Standard Test Method for
Gage Vapor Pressure of Liquefied Petroleum (LP) Gases (LP-Gas Method)[1]

1. Scope*

1.1 This test method covers the determination of the gage vapor pressures of liquefied petroleum gas products (**Warning—**Flammable gas. Harmful when inhaled.) at temperatures of 37.8°C (100°F) up to and including a test temperature of 70°C (158°F).

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are 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.* For specific warning statements, see 1.1 and Annex A2.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

D1265 Practice for Sampling Liquefied Petroleum (LP) Gases, Manual Method

3. Terminology

3.1 *Definitions:*

3.1.1 *liquefied petroleum gases, n*—narrow boiling range hydrocarbon mixtures consisting mainly of propane or propylene, or both, and butanes or butylenes, or both, plus limited amounts of other hydrocarbons and naturally occurring non-hydrocarbons.

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

4. Summary of Test Method

4.1 The test apparatus, consisting of two interconnected chambers and equipped with a suitable pressure gage, is purged with a portion of the sample which is then discarded. The apparatus is then filled completely with the portion of the sample to be tested. Thirty-three and one-third to forty volume percent of the sample content of the apparatus is immediately withdrawn to provide adequate free space for product expansion. The apparatus is then immersed in a water bath maintained at the standard test temperature of 37.8°C (100°F) or, optionally, at some higher test temperature up to and including a test temperature of 70°C (158°F).

4.2 The observed gage pressure at equilibrium, after correcting for gage error and correcting to a standard barometric pressure, is reported as the LPG Vapor Pressure at the selected test temperature.

5. Significance and Use

5.1 Information on the vapor pressures of liquefied petroleum gas products under temperature conditions from 37.8 to 70°C (100 to 158°F) is pertinent to selection of properly designed storage vessels, shipping containers, and customer utilization equipment to ensure safe handling of these products.

5.2 Determination of the vapor pressure of liquefied petroleum gas is important for safety reasons to ensure that the maximum operating design pressures of storage, handling, and fuel systems will not be exceeded under normal operating temperature conditions.

5.3 For liquefied petroleum gases, vapor pressure is an indirect measure of the most extreme low temperature conditions under which initial vaporization can be expected to occur. It can be considered a semi-quantitative measure of the amount of the most volatile material present in the product.

6. Apparatus

6.1 *Vapor Pressure Apparatus,* constructed as illustrated in Fig. A1.1, and the various items of auxiliary equipment, are completely described in Annex A1.

6.2 The vapor chamber of Test Method D323, can be interchangeable with the upper chamber of this method. Similarly, the liquid chamber (two-opening type) of Test

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[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.H0 on Liquefied Petroleum Gas.

Current edition approved Nov. 1, 2012. Published February 2013. Originally approved in 1953. Last previous edition approved in 2007 as D1267–02(2007). DOI: 10.1520/D1267-12.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

Method D323 is interchangeable with the B, 20 % lower chamber A1.1.4 of this method. Because of this interchangeability, the apparatus assembly of Test Method D323 shall pass, as a safety precaution, the hydrostatic test specified in A1.1.6 before using it in testing liquefied petroleum gas.

6.3 *Water Bath,* temperature controlled, of a size suitable for the vapor pressure apparatus. See A1.3.

6.4 *Temperature Measuring Device,* of verified accuracy and capable of monitoring the desired test temperature in the water bath in the range of 35 to 70°C to within ±0.1°C.

7. Sampling and Sample Handling

7.1 Samples shall be obtained and stored in accordance with Practice D1265 unless the test samples can be taken directly from the source of the material to be tested.

7.2 Any method of coupling the vapor pressure apparatus to the sample source may be employed. Tubing, 6 to 7 mm (¼ in.) in diameter, of minimum length, of suitable-working pressure, and made of material corrosion-resistant to the products being sampled, is satisfactory for this purpose. A flexible tubing connection of a satisfactory type greatly facilitates the purging and sampling operations. The tubing should be a conducting material or constructed with a built-in ground connection to minimize the effect of static electricity.

8. Preparation of Apparatus

8.1 If the apparatus has been used for testing products other than the type of product to be tested, disassemble, clean thoroughly, and purge the parts in a stream of dry air.

8.2 Assemble the apparatus with the inlet valve of the lower chamber open, the straight-through valve between the two chambers open, the bleeder valve closed, and with the proper range pressure gage attached.

9. Procedure

9.1 Safe means for the disposal of vapors and liquids during this operation and in the subsequent sampling operation shall be provided.

9.2 *Purging*—With the assembled apparatus in an upright position, connect the inlet valve of the lower chamber to the sample source with the sampling connection (7.2). Open the sample source valve to the apparatus. Cautiously open the bleeder valve on the upper chamber, permitting the air or vapors, or both, in the apparatus to escape until the apparatus is full of liquid. Close the lower chamber inlet valve and open the bleeder valve to its wide open position. Allow the contained liquid to evaporate until the apparatus is covered with white frost (may require more than one chilling), then invert the assembly, and expel any residual material through the bleeder valve. Allow the residual vapors to escape until the pressure in the apparatus is essentially atmospheric, then close the bleeder valve.

9.3 *Sampling*—Return the apparatus, now containing only vapors, to its normal upright position and open the inlet valve. As soon as the apparatus attains essentially the same pressure as the pressure of the sample source, momentarily open the bleeder valve. If liquid does not promptly emerge, repeat the purging step (9.2). If liquid appears immediately, close the bleeder and inlet valves in that order (Note 1). Close the valve on the sample source, and disconnect the sampling line. Immediately close the straight-through valve between the two chambers and open the inlet valve, with the apparatus in an upright position. Close the inlet valve as soon as no more liquid escapes, and immediately open the straight-through valve.

NOTE 1—Transfer of the sample is facilitated by chilling the apparatus with a portion of the material under test.

9.3.1 When using the 33⅓ % lower chamber (A1.1.3) proceed to 9.4.

9.3.2 When using the 20 % lower chamber (Appendix A1.1.4), close the straight-through valve and again open the inlet to permit expulsion of the lower chamber contents. As soon as no more liquid escapes from the lower chamber, close the inlet valve and immediately open the straight-through valve.

9.3.3 The upper chamber, prior to this operation, is liquid full at some temperature that is normally below the environmental temperature. Since any warming of the apparatus would cause expansion of the liquid content of the upper chamber, leading to possible rupture of the chamber, it is necessary that the procedural steps of providing free space in the apparatus be completed promptly.

9.4 *Vapor Pressure Determination:*

9.4.1 Invert the apparatus and shake it vigorously. Return the apparatus to its normal upright position and immerse it in the constant-temperature water bath maintained at the test temperature (4.1). The apparatus including the bleeder valve coupling, but not the pressure gage, must be immersed. Throughout the determination, the temperature of the water bath shall be checked periodically by means of the temperature measuring device.

9.4.1.1 At test temperatures from 37.8°C (100°F) up to and including 50°C (122°F), maintain the bath at ±0.1°C (0.2°F). At test temperatures above 50°C (122°F), up to and including 70°C (158°F), maintain the bath at ±0.3°C (0.5°F).

9.4.1.2 Observe the apparatus assembly throughout the test period to ensure freedom from leaks. Discontinue the test and discard the results at any time a leak is detected.

9.4.2 After 5 min have elapsed, withdraw the apparatus from the water bath, invert it, shake it vigorously, and then return it to the bath. Perform the shaking operation quickly to avoid excessive cooling of the apparatus and its contents. Thereafter, at intervals of not less than 2 min, withdraw the apparatus from the bath, invert, shake it vigorously, and then return it to the bath. Prior to each removal of the apparatus from the water bath, tap the gage lightly and observe the pressure reading. These operations will normally require 20 to 30 min to ensure equilibrium. After this time, if consecutive observed gage readings are constant, record the pressure reading as the Uncorrected LP-Gas Vapor Pressure of the sample at the test temperature.

9.4.3 If a pressure gage is used that is not calibrated against a dead-weight tester, it is necessary to determine if a gage correction needs to be applied to the pressure gage reading. Without removing the pressure gage from the apparatus or the apparatus from the bath, attach a test gage, previously calibrated against a dead-weight tester, to the bleeder valve outlet and open the bleeder valve. At the end of 5 min, compare the readings of the two gages. Record any correction thus determined as gage correction.

9.4.3.1 Alternatively, if a pressure gage is used that has been calibrated against a dead-weight tester, then the gage correction is zero and it is not necessary to determine a gage correction as per 9.4.3, using a second test gage that has been calibrated against a dead-weight tester.

10. Calculation

10.1 Correct the Uncorrected LP-Gas Vapor Pressure for gage errors (see 9.4.3 and 9.4.3.1).

10.2 Convert the corrected vapor pressure = (test gage reading) + (gage correction) as calculated in 9.4.3 to a standard barometric pressure of 760 mm (29.92 in.) Hg by means of the following equation:

10.2.1 *LP-Gas Vapor Pressure:*

$$=\text{corrected vapor pressure, kPa} - (760 - P_1)\ 0.1333 \tag{1}$$

$$=\text{corrected vapor pressure, psi} - (760 - P_1)\ 0.0193 \tag{2}$$

where:

P_1 = observed barometric pressure, mm Hg.

10.2.2 *LP-Gas Vapor Pressure:*

$$=\text{corrected vapor pressure, kPa} - (29.92 - P_2)\ 3.3864 \tag{3}$$

$$=\text{corrected vapor pressure, psi} - (29.92 - P_2)\ 0.4912 \tag{4}$$

where:

P_2 = observed barometric pressure, in. Hg.

10.2.3 *Conversion Factors:*

$$1\ \text{kPa} = 7.50064\ \text{mmHg} = 0.295301\ \text{in. Hg} \tag{5}$$

$$1\ \text{psi} = 51.7151\ \text{mmHg} = 2.03603\ \text{in. Hg} \tag{6}$$

11. Report

11.1 Report the LP-Gas vapor pressure test results in terms of kilopascals to the nearest 5 kPa or pounds per square inch, to the nearest 0.5 psi gage, the test temperature, and reference this test method.

12. Precision and Bias

12.1 The following shall be used as a basis for judging the acceptability of results (95 % probability).

12.1.1 *Repeatability*—The difference between two test results, obtained by the same operator with the same apparatus under constant operating conditions on identical test materials would in the normal and correct operation of the test method, exceed the following value only in one case in twenty:

$$12\ \text{kPa}\ (1.8\ \text{psi}) \tag{7}$$

12.1.2 *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:

$$19\ \text{kPa}\ (2.8\ \text{psi}) \tag{8}$$

12.2 *Bias*—The procedure in this test method for measuring vapor pressure has no bias because the value of vapor pressure is defined only in terms of this test method.

13. Keywords

13.1 natural gas liquids; liquefied petroleum gases; vapor pressure

ANNEXES

(Mandatory Information)

A1. APPARATUS FOR VAPOR PRESSURE OF LIQUEFIED PETROLEUM (LP) GASES

A1.1 *Vapor Pressure Apparatus*, consisting of two chambers, designated as the upper and lower chambers, shall conform to the following requirements. To maintain the correct volume ratio between the upper and lower chambers, the units shall not be interchanged without recalibrating to ascertain that the volume ratio is within satisfactory limits.

A1.1.1 *Upper Chamber*—This chamber, as shown in Fig. A1.1 (*c*), shall be a cylindrical vessel 51 ± 3 mm (2 ± ⅛ in.) in diameter and 254 ± 3 mm (10 ± ⅛ in.) in length, inside dimensions, 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 chamber, a suitable bleeder-valve coupling (Fig. A1.1 (*e*)) shall be provided to receive the bleeder-valve assembly and the pressure gage. In the other end of the chamber an opening approximately 13 mm (½ in.) in diameter shall be provided for coupling with the lower chamber. Care shall be taken that the connections to the end openings do not prevent the chamber from draining completely.

A1.1.2 *Bleeder-Valve Assembly*—The bleeder-valve for purging the apparatus (Fig. A1.1) (*d*)) shall be a normal 6 mm (¼ in.) valve fitted into the side of the bleeder-valve coupling (Fig. A1.1 (*e*)). The lower end shall be threaded to fit into the end fitting of the upper chamber, and the upper end shall be threaded to receive the gage coupling (Fig. A1.1 (*h*)).

A1.1.3 *Lower Chamber 33⅓ % (Fig. A1.1 (b))*—This chamber shall be a cylindrical vessel of such a volume that the ratio of the volume of the upper chamber to the volume of the lower chamber is between the limits of 1.97 to 2.03 (Note A1.2).

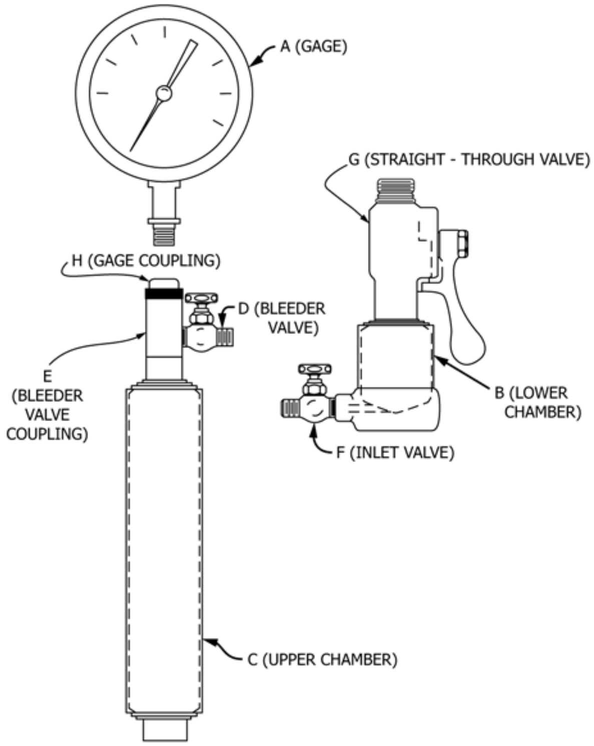

FIG. A1.1 Typical LPG Vapor Pressure Apparatus

A1.1.4 *Lower Chamber 20 % (Fig. A1.1 (b))*—This chamber shall be a cylindrical vessel of such a volume that the ratio of the volume of the upper chamber to the volume of the lower chamber is between the limits of 3.95 to 4.05 (Note A1.2) (Note A1.2). In one end of the lower chamber, an opening approximately 19 mm (¾ in.) in diameter shall be provided to receive a suitable straight-through valve (Fig. A1.1 (*g*)) having a minimum internal channel of 13 mm (½ in.) in diameter. The other end of the chamber shall be equipped with a nominal 6 mm (¼ in.) inlet valve.

NOTE A1.1—In determining the volumetric capacities of the chambers, the volume of the lower chamber is considered as that which is below the "straight-through" valve closure. The volume above the "straight-through" valve closure, including the portion of the coupling attached to the upper chamber, is considered as a part of the upper chamber volume. The volume ratios of the chambers are determined in accordance with the procedure outlined in the Appendix of Test Method D323.

NOTE A1.2—The apparatus requirements for this method, excluding the bleeder-valve assembly, are identical with those of Test Method D323 with the exception of the 33⅓ % lower chamber. Although the test procedural details are different, the air and liquid chambers of Test Method D323 may be used in the present method provided they are of sufficient strength to withstand the higher test pressures (A1.1.6).

A1.1.5 *Method of Coupling Upper and Lower Chambers*—Any method of coupling the chambers may be employed provided the volumetric requirements are met and that the assembly is free from leaks under the conditions of the test.

A1.1.6 *Hydrostatic Test*—The assembled chambers shall be certified by the manufacturer to withstand approximately 6920 kPa (1000 psi) gage hydrostatic pressure without permanent deformation.

A1.1.7 *Checking for Freedom from Leaks*—Before placing new apparatus in service, following any maintenance and at least annually thereafter, the assembled vapor pressure apparatus shall be checked for freedom from leaks by filling it with air, natural gas, nitrogen, or other similar gases, to a minimum pressure of 3460 kPa (500 psi) gage pressure, and then completely immersing it in a water bath. Only apparatus that will withstand this test without leaking shall be used.

A1.2 *Pressure Gage*—The pressure gage, shown in Fig. A1.1 (*a*), shall be a Bourdon-type spring gage of test gage quality 114 to 140 mm (4½ to 5½ in.) in diameter provided with a nominal 6 mm (¼ in.) male thread connection with a passageway not less than 5 mm (3⁄16 in.) in diameter from the Bourdon tube to the atmosphere. The range and graduations of the pressure gage used shall be governed by the vapor pressure of the sample being tested, as follows:

	Gage to Be Used		
LP-Gas Vapor Pressure, kPa (psi) gage at test temperature	Scale Range, kPa (psi)	Numbered Intervals, kPa (psi)	Intermediate Graduations, kPa (psi)
655 (95) and under	0 to 700 (100)	70 (10)	3.4 (0.5)
620 (90) to 1750 (250)	0 to 1750 (250)	172 (25)	7 (1)
1660 (240) to 3460 (500)	0 to 3500 (500)	344 (50)	35 (5)

Only accurate gages shall be continued in use. When the gage correction exceeds 2 % of the scale range, the gage shall be considered inaccurate.

A1.3 *Vapor Pressure Bath*—The vapor pressure bath (water) shall be of such dimensions that the vapor pressure apparatus may be immersed so as to completely cover the bleeder valve when the assembly is in an upright position. Means for maintaining the bath at the test temperature (2.1) within the range as follows: (*1*) Test temperature 50°C (122°F) and below, ±0.1°C (0.2°F); (*2*) Test temperature above 50°C (122°F), ±0.3°C (0.5°F). In order to check the bath temperatures, the temperature measuring device shall be immersed in the bath fluid throughout the vapor pressure determination.

A1.4 *Temperature Measuring Device*—of verified accuracy and capable of monitoring the desired test temperature in the water bath in the range of 35 to 70°C to within ±0.1°C.

A1.5 *Dead-Weight Tester*—A dead-weight tester of satisfactory range shall be provided as a means for checking the accuracy of vapor pressure gages.

A2. WARNING STATEMENT

A2.1 Propane/Butane, or Mixture of Both

A2.1.1 Vapors can cause flash fires.

A2.1.2 Keep away from heat, sparks, and open flame.

A2.1.3 Keep container closed.

A2.1.4 Use with adequate ventilation.

A2.1.5 Avoid buildup of vapors and eliminate all sources of ignition, especially nonexplosion–proof electrical apparatus and heaters.

A2.1.6 Avoid prolonged breathing of vapor or spray mist.

A2.1.7 Avoid prolonged or repeated skin contact.

SUMMARY OF CHANGES

Subcommittee D02.H0 has identified the location of selected changes to this standard since the last issue (D1267–02(2007)) that may impact the use of this standard.

(1) Editorial changes were made throughout the standard to comply with Form & Style requirements.
(2) Deleted reference to Specification E1 for mercury-in-glass thermometers.
(3) Deleted reference to IP 181 (withdrawn in 1976).
(4) Updated the definition of LPG to comply with Form & Style and made it a general definition.
(5) Added 6.3 and 6.4 in the Apparatus section.
(6) Modified 11.1, A1.1.7, A1.3, and A1.4.