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Liquefied petroleum gases — Calculation method for density and vapour pressure

Gaz de pétrole liquéfiés — Méthode de calcul de la masse volumique et de la pression de vapeur

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 8973 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants.*

Annex A forms an integral part of this International Standard. Annex B is for information only.

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Liquefied petroleum gases — Calculation method for density and vapour pressure

1 Scope

This International Standard describes a simplified method for the calculation of density and vapour pressure of liquefied petroleum gases (LPG) based on compositional data and density and vapour pressure factors for individual LPG components. A list of factors is provided in this International Standard. This method is intended for application in specifications of product quality and is not intended for application to quantity measurement in custody transfer (see ISO 6578).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6578:1991, *Refrigerated hydrocarbon liquids — Static measurement — Calculation procedure.*

ISO 7941:1988, *Commercial propane and butane — Analysis by gas chromatography.*

3 Definitions

For the purpose of this International Standard the following definitions apply.

3.1 liquefied petroleum gas (LPG): Hydrocarbon gas that can be stored and/or handled in the liquid phase under moderate conditions of pressure and at ambient temperature. It consists essentially of C_3 and C_4 alkanes or alkenes, or a mixture of these, contains generally less than 5 % by liquid volume of material of higher carbon number, and has a gauge vapour pressure not exceeding approximately 1 600 kPa at 40 °C.

3.2 density factor: Density, expressed in kilograms per cubic metre, of a component in the liquid phase under its own vapour pressure at a temperature of 15 °C.

3.3 vapour pressure: Vapour pressure, expressed in kilopascals on an absolute basis, i.e. the gauge pressure plus local ambient pressure.

3.4 vapour pressure factor: Absolute vapour pressure, expressed in kilopascals, of a component of the liquid at temperature of 37,8 °C, 40 °C, 50 °C or 70 °C.

4 Principle

The molar composition of the LPG is determined by gas chromatography in accordance with ISO 7941. This analysis is used to calculate the liquid density and vapour pressure by using, for each component, the liquid density and vapour pressure factors provided in this International Standard.

5 Procedure

Determine the molar composition in accordance with ISO 7941.

6 Calculation

6.1 Use the LPG component relative molecular mass, density and pressure factors given in table A.1 in the equations shown below.

6.2 Density

6.2.1 Calculate the mass fraction, W, of each component of the mixture as follows:

$$W_i = \frac{X_i M_i}{\sum_1^n X_i M_i}$$

where

i is the number of the specific component;

n is the total number of components;

W_i is the mass fraction of component i in the mixture;

X_i is the mole fraction of component i in the mixture;

M_i is the relative molecular mass of component i in the mixture;

$\sum_1^n X_i M_i$ is the sum of the products of X and M for each component.

6.2.2 Calculate the density of the LPG, ρ, in kilograms per cubic metre at 15 °C, as follows:

$$\rho = \frac{1}{\sum_1^n \frac{W_i}{\rho_i}}$$

where

ρ_i is the density factor of component i in the mixture, expressed in kilograms per cubic metre at 15 °C;

$\sum_1^n \frac{W_i}{\rho_i}$ is the sum of $\frac{W_i}{\rho_i}$ for each component in the mixture.

6.3 Vapour pressure

6.3.1 Calculate the partial vapour pressure, p_{vp}, due to each component of the mixture as follows:

$$p_{vp,i} = X_i p_{v,i}$$

where

$p_{vp,i}$ is the partial absolute vapour pressure of component i in the mixture, expressed in kilopascals at 37,8 °C, 40 °C, 50 °C or 70 °C;

X_i is the mole fraction of component i in the mixture;

$p_{v,i}$ is the vapour pressure factor of component i in the mixture, expressed in kilopascals at 37,8 °C, 40 °C, 50 °C or 70 °C.

6.3.2 Calculate the absolute vapour of the LPG, p_v, in kilopascals at 37,8 °C, 40 °C, 50 °C or 70 °C, as follows:

$$p_v = \sum_1^n p_{vp,i}$$

where $\sum_1^n p_{vp,i}$ is the sum of the $p_{vp,i}$ due to each component in the mixture.

6.3.3 Calculate the gauge vapour pressure, p_{ve}, as follows:

$p_{ve} = p_v$ – local atmospheric pressure (101,325 kPa)

7 Expression of results

Report the calculated density to the nearest 0,1 kg/m^3 and the calculated vapour pressure to the nearest 1 kPa.

8 Precision

The precision of this method is dependent on the precision of the original gas chromatography determination of the LPG composition and the accuracy of the factors which are entered into the calculation.

9 Test report

The test report shall contain at least the following information:

a) reference to this International Standard;

b) the type and complete identification of the product tested;

c) the result of the test (see clause 7);

d) any deviation, by agreement or otherwise, from the procedure specified;

e) the date of the test.

Annex A
(normative)

Factors for calculation

Table A.1 — Factors for determining the liquid density and the vapour pressure of liquefied petroleum gases by calculation

Component	Relative molecular mass	Density factor kg/m³	Vapour pressure factor[a] kPa			
		15 °C	37,8 °C	40 °C	50 °C	70 °C
Ethane	30,069 4	375,76	5 269	5 611	6 282	9 119
Ethene	28,053 6	369,00	8 106	8 821	9 930	13 679
Propane	44,097 2	507,30	1 317	1 352	1 672	2 634
Propene	42,081 4	521,33	1 570	1 661	2 026	3 141
2-Methyl propane (Iso butane)	58,123 0	562,98	507	531	659	1 115
Butane	58,123 0	584,06	355	377	486	831
1-Butene	56,107 2	601,15	415	457	588	973
2-Methyl propene (Iso butene)	56,107 2	600,50	426	467	598	993
cis-2-Butene	56,107 2	627,20	314	337	436	729
trans-2-Butene	56,107 2	610,00	340	365	466	800
1,2-Butadiene	54,091 4	658,00	—	272	—	—
1,3-Butadiene	54,091 4	627,3	405	436	547	973
Methyl butane (Iso pentane)	72,149 8	624,35	142	151	203	355
Pentane	72,149 8	631,00	106	115	152	284
1-Pentene	70,134 0	645,65	130 [b]	141	200 [b]	—

NOTES

1 The above factors are empirical values to be used only in the calculation procedures described in this International Standard. The factors have been taken from a number of sources of published data and provide standardized values for the calculations in this International Standard.

2 These values are based on the following values for the relative atomic masses of carbon and hydrogen:

$^{12}C = 12{,}011 \pm 0{,}001$

$^{1}H = 1{,}007\,9 \pm 0{,}000\,1$

a) Values taken from "Data Book on hydrocarbons" J.B. Maxwell.

b) These values are approximate values extrapolated or interpolated from a curve in the figures from "Vapour pressure of organic compounds" by T. Earl Jordan, in "Interscience Publishers, Inc.; New York 1954".