Designation: D1835 – 16

Standard Specification for Liquefied Petroleum (LP) Gases[1]

This standard is issued under the fixed designation D1835; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers those products commonly referred to as liquefied petroleum gases, consisting of propane, propene (propylene), butane, and mixtures of these materials. Four basic types of liquefied petroleum gases are provided to cover the common use applications.

1.2 This specification is applicable to products intended for use as domestic, commercial and industrial heating, and engine fuels.

1.3 The values stated in SI units are to be regarded as standard.

1.3.1 *Exception*—Non-SI values are provided 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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

D1267 Test Method for Gage Vapor Pressure of Liquefied Petroleum (LP) Gases (LP-Gas Method)

D1657 Test Method for Density or Relative Density of Light Hydrocarbons by Pressure Hydrometer

D1837 Test Method for Volatility of Liquefied Petroleum (LP) Gases

D1838 Test Method for Copper Strip Corrosion by Liquefied Petroleum (LP) Gases

D2158 Test Method for Residues in Liquefied Petroleum (LP) Gases

D2163 Test Method for Determination of Hydrocarbons in Liquefied Petroleum (LP) Gases and Propane/Propene Mixtures by Gas Chromatography

D2420 Test Method for Hydrogen Sulfide in Liquefied Petroleum (LP) Gases (Lead Acetate Method)

D2598 Practice for Calculation of Certain Physical Properties of Liquefied Petroleum (LP) Gases from Compositional Analysis

D2713 Test Method for Dryness of Propane (Valve Freeze Method)

D2784 Standard Test Method for Sulfur in Liquefied Petroleum Gases (Oxy-Hydrogen Burner or Lamp) (Withdrawn 2016)[3]

D3700 Practice for Obtaining LPG Samples Using a Floating Piston Cylinder

D5504 Test Method for Determination of Sulfur Compounds in Natural Gas and Gaseous Fuels by Gas Chromatography and Chemiluminescence

D5623 Test Method for Sulfur Compounds in Light Petroleum Liquids by Gas Chromatography and Sulfur Selective Detection

D6667 Test Method for Determination of Total Volatile Sulfur in Gaseous Hydrocarbons and Liquefied Petroleum Gases by Ultraviolet Fluorescence

D6897 Test Method for Vapor Pressure of Liquefied Petroleum Gases (LPG) (Expansion Method)

D7756 Test Method for Residues in Liquefied Petroleum (LP) Gases by Gas Chromatography with Liquid, On-Column Injection

D7828 Test Method for Determination of Residue Composition in Liquefied Petroleum Gas (LPG) Using Automated Thermal Desorption/Gas Chromatography (ATD/GC)

2.2 *Gas Processors Association Standard:*[4]

GPA Standard 2140 Liquefied Petroleum Gas Specifications and Test Methods

3. Terminology

3.1 *Definitions:*

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

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[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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from Gas Processors Association, 6526 E. 60th St., Tulsa, OK 74145. www.gasprocessors.com

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

3.1.1 *commercial butane, n*—a hydrocarbon product for use where low volatility is required.

3.1.2 *commercial PB mixtures, n*—mixtures of propane and butane for use where intermediate volatility is required.

3.1.3 *commercial propane, n*—a hydrocarbon product for use where high volatility is required. Commercial propane is suitable for certain low severity internal combustion engine applications.

3.1.4 *special-duty propane, n*—a product composed chiefly of propane which exhibits superior antiknock characteristics and was specifically developed for use as fuel in spark ignition internal combustion engines.

4. Sampling

4.1 Proper sampling of liquefied gases is extremely important if the test results are to be significant. Obtain representative samples in accordance with Practice D1265 or Practice D3700. In the event of a dispute involving sample integrity when sampling for testing against D1835 requirements, Practice D3700 shall be used as the referee sampling procedure.

5. Detailed Requirements

5.1 The four types of liquefied petroleum gases shall conform to the requirements prescribed in Table 1.

6. Keywords

6.1 butane; HD-5 propane; liquefied petroleum (LP) gases specifications; LPG; propane; special duty propane

TABLE 1 Detailed Requirements for Liquefied Petroleum Gases

	Product Type				
	Commercial Propane	Commercial Butane	Commercial PB Mixtures	Special-Duty Propane[A]	ASTM Test Methods (see Section 2)
Vapor pressure at 37.8 °C (100 °F), max					
kPa	1434	483	[B]	1434	D1267 or D2598 or D6897[C]
psig	208	70	[B]	208	D1267 or D2598 or D6897[C]
Volatile residue: evaporated temperature, 95 %, max					
°C	–38.3	2.2	2.2	–38.3	
°F	–37	36	36	–37	D1837
or					
Butane and heavier, max, % by volume	2.5	...	...	2.5	D2163
Pentane and heavier, max, % by volume	...	2.0	2.0	...	D2163
Propylene content, max, % by volume	...	...	...	5.0	D2163
Residual matter:[D] One of the following requirements shall be met:					
(*1*) Residue on evaporation of 100 mL, max, mL, and	0.05	0.05	0.05	0.05	D2158[F]
Oil stain observation	pass[E]	pass[E]	pass[E]	pass[E]	D2158[F]
or					
(*2*) Residue by gas chromatography, max, mg/kg	350	350	350	350	D7756
Density at 15 °C or relative density at 15.6/15.6 °C (60/60 °F)	[G]	[G]	[G]	...	D1657 or D2598
Corrosion, copper, strip	No. 1	No. 1	No. 1	No. 1	D1838[H]
Sulfur, mg/kg (ppm mass)	185[I]	140[I]	140[I]	123[I]	D2784 or D6667[J]
Hydrogen sulfide	pass	pass	pass	pass	D2420
Moisture content	pass	...	...	pass	D2713
Free water content	...	none[K]	none[K]	...	...

[A] Equivalent to Propane HD-5 of GPA Standard 2140.

[B] The permissible vapor pressures of products classified as PB mixtures shall not exceed 1430 kPa (208 psig) and additionally shall not exceed that calculated from the following relationship between the observed vapor pressure and the observed relative density:

$$\text{Vapor pressure, max} = 1167 - 1880\,(\text{relative density at 60 °F/60 °F}) \text{ or } 1167 - 1880\,(\text{relative density at 15.6 °C/15.6 °C})$$

A specific mixture shall be designated by the vapor pressure at 100 °F in pounds per square inch gage. To comply with the designation, the vapor pressure of the mixture shall be within +0 psi to –10 psi of the vapor pressure specified.

[C] In case of dispute about the vapor pressure of a product, the value actually determined by Test Method D1267 shall prevail over the value calculated by Practice D2598 or measured by Test Method D6897.

[D] See X1.2.4 for information about residues in LPG and for information about gas chromatographic tests for residues in LPG.

[E] An acceptable product shall not yield a persistent oil ring when 0.3 mL of solvent residue mixture is added to a filter paper, in 0.1 mL increments and examined in daylight after 2 min as described in Test Method D2158.

[F] In case of dispute, Test Method D2158 shall be the referee test method.

[G] Although not a specific requirement, the density or relative density can be needed for other purposes and should be reported. Additionally, the relative density of PB mixture is needed to establish the permissible maximum vapor pressure (see Footnote *B*).

[H] This method may not accurately determine the presence of reactive materials (for example, H_2S, S°) in liquefied petroleum gas if the product contains corrosion inhibitors or other chemicals which diminish the reaction with the copper strip.

[I] The total sulfur limits in these specifications *do include* sulfur compounds used for stenching purposes.

[J] In case of dispute, Test Method D6667 shall be the referee test method.

[K] The presence or absence of water may be determined by visual inspection of the samples on which the density or relative density is determined.

APPENDIX

(Nonmandatory Information)

X1. SIGNIFICANCE OF ASTM SPECIFICATIONS FOR LIQUEFIED PETROLEUM (LP) GASES

X1.1 General

X1.1.1 Liquefied petroleum gas products are composed of those readily liquefiable hydrocarbon compounds that are produced in the course of processing natural gas and also in the course of the conventional refining of crude oil. The composition of liquefied gases can vary widely depending upon the source and the nature of the treatment to which the products have been subjected.

X1.1.2 There are many uses for liquefied petroleum gases. Important uses include, (*1*) as domestic, commercial, and industrial fuels, (*2*) as a carbon source material in metal treating operations, (*3*) as refinery raw materials for synthesis of gasoline components, and (*4*) as petrochemical raw materials. The nature of the needs dictates the required composition characteristics in these various applications. Since the last three uses of those listed are in the category of specialty applications, which involve special requirements, they are excluded from consideration in the specifications.

X1.1.3 In substance, this specification is designed to properly define acceptable products for domestic, commercial, and industrial uses. In many cases it will be found that products meeting the specifications will also be usable in applications other than the ones for which they were designed. The following can be accepted as a general guide in the more common use applications of the four types of fuels:

X1.1.3.1 *Commercial Propane*—This fuel type is adequate for domestic, commercial, and industrial use, particularly in geographical areas and in seasons where low ambient temperatures are common, and where uniformity of fuel is an important consideration. Commercial propane can be suitable for certain low severity internal combustion engine applications.

X1.1.3.2 *Commercial PB Mixtures*—This fuel type, since it covers a broad range of mixtures, permits the tailoring of fuels to specific needs. The various mixtures find application as domestic, commercial, and industrial fuel in areas and at times when low ambient temperature conditions are not encountered. This fuel type is not suitable for vapor withdrawal applications in cool or cold climates.

X1.1.3.3 *Commercial Butane*—This fuel type finds limited application as a domestic fuel in areas of warmer climates. It is similarly used in industrial applications where problems of fuel vaporization are not present, such as direct liquid injection.

X1.1.3.4 *Special-Duty Propane*—This fuel type, equivalent to HD-5 propane, is a product tailored to meet the restrictive needs of internal combustion engines operating under moderate to high engine severity (that is, normal automotive applications). Fuel products of this type will be less variable in composition and combustion characteristics than the other products covered by this specification. Special-Duty Propane can be used as a substitute for Commercial Propane.

X1.2 Significance and Use

X1.2.1 This specification addresses commercial liquefied petroleum gases consisting of either propane or butane or mixtures thereof. Consequently, the important characteristics of these products can be defined and controlled by a relatively few simple measurements. The specification test methods provided achieve the desired results. The significance of the various tests as they can apply to consumer problems is summarized here.

X1.2.2 *Vapor Pressure, Volatility, and [Relative] Density:*

X1.2.2.1 *Vapor Pressure*—Indirect measure of the most extreme low-temperature conditions under which initial vaporization can be expected to take place. It can be considered as a semiquantitative measure of the amount of the most volatile material present in the product. It can also be used as a means for predicting the maximum pressures which can be experienced at fuel tank temperatures. Vapor pressure becomes more significant when it is related to volatility.

X1.2.2.2 *Volatility* —Expressed in terms of the 95 % evaporated temperature of the product, is a measure of the amount of least volatile fuel component present in the product. Coupled with a vapor pressure limit, it serves to assure essentially single-component products in the cases of commercial propane and commercial butane fuel types. When volatility is coupled with a vapor pressure limit which has been related to density or gravity, as in the case of the commercial PB-mixture type of fuels, the combination serves to assure essentially two component mixtures for such fuels. When coupled with a proper vapor pressure limit, this measurement serves to assure that special-duty propane products will be composed chiefly of propane and propylene and that propane will be the major constituent.

X1.2.2.3 *Density or Relative Density*—by itself, has little significance. It becomes of value when related to vapor pressure and volatility. Since density or relative density is of importance in meeting transportation and storage requirements it is always determined for all liquefied petroleum gas products.

Other Product Characteristics

X1.2.3 While the vaporization and combustion characteristics of commercial liquefied gas products are completely defined for the normal use applications by vapor pressure, volatility, and relative density, as given in X1.2.2, there are other properties which either affect or might affect the results obtained in some specific use applications. For that reason, limits are specified for residue content, copper corrosion, sulfur content, moisture content, and free water content to provide assurance of product dependability under the more extreme conditions of use.

X1.2.4 *Residue*—A measure of the concentration of soluble hydrocarbon materials present in the product which are substantially less volatile than the liquefied petroleum gas product being sampled. Control of residue content is of importance in applications where the fuel is used in liquid or vapor feed systems (where fuel vapors are withdrawn from the top of the LPG storage container). In either case, failure to limit the permissible concentration of residue materials can result in troublesome deposits or regulating equipment can become fouled, or both. In gas processing plants, LP gas generally is produced relatively free of residues, but the product can become contaminated by heavier hydrocarbons and other organic compounds during distribution, especially in multiproduct pipelines or while it is in contact with elastomers used in hoses. The current limit on residue contamination, while generally satisfactory for many conventional uses, may not be suitable for newer applications such as fuel cells and microturbines without some form of remediation.

X1.2.4.1 Gas chromatographic residue Test Methods D7756 and D7828 offer alternative ways to quantitatively analyze an LPG sample for soluble residues. LPG users who encounter residue problems should consider analyzing the suspect LPG by Test Method D7756 or D7828 to gain information about the composition and identification of residues.

X1.2.4.2 Test Method D7756 may be used as an alternative means of residual matter measurement for LPG samples within the range that has been validated in Test Method D7756. A residue limit of 350 mg⁄kg using Test Method D7756 has been found satisfactory to meet the requirements for both the residue on evaporation and oil stain observation as measured by Test Method D2158. The residue limit of 350 mg⁄kg relates particularly to the oil stain observation limit of Test Method D2158, which is more restrictive than the residue limit of 0.05 mL per 100 mL of LPG.

X1.2.5 *Copper Corrosion*—Limits are for the purpose of providing assurance that difficulties will not be experienced in the deterioration of the copper and copper-alloy fittings and connections which are commonly used in many types of utilization, storage, and transportation equipment. The copper corrosion test will detect the presence of elemental sulfur and hydrogen sulfide, which is highly toxic. Experience has shown that the combination of H_2S and elemental sulfur even at concentrations of less than 1 ppm can be very corrosive towards copper. The copper corrosion limits also provide assurance that the LP-Gas will not contain H_2S in such quantities as to present a health and safety hazard if it is known that the product does not contain corrosion inhibitors or other chemicals which diminish the reaction with the copper strip. In addition, Test Method D2420 is recommended as a field test and added safeguard to ensure that LP-Gas does not contain detectable amounts of hydrogen sulfide.

X1.2.5.1 Carbonyl sulfide (COS) can be present in LPG. While COS in LPG is not itself corrosive towards copper, it can hydrolyze and react to produce H_2S, which is corrosive. The LPG copper corrosion test, Test Method D1838, is designed to be severe, even encouraging hydrolysis and formation of aggressive sulfur species, by mandating that the test apparatus be water-wetted at the start of each test. Higher concentrations of COS can be tolerated in LPG because the rate of conversion to H_2S is normally low. However, under some conditions such as higher temperatures, traces of free water, methanol, caustic, other sulfur species often found in LPG, and catalytically active surfaces can increase the rate of conversion of COS considerably. There have been reports from industry that LPG has become corrosive towards copper during storage, distribution or use, especially after different batches of LPG containing different sulfur species were mixed. LPG containing less than 50 ppm COS is believed to present a low risk of developing corrosivity towards copper although some producers have experienced corrosivity toward copper with as little as 3 ppm to 4 ppm COS. LPG containing greater than 100 ppm COS presents a greater risk under typical commercial conditions. COS can be determined in LPG by gas chromatography using a pressurized liquid sampling valve and selective sulfur detector. Test Methods D5504 and D5623 can be modified to measure COS in liquid LPG samples.

X1.2.6 *Sulfur Content*—Limits are provided to more completely define liquefied petroleum gas products. Historically these products were lower in sulfur content than most other petroleum-derived fuels. This is generally no longer the case in areas where gasolines are typically below 30 mg⁄kg (ppm by mass) sulfur and diesel fuels are less than 15 mg/kg (ppm by mass) sulfur. The limit on sulfur content minimizes sulfur oxide emissions and limits potential corrosion by exhaust gases from combustion of LPG.

X1.2.7 *Moisture Content*—Limits the percent saturation of the product with water. This measurement using Test Method D2713 is a requirement only on the commercial and special duty propane types of liquefied petroleum gas which must be subsaturated with water at temperatures above about –26 °C. The purpose of moisture content control is to provide assurance that pressure-reducing regulators and similar equipment will operate consistently without troublesome freeze-ups caused by the separation of dissolved water from the product. The presence of an antifreeze agent such as methyl alcohol which prevents separated water from freezing can allow use of propane containing excessive dissolved water in many applications.

NOTE X1.1—Commercial propane and special duty propane should be produced to comply with the moisture content requirement, and de-icer additives should not routinely be used to pass dryness test requirements. That is, these products must be so dry that they are subsaturated with water at most ambient temperatures. They should be maintained dry during storage and distribution. A de-icer such as methyl alcohol (methanol) should not be added to these products without specific agreement and approval of the purchaser. During short-term upsets in production, or inadvertent contamination by trace water during storage or distribution, addition of 50 ppm methyl alcohol has proven to be acceptable to prevent valve freezing in normal applications. For guidance, based on historical experience and phase separation data, the maximum cumulative addition of methyl alcohol should not exceed 200 ppm by volume.

X1.2.8 *Free Water Content*—Of importance only on the commercial PB-mixtures and commercial butane type products. These two types of products are normally used under ambient conditions which are mild and, as a consequence, the only requirement is vigilance to ensure that no free water is present.

SUMMARY OF CHANGES

Subcommittee D02.H0 has identified the location of selected changes to this standard since the last issue (D1835 – 13) that may impact the use of this standard. (Approved Oct. 1, 2016.)

(1) In Table 1, Test Method D7756 has been added as an alternative test method to determine residues in LPG, and footnote F has been added to identify that Test Method D2158 is the referee test method.

(2) Revised footnote J of Table 1, relating to Test Method D6667.

(3) Subsection X1.2.4.2 has been added to explain that the residue limit of 350 mg⁄kg by Test Method D7756 is equivalent to the current residue limit by Test Method D2158, particularly relating to the oil stain observation limit, which is more restrictive than the limit of 0.05 mL per 100 mL of LPG.