer

5.2.5.2.1 Calibrate each hydrometer using the same concentration dispersant solution as is used in the test, at temperatures spanning the anticipated test temperatures, and by reading the top rather than the bottom of the meniscus. Calibrate each hydrometer using the procedure in 5.2.5.2.2 to 5.2.5.2.9.

5.2.5.2.2 Prepare 1 l of dispersant solution, as follows.

- a) Place $125 \text{ ml} \pm 2 \text{ ml}$ ($127 \text{ g} \pm 2 \text{ g}$) of dispersant solution from test procedure (7.11.1 and 7.12.2) into a 1 l volumetric flask.
- b) Dilute to the 1 000 ml mark with deionized water. Mix thoroughly.

5.2.5.2.3 Place the dispersant solution in a sedimentation cylinder. Then place the cylinder in a constant-temperature bath. Set bath temperature to the lowest expected temperature for any actual test. Allow to reach equilibrium $\pm 0,2^\circ\text{C}$ ($\pm 0,4^\circ\text{F}$). Insert the hydrometer being calibrated and wait at least 5 min for the hydrometer and solution to reach bath temperature.

5.2.5.2.4 Take a hydrometer reading at the top of the meniscus formed by the stem and take a thermometer reading. Repeat readings at least 5 min apart so as to obtain a minimum of four readings each.

5.2.5.2.5 Calculate the average hydrometer reading and designate as R_1 . Calculate the average temperature reading and designate as θ_1 .

5.2.5.2.6 Repeat 5.2.5.2.3 and 5.2.5.2.4, except set bath temperature to highest expected test temperature. Calculate the average hydrometer and temperature readings and designate these readings as R_2 and θ_2 .

5.2.5.2.7 Calculate the hydrometer correction curve slope, M_c , as given in Equation (1):

$$M_c = 1000 \frac{(R_1 - R_2)}{(\theta_2 - \theta_1)} \quad (1)$$

where

R_1 is the average hydrometer reading at lower temperature;

R_2 is the average hydrometer reading at higher temperature;

θ_1 is the average temperature reading at lower temperature;

θ_2 is the average temperature reading at higher temperature.

The temperature may be measured in either degrees Celsius or degrees Fahrenheit, so long as all measurements and calculations are consistent in units (including subsequent use of the hydrometer in routine test situations).

5.2.5.2.8 Calculate the hydrometer correction curve intercept, B_c , as given in Equation (2):

$$B_c = (M_c \times \theta_1) + [(R_1 - 1) \times 1000] \quad (2)$$

where

M_c is the hydrometer correction curve slope;

θ_1 is the average thermometer reading at the lower temperature;

R_1 is the average hydrometer reading at the lower temperature.

5.2.5.2.9 Record M_c , B_c and the hydrometer serial number in a permanent calibration record and on the data sheet used in the calculations in 7.13 and 8.13.

For hydrometer calibration, example data sheet and calculation, see Clause C.1.

5.2.6 Motor-driven, direct-indicating viscometer

5.2.6.1 The specifications for a direct-indicating viscometer are given in ISO 10414-1 and reproduced here for reference:

a) rotor sleeve:

- inside diameter: 36,83 mm (1,450 in),
- total length: 87,0 mm (3,425 in),
- scribed line: 58,4 mm (2,30 in) above the bottom of sleeve, with two rows of 3,18 mm (0,125 in) holes spaced 120° (2,09 rad) apart, around rotor sleeve just below scribed line;

b) bob, closed, with flat base and tapered top:

- diameter: 34,49 mm (1,358 in),
- cylinder length: 38,0 mm (1,496 in);

c) torsion-spring constant:

- 386 dyne-cm/degree deflection;

d) rotor sleeve speeds:

- high speed: 600 r/min,
- low speed: 300 r/min.

NOTE Other rotor speeds are available in viscometers from various manufacturers.

5.2.6.2 The manufacturer shall calibrate each meter with 20 mPa·s and 50 mPa·s, certified standard silicone fluids.

5.2.6.3 Apparatus and materials.

5.2.6.3.1 Standard thermometer, with an accuracy of $\pm 0,1$ °C ($\pm 0,2$ °F), e.g. ASTM 90c or 91c grade.

5.2.6.3.2 Certified calibration fluid, of viscosity 20 mPa·s, with chart (viscosity vs. temperature).

5.2.6.3.3 Certified calibration fluid, of viscosity 50 mPa·s, with chart (viscosity vs. temperature).

5.2.6.3.4 Magnifying glass, approximately $\times 3$ magnification.

5.2.6.4 Procedure.

5.2.6.4.1 Allow the viscometer and the calibration fluids to stand on counter-top a minimum of 2 h to approach temperature equilibrium.

5.2.6.4.2 Operate viscometer without fluid a minimum of 2 min to loosen bearing and gears.

5.2.6.4.3 Clean and dry viscometer cup. Fill the viscometer cup to scribed line with 20 mPa·s calibration fluid and place on meter stage. Raise stage until fluid level reaches the inscribed line on rotor sleeve.

5.2.6.4.4 Place thermometer into the fluid and hold or tape to the side of viscometer to prevent breakage.

5.2.6.4.5 Operate viscometer at 100 r/min setting until thermometer reading is stable to within $\pm 0,1$ °C ($\pm 0,2$ °F). Record the temperature reading.

5.2.6.4.6 Using magnifying glass, take dial readings at 300 r/min and 600 r/min settings. Estimate readings to nearest 0,5 dial unit and record.

5.2.6.4.7 Compare 300 r/min dial reading to certified viscosity at test temperature from fluid calibration chart. Record readings and deviation from certified calibration fluid viscosity as furnished by supplier. Divide 600 r/min reading by 1,98 to obtain viscosity value at 600 r/min. Compare this value to the certified fluid.

5.2.6.4.8 Repeat 5.2.6.4.1 through 5.2.6.4.7 using the 50 mPa·s fluid.

5.2.6.4.9 Compare the deviations to the values in Table 1. Tolerances shall not exceed values in Table 1.

**Table 1 — Dial reading tolerances with various calibration fluids,
F-1 spring (or equivalent) in motor-driven, viscometer**

Calibration fluid	Acceptable tolerance	
	300 r/min	600 r/min/1,98
20 mPa·s	± 1,5	± 1,5
50 mPa·s	± 1,5	± 1,5

5.2.7 Laboratory pressure-measuring device

5.2.7.1 The manufacturer shall document evidence of the laboratory pressure-measuring device calibration prior to use.

5.2.7.2 Calibration — Laboratory pressure-measuring device

5.2.7.2.1 Regarding type and accuracy, the pressure-measuring devices shall be readable to at least 2,5 % of full-scale range.

5.2.7.2.2 Pressure-measuring devices shall be calibrated to maintain ± 2,5 % accuracy of full-scale range.

5.2.7.2.3 Regarding usable range, the pressure measurements shall be made at not less than 25 % nor more than 75 % of the full-pressure span of pressure gauges.

5.2.7.2.4 Pressure-measuring devices shall be calibrated annually with a master pressure-measuring device or a dead-weight tester at at least three equidistant points of full scale (excluding zero and full scale as required points of calibration).

5.2.8 Mixer

EXAMPLE Multimixer® Model 9B ²⁾ with 9B29X impeller blades, or equivalent, mounted flash side up.

The manufacturer shall verify that all spindles rotate at 11 500 r/min ± 300 r/min under no load with one spindle operating. Each spindle is fitted with a single sine-wave impeller approximately 25 mm (1 in) in diameter mounted flash side up. New impellers shall be weighed prior to installation, with mass and date recorded.

2) Multimixer® Model 9B is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.

5.2.9 Chemicals and solutions

5.2.9.1 These shall meet ACS or international equivalent reagent grade, if available.

5.2.9.2 Calibration — EDTA solution

5.2.9.2.1 Reagent

5.2.9.2.1.1 Standard calcium chloride solution, $c(\text{CaCl}_2) = (0,010\,0 \pm 0,000\,1) \text{ mol/l}$.

5.2.9.2.2 Procedure

- To a suitable flask, add $50 \text{ ml} \pm 0,05 \text{ ml}$ of deionized water and $50 \text{ ml} \pm 0,05 \text{ ml}$ of standard CaCl_2 solution.
- Proceed as in 7.6.1 through 7.6.5, but without adding barite or additional water. (Use the 100 ml solution prepared above in place of the 100 ml deionized water specified in 7.6.1.)
- Calculate the calibration correction, C_c , as given in Equation (3):

$$C_c = C_m - 200 \quad (3)$$

where C_m is 40 times the EDTA volume, expressed in millilitres.

NOTE The calibration correction, as determined by this procedure, results in a number that is subtracted from the sample test value, S_s .

EXAMPLE 1 Calibration correction determination:

EDTA volume for the CaCl_2 solution is equal to 4,8 ml:

$$C_m = 40 \times 4,8 = 192$$

$$C_c = 192 - 200$$

$$C_c = -8$$

EXAMPLE 2 Calibration correction:

EDTA for the sample is equal to 6,1 ml:

Test value for the sample, $S_s = 244 \text{ mg/kg}$

Corrected test value, $S_c = S_s - C_c = 244 - (-8) = 252 \text{ mg/kg}$.

5.2.10 Deionized (or distilled) water

The manufacturer shall develop, document and implement a method to determine hardness of water. The water shall not be used if hardness is indicated.

5.2.11 API test calibration materials

The manufacturer shall perform in-house verification of API calibration barite and/or (where applicable) API test calibration bentonite for properties listed with their certificates of analysis, as required by this International Standard.

5.3 Calibration intervals

5.3.1 General

Any instrument subjected to movement that can affect its calibration shall be recalibrated prior to use.

5.3.2 Thermometers

Calibrate each thermometer before its first use by the manufacturer. After calibration, mark each thermometer with an identifying number that ties it to its corresponding correction chart. Check the calibration annually against the secondary reference thermometer.

5.3.3 Laboratory balances

Calibrate each balance prior to its first use by the manufacturer. Check calibration at least once per month for six months, then at least once per six months if required measurement capability is being maintained. If not, service and recalibrate, then check at least once per month until the required measurement capability is maintained for six months, then once per six months.

5.3.4 Sieves

No calibration of sieves is required. See 5.2.11 for periodic measurement requirements using standard reference materials.

5.3.5 Hydrometer

Calibrate each hydrometer prior to its first use by the manufacturer. After calibration, note and record each hydrometer identifying number that ties it to its correction chart. Periodic recalibration is not required.

5.3.6 Motor-driven, direct-indicating viscometers

Calibrate each viscometer prior to its first use by the manufacturer. Check the calibration at least once per week for three months, then at least once per month if required measurement capability is being maintained.

5.3.7 Mixer

EXAMPLE Multimixer® Model 9B with 9B29X impeller blades, or equivalent, mounted flash side up.

Check and record the mixer spindle speed at least once every 90 days to ensure that the operation falls within the prescribed range, using a phototachometer or similar device. Remove, clean, dry and weigh each impeller blade in use at least once every 90 days. Record masses and replace blades when the mass drops below 90 % of its original value.

5.3.8 Deionized (or distilled) water

The manufacturer shall determine the hardness of the water whenever a new batch of water is prepared or purchased, or whenever the deionizing cartridges are replaced.

5.3.9 Laboratory pressure-measuring devices

Manufacturer shall document evidence of laboratory pressure-measuring device calibration prior to its being placed into first use by the manufacturer, then annually thereafter.

5.3.10 API test calibration materials

The manufacturer shall test the applicable API test calibration material(s) at least once per 40 tests. Sieve calibration requirements have been removed.

6 Packaged material

6.1 Description

6.1.1 Packaging of palletized goods should safeguard the means of safe handling, transport, storage and identification, and minimize damage and spillage. Packed material should be inside the dimensions of the pallet although some overhang is allowed.

6.1.2 This procedure applies to products covered by this International Standard. The main intention is to improve the possibility of recycling of all packaging materials for components used in drilling fluids, completion fluids and oil well cements, including dry, powdered or granular materials not covered under this International Standard.

6.2 Apparatus — Pallets

6.2.1 The preferred pallet design and construction should be in accordance with ISO 6780.

6.2.2 Preferred sizes for wooden pallets include the following:

- a) 1 200 mm × 1 000 mm (47 in × 39 in) CP6;
- b) 1 140 mm × 1 140 mm (45 in × 45 in) CP8/CP9/CP3;
- c) 1 219 mm × 1 219 mm (48 in × 48 in);
- d) 1 118 mm × 1 321 mm (44 in × 52 in);
- e) 1 067 mm × 1 321 mm (42 in × 52 in), equivalent to CP4/CP7;
- f) 1 016 mm × 1 219 mm (40 in × 48 in).

NOTE CP is the size as defined in ISO 6780.

6.2.3 Other pallet sizes and details concerning design and construction should be agreed upon by the manufacturer and the customer.

6.2.4 The maximum outside dimensions of the total package shall be in accordance with the applicable pallet size plus a maximum overhang of 3 cm (1,2 in). The overall height shall not exceed 2,0 m (80 in).

6.2.5 The maximum net mass should not exceed 2 000 kg (4 409 lb).

6.3 Apparatus — Bags

6.3.1 The manufacturer filling the bag should take reasonable steps to ensure that the bag construction is capable of safe handling, transport and storage.

6.3.2 The manufacturer should take reasonable steps to select bags that minimize waste and provide the possibility for recycling of the packaging material.

6.3.3 The manufacturer should consider the humidity-barrier capabilities of the bags relative to the needs of the particular product when selecting bags.

6.4 Marking — Pallets

Markings should include the following, where applicable and as specified by individual contracts:

- a) product name;
- b) gross/net mass, in kilograms (pounds);
- c) other information as required, such as manufacturer's name, gross allowable mass, disposal options.

6.5 Marking — Bags

Markings shall include the following, where applicable and as specified by individual contracts:

- a) name of the material in print script at least 13 mm (0,5 in) high;
- b) mass, which shall be denominated in kilograms, of the material in letters, or numbers and letters, at least 6 mm (0,25 in) high;
- c) lot/batch number in print script and/or numbers at least 3 mm (0,125 in) high, traceable to manufacturer's country of origin;
- d) identification as recyclable;
- e) safety information.

6.6 Pallet covers

6.6.1 Each pallet may have a cover made of at least one of the following:

- a) polyethylene (PE) shrink or wrapped film;
- b) PE bonnet type;
- c) polypropylene (PP) bonnet type.

6.6.2 All plastics should be UV-stabilized, unless otherwise requested. Cardboard, carton or wood covers may be used in place of the above. If appropriate, a bottom layer of cardboard, PE sheet or plywood may be connected to the cover to unitize the overall package.

6.7 Package mass

Each sack shall contain a specified net mass $\pm 5\%$. The average weight of 5 % of all sacks in a shipment, taken at random, shall not be less than the specified weight.

6.8 Storage

The manufacturer shall advise on storage upon request.

6.9 Recycling

6.9.1 General

If appropriate, recycling of the remaining materials after using the contents may be done in accordance with the guidelines given in 6.9.2 to 6.9.4. All recycling should be done in accordance with local instructions and in compliance with the local regulatory administration concerned.

6.9.2 Pallets

General recovery and recycling, provided that pallet description is in accordance with ISO 6780.

6.9.3 Cover

Identify PE, PP or carton, and recycle accordingly.

6.9.4 Bags

Use of quality, high-performance paper results in less packaging materials and less waste for recycling. After separation of the various components, recycle accordingly.

NOTE When handling chemicals, reduction in the volume of packaging materials can be obtained by application of containers in a dedicated container scheme.

7 Barite

7.1 Principle

7.1.1 Drilling-grade barite is produced from commercial barium sulfate-containing ores. The manufacturer shall retain certificates of analysis or similar documentation on these commercial barium sulfate ores. It may be produced from a single ore or a blend of ores and may be a straight-mined product or processed by beneficiation methods, i.e. washing, tabling, jigging or flotation. It may contain accessory minerals in addition to the barium sulfate (BaSO_4) mineral. Because of mineral impurities, commercial barite can vary in colour from off-white to grey to red or brown. Common accessory minerals are silicates, such as quartz and chert, carbonate compounds such as siderite and dolomite, and metallic oxide and sulfide compounds. Although these minerals are normally insoluble, they can, under certain conditions, react with other components in some types of drilling fluids and cause adverse changes in the drilling fluid properties. (See Annex A for more details.)

7.1.2 Drilling-grade barite shall be deemed to meet the requirements of this International Standard if a composite sample representing no more than one day's production conforms to the chemical and physical specifications of Table 2, represents the product produced and is controlled by the manufacturer.

Table 2 — Barite physical and chemical requirements

Requirement	Standard
Density	4,20 g/ml, minimum
Water-soluble alkaline earth metals, as calcium	250 mg/kg, maximum
Residue greater than 75 μm	Maximum mass fraction 3,0 %
Particles less than 6 μm in equivalent spherical diameter	Maximum mass fraction 30 %

7.2 Reagents and apparatus — Density by Le Chatelier flask

7.2.1 Kerosene or mineral spirits.

7.2.2 Oven, regulated to $105\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ ($220\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$).

7.2.3 Desiccator, with calcium sulfate (CAS No. 7778-18-9) desiccant, or equivalent.

7.2.4 Le Chatelier flask, clamped or weighted to prevent flotation in water bath.

7.2.5 Constant-temperature bath, transparent, at $32\text{ }^{\circ}\text{C} \pm 0,5\text{ }^{\circ}\text{C}$ regulated to $\pm 0,1\text{ }^{\circ}\text{C}$ ($90\text{ }^{\circ}\text{F} \pm 1,0\text{ }^{\circ}\text{F}$ regulated to $\pm 0,2\text{ }^{\circ}\text{F}$), e.g. an approximately 40 l aquarium (fish tank) with heater/circulator attachment, or functional equivalent.

7.2.6 Balance, with accuracy of 0,01 g.

7.2.7 Pipette, volumetric, 10 ml.

7.2.8 Magnifying glass.

7.2.9 Dowel, wooden, approximately 8 mm (0,33 in) in diameter and 30 cm (12 in) in length, or a functional equivalent.

7.2.10 Tissue paper, absorbent.

NOTE Laboratory-grade tissues are non-absorbent and, thus, unsuitable for use in this test procedure.

7.2.11 Weighing dish, low-form, with spout, approximately 100 ml capacity, or a functional equivalent.

7.2.12 Brush, small, fine-bristle.

7.3 Procedure — Density by Le Chatelier flask

7.3.1 Take approximately 100 g of barite that has been oven dried for at least 2 h and cooled to room temperature in a desiccator.

7.3.2 Fill a clean Le Chatelier flask to approximately 22 mm (0,8 in) below the zero mark with kerosene.

7.3.3 Place the flask upright in the constant-temperature bath. The level of water in the bath shall be higher than the 24 ml graduation of the flask but below the stopper level. Assure that the flask is stabilized by the use of clamps or weights.

7.3.4 Allow the flask and contents to equilibrate for a minimum of 1 h. Using the magnifying glass with care to keep eyes at meniscus level, read the volume at the lowest portion of the curved interface and record the initial volume to the nearest 0,05 ml (doubtful digit) without removing the flask from the constant-temperature bath. Record as V_1 .

If the kerosene level is outside the $-0,2\text{ ml}$ to $+1,2\text{ ml}$ volume range after equilibrating, use the 10 ml pipette to add or remove kerosene in order to bring it within this range. Allow the flask to equilibrate for at least 1 h and record the initial volume as in 7.3.4.

7.3.5 Remove the Le Chatelier flask from the bath, wipe dry and remove the stopper. Roll several lengths of tissue paper diagonally along the length of the dowel and use this assembly as a swab to dry the inside neck of the flask. Do not allow the swab to come into contact with the kerosene in the flask.

7.3.6 Weigh $80\text{ g} \pm 0,05\text{ g}$ of dried barite into the weighing dish and carefully transfer it to the Le Chatelier flask. Take care to avoid splashing the kerosene or plugging the flask with barite at the bulb. This is a slow process, requiring repeated transfers of small amounts of barite. Use a brush to transfer any residual barite into the flask, then replace the stopper. Record the mass as m .

7.3.7 If necessary, carefully tap the neck of the flask with the wooden dowel, or agitate carefully side to side, to dislodge any barite clinging to the walls. Do not allow kerosene to come into contact with the ground glass stopper joint of the flask.

7.3.8 Gently roll the flask along a smooth surface at no more than 45° from vertical, or twirl the upright flask at the neck vigorously between the palms of both hands, to remove entrained air from the barite sample. Repeat this procedure until no more bubbles can be seen rising from the barite.

7.3.9 Return the flask to the bath and let stand for at least 0,5 h.

7.3.10 Remove the flask from the bath and repeat 7.3.8 to remove any remaining air from the barite sample.

7.3.11 Immerse the flask in the bath again for at least 1 h.

7.3.12 Record the final volume in the same manner as described in 7.3.4. Record the volume as V_2 .

7.4 Calculation — Density by Le Chatelier flask

Calculate the density, ρ , in grams per millilitre, according to Equation (4):

$$\rho = \frac{m}{(V_2 - V_1)} \quad (4)$$

where

m is the sample mass, expressed in grams;

V_1 is the initial volume, expressed in millilitres;

V_2 is the final volume, expressed in millilitres.

Record the calculated density.

7.5 Reagents and apparatus — Water-soluble alkaline earths as calcium

7.5.1 Aqueous EDTA solution, composed of $3,72 \text{ g} \pm 0,01 \text{ g}$ of the disodium salt of ethylenediaminetetraacetic acid dihydrate [disodium salt of (ethylenedinitrilo)tetraacetic acid dihydrate] (CAS No. 6381-92-6) diluted to a final volume of 1 000 ml with deionized water in a volumetric flask.

7.5.2 Hardness buffer solution, $0,001 \text{ mol/l}$, comprised of $67,5 \text{ g} \pm 0,01 \text{ g}$ of ammonium chloride (CAS No. 12125-02-9) and $570 \text{ ml} \pm 1 \text{ ml}$ of 15 mol/l ammonium hydroxide (CAS No. 1336-21-6) solution diluted to a final volume of 1 000 ml with deionized water in a volumetric flask.

7.5.3 Hardness indicator solution, comprised of $1 \text{ g} \pm 0,01 \text{ g}$ Calmagite (CAS No. 3147-14-6), or equivalent [1-(1-hydroxy-4-methylphenylazo)-2-naphthol-4-sulfonic acid] diluted to a final volume of 1 000 ml with deionized water in a volumetric flask.

7.5.4 Deionized (or distilled) water.

7.5.5 Balance, of capacity exceeding 100 g with an accuracy of $0,01 \text{ g}$.

7.5.6 Erlenmeyer flask, 250 ml nominal capacity, equipped with a tight-fitting stopper.

7.5.7 Graduated cylinder, 100 ml (TC) with 1 ml graduations.

7.5.8 Titration vessel, e.g. beaker, 100 ml to 150 ml capacity.

7.5.9 Serological pipettes or burette, with graduations of $0,1 \text{ ml}$.

7.5.10 Volumetric pipettes, 10 ml (TD), or equivalent.

7.5.11 Filter press, low-pressure/low-temperature, in accordance with ISO 10414-1:2008, Clause 7, or filtration funnel.

7.5.12 Filter paper, Whatman 50, or equivalent.

7.5.13 Glass container, small.

7.5.14 Wrist-action shaker, optional.

7.5.15 Volumetric flask, 1 000 ml.

7.5.16 Stirring rod.

7.6 Procedure — Water-soluble alkaline earth metals as calcium

7.6.1 Weigh $100\text{ g} \pm 0,05\text{ g}$ of barite. Transfer to the Erlenmeyer flask and add $100\text{ ml} \pm 1\text{ ml}$ of deionized water. Stopper the flask and shake for at least 5 min during an approximate 1 h interval or by an optional mechanical shaking apparatus for 20 min to 30 min.

7.6.2 After shaking, filter the suspension through the low-pressure filter cell or funnel using two sheets of filter paper and collect filtrate in a suitable glass container.

7.6.3 Add $50\text{ ml} \pm 1\text{ ml}$ of deionized water to the titration vessel. Add about 2 ml of hardness buffer and sufficient hardness indicator to achieve a distinct blue colour. Swirl to mix.

A solution with colour other than distinct blue at this point indicates contamination of equipment and/or water. Find and eliminate the source of contamination and rerun the test.

7.6.4 Using the volumetric pipette, measure 10 ml of the filtrate into the titrating vessel. Swirl to mix. A blue colour indicates no calcium hardness and the test is complete. A wine-red colour develops if calcium and/or magnesium are present. Record as V_4 .

7.6.5 If hardness is present, begin stirring and titrate with EDTA solution to the blue endpoint. The endpoint of the titration is best described as the point at which additional EDTA produces no further red to blue change. The EDTA volume used to produce the blue endpoint is used in the calculation in 7.7. Record as V_3 .

If endpoint is unclear or unobtainable, other tests shall be performed such as atomic absorption spectroscopy. Results and methodology of these tests shall be recorded.

7.7 Calculation — Water-soluble alkaline earths as calcium

Calculate the soluble alkaline earth metals as calcium, w_{AEM} , in milligrams per kilogram, according to Equation (5):

$$w_{\text{AEM}} = 400 \left(\frac{V_3}{V_4} \right) \quad (5)$$

where

V_3 is the volume EDTA used, expressed in millilitres;

V_4 is the volume of filtrate used, expressed in millilitres.

Record the calculated value.

7.8 Reagents and materials — Residue of diameter greater than 75 μm

7.8.1 Sodium hexametaphosphate (CAS No. 10124-56-8).

7.8.2 Oven, regulated to $105\text{ }^\circ\text{C} \pm 3\text{ }^\circ\text{C}$ ($220\text{ }^\circ\text{F} \pm 5\text{ }^\circ\text{F}$).

7.8.3 Desiccator, with calcium sulfate (CAS No. 7778-18-9) desiccant, or equivalent.

7.8.4 Balance, with an accuracy of 0,01 g.

7.8.5 Mixer (e.g. Multimixer® Model 9B with 9B29X ²⁾ impellers, or equivalent), having each spindle fitted with a single sine-wave impeller approximately 25 mm (1 in) in diameter, mounted flash side up.

7.8.6 Container, of approximate dimensions: depth, 180 mm (7,1 in); *d* top, 97 mm (3-5/6 in); *d* bottom, 70 mm (2,75 in) (e.g. Hamilton Beach® mixer cup No. M110-D ³⁾, or equivalent).

7.8.7 Sieve, 75 µm, in accordance with ASTM E161, approximate dimensions: 76 mm (3,0 in) in diameter and 69 mm (2,75 in) from top of frame to wire cloth.

NOTE Supplier's verification that sieve conforms to ASTM E161 is satisfactory evidence of compliance.

7.8.8 Spray nozzle with 1/4 TT body (Spraying Systems Co., No. TG 6.5 tip with 1/4 TT body ⁴⁾, or equivalent), attached to a water line with a 90° elbow.

7.8.9 Water pressure regulator, capable of regulation to 69 kPa ± 7 kPa (10 psi ± 1 psi).

7.8.10 Evaporating dish or functional equivalent.

7.8.11 Wash bottle.

7.9 Procedure — Residue of diameter greater than 75 µm

7.9.1 If required, equilibrate approximately 60 g of dried barite in a desiccator.

7.9.2 Weigh 50 g ± 0,01 g of dried barite. Record the mass as *m*. Add the weighed sample to approximately 350 ml of water containing about 0,2 g of sodium hexametaphosphate. Stir on the mixer for 5 min ± 1 min.

7.9.3 Transfer the sample to the 75 µm sieve. Use a wash bottle to remove all material from the container to the sieve. Wash the material on the sieve with water controlled to 690 kPa ± 35 kPa (100 psi ± 7 psi) from a spray nozzle for 2 min ± 15 s. While washing, hold the tip of the spray nozzle approximately in the plane of the top of sieve and move the spray of water repeatedly over the sample.

7.9.4 Wash the residue from the sieve into a tared evaporating dish and decant excess clear water.

7.9.5 Dry the residue in the oven to a constant mass. Record the residue mass as *m*₂ and total drying time.

7.10 Calculation — Residue of diameter greater than 75 µm

Calculate the mass fraction residue of particles greater than 75 µm, *w*₁, in percent, according to Equation (6):

$$w_1 = 100 \left(\frac{m_2}{m} \right) \quad (6)$$

where

m is the sample mass, expressed in grams;

*m*₂ is the residue mass, expressed in grams.

Record the calculated value.

3) Hamilton Beach® mixer cup No. M110-D is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.

4) Spraying Systems Co., No. TG 6.5 tip with 1/4 TT body, is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.

7.11 Reagents and apparatus — Particles less than 6 µm in equivalent spherical diameter by sedimentation method

7.11.1 Dispersant solution, comprised of 40 g ± 0,1 g of sodium hexametaphosphate and 3,60 g ± 0,1 g of anhydrous sodium carbonate (CAS No. 497-19-8) per 1 000 ml of solution. The sodium carbonate is used to adjust the pH of the solution to approximately 9,0.

7.11.2 Oven, regulated to 105 °C ± 3 °C (220 °F ± 5 °F).

7.11.3 Desiccator, with calcium sulfate (CAS No. 7778-18-9) desiccant, or equivalent.

7.11.4 Balance, with an accuracy of 0,01 g.

7.11.5 Mixer [e.g. Multimixer Model 9B with 9B29X²⁾ impellers, or equivalent], having each spindle fitted with a single sine-wave impeller approximately 25 mm (1 in) in diameter, mounted flash side up.

7.11.6 Container, of approximate dimensions: depth, 180 mm (7,1 in); *d* top, 97 mm (3-5/6 in); *d* bottom, 70 mm (2,75 in) (e.g. Hamilton Beach mixer cup No. M110-D, or equivalent).

7.11.7 Sedimentation cylinder, glass, approximately 457 mm (18 in) high and 63 mm (2,5 in) in diameter, marked for a volume of 1 000 ml (in accordance with ASTM D422).

7.11.8 Rubber stopper, Number 13.

7.11.9 Water bath or constant-temperature room, capable of maintaining a constant temperature of 24 °C ± 5 °C (75 °F ± 7 °F).

7.11.10 Thermometer, including the range 16 °C ± 0,5 °C to 32 °C ± 0,5 °C (60 °F ± 1,0 °F to 90 °F ± 1,0 °F).

7.11.11 Hydrometer, ASTM 151H, graduated to read the specific gravity of the suspension.

7.11.12 Timer, mechanical or electrical, with an accuracy of 0,1 min over the test period.

7.12 Procedure — Particles less than 6 µm in equivalent spherical diameter by sedimentation method

7.12.1 Weigh 80 g ± 0,1 g of the dry barite and place in container. Record the mass as *m*.

7.12.2 Add 125 ml ± 2 ml (127 g ± 2 g) of dispersant solution (7.11.1). Dilute to approximately 400 ml with deionized water. Rinse all adhering particles from the spatula into the suspension.

7.12.3 Stir for 5 min ± 0,5 min on a mixer.

7.12.4 Transfer the suspension to the sedimentation cylinder. Rinse container with deionized water to assure that all sample particles are transferred to the sedimentation cylinder.

7.12.5 Add deionized water to the 1 000 ml mark. Mix the contents thoroughly by constantly changing the cylinder from the upright to the inverted position and back for 60 s ± 5 s while holding a No. 13 rubber stopper in the top of the cylinder.

This is a critical step. The suspension shall be homogeneous at the start of sedimentation. This is difficult to obtain because of the high density of barite.

7.12.6 Set the cylinder into the water bath (or on the counter-top of a constant-temperature room) and simultaneously start the timer. Hang the thermometer in the water bath.

7.12.7 Take hydrometer readings at intervals of 10 min $\pm$ 0,1 min, 20 min $\pm$ 0,1 min, 30 min $\pm$ 0,1 min and 40 min $\pm$ 0,1 min (or until the first point below the 6 μ m value is reached). To take a hydrometer reading, carefully and slowly lower the hydrometer to approximately the 1,020 reading before releasing. After the hydrometer stabilizes, read the top of the meniscus at the prescribed time. Carefully and slowly remove the hydrometer, rinse with deionized water and dry after each reading. The hydrometer shall be removed immediately after each reading to eliminate particle build-up on the shoulders, which causes erroneous results. All hydrometer readings shall be done with a minimum of fluid disturbance to preserve the suspension-settling equilibrium.

7.12.8 Record the time, t , expressed in minutes, the temperature, θ , expressed in degrees Celsius (degrees Fahrenheit) and the hydrometer reading, R , on the data sheet.

Temperature may be measured in either degrees Celsius or degrees Fahrenheit, as long as all measurements and calculations are consistent in units, including hydrometer calibration.

7.12.9 For each time interval, determine the water viscosity, η , and the effective hydrometer depth, L , from Tables 3 and 4. Record on the data sheet.

7.13 Calculation — Particles less than 6 μ m in equivalent spherical diameter by sedimentation method

7.13.1 From the hydrometer calibration (5.2.5.2), enter the hydrometer correction slope, M_c , and the hydrometer correction intercept, B_c , onto the data sheet.

7.13.2 Calculate the sample constant, K_s , as given in Equation (7) (or determine from Table 5) and enter into data sheet:

$$K_s = 100 \frac{\rho}{m(\rho - 1)} \quad (7)$$

where

ρ is the sample density, expressed in grams per millilitre;

m is the sample mass, expressed in grams.

7.13.3 Calculate and enter onto the data sheet the equivalent spherical diameter, D_e , in micrometres, for each time interval as given in Equation (8):

$$D_e = 17,5 \sqrt{\frac{\eta L}{(\rho - 1)t}} \quad (8)$$

where

η is the viscosity of water, expressed in millipascal seconds;

ρ is the sample density, expressed in grams per millilitre;

t is the time, expressed in minutes;

L is the effective depth (see Table 4), expressed in centimetres.

7.13.4 Calculate and enter onto the data sheet the cumulative percent finer, w_a , for the equivalent particle diameter, D_e , immediately greater than 6 μ m, w_2 , and the equivalent particle diameter, D_e , immediately less than 6 μ m, w_3 , as given in Equation (9):

$$w_a = K_s \left[(M_c \cdot \theta) - B_c + (R - 1) 1\,000 \right] \quad (9)$$

where

K_s is the sample constant;

M_c is the hydrometer correction slope, determined in Equation (1);

θ is the suspension temperature, expressed in degrees Celsius [degrees Fahrenheit (see 7.12.8)];

B_c is the hydrometer correction intercept, as determined in Equation (2);

R is the hydrometer reading.

7.13.5 Calculate and enter onto the data sheet the cumulative percent less than 6 μm , w_4 , as given in Equation (10):

$$w_4 = \left[\left(\frac{w_2 - w_3}{D_1 - D_2} \right) (6 - D_2) \right] + w_3 \quad (10)$$

where

w_2 is the cumulative percent for the point immediately greater than 6 μm ;

w_3 is the cumulative percent for the point immediately less than 6 μm ;

D_1 is the equivalent particle diameter immediately greater than 6 μm , determined in Equation (8);

D_2 is the equivalent particle diameter immediately less than 6 μm , determined in Equation (8).

For an example of the calculation for particles less than 6 μm in equivalent spherical diameter, see Clause C.2.

7.13.6 A correction, $\log(\eta_{20}/\eta_\theta)$, for water not at the reference temperature of 20 °C (68 °F), can be calculated according to an established equation^[10] as given in Equation (11).

$$\log(\eta_{20}/\eta_\theta) = [1,370\,23 (\theta - 20) + 0,000\,836 (\theta - 20)^2]/(109 + \theta) \quad (11)$$

where

θ is the temperature, in degrees Celsius;

η_{20} 1,002, is the viscosity of water at 20 °C (68 °F);

η_θ is the viscosity at desired temperature (see Table 3).

Table 3 — Viscosity of water at various temperatures

Temperature θ °C (°F)	Viscosity η mPa·s	Temperature θ °C (°F)	Viscosity η mPa·s
15,6 (60)	1,121 1	22,2 (72)	0,949 8
16,1 (61)	1,105 0	22,8 (73)	0,937 4
16,7 (62)	1,089 3	23,3 (74)	0,925 3
17,2 (63)	1,073 9	23,9 (75)	0,913 4
17,8 (64)	1,058 9	24,4 (76)	0,901 8
18,3 (65)	1,044 2	25,0 (77)	0,890 4
18,9 (66)	1,029 8	25,6 (78)	0,879 2
19,4 (67)	1,015 8	26,1 (79)	0,868 3
20,0 (68)	1,002 0	26,7 (80)	0,857 6
20,6 (69)	0,988 5	27,2 (81)	0,847 0
21,1 (70)	0,975 3	27,8 (82)	0,836 7
21,7 (71)	0,962 4	28,3 (83)	0,826 6

**Table 4 — Values of effective depth based on readings on hydrometer
ASTM 151H used in specific sedimentation cylinder**

Uncorrected hydrometer reading	Effective depth L cm	Uncorrected hydrometer reading	Effective depth L cm
1,000	16,3	1,020	11,0
1,001	16,0	1,021	10,7
1,002	15,8	1,022	10,5
1,003	15,5	1,023	10,2
1,004	15,2	1,024	10,0
1,005	15,0	1,025	9,7
1,006	14,7	1,026	9,4
1,007	14,4	1,027	9,2
1,008	14,2	1,028	8,9
1,009	13,9	1,029	8,6
1,010	13,7	1,030	8,4
1,011	13,4	1,031	8,1
1,012	13,1	1,032	7,8
1,013	12,9	1,033	7,6
1,014	12,6	1,034	7,3
1,015	12,3	1,035	7,0
1,016	12,1	1,036	6,8
1,017	11,8	1,037	6,5
1,018	11,5	1,038	6,2
1,019	11,3	—	—

Table 5 — Sample constant, K_s , for barite (80,0 g sample)

Sample density g/ml	Sample constant K_s
4,20	1,641
4,21	1,640
4,22	1,639
4,23	1,637
4,24	1,636
4,25	1,635
4,26	1,634
4,27	1,633
4,28	1,631
4,29	1,630
4,30	1,629
4,31	1,628
4,32	1,627
4,33	1,625
4,34	1,624
4,35	1,623
4,36	1,622
4,37	1,621
4,38	1,620
4,39	1,619
4,40	1,618

8 Haematite (hematite)

8.1 Principle

8.1.1 Drilling-grade haematite is produced from commercial ores, and may be a single ore or blends of haematite ores. The haematite ores may be a straight, mined product or processed material. Minor amounts of common accessory materials, other than the iron oxide (Fe_2O_3) mineral, include silicon oxide, aluminium oxide, calcium oxide, and magnesium oxide.

8.1.2 Drilling-grade haematite shall be deemed to meet the requirements of this International Standard if a composite sample representing no more than one day's production conforms to the chemical and physical specifications of Table 6, represents the product produced, and is controlled by the manufacturer.

Table 6 — Haematite chemical and physical specifications

Requirement	Standard
Density	5,05 g/ml, minimum
Water-soluble alkaline earth metals, as calcium	100 mg/kg, maximum
Residue greater than 75 μm	maximum mass fraction 1,5 %
Residue greater than 45 μm	maximum mass fraction 15 %
Particles less than 6 μm in equivalent spherical diameter	maximum mass fraction 15 %

8.2 Reagent and apparatus — Density by Le Chatelier flask

8.2.1 **Kerosene or mineral spirits.**

8.2.2 **Oven**, regulated to $105\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ ($220\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$).

8.2.3 **Desiccator**, with calcium sulfate (CAS No. 7778-18-9) desiccant, or equivalent.

8.2.4 **Le Chatelier flask**, clamped or weighted to prevent flotation in water bath.

8.2.5 **Constant-temperature bath**, transparent, at $32\text{ }^{\circ}\text{C} \pm 0,5\text{ }^{\circ}\text{C}$ regulated to $\pm 0,1\text{ }^{\circ}\text{C}$ ($90\text{ }^{\circ}\text{F} \pm 1,0\text{ }^{\circ}\text{F}$ regulated to $\pm 0,2\text{ }^{\circ}\text{F}$), e.g. an approximately 40 l aquarium (fish tank) with heater/circulator attachment, or functional equivalent.

8.2.6 **Balance**, with accuracy of 0,01 g.

8.2.7 **Pipette**, volumetric, 10 ml.

8.2.8 **Magnifying glass.**

8.2.9 **Dowel**, wooden, approximately 8 mm (0,33 in) in diameter and 30 cm (12 in) in length, or a functional equivalent.

8.2.10 **Tissue paper**, absorbent.

NOTE Laboratory-grade tissues are non-absorbent and, thus, unsuitable for use in this test procedure.

8.2.11 **Weighing dish**, low-form, with spout, approximately 100 ml capacity, or a functional equivalent.

8.2.12 **Brush**, small, fine-bristle.

8.3 Procedure — Density by Le Chatelier flask

8.3.1 Take approximately 120 g of haematite that has been oven dried for at least 2 h and cooled to room temperature in a desiccator.

8.3.2 Fill a clean Le Chatelier flask to approximately 22 mm (0,8 in) below the zero mark with kerosene.

8.3.3 Place the flask upright in the constant-temperature bath. The level of water in the bath shall be higher than the 24 ml graduation of the flask but below the stopper level. Assure that the flask is stabilized by the use of clamps or weights.

8.3.4 Allow the flask and contents to equilibrate for a minimum of 1 h. Using the magnifying glass with care to keep the eyes at the meniscus level, read the volume at the lowest portion of the curved interface and record the initial volume to the nearest 0,05 ml (doubtful digit) without removing the flask from the constant-temperature bath.

If kerosene level is outside the $-0,2\text{ ml}$ to $+1,2\text{ ml}$ volume range after equilibrating, use the 10 ml pipette to add or remove kerosene in order to bring it within this range. Allow the flask to equilibrate for at least 1 h and record the initial volume as in 8.3.4.

8.3.5 Remove the Le Chatelier flask from the bath, wipe dry and remove the stopper. Roll several lengths of tissue paper diagonally along the length of the dowel, and use this assembly as a swab to dry the inside neck of the flask. Do not allow the swab to come into contact with the kerosene in the flask.

8.3.6 Weigh $100\text{ g} \pm 0,01\text{ g}$ of the dried haematite into the weighing dish and carefully transfer to the Le Chatelier flask. Take care to avoid splashing the kerosene or plugging of the flask with haematite at the bulb. This is a slow process, requiring repeated transfers of small amounts of haematite. Use a brush to transfer any residual haematite into the flask, then replace the stopper.

8.3.7 If necessary, carefully tap the neck of the flask with the wooden dowel or agitate carefully side to side to dislodge any haematite clinging to the walls. Do not allow the kerosene to come into contact with the ground-glass stopper joint of the flask.

8.3.8 Gently roll the flask along a smooth surface at no more than 45° from vertical or twirl the upright flask at the neck vigorously between the palms of both hands to remove entrained air from the haematite sample. Repeat this procedure until no more bubbles can be seen rising from the haematite.

8.3.9 Return the flask to the bath and let stand for at least 0,5 h.

8.3.10 Remove the flask from the bath and repeat 8.3.8 to remove any remaining air from the haematite sample.

8.3.11 Immerse the flask in the bath again for at least 1 h.

8.3.12 Record the final volume in the same manner as described in 8.3.4.

8.4 Calculation — Density by Le Chatelier flask

Calculate the density, ρ , in grams per millilitre, according to Equation (12):

$$\rho = \frac{m}{(V_2 - V_1)} \quad (12)$$

where

m is the sample mass, in grams;

V_1 is the initial volume, in millilitres;

V_2 is the final volume, in millilitres.

Record the calculated density.

8.5 Reagents and apparatus — Water-soluble alkaline earth metals as calcium

8.5.1 Aqueous EDTA solution, comprised of $3,72 \text{ g} \pm 0,01 \text{ g}$ of disodium salt of ethylenediaminetetraacetic acid dihydrate [disodium salt of (ethylenedinitrilo)tetraacetic acid dihydrate] (CAS No. 6381-92-6) diluted to a final volume of 1 000 ml with deionized water in a volumetric flask.

8.5.2 Buffer solution, comprised of $67,5 \text{ g} \pm 0,01 \text{ g}$ of ammonium chloride (CAS No. 12125-02-9) and $570 \text{ ml} \pm 1 \text{ ml}$ of ammonium hydroxide (CAS No. 1336-21-6) solution, $c(\text{NH}_4\text{OH}) = 15 \text{ mol/l}$, diluted to a final volume of 1 000 ml with deionized water in a volumetric flask.

8.5.3 Hardness indicator solution, $1 \text{ g} \pm 0,01 \text{ g}$ of Calmagite (CAS No. 3147-14-6), or equivalent [1-(1-hydroxy-4-methylphenylazo)-2-naphthol-4-sulfonic acid], diluted to a final volume of 1 000 ml with deionized water in a volumetric flask.

8.5.4 Deionized (or distilled) water.

8.5.5 Balance, of capacity exceeding 100 g with a precision of 0,01 g.

8.5.6 Erlenmeyer flask, 250 ml nominal capacity, equipped with a tight-fitting stopper.

8.5.7 Graduated cylinder, 100 ml (TC) with 1 ml graduations.

8.5.8 Titration vessel, e.g. beaker, 100 ml to 150 ml.

8.5.9 Serological pipettes or burette, graduated to 0,1 ml.

8.5.10 Volumetric pipettes, 10 ml (TD), or equivalent.

8.5.11 Filter press, low pressure/low-temperature, in accordance with ISO 10414-1:2008, Clause 7, or filtration funnel.

8.5.12 Filter paper, Whatman 50, or equivalent.

8.5.13 Glass container, small.

8.5.14 Wrist-action shaker, optional.

8.5.15 Volumetric flask, 1 000 ml.

8.5.16 Stirring rod.

8.6 Procedure — Water-soluble alkaline earth metals as calcium

8.6.1 Weigh $100\text{ g} \pm 0,05\text{ g}$ of haematite. Transfer to the Erlenmeyer flask and add $100\text{ ml} \pm 1\text{ ml}$ of deionized water. Stopper the flask and shake for at least 5 min during an approximate 1 h interval or by an optional mechanical shaking apparatus for 20 min to 30 min.

8.6.2 After shaking, filter the suspension through the low-pressure filter cell or funnel using two sheets of filter paper and collect filtrate into suitable glass container.

8.6.3 Add $50\text{ ml} \pm 1\text{ ml}$ of deionized water to the titration vessel. Add about 2 ml of hardness buffer and sufficient hardness indicator to achieve a distinct blue colour. Swirl to mix.

A solution with colour other than distinct blue at this point indicates contamination of equipment and/or water. Find and eliminate the source of contamination and rerun the test.

8.6.4 Using the volumetric pipette, measure 10 ml of the filtrate into the titrating vessel. Swirl to mix. A blue colour indicates no calcium hardness and the test is complete. A wine-red colour develops if calcium and/or magnesium is/are present.

8.6.5 If hardness is present, begin stirring and titrate with EDTA solution to the blue endpoint. The endpoint of the titration is best described as the point at which additional EDTA produces no further red to blue change. The EDTA volume used to produce the blue endpoint is used in the calculation in 8.7.

If endpoint is unclear or unobtainable, other tests such as atomic absorption spectroscopy shall be performed. Results and methodology of these tests shall be recorded.

8.7 Calculation — Water-soluble alkaline earth metals as calcium

Calculate the soluble alkaline earth metals as calcium, w_{AEM} , in milligrams per kilogram, according to Equation (13):

$$w_{\text{AEM}} = 400 \left(\frac{V_3}{V_4} \right) \quad (13)$$

where

V_3 is the volume EDTA used, expressed in millilitres;

V_4 is the volume of filtrate used, expressed in millilitres.

Record the calculated value.

8.8 Reagents and apparatus — Residues greater than 75 µm and less than 45 µm

8.8.1 **Sodium hexametaphosphate** (CAS No. 10124-56-8).

8.8.2 **Oven**, regulated to 105 °C ± 3 °C (220 °F ± 5 °F).

8.8.3 **Desiccator**, with calcium sulfate (CAS No. 7778-18-9) desiccant, or equivalent.

8.8.4 **Balance**, with an accuracy of 0,01 g.

8.8.5 **Mixer** (e.g. Multimixer® Model 9B, with 9B29X impellers, or equivalent) having each spindle fitted with a single sine-wave impeller approximately 25 mm (1 in) in diameter, mounted flash side up.

8.8.6 **Container**, of approximate dimensions: depth, 180 mm (7,1 in); *d* top, 97 mm (3-5/6 in); *d* bottom, 70 mm (2,75 in) (e.g. Hamilton® Beach mixer cup No. M110-D), or equivalent.

8.8.7 **Sieve**, 75 µm, in accordance with ASTM E 161-96, approximate dimensions: 76 mm (3,0 in) in diameter and 69 mm (2,75 in) from top of frame to wire cloth.

NOTE Supplier's verification that sieve conforms to ASTM E 161-96 is satisfactory evidence of compliance.

8.8.8 **Sieve**, 45 µm, in accordance with ASTM E 161-96, approximate dimensions: 76 mm (3,0 in) in diameter and 69 mm (2,75 in) from top of frame to wire cloth.

NOTE Supplier's verification that sieve conforms to ASTM E 161-96 is satisfactory evidence of compliance.

8.8.9 **Spray nozzle**, 1/4 TT body (Spraying Systems Company, No. TG 6.5 tip with a 1/4 TT body ⁵⁾, or equivalent), attached to a water line with a 90° elbow.

8.8.10 **Water pressure regulator**, capable of regulation to 69 kPa ± 7 kPa (10 psi ± 1 psi).

8.8.11 **Evaporating dish**, or functional equivalent.

8.8.12 **Wash bottle**.

8.9 Procedure — Residues of diameter greater than 75 µm and 45 µm

8.9.1 If required, equilibrate approximately 120 g of dried haematite to room temperature in the desiccator.

8.9.2 Weigh 50 g ± 0,01 g of dried haematite. Add the weighed sample to approximately 350 ml of water containing about 0,2 g of sodium hexametaphosphate. Stir on the mixer for 5 min ± 1 min.

8.9.3 Transfer the sample to the 75 µm sieve. Use a wash bottle to remove all material from the container to the sieve. Wash the material on the sieve with water controlled to 69 kPa ± 7 kPa (10 psi ± 1 psi) from a spray nozzle for 2 min ± 15 s. While washing, hold the tip of the spray nozzle approximately in the plane of the top of sieve and move the spray of water repeatedly over the sample.

8.9.4 Wash the residue from the sieve into a tared evaporating dish and decant excess clear water.

8.9.5 Dry the residue in the oven to a constant mass. Record the residue mass and total drying time.

8.9.6 Repeat steps 8.9.2 through 8.9.5 using the 45 µm sieve.

5) This item is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.