INTERNATIONAL
STANDARD

ISO
6578

Second edition
2017-10

Refrigerated hydrocarbon liquids — Static measurement — Calculation procedure

Hydrocarbures liquides réfrigérés — Mesurage statique — Procédure de calcul

Reference number
ISO 6578:2017(E)

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 28, *Petroleum and related products, fuels and lubricants from natural or synthetic sources*, Subcommittee SC 5, *Measurement of refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels*.

This second edition cancels and replaces the first edition (ISO 6578:1991), which has been technically revised.

Introduction

Large quantities of refrigerated hydrocarbon liquids such as liquefied natural gas (LNG), liquefied petroleum gas (LPG), etc. are transported by marine carriers dedicated for these applications. These gases are traded based on static measurement on board marine carriers rather than the measurement at shore tanks or pipelines due mainly to the nature of the tank operation.

The measurement on board involves determination of liquid/vapour interface, i.e. liquid level, average temperatures of liquid and vapour, and vapour pressure in the tanks of marine carriers. The volumetric quantity of the liquid and gas is then computed with the tank capacity tables.

This document is applicable to calculate the volume at standard condition, liquid density from chemical composition, mass and energy content of fully refrigerated hydrocarbon liquids at a vapour pressure near to atmospheric pressure from the results of custody transfer measurement. This document is also applicable to ascertain the inventory in shore tanks. Calculation procedures for refrigerated hydrocarbon liquids consisting predominantly of ethane or ethylene, or for partially refrigerated hydrocarbon liquids at pressures substantially above atmospheric, are not included. No recommendations are given for the measurement of small parcels of refrigerated liquids, which are directly weighed.

Aspects of safety are not dealt with in this document. It is the responsibility of the user to ensure that the procedure of measurement meets applicable safety regulations.

Basic data and source references used in the calculation procedures are given in annexes.

Annexes A to G form an integral part of this document.

INTERNATIONAL STANDARD **ISO 6578:2017(E)**

Refrigerated hydrocarbon liquids — Static measurement — Calculation procedure

1 Scope

This document specifies the calculation procedure to convert the volume of liquefied petroleum gas (LPG) and liquefied natural gas (LNG) under the conditions at the time of measurement to the equivalent volume of liquid or vapour at the standard condition, i.e. 15 °C and 101,325 kPaA, or to the equivalent mass or energy (calorific content). It applies to the quantities of refrigerated hydrocarbon liquids stored in or transferred to/from tanks and measured under static storage conditions. Calculation of pressurized gases is out of the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 91, *Petroleum and related products — Temperature and pressure volume correction factors (petroleum measurement tables) and standard reference conditions*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms, definitions and symbols apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1.1
compression factor
actual (real) volume of a given amount of gas at a specified pressure and temperature divided by its volume, under the same conditions as calculated from the ideal gas law

[SOURCE: ISO 6976:2016, 3.10]

3.1.2
gross calorific value
amount of heat that would be released by the complete combustion with oxygen of a specified quantity of gas, in such a way that the pressure, p_1, at which the reaction takes place remains constant, and all the products of combustion are returned to the same specified temperature, t_1, as that of the reactants, all of these products being in the gaseous state except for water, which is condensed to the liquid state at t_1

Note 1 to entry: t_1 and p_1 are combustion reference temperature and combustion reference pressure, respectively.

[SOURCE: ISO 6976:2016, 3.1, modified — Note 1 to entry has been replaced.]

3.1.3
liquefied natural gas

LNG

liquid composed predominantly of methane

3.1.4
liquefied petroleum gas

LPG

liquid composed predominantly of any of the following hydrocarbons or mixtures thereof: propane, propene, butanes and butene

3.1.5
refrigerated hydrocarbon liquid

liquid composed predominantly of hydrocarbons, which are stored in a fully refrigerated condition at pressures near atmospheric

3.1.6
volumetric basis (ideal)

volume calculated on the basis that the vapour behaves like an ideal gas

3.1.7
volumetric basis (real)

volume calculated on the basis that the vapour behaves like a super-compressible gas

3.2 Symbols

The following symbols are defined here for use in this document, but additionally, some symbols are given more restricted meanings when used in some formulae. The restricted meaning is then given after the formulae.

$H_{s,m,i}$	gross (superior) calorific value on a mass basis, in megajoules per kilogram, of component *i* (see Table D.1)
$H_{s,m}$	gross (superior) calorific value on a mass basis, in megajoules per kilogram, of the liquid
$H_{s,V,i}$	gross (superior) calorific value on a volumetric basis (ideal), in megajoules per cubic metre, of component *i* (see Table D.1)
$H_{s,\mathrm{vol}}$	gross (superior) calorific value on a volumetric basis, in megajoules per cubic metre, of the vapour at standard condition
m	mass, in kilograms, of product transferred, i.e. liquid plus vapour
m_{liq}	mass, in kilograms, of liquid
M_i	molar mass, in kilograms per kilomole, of component *i* (see Table E.1)
M_{mix}	relative molar mass, in kilograms per kilomole, of the vapour mixture
P_s	standard reference pressure, i.e. 101,325 kPaA (kilopascal absolute)
P_{vap}	pressure, in kilopascals absolute, of the vapour in the container
Q	net energy, in megajoules, transferred, based on gross calorific value
Q_{liq}	energy (calorific) content, in megajoules, of the liquid
R	molar gas constant, 8,314 462 1 $\mathrm{J{\cdot}mol^{-1}{\cdot}K^{-1}}$, see ISO 6976:2016, A.1
t	temperature, in degrees Celsius, of the liquid

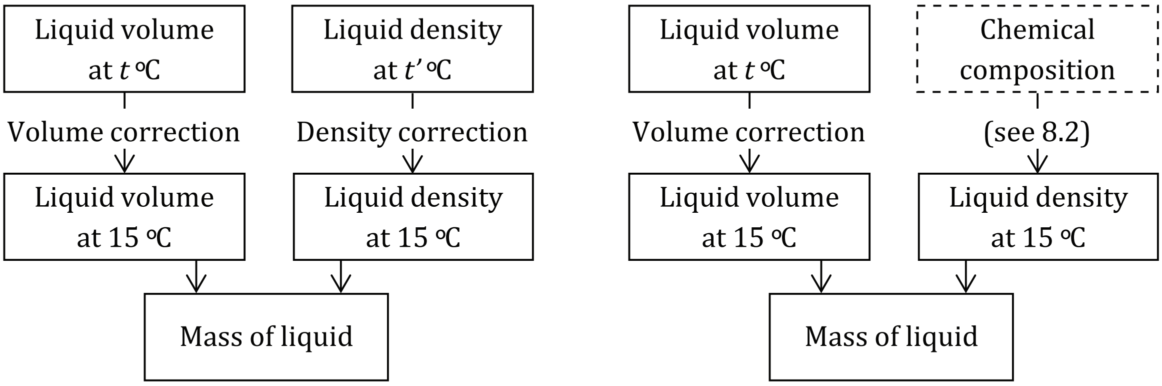
T_s	standard reference temperature, i.e. 288,15 K (15 °C)
T_vap	temperature, in kelvins, of the vapour in the container
V_i	molar volume, in cubic metres per kilomole, of component *i*, as a liquid at *t*
V_liq	volume, in cubic metres, of the liquid at *t*
V_m	ideal gaseous molar volume, in cubic metres per kilomole, at standard conditions: i.e. $V_\mathrm{m} = (R \times T_\mathrm{s})/P_\mathrm{s} = 23{,}644\ 8\ \mathrm{m}^3/\mathrm{kmol}$ at 15 °C and 101,325 kPaA (kilopascal absolute)
V_vap	vapour volume, in cubic metres, in the container
$V_\mathrm{vap,s}$	vapour volume at standard condition
x_i; x_j	mole fractions of the components *i* and *j*, respectively
x_1	mole fraction of methane in the LNG
x_2	mole fraction of nitrogen in the LNG
Z_i	compression factor for component *i* at the required pressure and temperature
Z_mix	compression factor for the vapour mixture under known conditions of temperature and pressure
ρ_s	density, in kilograms per cubic metre, of the liquid at T_s
ρ_t	density, in kilograms per cubic metre, of the liquid at *t*

NOTE Additional subscripts *F* and *I* indicate, respectively, the final and initial measurements or product properties in either of the two containers used for a transfer.

4 Outline of calculation

4.1 LPG

Figure 1 outlines the calculation of mass of LPG from liquid volume at *t* °C.



a) Density by hydrometer **b) Density from composition**

Figure 1 — Calculation flow (LPG)

The procedure for converting the volume of refrigerated LPG to its equivalent volume at a standard temperature and corresponding equilibrium pressure includes the following aspects.

a) Very large factors may have to be applied for the correction of observed density to density at standard temperature, e.g. a correction for the effect of a temperature difference of 60 °C may be necessary for refrigerated propane. Provided that the LPG does not contain more than 20 % of unsaturated hydrocarbons, the correction tables introduced in ISO 91 shall be used for volume corrections. Mass of LPG is calculated by multiplying its volume at standard temperature by its density at standard temperature.

b) The equivalent liquid content in the vapour space of a container holding refrigerated LPG is significantly less than the liquid in the container if the tank and contents are at ambient temperature. Therefore, any error in accounting for the equivalent liquid content in the vapour space will be of lesser significance.

NOTE The following examples illustrate the magnitude of errors that can be introduced by using the tables referred to in ISO 91.

a) Pure butene or propene: the maximum error will be approximately 2 % for a correction from −60 °C to +20 °C.

b) Mixtures containing approximately 20 % of unsaturated hydrocarbons: a typical error will be approximately 0,1 % for a temperature difference of 20 °C.

A condition in which a liquid has a vapour pressure significantly higher than atmospheric pressure at a standard temperature of 15 °C can only be considered as a pseudo-condition, and the volume of the liquid in this condition may be used only when convenient in a procedure for obtaining the density at refrigerated temperatures by means of pressure hydrometer measurement at ambient conditions (see ISO 3993).

4.2 LNG

Figure 2 outlines the calculation energy content of LNG from liquid volume at t °C.

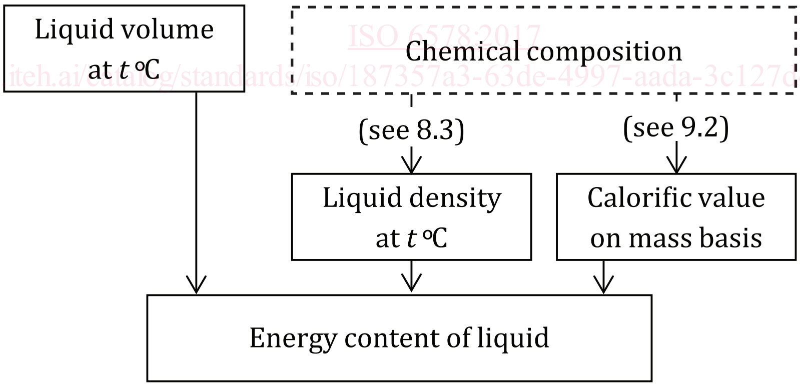


Figure 2 — Calculation flow (LNG)

Energy content of LNG is the product of its volume at observed temperature, the density at that temperature and the calorific value per unit mass. This calculation does not involve conversion of volume at observed temperature to the equivalent volume at standard temperature.

4.3 Data for calculation

Values specified in the normative annexes (Annexes B, C, D and E), such as physical properties of components of refrigerated hydrocarbon liquids, constants, factors, etc., shall be normatively applied in the use of this document.

5 Mass

5.1 Mass of liquid phase

5.1.1 The mass of liquid (m_{liq}), in kilograms, is calculated from Formula (1):

$$m_{\text{liq}} = V_{\text{liq}} \rho \tag{1}$$

where V_{liq} and ρ are for the same temperature.

EXAMPLE 1

Measured volume of liquid LNG in a container = 45 550 m^3 at −159,5 °C.

Calculated density at −159,5 °C = 462,4 kg/m^3

Mass of LNG (m_{liq}) = 45 550 × 462,4 = 21,06 × 10^6 kg or 21,06 × 10^3 t

5.1.2 The density of refrigerated LPG may be determined at the standard temperature of 15 °C by use of the pressure hydrometer method (see ISO 3993) or suitable densimeter. The liquid sample drawn into a suitable container is allowed to approach ambient temperature under pressure, without loss of vapour, before it is introduced into the hydrometer cylinder.

The density of liquid may also be calculated from a composition analysis (see Clause 8).

5.1.3 If the actual temperature t_2, at which the density is measured, does not differ by more than 5 °C from the temperature t_1 of the main bulk of liquid in the container, then the observed density may be corrected to the required bulk temperature by using Formula (2). The density at t_1 shall be measured or calculated if the difference of the temperatures exceeds 5 °C.

$$\rho_{t,1} = \rho_{t,2} + F(t_2 - t_1) \tag{2}$$

where

$\rho_{t,1}$ and $\rho_{t,2}$	are the densities at temperatures t_1 and t_2, respectively;
F	is the density correction factor applicable to the particular liquid. The units of F shall be compatible with the units of ρ, e.g. when ρ is expressed in kilograms per cubic metre, F is expressed in kg/(m^3·°C).

Product	F kg/(m^3·°C)
LNG [>80 % (m/m) methane]	1,4
Liquid propanes [>60 % (m/m) propane]	1,2
Liquid butanes [>60 % (m/m) butane]	1,1