



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

This standard is issued under the fixed designation D 323; 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 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. Procedure A is applicable to gasoline and other petroleum products with a vapor pressure of less than 180 kPa (26 psi). 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. Neither procedure is applicable to liquefied petroleum gases or fuels containing oxygenated compounds other than methyl *t*-butyl ether (MTBE) (see Note 2). Procedure C is for materials with a vapor pressure of greater than 180 kPa (26 psi) and 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.

NOTE 2—For determination of the vapor pressure of liquefied petroleum gases refer to Test Method D 1267. For determination of the vapor pressure of gasoline-oxygenate blends refer to Test Method D 4953.

1.2 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are provided for information only.

1.3 *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 precautionary statements are given in Sections 6 and 17, and Note 6, Note 9, Note 12, Note 13, Note A1.1 and Note A1.2.

2. Referenced Documents

2.1 ASTM Standards:

D 1267 Test Method for Vapor Pressure of Liquefied Petro-

leum (LP) Gases (LP-Gas Method)²

D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products³

D 4953 Test Method for Vapor Pressure of Gasoline and Gasoline-Oxygenate Blends (Dry Method)³

E 1 Specification for ASTM Thermometers⁴

3. Summary of Test Method

3.1 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.

3.2 All four procedures utilize liquid and vapor chambers of the same internal volume. Procedure B utilizes a semi-automatic apparatus immersed in a horizontal bath and rotated while attaining equilibrium. Either a Bourdon gage 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.

4. Significance and Use

4.1 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).

4.2 Vapor pressure is critically important for both automotive and aviation gasolines, affecting starting, warmup, 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.

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

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

¹ This test method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.08 on Volatility.

Current edition approved April 10, 1999. Published June 1999. Originally published as D 323 – 30. Last previous edition D 323 – 99.

² *Annual Book of ASTM Standards*, Vol 05.01.

³ *Annual Book of ASTM Standards*, Vol 05.02.

⁴ *Annual Book of ASTM Standards*, Vol 14.03.

5. Apparatus

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

6. Hazards

6.1 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:

6.1.1 *Checking the Pressure Gage*—Check all gages against a pressure measuring device (see A1.6) after each test to ensure higher precision of results (see 11.4). Read the gage while in a vertical position and after tapping it lightly.

6.1.2 *Checking for Leaks*—Check all apparatus before and during each test for both liquid and vapor leaks (see Note 7).

6.1.3 *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 7 and 11.1). In no case shall any part of the Reid apparatus itself be used as the sample container prior to actually conducting the test.

6.1.4 *Purging the Apparatus*—Thoroughly purge the pressure gage, 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 11.5 and 14.5).

6.1.5 *Coupling the Apparatus*—Carefully observe the requirements of 11.2.

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

7. Sampling

7.1 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 18.

7.2 Sampling shall be done in accordance with Practice D 4057.

7.3 *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.

7.3.1 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 Practice D 4057 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.

7.4 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.

7.4.1 Protect samples from excessive heat prior to testing.

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

7.5 *Sampling Handling Temperature*—In all cases, cool the sample container and contents to 0 to 1°C (32 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.

8. Report

8.1 Report the result observed in 11.4 or 14.4, after correcting for any difference between the gage and the pressure measuring device (see A1.6), to the nearest 0.25 kPa (0.05 psi) as the Reid vapor pressure.

9. Precision and Bias

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

9.1.1 *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.

Procedure	Range		Repeatability		
	kPa	psi	kPa	psi	
A Gasoline	35–100	5–15	3.2	0.46	Note 3
B Gasoline	35–100	5–15	1.2	0.17	Note 3
A	0–35	0–5	0.7	0.10	Note 4
A	110–180	16–26	2.1	0.3	Note 4
C	>180	>26	2.8	0.4	Note 4
D Aviation Gasoline	50	7	0.7	0.1	Note 4

9.1.2 *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.

Procedure	Range		Reproducibility		
	kPa	psi	kPa	psi	
A Gasoline	35–100	5–15	5.2	0.75	Note 3
B Gasoline	35–100	5–15	4.5	0.66	Note 3
A	0–35	0–5	2.4	0.35	Note 4
A	110–180	16–26	2.8	0.4	Note 4
C	>180	>26	4.9	0.7	Note 4
D Aviation Gasoline	50	7	1.0	0.15	Note 4

NOTE 3—These precision values are derived from a 1987 cooperative program⁵ and the current Committee D-2 Statistical Method RR:D02-1007.

NOTE 4—These precision values were developed in the early 1950's prior to the current statistical evaluation method.

9.2 Bias:

9.2.1 *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.

⁵ The results of the cooperative test program from which these values have been derived are filed at ASTM Headquarters. Request RR:D02-1245.

9.2.2 *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)**

10. Preparation for Test

10.1 *Verification of Sample Container Filling*—With the sample at a temperature of 0 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 gage, confirm that the sample volume equals 70 to 80 % of the container capacity (see Note 5). If the sample is contained in a transparent glass container, verify that the container is 70 to 80 % full by suitable means (see Note 5).

NOTE 5—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 that has the 70 and 80 % levels clearly marked, has been found suitable.

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

10.1.2 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.

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

10.2 Air Saturation of Sample in Sample Container:

10.2.1 *Non-transparent Containers*—With the sample again at a temperature between 0 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.

10.2.2 *Transparent Containers*—Since 10.1 does not require that the sample container be opened to verify the sample 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 non-transparent containers. After performing this task, proceed with 10.2.1.

10.2.3 Repeat 10.2.1 twice more. Return the sample to the bath until the beginning of the procedure.

10.3 *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 and 1°C (32 and 34°F) for at least 10 min.

10.4 *Preparation of Vapor Chamber*—After purging and rinsing the vapor chamber and pressure gage in accordance with 11.5, connect the gage 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 $37.8 \pm 0.1^\circ\text{C}$ ($100 \pm 0.2^\circ\text{F}$) 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 11.1.

11. Procedure

11.1 *Sample Transfer*— Remove the sample from the cooling bath, uncup, 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 (see Note 6). Withdraw the transfer tube from the liquid chamber while allowing the sample to continue flowing up to complete withdrawal.

NOTE 6—**Precaution:** In addition to other precautions, make provision for suitable containment and disposal of the overflowing sample to avoid fire hazard.

11.2 *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.

11.3 *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 gage end up, immerse the assembled apparatus in the bath, maintained at $37.8 \pm 0.1^\circ\text{C}$ ($100 \pm 0.2^\circ\text{F}$), 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 7). 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 7—Liquid leaks are more difficult to detect than vapor leaks; and because the coupling between the chambers is normally in the liquid section of the apparatus, give it particular attention.

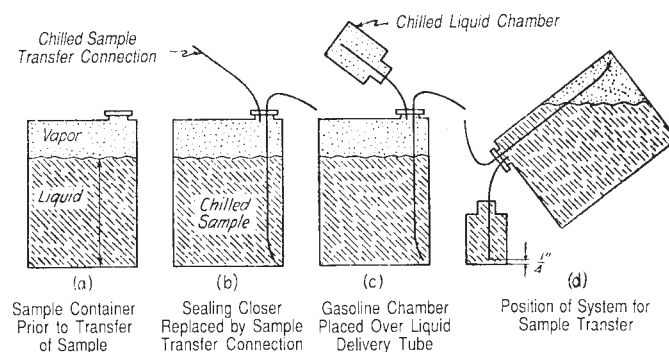


FIG. 1 Simplified Sketches Outlining Method Transferring Sample to Liquid Chamber from Open-Type Containers



11.4 *Measurement of Vapor Pressure*—After the assembled apparatus has been in the water bath for at least 5 min, tap the pressure gage lightly and observe the reading. Withdraw the apparatus from the bath and repeat the instructions of 11.3. At intervals of not less than 2 min, tap the gage, observe the reading, and repeat 11.3 until a total of not less than five shakings and gage readings have been made. Continue this procedure, as necessary, until the last two consecutive gage readings are the same, indicating that equilibrium has been attained. Read the final gage 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 gage from the apparatus (see Note 8) without attempting to remove any liquid that may be trapped in the gage, 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 gage 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 8—Cooling the assembly prior to disconnecting the gage will facilitate disassembly and reduce the amount of hydrocarbon vapors released into the room.

11.5 *Preparation of Apparatus for Next Test:*

11.5.1 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, then several times with acetone, then blow dry using dried air. Place the liquid chamber in the cooling bath or refrigerator in preparation for the next test.

11.5.2 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.

11.5.3 *Preparation of Gage*—Disconnect the gage from its manifold connection with the pressure measuring device and remove trapped liquid in the Bourdon tube of the gage by repeated centrifugal thrusts. This is accomplished in the following manner: hold the gage between the palms of the hands with the right palm on the face of the gage and the threaded connection of the gage forward. Extend the arms forward and upward at an angle of 45°. Swing the arms rapidly downward through an arc of about 135° so that centrifugal force aids gravity in removing trapped liquid. Repeat this operation at least three times or until all liquid has been expelled from the gage. Connect the gage to the vapor chamber with the liquid connection closed and place in the 37.8°C (100°F) bath to condition for the next test. (see Note 9).

NOTE 9—**Caution:** Do not leave the vapor chamber with the gage attached in the water bath for a longer period of time than necessary to condition for the next test. Water vapor can condense in the Bourdon tube and lead to erroneous results.

PROCEDURE B FOR PETROLEUM PRODUCTS HAVING REID VAPOR PRESSURES BELOW 180 kPa (26 psi), (HORIZONTAL BATH)

12. Sampling

12.1 Refer to Section 7.

13. Preparation for Test

13.1 Refer to Section 10.

14. Procedure

14.1 *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 (see Note 6). Withdraw the transfer tube from the liquid chamber while allowing the sample to continue flowing up to complete withdrawal.

14.2 *Assembly of Apparatus*—Immediately remove the vapor chamber from the water bath. Disconnect the spiral tubing at the quick action disconnect. Couple the filled liquid chamber to the vapor chamber as quickly as possible without spillage or movement that could promote exchange of room temperature air with the 37.8°C (100°F) air in the vapor 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.

14.3 *Introduction of the Apparatus into the Bath*—While holding the apparatus vertically, immediately reconnect the spiral tubing at the quick action disconnect. Tilt the apparatus between 20 and 30° downward for 4 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 gage, or pressure transducer. Place the assembled apparatus into the water bath maintained at $37.8 \pm 0.1^\circ\text{C}$ ($100 \pm 0.2^\circ\text{F}$) 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. Turn on the switch to begin the rotation of the assembled liquid-vapor chambers. Observe the apparatus for leakage throughout the test (see Note 7). Discard the test at anytime a leak is detected.

14.4 *Measurement of Vapor Pressure*—After the assembled apparatus has been in the bath for at least 5 min, tap the pressure gage lightly and observe the reading. Repeat the tapping and reading at intervals of not less than 2 min, until two consecutive readings are the same. (Tapping is not necessary with the transducer model but the reading intervals should be the same.) Read the final gage 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 gage from the apparatus. Connect the gage or pressure transducer to a pressure measuring device. Check its reading against that of the pressure measuring device 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 gage or transducer 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.

14.5 Preparation of Apparatus for Next Test:

14.5.1 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, then several times with acetone, then blow dry using dried air. Place the liquid chamber in the cooling bath or refrigerator in preparation for the next test (see Note 9).

14.5.2 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.

14.5.3 *Preparation of Gage or Transducer*—In the correct operation of this procedure, liquid should not reach the gage or transducer. If it is observed or suspected that liquid has reached the gage, purge the gage as described in 11.5.3. 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 gage or transducer to the vapor chamber with the liquid connection closed and place in the 37.8°C (100°F) bath to condition for the next test.

PROCEDURE C FOR PETROLEUM PRODUCTS HAVING REID VAPOR PRESSURES ABOVE 180 kPa (26 psi)

15. Introduction

15.1 With products having vapor pressure over 180 kPa (26 psi) see Note 10), the procedure described in Sections 7-11 is hazardous and inaccurate. Consequently, the following sections define changes in apparatus and procedure for the determinations of vapor pressures above 180 kPa. Except as specifically stated, all the requirements of Sections 1-11 shall apply.

NOTE 10—If necessary, either Procedure A or B can be used to determine if the vapor pressure of a product is above 180 kPa.

16. Apparatus

16.1 Apparatus as described in Annex A1 using the liquid chamber with two openings.

16.2 *Pressure Gage Calibration*—A dead-weight tester (see A1.7) can be used in place of the mercury manometer as a pressure measuring device (see A1.6) for checking gage readings above 180 kPa (26 psi). In 6.1.1, 8.1, 11.4, and 11.5.3 where the words *pressure measuring device* and *pressure measuring device reading* appear, include as an alternative *dead-weight tester* and *calibrated gage reading* respectively.

17. Hazards

17.1 The precaution in 6.1.6 shall not apply.

18. Sampling

18.1 Sections 7.3, 7.3.1, 7.4 and 7.5 shall not apply.

18.2 *Sample Container Size*—The size of the sample container from which the vapor pressure sample is taken shall not be less than 0.5 L (1 pt) liquid capacity.

19. Preparation for Test

19.1 Paragraphs 10.1 and 10.2 shall not apply.

19.2 Any safe method of displacement of the test sample from the sample container that ensures filling the liquid chamber with a chilled, unweathered sample may be employed. The following, 19.3-19.5, describe displacement by self-induced pressure.

19.3 Maintain the sample container at a temperature sufficiently high to maintain superatmospheric pressure but not substantially over 37.8°C (100°F).

19.4 Completely immerse the liquid chamber, with both valves open, in the water cooling bath for a sufficient length of time to allow it to reach the bath temperature of 0 to 4.5°C (32 to 40°F).

19.5 Connect a suitable ice-cooled coil to the outlet valve of the sample container (see Note 11).

NOTE 11—A suitable ice-cooled coil can be prepared by immersing a spiral of approximately 8 m (25 ft) of 6.35-mm (0.25-in.) copper tubing in a bucket of ice water.

20. Procedure

20.1 Paragraphs 11.1 and 11.2 shall not apply.

20.2 Connect the 6.35-mm (0.25-in.) valve of the chilled liquid chamber to the ice-cooled coil. With the 12.7-mm (0.5 in.) valve of the liquid chamber closed, open the outlet valve of the sample container and the 6.35-mm (0.25-in.) valve of the liquid chamber. Open the liquid chamber 12.7-mm (0.5-in.) valve slightly and allow the liquid chamber to fill slowly. Allow the sample to overflow until the overflow volume is 200 mL or more. Control this operation so that no appreciable drop in pressure occurs at the liquid chamber 6.35-mm (0.25-in.) valve. In the order named, close the liquid chamber 12.7-mm (0.5-in.) and 6.35-mm (0.25-in.) valves; and then close all other valves in the sample system. Disconnect the liquid chamber and the cooling coil.

NOTE 12—**Warning:** Combustible. Keep away from heat, sparks, and open flame. Keep container closed. Use only with adequate ventilation. Avoid prolonged breathing of vapor or spray mist. Avoid prolonged, repeated contact with skin.

NOTE 13—**Precaution:** In addition to other precautions, provide a safe means of disposal of liquid and vapor escaping during this whole operation.

20.2.1 To avoid rupture because of the liquid-full condition of the liquid chamber, the liquid chamber must be quickly attached to the vapor chamber and the 12.7-mm (0.5-in.) valve opened.

20.3 Immediately attach the liquid chamber to the vapor chamber and open the liquid chamber 12.7-mm (0.5-in.) valve. Not more than 25 s shall pass in completing the assembly of the apparatus after filling the liquid chamber, using the following sequence of operations:

20.3.1 Remove the vapor chamber from the water bath.



20.3.2 Connect the vapor chamber to the liquid chamber.

20.3.3 Open the liquid chamber 12.7-mm (0.5-in.) valve.

20.4 If a dead-weight tester is used instead of the mercury manometer as a pressure measuring device (see 16.2), apply the calibration factor in kilopascals (pounds-force per square inch) established for the pressure gage to the uncorrected vapor pressure. Record this value as the calibrated gage reading and use in Section 8 in place of the pressure measuring device reading.

PROCEDURE D FOR AVIATION GASOLINES APPROXIMATELY 50 kPa (7 psi) REID VAPOR PRESSURE

21. Introduction

21.1 The following sections define changes in apparatus and procedure for the determination of the vapor pressure of aviation gasoline. Except as specifically stated hererin, all the requirements set forth in Sections 1-11 shall apply.

22. Apparatus

22.1 *Ratio of Vapor and Liquid Chambers*—The ratio of the volume of the vapor chamber to the volume of the liquid chamber shall be between the limits of 3.95 and 4.05 (see A1.1.4).

23. Sampling

23.1 Refer to Section 7.

24. Preparation for Test

24.1 *Checking the Pressure Gage or Pressure Transducer*—The gage shall be checked at 50 kPa (7 psi) against a mercury column (or some other calibrated pressure measuring device) before each vapor pressure measurement to ensure that it conforms to the requirements of A1.2. This preliminary check shall be made in addition to the final gage comparison specified in 11.4 or 14.4.

25. Procedure

25.1 Refer to Section 11.

26. Keywords

26.1 crude oils; gasoline; Reid vapor pressure; spark-ignition engine fuel; vapor pressure; volatility

ANNEXES

(Mandatory Information)

A1. APPARATUS FOR VAPOR PRESSURE TEST PROCEDURE A

A1.1 *Reid Vapor Pressure Apparatus*, consisting of two chambers, a vapor chamber (upper section) and a liquid chamber (lower section), shall conform to the following requirements:

A1.1.1 *Vapor Chamber*— The upper section or chamber, as shown in Fig. A1.1, shall be a cylindrical vessel having the inside dimensions of 51 ± 3 mm ($2 \pm \frac{1}{8}$ in.) in diameter and 254 ± 3 mm ($10 \pm \frac{1}{8}$ in.) in length, with the inner surfaces of the ends slightly sloped to provide complete drainage from either end when held in a vertical position. On one end of the vapor chamber, a suitable gage coupling with an internal diameter of not less than 4.7 mm ($\frac{3}{16}$ in.) shall be provided to receive the 6.35-mm ($\frac{1}{4}$ -in.) gage connection. In the other end of the vapor chamber, an opening approximately 12.7 mm ($\frac{1}{2}$ -in.) in diameter shall be provided for coupling with the liquid chamber. Care shall be taken that the connections to the openings do not prevent the chamber from draining completely.

A1.1.2 *Liquid Chamber—One Opening*—The lower section or liquid chamber, as shown in Fig. A1.1, shall be a cylindrical vessel of the same inside diameter as the vapor chamber and of such a volume that the ratio of the volume of the vapor chamber to the volume of the liquid chamber shall be between 3.8 and 4.2. (see A1.1.3). In one end of the liquid chamber an opening of approximately 12.7 mm ($\frac{1}{2}$ in.) in diameter shall be

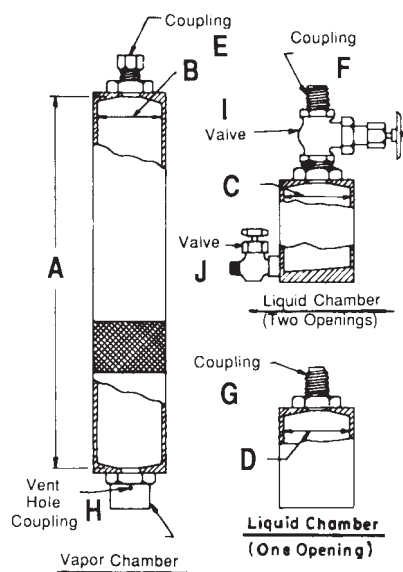
provided for coupling with the vapor chamber. The inner surface of the coupling end shall be sloped to provide complete drainage when inverted. The other end of the chamber shall be completely closed.

NOTE A1.1—**Caution:** To maintain the correct volume ratio between the vapor chamber and the liquid chamber, paired chambers shall not be interchanged without recalibration to ascertain that the volume ratio is within the required limits.

A1.1.3 The ratio of paired vapor and liquid chambers to be used for aviation gasoline testing shall be between 3.95 and 4.05.

A1.1.4 *Liquid Chamber—Two Openings*—For sampling from closed vessels, the liquid section of liquid chamber, as shown in Fig. A1.1, shall be essentially the same as the liquid chamber described in A1.1.2, except that a 6.35-mm (0.25-in.) valve shall be attached near the bottom of the liquid chamber and a 12.7-mm (0.5-in.) straight-through, full-opening valve shall be introduced in the coupling between the chambers. The volume of the liquid chamber, including only the capacity enclosed by the valves, shall fulfill the volume ratio requirements as set forth in A1.1.2.

A1.1.5 In determining the capacities for the two-opening liquid chamber (Fig. A1.1), the capacity of the liquid chamber shall be considered as that below the 12.7-mm (0.5-in.) valve



DIMENSIONS OF VAPOR PRESSURE APPARATUS

Key	Description	mm	in.
A	Vapor chamber, length	254 ± 3	10 ± 1/8
B, C, D	Vapor and gasoline chambers, Liquid ID	51 ± 3	2 ± 1/8
E	Coupling, ID min	4.7	3/16
F, G	Coupling, OD	12.7	1/2
H	Coupling, ID	12.7	1/2
I	Valve	12.7	1/2
J	Valve	6.35	1/4

FIG. A1.1 Vapor Pressure Apparatus

closure. The volume above the 12.7-mm (0.5-in.) valve closure, including the portion of the coupling permanently attached to the liquid chamber, shall be considered as a part of the vapor chamber capacity.

A1.1.6 Method of Coupling Vapor and Liquid Chambers—Any method of coupling the vapor and liquid chambers can be employed, provided that no sample is lost from the liquid chamber during the coupling operation, that no compression effect is caused by the act of coupling, and that the assembly is free of leaks under the conditions of the tests. To avoid displacement of sample during assembly, the male fitting of the coupling must be on the liquid chamber. To avoid compression of air during assembly, a vent hole must be present to ensure atmospheric pressure in the vapor chamber at the instant of sealing.

NOTE A1.2—Caution: Some commercially available apparatus do not make adequate provision for avoiding air compression effects. Before employing any apparatus, it shall be established that the act of coupling the two chambers does not compress air in the vapor chamber. This can be accomplished by tightly stoppering the liquid chamber and coupling the apparatus in the normal manner, utilizing a 0 to 35 kPa (0 to 5 psi) gage. Any observable pressure increase on the gage is an indication that the apparatus does not adequately meet the specifications of this test method. If this problem is encountered, consult the manufacturer for a remedy.

A1.1.7 Volumetric Capacity of Vapor and Liquid Chambers—To ascertain if the volume ratio of the chambers is within the specified limits of 3.8 to 4.2 (see A1.1.3), carefully measure a quantity of water greater than will be required to fill the two chambers. (A dispensing buret is a convenient vessel for this operation.) Without spillage fill the liquid chamber completely. The difference between the original volume and the remaining volume of the measured water quantity is the volume of the liquid chamber. Without spillage couple the liquid and vapor chambers and fill the vapor chamber to the seat of the gage connection with more of the measured water. The difference between the final volume of the measured water quantity and the intermediate volume measured after ascertaining the liquid chamber volume is the volume of the vapor chamber.

A1.2 Pressure Gage—The pressure gage shall be a Bourdon type spring gage of test gage quality 100 to 150 mm (4.5 to 6.5 in.) in diameter provided with a nominal 6.35-mm (0.25-in.) male thread connection with a passageway not less than 4.7 mm (3/16 in.) in diameter from the Bourdon tube to the atmosphere. The range and graduations of the pressure gage shall be governed by the vapor pressure of the sample being tested, in accordance with Table A1.1. Only accurate gages shall be continued in use. When the gage reading differs from the pressure measuring device reading, or dead-weight tester reading when testing gages above 180 kPa (26 psi), by more than 1 % of the scale range of the gage, the gage shall be considered inaccurate. For example, the calibration correction shall not be greater than 0.3 kPa (0.15 psi) for a 0 to 30-kPa (0 to 15 psi-) gage or 0.9 kPa (0.3 psi) for a 0 to 90-kPa (0 to 30-psi) gage.

NOTE A1.3—Gages 90 mm (3.5 in.) in diameter can be used in the 0 to 35 kPa (0 to 5 psi) range.

A1.3 Cooling Bath—A cooling bath shall be provided of such dimensions that the sample containers and the liquid

TABLE A1.1 Pressure Gage Range and Graduations

Reid Vapor Pressure		Gage to be Used					
		Scale Range		Maximum Numbered Intervals		Maximum Intermediate Graduations	
kPa	psi	kPa	psi	kPa	psi	kPa	psi
≤ 27.5	≤ 4	0–35	0–5	5.0	1	0.5	0.1
20.0–75.0	3–12	0–100	0–15	15.0	3	0.5	0.1
70.0–180.0	10–26	0–200	0–30	25.0	5	1.0	0.2
70.0–250.0	10–36	0–300	0–45	25.0	5	1.0	0.2
200.0–375.0	30–55	0–400	0–60	50.0	10	1.5	0.25
≥ 350.0	≥ 50	0–700	0–100	50.0	10	2.5	0.5

chambers can be completely immersed. Means for maintaining the bath at a temperature between 0 and 1 (32 and 34°F) must be provided. Do not use solid carbon dioxide to cool samples in storage or in the preparation of the air saturation step. Carbon dioxide is appreciably soluble in gasoline and its use has been found to be the cause of erroneous vapor pressure data.

A1.4 Water Bath—The water bath shall be of such dimensions that the vapor pressure apparatus can be immersed to at least 25.4 mm (1 in.) above the top of the vapor chamber. Means for maintaining the bath at a constant temperature of $37.8 \pm 0.1^\circ\text{C}$ ($100 \pm 0.2^\circ\text{F}$) shall be provided. In order to check this temperature, the bath thermometer shall be immersed to the 37°C (98°F) mark throughout the vapor pressure determination.

A1.5 Thermometer—An ASTM Reid Vapor Pressure Thermometer 18C (18F) having a range from 34 to 42°C (94 to 108°F) and conforming to the requirements in Specification E 1.

A1.6 Pressure Measuring Device—A pressure measuring device having a range suitable for checking the pressure gage employed shall be used. The pressure measuring device shall have a minimum accuracy of 0.5 kPa (0.07 psi) with increments no larger than 0.5 kPa (0.07 psi).

A1.6.1 When a mercury manometer is not used as the pressure measuring device, the calibration of the pressure measuring device employed shall be periodically checked

(with traceability to a nationally recognized standard) to ensure that the device remains within the required accuracy specified in A1.6.

A1.7 Dead-Weight Tester—A dead-weight tester can be used in place of the mercury manometer if used as the pressure measuring device(A1.6) for checking gage readings above 180 kPa (26 psi).

A1.8 Sample Transfer Connection—This is a device for removing liquid from the sample container without interfering with the vapor space. The device consists of two tubes inserted into a two-holed stopper of appropriate dimensions to fit the opening of the sample container. One of the tubes is short for the delivery of the sample, and the other is long enough to reach the bottom corner of the sample container. Fig. A1.2 shows a suitable arrangement.

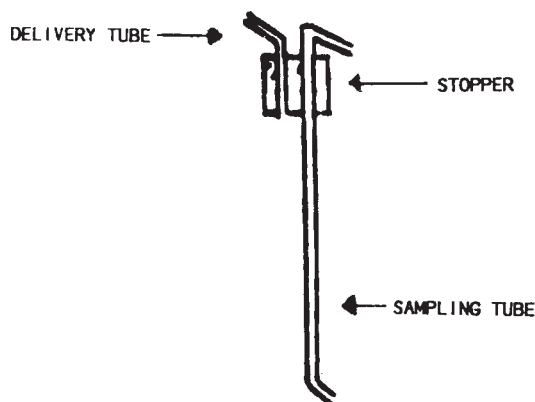


FIG. A1.2 Sample Transfer Connection

A2. APPARATUS FOR VAPOR PRESSURE TEST PROCEDURE B

A2.1 Vapor Pressure Apparatus—Refer to A1.1.1 through Note A1.1 and A1.1.6 and A1.1.7.

A2.2 Pressure Gage—The pressure measuring system shall be a Bourdon type spring gage, as described in A1.2 or a suitable pressure transducer and digital readout. The pressure measuring system shall be remotely mounted from the vapor pressure apparatus and terminations provided for use of a quick connection type fitting.

A2.3 Cooling Bath—Refer to Note A1.1

A2.4 Water Bath—The water bath shall be of such dimensions that the vapor pressure apparatus can be immersed in a horizontal position. Provision shall be made to rotate the apparatus on its axis 350° in one direction and then 350° in the opposite direction in repetitive fashion. Means for maintaining the bath at a constant temperature of $37.8 \pm 0.1^\circ\text{C}$ ($100 \pm 0.2^\circ\text{F}$) shall be provided. In order to check this temperature, the

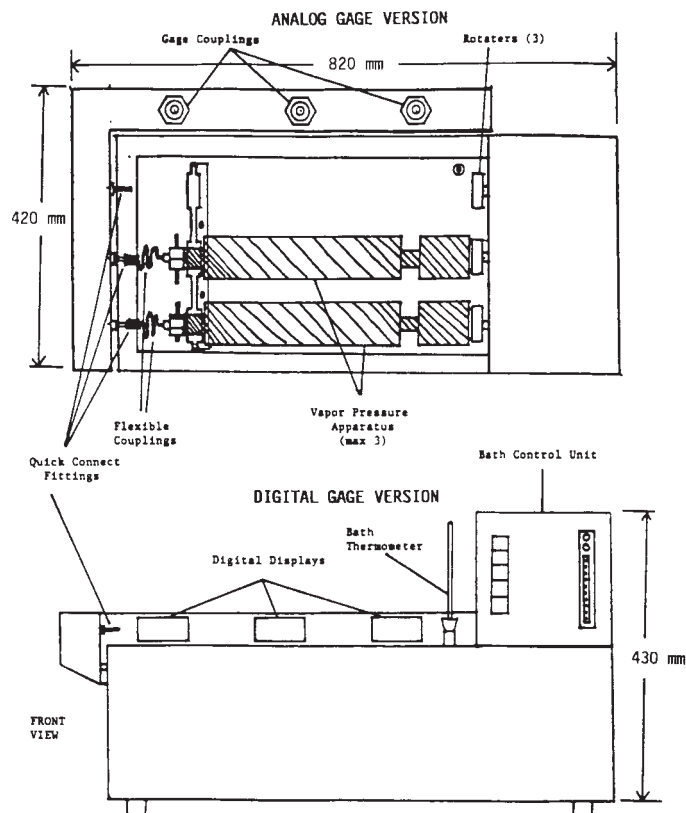


FIG. A2.1 Apparatus for Vapor Pressure, Procedure B

bath thermometer shall be immersed to the 37°C (98°F) mark throughout the vapor pressure determination. A suitable bath is shown in Fig. A2.1 and is available commercially.

A2.5 *Thermometers*—Refer to A1.5.

A2.6 *Pressure Measuring Device*—Refer to A1.6.

A2.7 *Flexible Coupler*—A suitable flexible coupling shall be provided for connection of the rotating vapor pressure apparatus to the pressure measuring device.

A2.8 *Vapor Chamber Tube*—The vapor chamber tube of inner diameter 3 mm ($\frac{1}{8}$ in.) and length of 114 mm (4.5 in.) shall be inserted into the pressure measuring end of the vapor chamber to prevent liquid from entering the vapor pressure measuring connections (see Fig. A2.2).

A2.9 *Sample Transfer Connection*—Refer to A1.8.

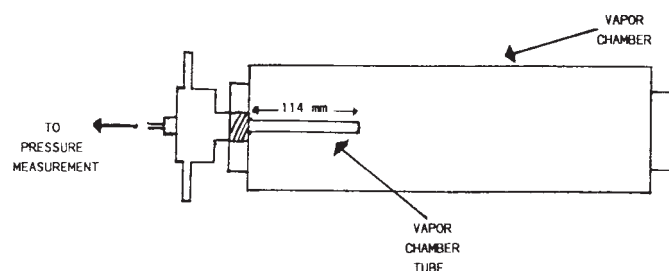


FIG. A2.2 Vapor Chamber Tube Inserted in Vapor Chamber

SUMMARY OF CHANGES

Committee D02.08 has identified the location of selected changes to this standard since the last issue (Test Method D 323-94) that may impact the use of this standard.

- (1) Updated the information in Footnote 6 to reflect current supplier.
- (2) A new Note 5 has been added after section 10.1 to provide guidance as to how to verify whether a transparent or non-transparent container is filled to between 70 and 80 % by volume of the sample container capacity.
- (3) A new paragraph, 10.1.3, has been added to explicitly state to reseal the sample container, if necessary.
- (4) A new paragraph, 10.2.1, has been added (and subsequent sections renumbered) to ensure that transparent and non-transparent containers are opened the same number of times prior to analysis.
- (5) A1.6 and A2.6 requirements have been changed from mercury manometer to pressure measuring device. An accuracy requirement for the pressure measuring device has also been specified. References to manometer have been replaced with pressure measuring device as appropriate throughout the method. Paragraph A1.6.1 has been added to require pressure measuring devices that are not mercury manometers to have their calibrations periodically checked (with traceability to a nationally recognized standard).

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