



BSI Standards Publication

**Refrigerated hydrocarbon and non-petroleum
based liquefied gaseous fuels — Liquefied
Natural Gas (LNG) as marine fuel —
Measurement on board LNG bunkering ship**

National foreword

This British Standard is the UK implementation of ISO 11982:2025.

The UK participation in its preparation was entrusted to Technical Committee PTI/12, Petroleum Measurement and Sampling.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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© The British Standards Institution 2025
Published by BSI Standards Limited 2025

ISBN 978 0 539 21089 7

ICS 75.180.30

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2025.

Amendments/corrigenda issued since publication

Date	Text affected



International
Standard

ISO 11982

Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels — Liquefied Natural Gas (LNG) as marine fuel — Measurement on board LNG bunkering ship

Hydrocarbures réfrigérés et combustibles gazeux liquéfiés à base non pétrolière — Utilisation du Gaz Naturel Liquéfié (GNL) comme combustible marin — Mesurage à bord des navires avitailleurs de GNL

**First edition
2025-11**

Reference number
ISO 11982:2025(en)

Full document details: BS ISO 11982:2025

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Published in Switzerland

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Foreword

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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*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Efforts such as the restriction of sulfur content in marine fuel oil introduced by IMO MARPOL ANNEX IV^[23] and growing trends towards decarbonisation have promoted cleaner marine fuel.

Liquefied natural gas (LNG) is one of the most practical marine fuel choices. It is considered cleaner than conventional fuel oils. The conventional trade volume of LNG transported by one shipment is large, with a total capacity of 170 000 m³ at the time of publication of this document. The trade quantity is calculated according to the method defined by the sales and purchase agreement between the cargo supplier and receiver.

On the other hand, the trade quantity of LNG as a marine fuel by one shipment can be smaller than the conventional trade volume of 170 000 m³. Furthermore, the LNG containment system of the LNG bunkering ship is unlike the systems of conventional LNG carriers, especially the pressure in the tanks, which is relatively higher than that of the conventional carrier type. Tank types, including IMO type C, membrane, and SPB type, are available.

In addition to the difference in trade quantity and the cargo containment system between LNG bunkering shipments and conventional shipments, the energy transferred during the operations also differs. Determining the amount of energy transfer involves calculating not only the quantity but also the quality of transferred liquid and vapour, as well as the gas used during the transfer operation. This document provides the data treatment, calculation methods and calculation examples.

Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels — Liquefied Natural Gas (LNG) as marine fuel — Measurement on board LNG bunkering ship

1 Scope

This document provides requirements and guidance for quantifying liquefied natural gas (LNG) as a marine fuel on board LNG bunkering ships.

It is applicable to the measurement of LNG from any source, e.g. gas from conventional reservoirs, shale gas, coalbed methane, at the time of:

- ship to ship (STS) transfer to LNG-fuelled ships,
- STS transfer between LNG bunkering ships, and
- transfer to or from shore tanks or other facilities, irrespective of the type of tanks.

This document is also applicable to the quantification of biomethane and synthetic methane from fossil fuels or renewable sources.

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 6976:2016, *Natural gas — Calculation of calorific values, density, relative density and Wobbe indices from composition*

ISO 23306:2020, *Specification of liquefied natural gas as a fuel for marine applications*

3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

liquefied natural gas

LNG

liquid composed predominantly of methane

[SOURCE: ISO 6578: 2025, 3.1.3]

3.2

LNG bunkering ship

ship that supplies *liquefied natural gas (LNG)* ([3.1](#)) as marine fuel to LNG-fuelled ships

3.3

LNG-fuelled ship

ship that utilises *liquefied natural gas (LNG)* (3.1) for the purpose of propulsion

3.4

LNG carrier

cargo ship specifically constructed and used for the carriage of *liquefied natural gas (LNG)* (3.1) in bulk

[SOURCE: ISO 10976:2023, 3.1.21]

3.5

custody transfer measurement

measurement of liquid level, liquid and *vapour* (3.11) temperature, *vapour pressure* (3.12) and analysis of the composition of *liquefied natural gas (LNG)* (3.1) to be delivered to/from a tank, by which volumetric and other data are determined to be a basis of payment of cost or assessment of duty

[SOURCE: ISO 19970:2025, 3.3, modified — "measurement" has replaced "measuring" in the definition.]

3.6

custody transfer measurement system

CTMS

system that processes inputs from an *automatic tank gauge (ATG)* (3.7) system, thermometers, pressure gauges, etc., and provides *custody transfer measurement* (3.5) information on board, generating documents with regard to custody transfer of *liquefied natural gas (LNG)* (3.1)

Note 1 to entry: The ATG system can be incorporated as part of a CTMS.

[SOURCE: ISO 18132-1:2011, 2.1.4]

3.7

automatic tank gauge

ATG

instrument that automatically measures and displays liquid levels or ullages in one or more tanks, either continuously, periodically or on demand

[SOURCE: ISO 10976:2023, 3.1.4]

3.8

tank capacity table

capacity table

calibration table

tank table

table showing the capacities of, or volumes in, a tank corresponding to various liquid levels measured from a reference point

[SOURCE: ISO 8311:2013, 3.18]

3.9

trim

difference between the fore and aft draught of the vessel

Note 1 to entry: When the aft draught is greater than the forward draught, the vessel is said to be trimmed by the stern. When the aft draught is less than the forward draught, the vessel is said to be trimmed by the head.

[SOURCE: ISO 8311:2013, 3.19]

3.10

list

transverse inclination of a ship

Note 1 to entry: It is expressed in degrees.

[SOURCE: ISO 8311:2013, 3.7]

3.11

vapour

fluid in the gaseous state that is transferred to/from or contained within the cargo tank

[SOURCE: ISO 10976:2023, 3.1.30]

3.12

vapour pressure

pressure at which a liquid and its *vapour* (3.11) are in equilibrium at a given temperature

[SOURCE: ISO 10976:2023, 3.1.31]

3.13

absolute pressure

total of the gauge pressure plus the pressure of the surrounding atmosphere

[SOURCE: ISO 10976:2023, 3.1.1]

3.14

bunker delivery note

BDN

proprietary document of the bunker supplier providing details of the quality and quantity of the bunker(s) delivered by the *liquid natural gas (LNG) bunkering ship* (3.2) to the *LNG-fuelled ship* (3.3)

[SOURCE: ISO 22192:2021, 3.6, modified — replaced “the bunker tanker to the vessel” with “the LNG bunkering ship to the LNG-fuelled ship”.]

3.15

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 the combustion reference temperature and the combustion reference pressure, respectively.

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

3.16

net 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

[SOURCE: ISO 6976:2016, 3.2, modified — Note 1 to entry has been removed.]

3.17

methane number

rating indicating the knocking characteristics of a fuel gas

Note 1 to entry: It is comparable to the octane number for petrol. One expression of the methane number is the volume percentage of methane in a methane-hydrogen mixture, that in a test engine under standard conditions has the same tendency to knock as the fuel gas to be examined.

[SOURCE: ISO 14532:2014, 2.6.6.1]

3.18

Wobbe index

calorific value on a volumetric basis at specified reference conditions, divided by the square root of the relative density at the same specified metering reference conditions

Note 1 to entry: The Wobbe index is specified as superior (denoted by the subscript “S”) or inferior (denoted by the subscript “I”), depending on the calorific value.

[SOURCE: ISO 14532:2014, 2.6.4.3]

3.19

calibration

operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

[SOURCE: ISO/IEC Guide 99:2007, 2.39, modified — Notes 1, 2 and 3 to entry have been removed.]

3.20

verification

process of confirming the accuracy of an instrument by comparing to a source with known *uncertainty* ([3.24](#))

[SOURCE: ISO 10976:2023, 3.1.32]

3.21

biomethane

methane rich gas derived from biogas or from gasification of biomass by upgrading with the properties similar to natural gas

[SOURCE: ISO 14532:2014, 2.1.1.15]

3.22

working range

range of an instrument in normal operation

[SOURCE: ISO 10976:2023, 3.1.36]

3.23

flowmeter

flow measuring device which indicates the measured flowrate

[SOURCE: ISO 19970:2025, 3.6]

3.24

uncertainty

non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used

[SOURCE: ISO 19970:2025, 3.13]

4 On-board measurement

4.1 Outline

Proper on-board measurement is necessary to ensure reliable energy determination. Energy transferred is calculated via volume/mass and composition of the product transferred. There are two kinds of measurement principles: one is static, and the other is dynamic. The measurement equipment for the cargo measurement shall be calibrated and verified with reasonable uncertainty.

Either the volume or mass, or both, of the LNG bunker is obtained by measurement on board LNG bunkering ships. Other parameters such as density, calorific value, methane number etc. are calculated from the LNG bunker composition. These quantity and quality measurements of LNG as a marine fuel are required by the contract between supplier and receiver. The items described in the bunker delivery note (BDN) reflect those in the contract between the supplier and the receiver. Refer to [Annex D](#) for an example of the parameters of a BDN.

4.2 Static measurement

4.2.1 General

To obtain the volume of the cargo by static measurement, the items and equipment listed in [4.2.2](#) and [4.2.3](#) are necessary on board the LNG bunkering ship.

4.2.2 Tank capacity table

4.2.2.1 General

Tank capacity tables consist of a main capacity table and various correction tables. The main capacity table shows the relationship between the liquid level and cargo volume in the specified cargo tank. The volume of the cargo can be obtained by the corrected liquid level. The main capacity table is prepared when the ship is upright and the tanks are at the reference temperature and pressure.

The instant liquid level shall be corrected by correction tables due to trim, list, vapour temperature and pressure. The apparent liquid volume can be found by the corrected liquid level from tank capacity tables. The apparent liquid volume shall also be corrected due to the expansion or contraction of the tank shell by temperature and pressure.

Tank capacity tables consist of the following individual tables depending on the type of cargo containment system and level measuring devices for each cargo tank:

- main capacity tables;
- trim correction tables;
- list correction tables;
- float correction tables due to liquid density;
- temperature correction tables for the automatic tank gauge (ATG);
- temperature correction tables for the tank shell;
- pressure correction tables for the ATG;
- pressure correction tables for the tank shell.

NOTE ISO 12917-1 gives guidance on pressure correction of horizontal cylindrical tanks with hemispherical ends.

Tank capacity tables shall be prepared based on actual measurements of the cargo tanks. Cargo tanks calibration should be done according to International Standards such as ISO 12917-1 for horizontal cylindrical tanks and ISO 8311 for the membrane and prismatic tanks.

4.2.2.2 Uncertainty requirement

Uncertainty of tank capacity tables shall be smaller than or equal to 0,2 % with 95 % confidence level. The uncertainty can be estimated according to ISO 8311:2013, Annex A; ISO 12917-1:2017, Annex C; or ISO/IEC Guide 98-3. The confidence level of the uncertainty in this document is 95 % unless otherwise stated. Apply two for the coverage factor (k) to combined standard uncertainty in order to obtain an expanded uncertainty.

4.2.3 Custody transfer measurement system (CTMS)

4.2.3.1 General

The following measurands are taken by custody transfer measurement.

- liquid level
- liquid temperature
- vapour temperature
- vapour pressure
- trim and list of the ship

Refer to ISO 8310, ISO 10976, ISO 18132-1 and ISO 19636 for the details of the static measurement equipment.

There are several kinds of measurement principles, and any kind of static measurement equipment can be used if its tolerance is according to [Table 1](#).

4.2.3.2 Static measurement equipment performance

Tolerance and minimum display resolution of static measurement equipment are shown in [Table 1](#). The tolerance shall be the integration of sensor uncertainty and display uncertainty.

Table 1 — Static measurement equipment performance

Static measurement equipment	Measurable range	Tolerance	Minimum display resolution
Level	Near to the bottom ^a to the top	+/- 7,5 mm	1 mm
Pressure	80 kPaA (kilopascal absolute) to 460 kPaA ^b	+/- 1 % of working range	0,1 kPa
Temperature ≤ -145 °C > -145 °C	-165 °C to 50 °C ^c	+/- 0,2 °C +/- 1,5 °C	0,1 °C 0,1 °C
Trim (by inclinometer)	Typically, -2° to +2° ^d	+/- 0,5 % of working range	0,01 m
List (by inclinometer)	Typically, -5° to +5° ^d	+/- 0,5 % of working range	0,01°

The working range is equal to the full range or smaller. The working range shall be decided by the parties concerned.

^a As described in ISO 18132-1.

^b The range of pressure measurement is dependent on the tank design. The pressure range shown in this table is only an example.

^c Automatic tank thermometers shall have a sufficient measurable range in accordance with the intended cargoes to be loaded. See ISO 8310 for further details.

^d As described in ISO 19636.

4.2.3.3 Calibration

To clarify the uncertainty of the transferred volume, the static measurement equipment shall be calibrated and verified by an independent party before initial use. Re-calibration of the static measurement equipment shall be done on a periodic basis. The period should be determined by the LNG bunkering ship, charter party or relevant regulations. If this period is not specified in any contracts or regulations, certification and verification should be completed twice in five years but not exceeding three years. The LNG bunkering ship is responsible for calibration, verification and certification.