



Designation: **D4380—12** **D4380 – 20**

Standard Test Method for Determining Density of Bentonite Construction Slurries¹

This standard is issued under the fixed designation D4380; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope—Scope*

1.1 This test method covers the determination of the density of slurries used in slurry construction techniques, such as those used for barriers to control the horizontal movement of liquids, to drill borings, maintain trench stability, perform ground improvement, and form hydraulic barriers. This test method is modified from API Recommended Practice 13B.

1.2 *Units*—The values stated in SI units are to be regarded as standard, unless other units are also specified, such as density in lbm/ft³ standard. The values given in parentheses are provided for information only and are not considered standard. Reporting of test results in units³ or lbm/gal. No other units of measurement are included in other than SI shall not be regarded as nonconformance with this standard.

1.2.1 Note that unitless specific gravity is equivalent to SI density in g/cm³.

1.2.2 It is common practice in the engineering/construction profession to concurrently use pounds to represent both a unit of mass (lbm) and of force (lbf). This practice implicitly combines two separate systems of units; the absolute and the gravitational systems. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. As stated, this standard includes the gravitational system of inch-pound units and does not use/present the slug unit of mass. However, the use of balances and scales recording pounds of mass (lbm) or recording density in lbm/ft³ shall not be regarded as nonconformance with this standard.

1.3 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice **D6026**, unless superseded by this test method.

1.3.1 For purposes of comparing a measured or calculated value(s) with specified limits, the measured or calculated value(s) shall be rounded to the nearest decimal of significant digits in the specified limit.

1.3.2 The procedures used to specify how data are collected/recorded or calculated in the standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis methods for engineering design.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

¹ This test method is under the jurisdiction of ASTM Committee **D18** on Soil and Rock and is the direct responsibility of Subcommittee **D18.16** on Grouting. Current edition approved Aug. 1, 2012; Nov. 1, 2020. Published November 2012; November 2020. Originally approved in 1984. Last previous edition approved in 2006; 2012 as **D4380-84(2006)**; **D4380-12**. DOI: 10.1520/D4380-12; 10.1520/D4380-20.

*A Summary of Changes section appears at the end of this standard

1.5 This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 ASTM Standards:²

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D6026 Practice for Using Significant Digits in Geotechnical Data

2.2 American Petroleum Institute (API) Standard:

API RP 13B Recommended Practice Standard Procedure for Testing Drilling Fluids (Section 4.1)³

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms relating to this test method, common technical terms used in this standard, refer to Terminology D653.

4. Summary of Test Method

4.1 The mud balance is the instrument generally used for this test method. The weight mass of a fixed volume of the slurry is measured by moving a rider counterweight along a graduated scale using a mechanical balance. The weight of the slurry is balanced against a rider counterweight on a graduated beam. The density of the slurry is then read directly off the graduated scale after the instrument is balanced.

5. Significance and Use

5.1 This test method is used to determine the density of bentonite construction slurries in the laboratory and field. For freshly mixed slurry, this test method may be used as an indicator of mix proportions. For in-trench slurry or in-borehole slurry, a certain value may be specified for maintaining trench or borehole stability.

NOTE 1—The quality of the result produced by this standard depends on the competence of the personnel performing it and the suitability of the equipment and facilities being used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing, sampling, inspection, etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself ensure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.



NOTE 1—Photo courtesy of N. L. Baroid—N. L. Industries, Inc., Houston TX.

Photo courtesy of University of Texas at Austin.

FIG. 1 Mud Balance

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from the American Petroleum Institute, 2101 L-Institute (API), 1220 L. St., NW, Washington, DC 20037-20005-4070, http://www.api.org.

6. Apparatus

6.1 *Mud Balance*—~~Any instrument~~ A mechanical balance of sufficient accuracy to permit measurement within $\pm 0.01 \text{ g/cm}^3$ ~~may be used, however, the~~. A typical mud balance is the instrument generally used (see illustrated in Fig. 1). The mud balance consists of a ~~mud cup~~ graduated beam balanced over an intermediate knife edge point. A mud cup of known volume is attached to one end of a beam which is balanced on the beam, and a well is attached to the other end by a fixed counterweight and a of the beam. A cap is included with the mechanical balance and is placed on the cup to discharge excess volume in the cup and prevent spilling from the cup. A typical mud balance cap is shown in Fig. 2. Weights can be added to the well to calibrate the beam (see 7.1 ~~rider free to move along a graduated scale~~ for calibration procedure). A rider is attached to the graduated beam and is free to slide along the beam for balancing the mass of the mud in the cup. A level bubble is mounted on the beam. Attachments for extending the range of the balance may be used. ~~beam to verify the balance point.~~

6.2 *Thermometer*—A thermometer with a range of 0 to 105°C with a resolution of 1°C.

7. Calibration

7.1 The instrument apparatus calibration should be ~~calibrated~~ checked frequently with fresh water. ~~water using the procedure stated in Section 9. Check that the balance is free to rotate in the vertical plane. If not free to rotate in the vertical plane, check that the balance point is clean and free of foreign material. Check that the balance and the inside and outside of the cup and cap are free of foreign material. Fresh water should give a density reading of 1.00 g/cm^3 (8.34 lb/gal or 62.4 lb/ft^3) at 20°C (68°F). If it does not, adjust the balancing screw or the amount of lead shot in the measure the temperature of the water with the thermometer and check that the density produced by the water corresponds accurately to the temperature of the water. If the density does not correspond to the water temperature, add weights to the well at the end of the graduated arm as required or remove weights from the well as necessary to achieve the 1.00 g/cm^3 reading.~~

7.2 To check the calibration of the thermometer, fill a container with ice and cold water, stir the water, allow the water to sit for 3 minutes, and insert the thermometer into the water. The thermometer should return a reading of 0°C (32°F) if the thermometer is not touching the container. If not, replace the thermometer or recalibrate the thermometer in accordance with manufacturer recommendations.

8. Sampling and Test Specimen

8.1 Obtain a 0.5L representative sample of the slurry to be tested using dippers, buckets, mud or slurry samplers, or equivalent equipment from a laboratory slurry mix or field construction operation.



Photo courtesy of University of Texas at Austin.

FIG. 2 Mud Balance Cap

8.2 The specimen should be sampled from thoroughly-mixed slurry immediately prior to testing.

NOTE 2—When allowed to sit undisturbed, slurries containing clay and/or other viscosity modifiers may form a gel, which may affect the flow into the cup and produce an unrepresentative specimen. Particles in slurries may also settle if allowed to sit, which may result in variable density in the sample and an unrepresentative specimen.

9. Procedure

9.1 Verify calibration of apparatus, and verify that balance, cup, and cap are clean and free of old slurry or other foreign materials.

9.2 Set up the instrument/apparatus base approximately level.

9.3 Fill the clean, dry cup with slurry to be tested. Gently tap the side of the slurry cup to break up any entrained gases. Make sure there are no bubbles on the top of the slurry.

9.4 Fill the clean, dry cup with slurry to be tested, place the cap on the cup, and rotate the cap until firmly seated. Make sure some of the slurry is expelled through the hole in the cap as the cap is seated.

9.5 Cover the hole in the cap. Wash or wipe the excess slurry from the outside of the cup.

9.6 Place the beam on the support and balance it by moving the rider along the graduated scale. The beam is horizontal when the leveling bubble is on the center line.

8.5 Read the density at the side of the rider toward the knife edge. Make appropriate corrections when a range extender is used.

9.7 Record the density. Read the density as indicated on the rider, and record the density to the nearest 0.01 g/cm³.

9.8 Remove the cap, measure the temperature of the slurry in the cup, and record the temperature to the nearest 1°C.

9.9 Clean and Empty the sample from the cup and clean and dry the instrument thoroughly after each use.

9. Calculation

9.1 To convert the density to other units, use the following relationships:

$$\rho \text{ in lb/ft}^3 = 62.43 \cdot \rho \text{ in g/cm}^3 \quad (1)$$

$$\rho \text{ in lb/gal} = 8.35 \cdot \rho \text{ in g/cm}^3$$

10. Report: Test Data Sheet(s)/Form(s)

10.1 Record as a minimum the following general information (data): sample/specimen information:

10.1.1 Project Name/Designation;

10.1.2 Project location;

10.1.3 Specimen material/mix design;

10.1.4 Date and time;

10.1.5 Sample/specimen identifying information, such as location, project, date and time, the source/Source of the slurry tested, such as its station and depth, person who conducted the test, and general testing conditions: depth;

10.1.6 Initials of person who conducted the test.