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.

Designation: D323 – 26

Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method)[1]

This standard is issued under the fixed designation D323; 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 procedures for the determination of vapor pressure (see Note 1) of gasoline, volatile crude oil, and other volatile petroleum products.

1.2 Procedure A is applicable to gasoline and other petroleum products with a vapor pressure of less than 180 kPa (26 psi).

1.3 Procedure B may also be applicable to these other materials, but only gasoline was included in the interlaboratory test program to determine the precision of this test method.

1.4 Procedure C is for materials with a vapor pressure of greater than 180 kPa (26 psi).

1.5 Procedure D for aviation gasoline with a vapor pressure of approximately 50 kPa (7 psi).

NOTE 1—Because the external atmospheric pressure is counteracted by the atmospheric pressure initially present in the vapor chamber, the Reid vapor pressure is an absolute pressure at 37.8 °C (100 °F) in kilopascals (pounds-force per square inch). The Reid vapor pressure differs from the true vapor pressure of the sample due to some small sample vaporization and the presence of water vapor and air in the confined space.

1.6 This test method is not applicable to liquefied petroleum gases or fuels containing oxygenated compounds other than methyl *t*-butyl ether (MTBE). For determination of the vapor pressure of liquefied petroleum gases, refer to Test Method D1267 or Test Method D6897. For determination of the vapor pressure of gasoline-oxygenate blends, refer to Test Method D4953. The precision for crude oil has not been determined since the early 1950s (see Note 3). Test Method D6377 has been approved as a method for determination of vapor pressure of crude oil. IP 481 is a test method for determination of the air-saturated vapor pressure of crude oil.

1.7 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.8 *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 Sections 7 and 18, and 12.5.3, 15.5, 21.2, A1.1.2, A1.1.6, and A2.3.

1.9 *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]

D1267 Test Method for Gauge Vapor Pressure of Liquefied Petroleum (LP) Gases (LP-Gas Method)
D4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants
D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products
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)
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
D6377 Test Method for Determination of Vapor Pressure of Crude Oil: $VPCR_x$ (Expansion Method)
D6897 Test Method for Vapor Pressure of Liquefied Petroleum Gases (LPG) (Expansion Method)
E1 Specification for ASTM Liquid-in-Glass Thermometers

[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] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. 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**

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E2251 Specification for Liquid-in-Glass ASTM Thermometers with Low-Hazard Precision Liquids
E2877 Guide for Digital Contact Thermometers

2.2 *Energy Institute Standards:*
IP 481 Test Method for Determination of the Air Saturated Vapour Pressure (ASVP) of Crude Oil[3]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to Terminology D4175.

3.1.2 *Bourdon spring gauge, n*—pressure measuring device that employs a Bourdon tube connected to an indicator.

3.1.3 *Bourdon tube, n*—flattened metal tube bent to a curve that straightens under internal pressure.

3.1.4 *oxygenate, n*—oxygen-containing ashless organic compound, such as an alcohol or ether, which may be used as a fuel or fuel supplement. **D4175**

3.1.5 *Reid vapor pressure (RVP), n*—resultant total pressure reading, corrected for measuring error, of a specific empirical test method (Test Method D323) for measuring the vapor pressure of gasoline and other volatile products.

3.1.6 *vapor pressure, n*—pressure exerted by the vapor of a liquid when in equilibrium with the liquid. **D4175**

3.2 *Abbreviations:*

3.2.1 *ASVP, n*—air saturated vapor pressure.

3.2.2 *LPG, n*—liquefied petroleum gases.

3.2.3 *MTBE, n*—methyl *t*-butyl ether.

3.2.4 *RVP, n*—Reid Vapor Pressure.

4. Summary of Test Method

4.1 The liquid chamber of the vapor pressure apparatus is filled with the chilled sample and connected to the vapor chamber that has been heated to 37.8 °C (100 °F) in a bath. The assembled apparatus is immersed in a bath at 37.8 °C (100 °F) until a constant pressure is observed. The reading, suitably corrected, is reported as the Reid vapor pressure.

4.2 All four procedures utilize liquid and vapor chambers of the same internal volume. Procedure B utilizes a semiautomatic apparatus immersed in a horizontal bath and rotated while attaining equilibrium. Either a Bourdon gauge or pressure transducer may be used with this procedure. Procedure C utilizes a liquid chamber with two valved openings. Procedure D requires more stringent limits on the ratio of the liquid and vapor chambers.

5. Significance and Use

5.1 Vapor pressure is an important physical property of volatile liquids. This test method is used to determine the vapor pressure at 37.8 °C (100 °F) of petroleum products and crude oils with initial boiling point above 0 °C (32 °F).

5.2 Vapor pressure is critically important for both automotive and aviation gasolines, affecting starting, warm-up, and tendency to vapor lock with high operating temperatures or high altitudes. Maximum vapor pressure limits for gasoline are legally mandated in some areas as a measure of air pollution control.

5.3 Vapor pressure of crude oils is of importance to the crude producer and the refiner for general handling and initial refinery treatment.

5.4 Vapor pressure is also used as an indirect measure of the evaporation rate of volatile petroleum solvents.

6. Apparatus

6.1 The required apparatus for Procedures A, C, and D is described in Annex A1. Apparatus for Procedure B is described in Annex A2.

7. Hazards

7.1 Gross errors can be obtained in vapor pressure measurements if the prescribed procedure is not followed carefully. The following list emphasizes the importance of strict adherence to the precautions given in the procedure:

7.1.1 *Checking the Pressure Gauge*—Check all gauges against a pressure measuring device (see A1.6) after each test to ensure higher precision of results (see 12.4). Read the gauge while in a vertical position and after tapping it lightly.

7.1.2 *Checking for Leaks*—Check all apparatus before and during each test for both liquid and vapor leaks (see Note 5).

7.1.3 *Sampling*—Because initial sampling and the handling of samples will greatly affect the final results, employ the utmost precaution and the most meticulous care to avoid losses through evaporation and even slight changes in composition (see Section 8 and 12.1). In no case shall any part of the Reid apparatus itself be used as the sample container prior to actually conducting the test.

7.1.4 *Purging the Apparatus*—Thoroughly purge the pressure gauge, the liquid chamber, and the vapor chamber to be sure that they are free of residual sample. This is most conveniently done at the end of the test in preparation for the next test (see 12.5 and 15.5).

7.1.5 *Coupling the Apparatus*—Carefully observe the requirements of 12.2.

7.1.6 *Shaking the Apparatus*—Shake the apparatus vigorously as directed to ensure equilibrium.

8. Sampling

8.1 The extreme sensitivity of vapor pressure measurements to losses through evaporation and the resulting changes in composition is such as to require the utmost precaution and the most meticulous care in the handling of samples. The provisions of this section shall apply to all samples for vapor pressure determinations, except as specifically excluded for samples having vapor pressures above 180 kPa (26 psi); see Section 19.

8.2 Obtain a sample and test specimen in accordance with Practices D4057, D4177, D4306, D5842, or D5854 when appropriate, except do not use the Sampling by Water Displacement section for fuels containing oxygenates.

[3] Available from Energy Institute, 61 New Cavendish St., London, WIG 7AR, U.K., http://www.energyinst.org.uk.

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8.3 *Sample Container Size*—The size of the sample container from which the vapor pressure sample is taken shall be 1 L (1 qt). It shall be 70 % to 80 % filled with sample.

8.3.1 The present precision statement has been derived using samples in 1 L (1 qt) containers. However, samples taken in containers of other sizes as prescribed in 8.2 can be used if it is recognized that the precision could be affected. In the case of referee testing, the 1 L (1 qt) sample container shall be mandatory.

8.4 The Reid vapor pressure determination shall be performed on the first test specimen withdrawn from the sample container. The remaining sample in the container cannot be used for a second vapor pressure determination. If necessary, obtain a new sample.

8.4.1 Protect samples from excessive heat prior to testing.

8.4.2 Do not test samples in leaky containers. They should be discarded and new samples obtained.

8.5 *Sampling Handling Temperature*—In all cases, cool the sample container and contents to 0 °C to 1 °C (32 °F to 34 °F) before the container is opened. Sufficient time to reach this temperature shall be ensured by direct measurement of the temperature of a similar liquid in a like container placed in the cooling bath at the same time as the sample.

9. Report

9.1 Report the result observed in 12.4 or 15.4, after correcting for any difference between the gauge and the pressure measuring device (see A1.6), to the nearest 0.25 kPa (0.05 psi) as the Reid vapor pressure.

10. Precison and Bias

10.1 The following criteria are to be used for judging the acceptability of results (95 % confidence):

10.1.1 *Repeatability*—The difference between successive test results obtained by the same operator with the same apparatus under constant operating conditions on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following value only in one case in twenty.

	Range		Repeatability		
Procedure	kPa	psi	kPa	psi	
A Gasoline	35–100	5–15	3.2	0.46	Note 2
B Gasoline	35–100	5–15	1.2	0.17	Note 2
A	0–35	0–5	0.7	0.10	Note 3
A	110–180	16–26	2.1	0.3	Note 3
C	>180	>26	2.8	0.4	Note 3
D Aviation Gasoline	50	7	0.7	0.1	Note 3

10.1.2 *Reproducibility*—The difference between two, single and independent results, obtained by different operators working in different laboratories on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following value only in one case in twenty.

	Range		Reproducibility		
Procedure	kPa	psi	kPa	psi	
A Gasoline	35–100	5–15	5.2	0.75	Note 2
B Gasoline	35–100	5–15	4.5	0.66	Note 2
A	0–35	0–5	2.4	0.35	Note 3
A	110–180	16–26	2.8	0.4	Note 3
C	>180	>26	4.9	0.7	Note 3
D Aviation Gasoline	50	7	1.0	0.15	Note 3

NOTE 2—These precision values are derived from a 1987 cooperative program[4] and the current Committee D02 Statistical Method RR:D02-1007.

NOTE 3—These precision values were developed in the early 1950's, prior to the current statistical evaluation method.

10.2 *Bias:*

10.2.1 *Absolute Bias*—Since there is no accepted reference material suitable for determining the bias for this test method, bias cannot be determined. The amount of bias between this test vapor pressure and true vapor pressure is unknown.

10.2.2 *Relative Bias*—There is no statistically significant bias between Procedures A and B for gasolines as determined in the last cooperative test program.

PROCEDURE A

FOR PETROLEUM PRODUCTS HAVING REID VAPOR PRESSURES BELOW 180 kPa (26 psi)

11. Preparation for Test

11.1 *Verification of Sample Container Filling*—With the sample at a temperature of 0 °C to 1 °C, take the container from the cooling bath or refrigerator and wipe dry with absorbent material. If the container is not transparent, unseal it, and using a suitable gauge, confirm that the sample volume equals 70 % to 80 % of the container capacity (see Note 4). If the sample is contained in a transparent glass container, verify that the container is 70 % to 80 % full by suitable means (see Note 4).

NOTE 4—For nontransparent containers, one way to confirm that the sample volume equals 70 % to 80 % of the container capacity is to use a dipstick that has been pre-marked to indicate the 70 % and 80 % container capacities. The dipstick should be of such material that it shows wetting after being immersed and withdrawn from the sample. To confirm the sample volume, insert the dipstick into the sample container so that it touches the bottom of the container at a perpendicular angle, before removing the dipstick. For transparent containers, using a marked ruler or by comparing the sample container to a like container that has the 70 % and 80 % levels clearly marked, has been found suitable.

11.1.1 Discard the sample if its volume is less than 70 % of the container capacity.

11.1.2 If the container is more than 80 % full, pour out enough sample to bring the container contents within the 70 % to 80 % range. Under no circumstances shall any sample poured out be returned to the container.

11.1.3 Reseal the container, if necessary, and return the sample container to the cooling bath.

11.2 *Air Saturation of Sample in Sample Container:*

11.2.1 *Nontransparent Containers*—With the sample again at a temperature between 0 °C and 1 °C, take the container from the cooling bath, wipe it dry with an absorbent material, remove the cap momentarily taking care that no water enters, reseal, and shake vigorously. Return it to the cooling bath for a minimum of 2 min.

11.2.2 *Transparent Containers*—Since 11.1 does not require that the sample container be opened to verify the sample

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1245. Contact ASTM Customer Service at www.astm.org/contact.

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capacity, it is necessary to unseal the cap momentarily before resealing it so that samples in transparent containers are treated the same as samples in nontransparent containers. After performing this task, proceed with 11.2.1.

11.2.3 Repeat 11.2.1 twice more. Return the sample to the bath until the beginning of the procedure.

11.3 *Preparation of Liquid Chamber*—Completely immerse the open liquid chamber in an upright position and the sample transfer connection (see Fig. A1.2) in a bath at a temperature between 0 °C and 1 °C (32 °F and 34 °F) for at least 10 min.

11.4 *Preparation of Vapor Chamber*—After purging and rinsing the vapor chamber and pressure gauge in accordance with 12.5, connect the gauge to the vapor chamber. Immerse the vapor chamber to at least 25.4 mm (1 in.) above its top in the water bath maintained at 37.8 °C ± 0.1 °C (100 °F ± 0.2 °F) for not less than 10 min just prior to coupling it to the liquid chamber. Do not remove the vapor chamber from the bath until the liquid chamber has been filled with sample, as described in 12.1.

12. Procedure

12.1 *Sample Transfer*—Remove the sample from the cooling bath, uncap, and insert the chilled transfer tube (see Fig. 1). Remove the liquid chamber from the cooling bath, and place the chamber in an inverted position over the top of the transfer tube. Invert the entire system rapidly so that the liquid chamber is upright with the end of the transfer tube approximately 6 mm (0.25 in.) from the bottom of the liquid chamber. Fill the chamber to overflowing (in addition to other precautions, make provision for suitable containment and disposal of the overflowing sample to avoid fire hazard). Withdraw the transfer tube from the liquid chamber while allowing the sample to continue flowing up to complete withdrawal.

12.2 *Assembly of Apparatus*—Immediately remove the vapor chamber from the water bath and couple the filled liquid chamber to the vapor chamber as quickly as possible without spillage. When the vapor chamber is removed from the water bath, connect it to the liquid chamber without undue movement that could promote exchange of room temperature air with the 37.8 °C (100 °F) air in the chamber. Not more than 10 s shall elapse between removing the vapor chamber from the water bath and completion of the coupling of the two chambers.

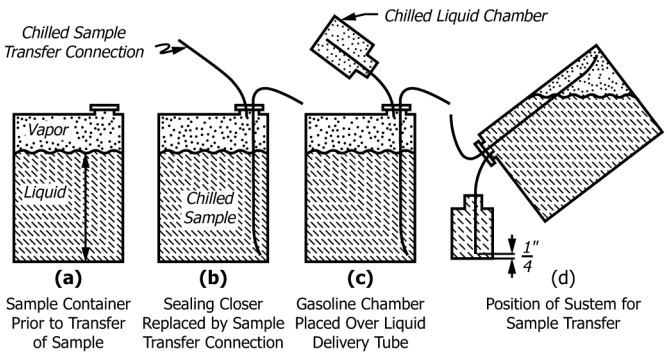


FIG. 1 Simplified Sketches Outlining Method Transferring Sample to Liquid Chamber from Open-Type Containers

12.3 *Introduction of the Apparatus into Bath*—Turn the assembled apparatus upside down and allow all the sample in the liquid chamber to drain into the vapor chamber. With the apparatus still inverted, shake it vigorously eight times up and down. With the gauge end up, immerse the assembled apparatus in the bath, maintained at 37.8 °C ± 0.1 °C (100 °F ± 0.2 °F), in an inclined position so that the connection of the liquid and vapor chambers is below the water level and carefully examine for leaks (see Note 5). If no leaks are observed, further immerse the apparatus to at least 25 mm (1 in.) above the top of the vapor chamber. Observe the apparatus for leaks throughout the test and discard the test at anytime a leak is detected.

NOTE 5—Liquid leaks are more difficult to detect than vapor leaks. Pay particular attention to the coupling between the chambers, which is normally in the liquid section of the apparatus.

12.4 *Measurement of Vapor Pressure*—After the assembled apparatus has been in the water bath for at least 5 min, tap the pressure gauge lightly and observe the reading. Withdraw the apparatus from the bath and repeat the instructions of 12.3. At intervals of not less than 2 min, tap the gauge, observe the reading, and repeat 12.3 until a total of not less than five shakings and gauge readings have been made. Continue this procedure, as necessary, until the last two consecutive gauge readings are the same, indicating that equilibrium has been attained. Read the final gauge pressure to the nearest 0.25 kPa (0.05 psi) and record this value as the uncorrected vapor pressure of the sample. Without undue delay, remove the pressure gauge from the apparatus (see Note 6) without attempting to remove any liquid that may be trapped in the gauge, check its reading against that of the pressure measuring device (see A1.6) while both are subjected to a common steady pressure that is within 1.0 kPa (0.2 psi) of the recorded uncorrected vapor pressure. If a difference is observed between the pressure measuring device and the pressure gauge readings, the difference is added to the uncorrected vapor pressure when the pressure measuring device reading is higher, or subtracted from the uncorrected vapor pressure when the pressure measuring device reading is lower, and the resulting value recorded as the Reid vapor pressure of the sample.

NOTE 6—Cooling the assembly prior to disconnecting the gauge will facilitate disassembly and reduce the amount of hydrocarbon vapors released into the room.

12.5 *Preparation of Apparatus for Next Test:*

12.5.1 Thoroughly purge the vapor chamber of residual sample by filling it with warm water above 32 °C (90 °F) and allowing it to drain. Repeat this purging at least five times. Purge the liquid chamber in the same manner. Rinse both chambers and the transfer tube several times with petroleum naphtha, or similar material, then several times with acetone, then blow dry using oil-free dried air. Place the liquid chamber in the cooling bath or refrigerator in preparation for the next test.

NOTE 7—Some samples, like crude oils, can be difficult to clean out with the standard procedure if it is viscous. Rinsing the apparatus with a solvent, like toluene, is helpful before performing washing as described in 12.5.1.

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