



Designation: D5002 – 22

Standard Test Method for Density, Relative Density, and API Gravity of Crude Oils by Digital Density Analyzer¹

This standard is issued under the fixed designation D5002; 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 reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers the determination of the density, relative density, and API gravity of crude oils that may be handled in a normal fashion as liquids at test temperatures between 15 °C and 35 °C utilizing either manual or automated sample injection equipment. This test method applies to crude oils with high vapor pressures provided appropriate precautions are taken to prevent vapor loss during transfer of the sample to the density analyzer.

1.2 This test method was evaluated in interlaboratory study testing using crude oils in the 0.75 g/mL to 0.95 g/mL range. Lighter crude oil may require special handling to prevent vapor losses.

1.3 The values stated in SI units are to be regarded as standard. Other units of measurement are included in this standard. The accepted units of measurement of density are grams per millilitre and kilograms per cubic metre.

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.* Specific warning statements are given in 7.4, 7.5, and 7.6.

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

¹ This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.04.0D on Physical and Chemical Methods.

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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.

D287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)

D941 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Lipkin Bicapillary Pycnometer (Withdrawn 1993)³

D1193 Specification for Reagent Water

D1217 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer

D1250 Guide for the Use of the Joint API and ASTM Adjunct for Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils: API MPMS Chapter 11.1

D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products

D4377 Test Method for Water in Crude Oils by Potentiometric Karl Fischer Titration (Withdrawn 2020)³

3. Terminology

3.1 Definitions:

3.1.1 *density, n*—mass per unit volume at a specified temperature.

3.1.1.1 *Discussion*—The SI unit of density is kg/m³; the unit of measure g/cm³ is commonly used in industry. Less preferred units, for example, kg/L or g/mL, are still in use.

3.1.2 *relative density, n*—the ratio of the density of a material at a stated temperature to the density of water at a stated temperature.

3.1.2.1 *Discussion*—Relative density is also commonly known as specific gravity. Commonly used stated temperatures are 20 °C/20 °C, 15 °C/15 °C, 20 °C/4 °C and 60 °F/60 °F. “Relative density” was historically known as the deprecated term “specific gravity”.

³ The last approved version of this historical standard is referenced on www.astm.org.

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

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *API gravity, n*—a special function of relative density 60 °F/60 °F, represented by:

$$^{\circ}\text{API} = \frac{141.5}{\text{relative density}} - 131.5 \quad (1)$$

3.2.1.1 *Discussion*—No statement of reference temperature is required since 60 °F is included in the definition.

3.2.2 *test specimen, n*—the volume of the sample aliquot residing in the U-tube during the measurement cycle.

3.2.2.1 *Discussion*—Sample material residing in filling nozzles, tubing and valve manifolds is not considered “Test Specimen.” A test specimen may be measured only once.

4. Summary of Test Method

4.1 Approximately 1 mL to 2 mL of crude oil sample is introduced into an oscillating U-tube and the change in oscillating frequency caused by the change in the mass of the tube is used in conjunction with adjustment data to determine the density, relative density, and API gravity of the sample. Both manual and automated injection techniques are described.

5. Significance and Use

5.1 Density is a fundamental physical property that may be used in conjunction with other properties to characterize the quality of crude oils.

5.2 The density or relative density of crude oils is used for the conversion of measured volumes to volumes at the standard temperatures of 15 °C or 60 °F and for the conversion of crude mass measurements into volume units.

5.3 The application of the density result obtained from this test method, for fiscal or custody transfer accounting calculations, may require measurements of the water and sediment contents obtained on similar specimens of the crude oil parcel.

6. Apparatus

6.1 *Digital Density Analyzer*—A digital analyzer consisting of a U-shaped, oscillating tube, U-tube, and a system for electronic excitation, frequency counting, and display. The analyzer shall accommodate the accurate measurement of the sample temperature during measurement or shall control the sample temperature. The instrument shall be capable of meeting the precision requirements described in 6.1 of Test Method D4052.

6.2 *Syringes*, at least 2 mL in volume with a tip or an adapter tip that will fit the inlet of the density analyzer.

6.3 *Flow-Through or Pressure Adapter*, for use as an alternative means of introducing the sample into the density meter.

6.4 *Autosampler*, required for use in automated injection analyses. The autosampler shall be designed to ensure the integrity of the test specimen prior to and during the analysis and be equipped to transfer a representative portion of test specimen to the digital density analyzer.

7. Reagents and Materials

7.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated it is intended that

all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.⁴ Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water as defined by Type II of Specification D1193 or better.

7.3 *Water*, reagent water, freshly boiled, to remove dissolved gasses, for use as a primary calibration standard. (**Warning**—Handling water at boiling or near boiling temperature can present a safety hazard. Wear appropriate personal protective equipment.)

7.4 *Acetone*, for flushing and drying the sample tube. (**Warning**—Extremely flammable.)

7.5 *Petroleum Naphtha*, for flushing viscous petroleum samples from the sample tube. (**Warning**—Extremely flammable.)

NOTE 1—Suitable solvent naphthas are marketed under various designations such as “petroleum ether,” “ligroine,” or “precipitation naphtha.”

7.6 *n-Nonane, n-tridecane or cyclohexane*, 99 % purity or better, or similar pure material for which the density is known precisely from literature references or by direct determination in accordance with Test Method D941 or D1217. (**Warning**—Extremely flammable.)

8. Sampling, Test Specimens, and Test Units

8.1 Sampling is defined as all the steps required to obtain an aliquot of the contents of any pipe, tank or other system, and to place the sample into the laboratory test container. The laboratory test container and sample volume shall be of sufficient dimensions to allow mixing as described in 8.3.1. Mixing is required to obtain a homogeneous sample for analysis.

8.2 *Laboratory Sample*—Use only representative samples obtained as specified in Practices D4057 or D4177 for this test method.

8.3 *Test Specimen*—A portion or volume of sample obtained from the laboratory sample and delivered to the density analyzer U-tube. Obtain the test specimen as follows:

8.3.1 Mix the sample of crude oil to homogenize any sediment and water present. The mixing may be accomplished as described in Practice D4177 or Test Method D4377. Mixing at room temperature in an open container can result in the loss of light ends, so mixing in closed, pressurized containers or at sub-ambient temperatures is recommended.

8.3.2 Draw the test specimen from a properly mixed laboratory sample using an appropriate syringe. Alternatively, if the

⁴ACS Reagent Chemicals, Specifications and Procedures for Reagents and Standard-Grade Reference Materials, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.