Designation: D6378 – 22

Standard Test Method for Determination of Vapor Pressure (VP_X) of Petroleum Products, Hydrocarbons, and Hydrocarbon-Oxygenate Mixtures (Triple Expansion Method)[1]

This standard is issued under the fixed designation D6378; 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 use of automated vapor pressure instruments to determine the vapor pressure exerted in vacuum by volatile, liquid petroleum products, hydrocarbons, and hydrocarbon-oxygenate mixtures including ethanol blends up to 85 % (volume fraction). This test method is suitable for testing samples with boiling points above 0 °C (32 °F) that exert a vapor pressure between 7 kPa and 150 kPa (1.0 psi and 21 psi) at 37.8 °C (100 °F) at a vapor-to-liquid ratio of 4:1. The liquid sample volume size required for analysis is dependent upon the vapor-to-liquid ratio chosen (see Note 1) and the measuring chamber volume capacity of the instrument (see 6.1.1 and Note 5).

NOTE 1—The test method is suitable for the determination of the vapor pressure of volatile, liquid petroleum products at temperatures from 0 °C to 100 °C at vapor to liquid ratios of 4:1 to 1:1 (X = 4 to 1) and pressures up to 500 kPa (70 psi), but the precision statement (see Section 16) may not be applicable.

NOTE 2—The precision (see Section 16) using 1 L containers was determined in a 2003 interlaboratory study (ILS);[2] the precision using 250 mL containers was determined in a 2016 ILS.[3]

1.2 This test method also covers the use of automated vapor pressure instruments to determine the vapor pressure exerted in vacuum by aviation turbine fuels. This test method is suitable for testing aviation turbine fuel samples with boiling points above 0 °C (32 °F) that exert a vapor pressure between 0 kPa and 110 kPa (0 psi and 15.5 psi) at a vapor-to-liquid ratio of 4:1, in the temperature range from 25 °C to 100 °C (77 °F to 212 °F).

NOTE 3—The precision (see Section 16) for aviation turbine fuels using 100 mL containers was determined in a 2007 ILS.[4]

1.3 The vapor pressure (VP_X) determined by this test method at a vapor-liquid ratio of 4:1 (X = 4) of gasoline and gasoline-oxygenate blends at 37.8 °C can be correlated to the dry vapor pressure equivalent (DVPE) value determined by Test Method D5191 (see 16.3). This condition does not apply when the sample is aviation turbine fuel.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.5 *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.* For specific warning statements, see 7.2 – 7.8.

1.6 *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:*[5]

D323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)

D2892 Test Method for Distillation of Crude Petroleum (15-Theoretical Plate Column)

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products

[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 D02.08 on Volatility.

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[2] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1619. Contact ASTM Customer Service at service@astm.org.

[3] Research Report IP 394 (EN 130161) and IP 619 (EN 130163) 2016, available from the Energy Institute, 61 New Cavendish Street, London W1G 7AR, UK , email: ILS@energyinst.org.

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1651. Contact ASTM Customer Service at service@astm.org.

[5] 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.

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

D4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination
D4953 Test Method for Vapor Pressure of Gasoline and Gasoline-Oxygenate Blends (Dry Method)
D5191 Test Method for Vapor Pressure of Petroleum Products and Liquid Fuels (Mini Method)
D5842 Practice for Sampling and Handling of Fuels for Volatility Measurement
D5854 Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products
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
D6708 Practice for Statistical Assessment and Improvement of Expected Agreement Between Two Test Methods that Purport to Measure the Same Property of a Material

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *dry vapor pressure equivalent (DVPE), n*—a value calculated by a correlation equation from the total pressure (Test Method D5191), which is equivalent to the value obtained on the sample by Test Method D4953, Procedure A.

3.1.2 *partial pressure from dissolved air (PPA), n*—the pressure exerted in vacuum from dissolved air that escapes from the liquid phase into the vapor phase.

3.1.3 *Reid vapor pressure equivalent (RVPE), n*—a value calculated by a correlation equation from the TP_X, which is equivalent to the value obtained on the sample by Test Method D323.

3.1.4 *total pressure (TP_X), n*—the pressure exerted in vacuum by air- and gas-containing petroleum products, components and feedstocks, and other liquids, in the absence of undissolved water at a vapor-liquid ratio of X:1.

3.1.5 *vapor pressure (VP_X), n*—the total pressure minus the PPA in the liquid at a vapor-liquid ratio of X:1.

$$VP_X = TP_X - PPA \quad (1)$$

4. Summary of Test Method

4.1 Employing a measuring chamber with a built-in piston, a sample of known volume is drawn into the temperature controlled chamber at 20 °C or higher. After sealing the chamber, the temperature of the chamber is increased to a specified value simultaneously with the first expansion. Two further expansions are performed to a final volume of (X + 1) times that of the test specimen. After each expansion, the TP_X is determined. The PPA and the solubility of air in the specimen are calculated from the three resulting pressures. The (VP_X) is calculated by subtracting the PPA in the liquid from TP_X.

NOTE 4—For liquids containing very low levels of high vapor pressure contaminants, which behave like a gas, this test method of determination of the PPA and gases may lead to wrong results since the partial pressure of the contaminants will be included in the PPA. This effect is shown when the value of the PPA and gases exceeds the average maximum limit of 7 kPa (1 psi).

5. Significance and Use

5.1 Vapor pressure is a very important physical property of volatile liquids for shipping and storage.

5.2 The vapor pressure of gasoline and gasoline-oxygenate blends is regulated by various government agencies.

5.3 Specifications for volatile petroleum products generally include vapor pressure limits to ensure products of suitable volatility performance.

5.4 In this test method, an air saturation procedure prior to the measurement is not required, thus eliminating losses of high volatile compounds during this step. This test method is faster and minimizes potential errors from improper air saturation. This test method permits VP_X determinations in the field.

5.5 This test method can be applied in online applications in which an air saturation procedure prior to the measurement cannot be performed.

6. Apparatus

6.1 The apparatus suitable for this test method employs a small volume, cylindrically shaped measuring chamber with associated equipment to control the chamber temperature within the range from 0 °C to 100 °C. The measuring chamber shall contain a movable piston with a maximum dead volume of less than 1 % of the total volume at the lowest position to allow sample introduction into the measuring chamber and expansion to the desired vapor-liquid ratio. A static pressure transducer shall be incorporated in the piston. The measuring chamber shall contain an inlet/outlet valve combination for sample introduction and expulsion. The piston and the valve combination shall be at the same temperature as the measuring chamber to avoid any condensation or excessive evaporation.

6.1.1 The measuring chamber shall be designed to contain between 5 mL and 15 mL of liquid and vapor and be capable of maintaining a vapor-liquid ratio of 4:1 to 1:1. The accuracy of the adjusted vapor-liquid ratio shall be within 0.05.

NOTE 5—The measuring chamber employed by the instruments used in generating the precision and bias statements were constructed of nickel plated aluminum and stainless steel with a total volume of 5 mL. Measuring chambers exceeding a 5 mL capacity can be used, but the precision and bias statements (see Section 16) are not known to apply.

6.1.2 The pressure transducer shall have a minimum operational range from 0 kPa to 200 kPa (0 psi to 29 psi) with a minimum resolution of 0.1 kPa (0.01 psi) and a minimum accuracy of ±0.2 kPa (±0.03 psi). The pressure measurement system shall include associated electronics and readout devices to display the resulting pressure reading.

6.1.3 Electronic temperature control shall be used to maintain the measuring chamber at the prescribed temperature within ±0.1 °C for the duration of the vapor pressure measurement.

6.1.4 A platinum resistance thermometer shall be used for measuring the temperature of the measuring chamber. The minimum temperature range of the measuring device shall be from 0 °C to 100 °C with a resolution of 0.1 °C and an accuracy of ±0.1 °C.