



Designation: D1218 – 21

Standard Test Method for Refractive Index and Refractive Dispersion of Hydrocarbon Liquids¹

This standard is issued under the fixed designation D1218; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method covers the measurement of refractive index, accurate to four decimal places or better, of transparent and light-colored hydrocarbons in the range of 1.3300 to 1.5000 at temperatures from 20 °C to 30 °C by manual (optical-mechanical) or automatic (digital) procedure.

1.2 The manual (optical-mechanical) procedure also covers the measurement of refractive dispersion accurate to the fourth decimal place or better.

NOTE 1—The test method may be suitable for measuring the refractive indices of liquids above 1.5000 and at temperatures both below 20 °C and above 30 °C; however, the test method precision may not apply. Verification of the accuracy of such measurements will depend upon the availability of reliable, certified reference standards that demonstrate the performance of the instrument used under the particular measuring conditions.

1.3 The test method may not be applicable to liquids that are strongly colored, or that have bubble points so near the test temperature that a reading cannot be obtained before substantial weathering takes place. Liquid color should be limited to No. 4 ASTM Color or lighter, as determined by Test Method **D1500**.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 **WARNING**—Mercury has been designated by many regulatory agencies as a hazardous substance that can cause serious medical issues. Mercury, or its vapor, has been demonstrated to be hazardous to health and corrosive to materials. Use Caution when handling mercury and mercury-containing products. See the applicable product Safety Data Sheet (SDS) for additional information. The potential exists that selling mercury or mercury-containing products, or both, is prohibited by local or national law. Users must determine legality of sales in their location.

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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1.6 *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.*

1.7 *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

D1193 Specification for Reagent Water

D1500 Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)

D6299 Practice for Applying Statistical Quality Assurance and Control Charting Techniques to Evaluate Analytical Measurement System Performance

D6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products, Liquid Fuels, and Lubricants

E1 Specification for ASTM Liquid-in-Glass Thermometers

2.2 ASTM Adjuncts:

Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products and Lubricants, Version 4.0.65³

3. Terminology

3.1 Definitions:

3.1.1 *refractive dispersion, n* —the difference between the refractive indices of a substance for light of two different wavelengths, both indices being measured at the same temperature.

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 Out of print. No longer available from ASTM International Headquarters.

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

3.1.1.1 *Discussion*—For convenience in calculations, the value of the difference thus obtained is usually multiplied by 10 000.

3.1.2 *refractive index, n* —the ratio of the velocity of light (of specified wavelength) in air, to its velocity in the substance under examination.

3.1.2.1 *Discussion*—It may also be defined as the sine of the angle of incidence divided by the sine of the angle of refraction, as light passes from air into the substance. This is the relative index of refraction. If absolute refractive index (that is, referred to vacuum) is desired, this value should be multiplied by the factor 1.00027, the absolute refractive index of air. The numerical value of refractive index of liquids varies inversely with both wavelength and temperature.

4. Summary of Test Method

4.1 The refractive index is measured using a high-resolution refractometer of an optical-mechanical or automatic digital type with the prism temperature accurately controlled. The instrument principle is based on the critical angle concept.

5. Significance and Use

5.1 Refractive index and refractive dispersion are fundamental physical properties, which can be used in conjunction with other properties to characterize pure hydrocarbons and their mixtures.

PROCEDURE A—MANUAL (OPTICAL-MECHANICAL) PROCEDURE

6. Apparatus

6.1 *Refractometer*, high-resolution optical-mechanical refractometer of the “Abbe” type with suitable measuring range (1.3300 to 1.5000 or higher) and an accuracy/resolution of 0.0001 or better refractive index.

NOTE 2—Prior to 2001, Test Method D1218 was based on a Bausch & Lomb Refractometer. However, this instrument is no longer manufactured. Currently available manual refractometers are of the “Abbe” type (critical angle refractometers, see X1.2.3). There is a variety of refractometers that have been found to be suitable for this measurement. Some instruments offer a wider measuring range but it is important to verify the uniformity of accuracy across the entire measuring range and to ensure suitable calibration materials are available for this verification.

6.2 *Temperature Control Unit*, either an external liquid bath with both heating and cooling capability and pump for maintaining the indicated prism temperature within 0.1 °C, or an internal electronic temperature control system (such as Peltier system). If an external bath is used, the thermostating liquid shall pass the temperature measuring device on leaving, not on entering the prism. The temperature control unit (external or internal) shall have the following control specification:

Stability	±0.1 °C
Uniformity	±0.1 °C
Display Resolution	0.1 °C or better

6.3 *Temperature Measuring Device*, for those apparatus employing mercury in glass thermometer, ASTM Thermometer 17C having a range from 19 °C to 27 °C, and conforming to the requirements of Specification E1. For apparatus using non-

mercury in glass thermometer, a platinum resistance probe, thermocouple, or equivalent temperature sensors are acceptable.

6.4 *Light Sources*—The following type of light source can be used in conjunction with an optical-mechanical (Abbe type) refractometer:

6.4.1 *Sodium Arc Lamp*, Na_D line at 589 nm.

6.4.2 *Mercury Arc Lamp*, Hg_c line at 546 nm or Hg_g line at 436 nm.

6.4.3 *Cadmium Arc Lamp*, Cd_C line at 644 nm.

6.4.4 *Mercury-Cadmium Arc Lamp*.

6.4.5 *Helium Discharge Lamp*.

NOTE 3—Measurement of refractive dispersion requires more than one type of light source.

6.5 *Light Filters*—Arc lamps can emit a number of spectral lines that result in multiple-borderlines observed in the refractometer. Filters can be used to eliminate unwanted lines (borderlines). Depending upon instrument design, the manufacturer will recommend and supply a suitable filter or adapt a commercially-available filter (for example, interference filter) to suit the application.

7. Reagents and Materials

7.1 *n-Pentane, 95 mol % Minimum Purity*, for cleaning the prism faces. (**Warning**—Flammable. Harmful if inhaled. Vapors may cause flash fire.)

NOTE 4—Low boiling hydrocarbon fractions with boiling range 50 °C to 100 °C have also been found to be acceptable.

7.2 *Toluene, HPLC Grade*, for cleaning the prism faces. (**Warning**—Flammable. Vapor harmful.)

7.3 *1-Bromonaphthalene, 98 mol % Minimum Purity*, contact liquid when calibrating with solid reference standard. (**Warning**—Toxic when ingested.)

7.4 *Primary Reference Materials*, for calibrating the instrument.

7.4.1 *Solid Reference Standard*, with the value of refractive index engraved on its upper face.

7.4.2 *Distilled or Deionized Water*, conforming to Type II or III of Specification D1193. At 20 °C, $n_D = 1.3330$; at 25 °C, $n_D = 1.3325$; and at 30 °C, $n_D = 1.3319$

7.4.3 *2,2,4-trimethylpentane, 99 mol % Minimum Purity*, at 20 °C, $n_D = 1.3915$; at 25 °C, $n_D = 1.3890$.

7.4.4 *Methylcyclohexane, 99 mol % Minimum Purity*, at 20 °C, $n_D = 1.4231$; at 25 °C, $n_D = 1.4206$.

7.4.5 *Toluene, 99 mol % Minimum Purity*, at 20 °C, $n_D = 1.4969$; at 25 °C, $n_D = 1.4941$. (**Warning**—2,2,4-trimethylpentane, methylcyclohexane, and toluene are all flammable. Their vapor can be harmful.)

NOTE 5—Other pure materials may be used to calibrate the instrument as primary reference material, as long as they can be obtained in 99 mol % minimum purity and accurate values of their refractive indices at specific temperatures are available. The precision of the test method (see 15.1 and 24.1) were obtained using distilled water as the calibrant.

7.5 *Secondary Reference Materials*, for calibrating the instrument.