



Designation: D4953 – 15

# Standard Test Method for Vapor Pressure of Gasoline and Gasoline-Oxygenate Blends (Dry Method)<sup>1</sup>

This standard is issued under the fixed designation D4953; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This test method covers and is applicable to gasolines and gasoline-oxygenate blends with a vapor pressure range from 35 kPa to 100 kPa (5 psi to 15 psi) (see Note 2). This test method, a modification of Test Method D323 (Reid Method), provides two procedures to determine the vapor pressure (Note 1) of gasoline and gasoline-oxygenate blends.

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

NOTE 2—Vapor pressure of gasoline or gasoline-oxygenate blends below 35 kPa (5 psi) or greater than 100 kPa (15 psi) can be determined with this test method but the precision and bias (Section 11) do not apply. For materials with a vapor pressure greater than 100 kPa (15 psi), use a 0 kPa to 200 kPa (0 psi to 30 psi) gauge as specified in the annex of Test Method D323.

1.2 Some gasoline-oxygenate blends may show a haze when cooled to 0 °C to 1 °C. If a haze is observed in 9.4, it shall be indicated in the reporting of results. The precision and bias statements for hazy samples have not been determined (see Note 7).

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

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 and health practices and determine the applicability of regulatory limitations prior to use.* Specific warnings are given in 7.5, 8.4.1, 8.5.1, 9.1, A1.1, and A1.1.3.

<sup>1</sup> This test method is under the jurisdiction of 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. Referenced Documents

2.1 *ASTM Standards*:<sup>2</sup>

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

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D4175 Terminology Relating to Petroleum, Petroleum Products, and Lubricants

D5190 Test Method for Vapor Pressure of Petroleum Products (Automatic Method) (Withdrawn 2012)<sup>3</sup>

D5191 Test Method for Vapor Pressure of Petroleum Products (Mini Method)

E1 Specification for ASTM Liquid-in-Glass Thermometers

## 3. Terminology

3.1 *Definitions*:

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

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

3.1.3 *dry method, n*—in vapor pressure methods, a specific empirical test method (D4953) for measuring the vapor pressure of gasoline and other volatile products in which contact of the test specimen with water is not allowed.

3.1.4 *dry vapor pressure equivalent (DVPE), n*—value calculated by a defined correlation equation, that is expected to be comparable to the vapor pressure value obtained by Test Method D4953, Procedure A.

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

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

<sup>2</sup> 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.

<sup>3</sup> 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 Abbreviations:

3.2.1 *DVPE*, *n*—dry vapor pressure equivalent

## 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 at 37.8 °C (100 °F). The apparatus is immersed in a bath at 37.8 °C (100 °F) until a constant pressure is observed. The pressure reading, suitably corrected, is reported as the vapor pressure.

4.2 Procedure A utilizes the same apparatus and essentially the same procedure as Test Method **D323** with the exception that the interior surfaces of the liquid and vapor chambers are maintained completely free of water. Procedure B utilizes a semi-automatic apparatus with the liquid and vapor chambers identical in volume to those in Procedure A. The apparatus is suspended in a horizontal bath and rotated while attaining equilibrium. Either a Bourdon gauge or pressure transducer can be used with this procedure. The interior surfaces of the liquid and vapor chambers are maintained free of water.

## 5. Significance and Use

5.1 Vapor pressure is an important physical property of liquid spark-ignition engine fuels. It provides an indication of how a fuel will perform under different operating conditions. For example, vapor pressure is a factor in determining whether a fuel will cause vapor lock at high ambient temperature or at high altitude, or will provide easy starting at low ambient temperature.

5.2 Petroleum product specifications generally include vapor pressure limits to ensure products of suitable volatility performance.

NOTE 3—Vapor pressure of fuels is regulated by various government agencies.

## 6. Apparatus

6.1 The apparatus for Procedure A is described in **Annex A1**.

6.2 The essential dimensions and requirements for the liquid and vapor chamber for Procedure B are identical with those for Procedure A and described in **Annex A1**. External fittings and features will vary depending on whether a gauge or transducer is used and the provision for rotating the apparatus in the bath. Details of a commercially available unit are shown in **Annex A2**.

## 7. Handling of Test Samples

7.1 This section applies to both Procedure A and B.

7.2 The extreme sensitivity of vapor pressure measurements to losses through evaporation is such as to require the utmost precaution and the most meticulous care in handling of samples.

7.3 Sampling shall be done in accordance with the Reid Vapor Pressure section (10.3) of Practice **D4057** except for fuels containing oxygenates where the Water Displacement Procedure section (10.3.1.8) of **D4057** must not be used.

### 7.4 Sample Container Size:

7.4.1 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.

7.4.2 The present precision statement has been derived using samples in 1 L (1 qt) containers. Samples taken in containers of other sizes as prescribed in Practice **D4057** can be used if it is recognized that the precision can be affected. In the case of referee testing the 1 L (1 qt) sample container shall be mandatory.

### 7.5 Hazards:

7.5.1 The vapor pressure determination shall be the first test 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.

7.5.2 Samples shall be protected from excessive heat prior to testing.

7.5.3 Samples in leaky containers shall not be tested. Discard and obtain a new sample.

7.6 *Sample Handling Temperature*—In all cases, the sample container and contents shall be cooled to 0 °C to 1 °C (32 °F to 34 °F) before the container is opened. Sufficient time to reach this temperature shall be assured 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. See **A1.3.1**.

## 8. Preparation of Apparatus

8.1 This section applies to both Procedure A and Procedure B.

8.2 *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 non-transparent 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 which has the 70 % and 80 % levels clearly marked, has been found suitable.

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

8.2.2 If the container is more than 80 % full, pour out enough sample to bring the container contents within 70 % to 80 % range. Under no circumstance return any of the poured out sample to the container.

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

8.3 *Air Saturation of the Sample in Sample Container:*

8.3.1 *Transparent Containers Only*—Since 8.2 does not require that the sample be opened to verify the sample capacity, it is necessary to unseal the cap momentarily before resealing it, so that the samples in transparent containers are treated the same as samples in non-transparent containers.

8.3.2 With the sample again at a temperature of 0 °C to 1 °C, take the container from the cooling bath or refrigerator, 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 or refrigerator for a minimum of 2 min.

8.3.3 Repeat 8.3.2 twice more. Return the sample to the cooling bath until the beginning of the procedure.

#### 8.4 Preparation of Liquid Chamber:

8.4.1 Place the stoppered or closed liquid chamber and the sample transfer tube in a refrigerator or cooling bath for sufficient time to allow the chamber and the transfer tube to reach a temperature of 0 °C to 1 °C (32 °F to 34 °F). Keep the liquid chamber upright and not immersed over the top of the coupling threads. (**Warning**—The transfer connection must be kept completely dry during cooling. This can be accomplished by placing the transfer connection in a water tight plastic bag.)

#### 8.5 Preparation of the Vapor Chamber:

8.5.1 Connect the gauge or pressure transducer to the vapor chamber and make a water tight closure of the lower opening of the chamber where the liquid chamber attaches. Make sure that the vent hole in the vapor chamber connection is also securely closed. (**Warning**—Making a water tight closure of both the liquid and vapor chambers is extremely important. For some samples containing oxygenated compounds, contact with water can cause phase separation and invalidate results.)

NOTE 5—For some Test Method D323 apparatus, a Number 6.5 rubber stopper has been found satisfactory. For the horizontal or Herzog apparatus, a Number 3 rubber stopper and a Number 000 cork in the vent hole is satisfactory. Another procedure is to attach a spare liquid chamber to the vapor chamber during the conditioning period. A third alternative is to utilize a cap threaded to match the threads of the vapor chamber. Several apparatus manufacturers have indicated the intention to supply such caps for equipment. In any procedure used, the interior surfaces of the vapor pressure apparatus and the sample must be kept completely free of water.

8.5.2 Immerse the vapor chamber in a water bath maintained at 37.8 °C ± 0.1 °C (100 °F ± 0.2 °F) for not less than 20 min. The top of the vapor chamber must be at least 25 mm (1 in.) below the surface of the water (Procedure A). (In Procedure B the vapor chamber lies horizontally, completely immersed in the water bath.) Do not remove the vapor chamber from the water bath until the liquid chamber has been filled with sample as described in 9.1.

## 9. Procedure

9.1 *Sample Transfer*—Remove the sample from the cooling bath, dry the exterior of the container with absorbent material, uncap, and insert the chilled transfer tube (see Fig. 1). Remove the liquid chamber from the cooling bath and, using an absorbent material, dry the threaded top 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.)

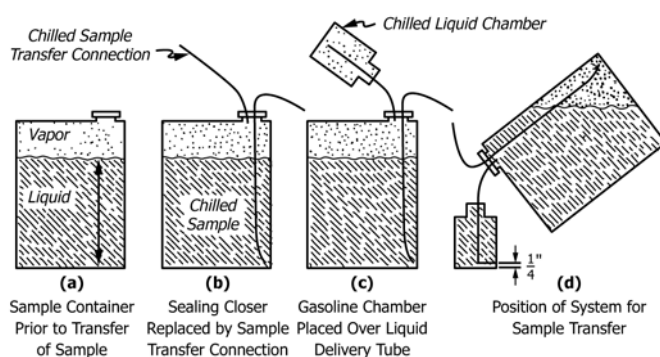


FIG. 1 Simplified Sketches Outlining Method Transferring Sample to Liquid Chamber from Open-Type Containers

from the bottom of the liquid chamber. Fill the chamber to overflowing. Withdraw the transfer tube from the liquid chamber while allowing the sample to continue flowing up to complete withdrawal. (**Warning**—Provision shall be made for suitable containment and disposal of the overflowing sample to avoid fire hazard.)

9.2 *Assembly of Apparatus*—Immediately remove the vapor chamber from the water bath and, as quickly as possible, dry the exterior of the chamber with absorbent material with particular care given to the connection between the vapor chamber and the liquid chamber. Remove the closure from the vapor chamber 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 and dried and the closure is removed, 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 should elapse between removing the vapor chamber from the water bath and completion of the coupling of the two chambers. With Procedure B it is necessary to disconnect the spiral tubing at the quick action disconnect after removing from the water bath and before making the connection to the vapor chamber.

#### 9.3 Introduction of the Apparatus into Bath:

9.3.1 *Procedure A*—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 lengthwise. 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. Carefully examine for leaks. 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.

9.3.2 *Procedure B*—While holding the apparatus in a vertical position immediately reconnect the spiral tubing at the quick action disconnect. Tilt the apparatus to 20° to 30° downward for 4 s or 5 s to allow the sample to flow into the vapor chamber without getting into the tube extending into the vapor chamber from the gauge or pressure transducer. Place the assembled apparatus into the water bath maintained at 37.7 °C

$\pm 0.1\text{ }^{\circ}\text{C}$  ( $100\text{ }^{\circ}\text{F} \pm 0.2\text{ }^{\circ}\text{F}$ ) in such a way that the bottom of the liquid chamber engages the drive coupling and the other end of the apparatus rests on the support bearing. Observe the apparatus for leakage throughout the test. Discard the test anytime a leak is detected.

**9.4 Verification of Single Phase Sample**—After the apparatus has been immersed in the bath, check the remaining sample for phase separation. If the sample is contained in a transparent container, this observation can be made prior to sample transfer (9.1). If the sample is contained in a non-transparent container, mix the sample thoroughly and immediately pour a portion of the remaining sample into a clear glass container and observe for evidence of phase separation. A hazy appearance is to be carefully distinguished from separation into two distinct phases. The hazy appearance shall not be considered grounds for rejection of the fuel. If a second phase is observed, discard the test and the sample. Hazy samples may be analyzed (see Report section).

#### 9.5 Measurement of Vapor Pressure:

**9.5.1 Procedure A**—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 9.3. At intervals of not less than 2 min, tap the gauge, observe the reading and repeat the instructions given in 9.3 until a total of not less than five shakings and gauge readings have been made and continuing thereafter if necessary until the last two consecutive gauge readings are constant, 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 and, without attempting to remove any liquid that may be trapped in the gauge, check its reading against that of the pressure measuring device while both are subjected to a common steady pressure that is not more than 1.0 kPa (0.2 psi) from the recorded uncorrected vapor pressure. If a difference is observed between the gauge and the pressure measuring device readings, add to or subtract the difference from the uncorrected vapor pressure and record the resulting value as the vapor pressure of the sample.

**9.5.2 Procedure B**—After the assembled apparatus has been in the bath for at least 5 min, tap the pressure gauge lightly and observe the reading. Repeat the tapping and reading at intervals of not less than 2 min, until 2 consecutive readings are constant. (Tapping is not necessary with transducer model but the reading intervals are the same.) Read the final gauge or transducer pressure to the nearest 0.25 kPa (0.05 psi) and record this value as the uncorrected vapor pressure. Without undue delay, disconnect the gauge or pressure transducer from the apparatus and check its reading against that of the pressure measuring device while both are subjected to a common steady pressure that is not more than 1.0 kPa (0.2 psi) different from the recorded uncorrected vapor pressure. If a difference is observed between the gauge or transducer and the pressure measuring device, add to or subtract the difference from the uncorrected vapor pressure and record the resulting value as the vapor pressure of the sample.

NOTE 6—If it is suspected that phase separation of the sample may have

occurred during the test procedure, the following procedure can be performed to verify the integrity of the test sample. Perform the following operations as quickly as possible after removing the apparatus from the water bath in order to maintain the temperature of the sample at or near the test temperature. Quickly dry the exterior surfaces of the liquid and vapor chambers with absorbent material. With the apparatus in an upright position, disconnect the vapor and liquid chambers. Quickly drain the contents of the liquid chamber into a dry, clear, glass container and observe the sample. If the sample is not clear and bright and free of a second phase, cap the container, reheat the sample to  $37.8\text{ }^{\circ}\text{C}$  ( $100\text{ }^{\circ}\text{F}$ ), mix the sample well, and observe the sample again. If the sample is still not clear and bright and free of a second phase, phase separation has occurred and the test may not be valid.

**9.6 Preparation of Apparatus for Next Test**—Thoroughly purge the vapor chamber of residual sample by filling it with warm water above  $32\text{ }^{\circ}\text{C}$  ( $90\text{ }^{\circ}\text{F}$ ) 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, then several times with acetone, then blow dry using dried air. Appropriately close the liquid chamber and place it in the cooling bath or refrigerator in preparation for the next test. Use an appropriate closure for the bottom connection (where liquid chamber attaches) of the vapor chamber and attach the gauge after the gauge has been prepared in accordance with 9.6.2.

**9.6.1** If the purging of the vapor chamber is done in a bath, be sure to avoid small films of floating sample by keeping the bottom and top openings of the chamber closed as they pass through the water surface.

**9.6.2 Preparation of Gauge (Procedure A)**—Disconnect the gauge from its manifold connection with the pressure measuring device, remove trapped liquid in the Bourdon tube of the gauge by repeated centrifugal thrusts. Accomplish this in the following manner: hold the gauge between the palms of the hands with the right palm on the face of the gauge and the threaded connection of the gauge forward, extend the arms forward and upward at an angle of  $45^{\circ}$ , and swing the arms rapidly downward through an arc of about  $135^{\circ}$  so that centrifugal force aids gravity in removing trapped liquid. Repeat this operation at least 3 times or until all liquid has been expelled from the gauge. Connect the gauge to the vapor chamber with the liquid connection closed and place in the  $37.8\text{ }^{\circ}\text{C}$  ( $100\text{ }^{\circ}\text{F}$ ) bath to condition for the next test.

**9.6.3 Preparation of Gauge or Transducer (Procedure B)**—In the correct operation of Procedure B liquid does not reach the gauge or transducer. If it is observed or suspected that liquid has reached the gauge, purge the gauge as described in 9.6.2. The transducer has no cavity to trap liquid. Ensure that no liquid is present in the T-handle fitting or spiral tubing by forcing a stream of dry air through the tubing. Connect the gauge or transducer to the vapor chamber with the liquid connection closed and place in the  $37.8\text{ }^{\circ}\text{C}$  ( $100\text{ }^{\circ}\text{F}$ ) bath to condition for the next test.

## 10. Report

**10.1 Reporting Results**—Report the vapor pressure to the nearest 0.25 kPa (0.05 psi) in kilopascals (pounds-force per square inch) without reference to temperature.

**10.2** If the sample was observed to be hazy in 9.4, report the test result as in 10.1, followed by the letter “H.”