Designation: D2598 – 16

Standard Practice for Calculation of Certain Physical Properties of Liquefied Petroleum (LP) Gases from Compositional Analysis[1]

This standard is issued under the fixed designation D2598; 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 practice covers, by compositional analysis, the approximate determination of the following physical characteristics of commercial propane, special-duty propane, commercial propane/butane mixtures, and commercial butane (covered by Specification D1835): vapor pressure, relative density, and motor octane number (MON).

1.1.1 This practice is not applicable to any product exceeding specifications for nonvolatile residues. (See Test Method D2158.)

1.1.2 For calculating motor octane number, this practice is applicable only to mixtures containing 20 % or less of propene.

1.1.3 For calculated motor octane number, this practice is based on mixtures containing only components shown in Table 1.

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

1.2.1 *Exceptions:*

1.2.1.1 Non-SI units in parentheses are given for information only.

1.2.1.2 Motor octane number and relative density are given in MON numbers and dimensionless units, respectively.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

D1835 Specification for 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

D2421 Practice for Interconversion of Analysis of C_5 and Lighter Hydrocarbons to Gas-Volume, Liquid-Volume, or Mass Basis

2.2 *Australian Liquefied Petroleum Gas Association Publication:*[3]

Liquefied Petroleum Gas for Automotive Use Specification

2.3 *Gas Processors Suppliers Association:*[4]

GPSA Engineering Data Book, 12th Edition, 2004

3. Summary of Practice

3.1 The composition of a sample of LP-gas is obtained by using Test Method D2163 or other acceptable method. From the analysis (expressed in liquid volume percent), the vapor pressure, relative density, and motor octane number of the sample may be determined.

3.2 Conversion of a compositional analysis from mole, gas volume, or weight basis to liquid volume is obtained by using Practice D2421 or other suitable method.

4. Significance and Use

4.1 Vapor pressure is an important specification property of commercial propane, special duty propane, propane/butane mixtures, and commercial butane that assures adequate vaporization, safety, and compatibility with commercial appliances. Relative density, while not a specification criterion, is necessary for determination of filling densities and custody transfer. The motor octane number (MON) is useful in determining the products' suitability as a fuel for internal combustion engines.

5. Calculation

5.1 *Calculated LP-Gas Vapor Pressure* (see Test Method D1267):

[1] This practice 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] Available from Australian Liquefied Petroleum Gas Association Limited, ABN 11002703951, 30 George Street, Redfern NSW 2016, http://www.lpgaustralia.com.au/site/

[4] Available from Gas Processors Suppliers Association (GPSA), 6526 E. 60th St., Tulsa, OK 74145, http://www.gpsa.gpaglobal.org.

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

TABLE 1 Factors for Determining the Physical Characteristics of LP-Gases[A]

Component	Vapor Pressure Blend Factor, kPa-gauge (PSIG) at 37.8 °C (100 °F)	Relative Density at 15.6 °C/15.6 °C (60 °F/60 °F)	MON Blend Value
Methane	17547 (2545)	0.3	. . .
Ethane	4213 (611)	0.3563	100.7
Ethene (Ethylene)	8720 (1265)	0.37	75.6
Propane	1200 (174)	0.5072	97.1
Propene (Propylene)	1466 (213)	0.5226	84.9
Methylpropane (Isobutane)	400 (58)	0.5629	97.6
n-Butane	255 (37)	0.5842	89.6
t-2-Butene	242 (35)	0.6099	...
1-Butene	328 (48)	0.6004	80.8
2-Methylpropene (Isobutylene)	340 (49)	0.6004	...
c-2-Butene	216 (31)	0.6275	83.5
2,2-Dimethylpropane (Neopentane)	152 (22)	0.5961	80.2
Cyclopentane	-33 (-4.7)	0.7503	84.9
2-Methylbutane (Isopentane)	40 (5.8)	0.6251	90.3
n-Pentane	6.4 (0.9)	0.6307	62.6
n-Hexane	-67 (-9.7)	0.6641	26.0

[A] Some constants for vapor pressure and motor octanes are empirical values to be used only in the calculation procedures described in this practice. References are located in Appendix X1.

5.1.1 Calculate the partial gauge vapor pressure due to each component in the mixture as follows:

$$\text{Partial gauge vapor pressure} = (vp' \times C)/100 \quad (1)$$

where:

vp' = vapor pressure factor of specific component at 37.8 °C (100 °F) (see Table 1), and
C = liquid volume percent of component in the mixture.

5.1.2 Add the partial gauge vapor pressures due to all components, rounding to the nearest 7 kPa (1 psi). The total is reported as the LP-gas vapor pressure of the sample, kPa gauge at 37.8 °C (100 °F).

5.2 *Calculated Relative Density* (see Test Method D1657):

5.2.1 Calculate the relative mass of each component in the mixture as follows:

$$\text{Relative mass of component} = (sg' \times C)/100 \quad (2)$$

where:

sg' = relative density of the pure component at 15.6 °C (60 °F) (see Table 1), and
C = liquid volume percent of component in the mixture.

5.2.2 Add the relative mass of all components, rounding the total to three decimal places. The total is reported as the relative density of the mixture.

5.3 *Calculated Motor Octane Number* (see ASTM Data Series DS 4B.[5]).

5.3.1 Using only the components and values in Table 1, calculate the partial motor octane number of each component in the mixture to the nearest 0.1 MON as follows:

$$\text{Partial motor octane number of component} = (m \times C)/100 \quad (3)$$

where:

m = motor octane number of component (see Table 1), and
C = liquid volume percent of component in mixture.

5.3.2 Add the partial motor octane numbers of all components determined in 5.3.1 and round the total to the nearest one-half number. The total is reported as the calculated motor octane number of the mixture.

6. Keywords

6.1 butane; calculated physical properties; liquefied petroleum gases; motor octane number; propane; relative density; vapor pressure

[5] DS 4B, *Physical Constants of Hydrocarbon and Non-Hydrocarbon Compounds*, ASTM International, W. Conshohocken, PA, 1987.

APPENDIX

(Nonmandatory Information)

X1. SOURCES OF PHYSICAL CONSTANT DATA

X1.1 See Table X1.1.

TABLE X1.1 Sources of Physical Constant Data

Component	Vapor Pressure Blend Factor[A]	Relative Mass	MON Blend Value
Methane	B	C	...
Ethane	B	D	B
Ethene (Ethylene)	E	F	E
Propane	D	D	C
Propene (Propylene)	D	D	C
Methylpropane (Isobutane)	D	D	C
n-Butane	D	D	C
t-2-Butene	D	D	...
1-Butene	D	D	C
2-Methylpropene (Isobutylene)	D	D	...
c-2-Butene	D	D	C
2,2-Dimethylpropane (Neopentane)	D	D	C
Cyclopentane	D	D	C
2-Methylbutane (Isopentane)	D	D	C
n-Pentane	D	D	C
n-Hexane	D	D	C

[A] Vapor pressure values were converted from atmospheric to gauge by the following equations: PSIG = PSIA – 14.7; kPa(G) = kPa(A)-101.
[B] Empirical values for use in D2598 calculations.
[C] GPSA Engineering Data Book, 12th Edition, 2004.
[D] TRC (formerly the Thermodynamic Research Center), NIST, Boulder, CO, 2012.
[E] Australian Liquefied Petroleum Gas Association Publication, Liquefied Petroleum Gas for Automotive Use Specification.
[F] The relative density of ethylene is estimated, and consistent with the historical value in Practice D2421-95. Later revisions of Practice D2421 used a theoretical, calculated value from GPA 2145-00. Uncertainties in the equations of state used in the calculation for ethylene at typical pressures and temperatures of LPG caused GPA to later retract that value.

SUMMARY OF CHANGES

Subcommittee D02.H0 has identified the location of selected changes to this standard since the last issue (D2598 – 12) that may impact the use of this standard. (Approved Oct. 1, 2016.)

(1) Updated heading for relative density in Table 1.