



**International  
Standard**

**ISO 6919**

**Measurement of refrigerated  
hydrocarbon and non-petroleum  
based liquefied gaseous fuels —  
Dynamic measurement of liquefied  
natural gas (LNG) as marine fuel —  
Truck-to-ship (TTS) bunkering**

*Mesurage des combustibles gazeux liquéfiés réfrigérés à  
base d'hydrocarbures ou à base non pétrolière — Mesurage  
dynamique du gaz naturel liquéfié (GNL) en tant que combustible  
marin — Soutage de camion à navire*

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## Foreword

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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 document 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](http://www.iso.org/directives)).

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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](http://www.iso.org/members.html).

# Measurement of refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels — Dynamic measurement of liquefied natural gas (LNG) as marine fuel — Truck-to-ship (TTS) bunkering

## 1 Scope

This document defines procedures and requirements for measuring liquefied natural gas (LNG) from truck-to-ship (TTS) using the combination of Coriolis mass flowmeter (MFM) and gas chromatography (GC). It also gives guidance and requirements for portable packaging of the combination system in mobile form which minimizes facility storage space and streamlines the use of development systems. Output from the system in calorie units is applicable to commercial transactions between suppliers and users of liquefied natural gas (LNG) as marine fuel.

This document also consists of general requirements, metrological requirements, system flawless requirements, requirements and test methods, and procedures for measurement methods.

## 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 6974-1:2012, *Natural gas — Determination of composition and associated uncertainty by gas chromatography — Part 1: General guidelines and calculation of composition*

ISO 22192:2021, *Bunkering of marine fuel using the Coriolis mass flow meter (MFM) system*

ISO 10790:2015, *Measurement of fluid flow in closed conduits — Guidance to the selection, installation and use of Coriolis flowmeters (mass flow, density and volume flow measurements)*

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

ISO 21903, *Refrigerated hydrocarbon fluids — Dynamic measurement — Requirements and guidelines for the calibration and installation of flowmeters used for liquefied natural gas (LNG) and other refrigerated hydrocarbon fluids*

ISO 6578:2017, *Refrigerated hydrocarbon liquids — Static measurement — Calculation procedure*

## 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

**bunker**

fuel supplied to a vessel for its propulsion and/or operation

Note 1 to entry: The fuel in this document is Class F, as specified in ISO 8217.

3.2

**bunker delivery note**

**BDN**

proprietary document of the bunker supplier providing details of the quality and quantity of the bunker(s) delivered by the truck to the receiving ship

3.3

**bunker metering ticket**

ticket printed at the end of bunkering operation

3.4

**bunkering operation**

transfer operation between the truck and receiving ship

3.5

**bunker supplier**

company which contractually agrees with the buyer to deliver the product

3.6

**bunker surveyor**

person who inspects, measures, samples, investigates and reports as required on the *bunkering operations* (3.4)

3.7

**LNG representative**

individual who represents the *bunker supplier* (3.5) and is responsible for *bunkering operations* (3.4) and documentations

3.8

**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 to entry have been deleted.]

3.9

**chief engineer**

high-level technical position for receiving bunkers and documentation of the *bunkering operation* (3.4) on the vessel

3.10

**container**

portable tank unit

3.11

**expanded uncertainty**

quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that can reasonably be attributed to the measuring

Note 1 to entry: The fraction may be viewed as the coverage probability or level of confidence of the interval.

Note 2 to entry: To associate a specific level of confidence with the interval defined by the expanded uncertainty requires explicit or implicit assumptions regarding the probability distribution characterized by the measurement result and its combined standard uncertainty. The level of confidence that may be attributed to this interval can be known only to the extent to which such assumptions may be justified.

Note 3 to entry: The expanded uncertainty is referred to as "overall uncertainty" in Recommendation INC-1 (1980), Paragraph 5.

[SOURCE: ISO/IEC Guide 98-3:2008, 2.3.5, modified — in the definition, "measuring" has replaced "measurand".]

### 3.12

#### **liquefied natural gas**

##### **LNG**

cryogenic liquid produced by reducing the temperature of natural gas to about  $-162\text{ °C}$  at atmospheric pressure

[SOURCE: ISO 12617:2015, 3.6]

### 3.13

#### **Coriolis flowmeter**

device consisting of a flow sensor (primary device) and a *transmitter* (3.19) (secondary device) which primarily measure the mass flow by means of the interaction between a flowing fluid and the oscillation of a tube or tubes

Note 1 to entry: The mass flow meter may also provide measurements of the density and the process temperature of the fluid.

[SOURCE: ISO 10790:2015, 3.1.1, modified — in the definition, "primarily" has been added and "density" has been removed; note 1 to entry has been modified.]

### 3.14

#### **mass flow meter system**

##### **MFM system**

system that comprises the mass flow meter, its ancillary devices, pipelines and sealing points between the pump suction and the custody transfer point

[SOURCE: ISO 22192:2021, 3.26]

### 3.15

#### **online gas chromatography**

gas chromatography that is directly connected to the pipelines or sampling device to implement online analysis

### 3.16

#### **risk assessment**

overall process of risk identification, analysis and evaluation

### 3.17

#### **safety zone**

zone, extending beyond the hazardous zone, where special precautions are required because of the hazards presented by natural gas/ *liquefied natural gas* (3.12) during *bunkering operations* (3.4)

[SOURCE: SGMF FP 02-01, 4.2]

### 3.18

#### **transfer system**

system used to connect the bunkering facility and the receiving ship in order to transfer *liquefied natural gas* (LNG) (3.15) only, or both LNG and vapours

Note 1 to entry: The transfer system consists of all equipment contained between the bunkering manifold flange on the facility or vessel providing LNG fuel and the bunkering manifold flange on the receiving LNG fuelled vessel. It includes transfer arms, articulated rigid piping, hoses, swivels, couplings, supporting structure handling system and its control/monitoring system.

### 3.19

#### transmitter

transmitting apparatus providing the drive and transforming the signals from the flow sensor, to give output(s) of measured and inferred parameters

Note 1 to entry: The transmitter also provides corrections derived from parameters such as temperature.

## 4 General requirements and safety precautions

All personnel involved in the measurement of transporting liquefied natural gas (LNG) from truck-to-ship (TTS) shall wear proper and adequate personal protective equipment.

NOTE Approved industry standards can apply.

All parties involved in the measurement of transporting LNG shall be free from the influence of any alcohol, drugs or other substances which impair the safe and efficient execution of their work and personal health.

The International Association of Ports and Harbors (IAPH)<sup>[8]</sup> has developed a TTS bunkering scheme to provide safety and operational checklists (see [Annex D](#)) for LNG bunkering.

## 5 Measurement systems and equipment

### 5.1 General

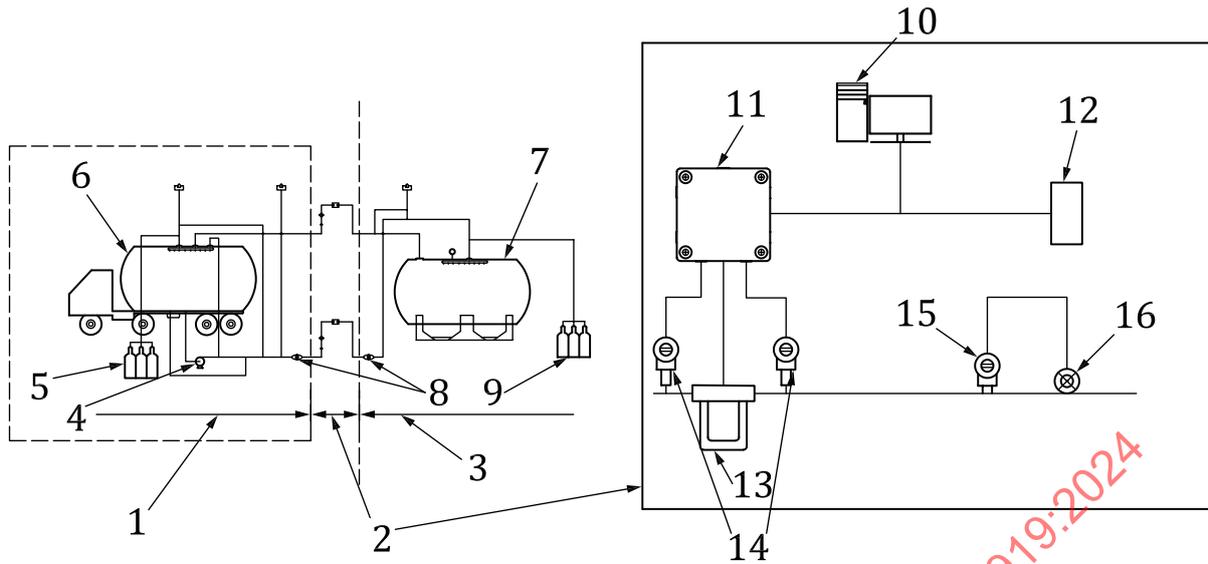
**5.1.1** The determination of quantities for TTS bunkering requires measuring the quantity in mass and measuring the net calorific value of the fuel. The application of the measurement process to LNG is limited in this document to establishing the quantity and composition of LNG relative to an end-point use such as a fuel or as a feed stock.

**5.1.2** To determine the gross calorific value of the fuel, the following quantities shall be measured and/or calculated:

- a) mass of bunker(s) transferred, expressed in kilograms (kg);
- b) net or gross calorific (heating) value, expressed in joules per kilogram (J/kg);
- c) density, expressed in kilograms per cubic metre (kg/m<sup>3</sup>).

### 5.2 Portable packaging measurement system

A Coriolis mass flow meter and gas chromatograph are made in the portable package. This is done to quickly calculate, reduce stakeholder disputes caused by supply and demand quantity differences, minimize facility storage space, and overcome the possibility of weathering effect<sup>[1]</sup> on the LNG from truck refuelling time to delivery time (see [Figure 1](#)). A Coriolis mass flow meter measures the actual supply by calculating the supply, return, and density in real time at the site while simultaneously measuring ethane, methane, and propane mole fractions, the major components of LNG, in real time by gas chromatography.

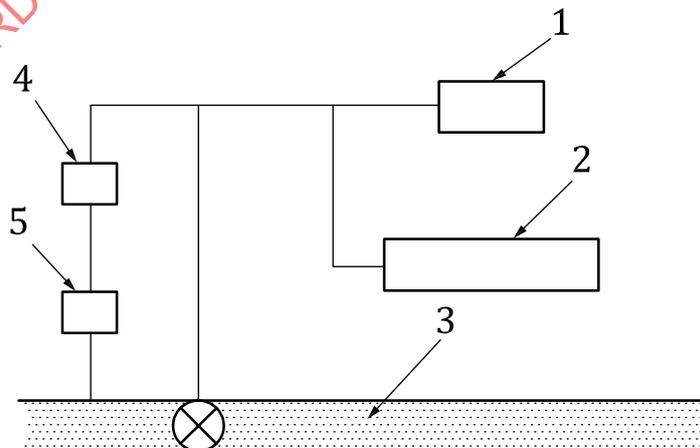


**Key**

- |   |                             |    |                                 |
|---|-----------------------------|----|---------------------------------|
| 1 | LNG bunker facility (truck) | 8  | ESD                             |
| 2 | interface                   | 9  | nitrogen supply (RS side)       |
| 3 | receiving ship              | 10 | bunkerlink PC                   |
| 4 | cyrogenic pump              | 11 | bunker box                      |
| 5 | nitrogen supply (BFO side)  | 12 | bunker ticket printer           |
| 6 | bunker supply (Type-C)      | 13 | ELTE high capacity flow meter   |
| 7 | receiving tank (Type-C)     | 14 | liquid detector                 |
|   |                             | 15 | pressure transmitter            |
|   |                             | 16 | backpressure valve and actuator |

SOURCE: Reference [2], reproduced with the permission of the authors.

**a) Measuring supply flow**

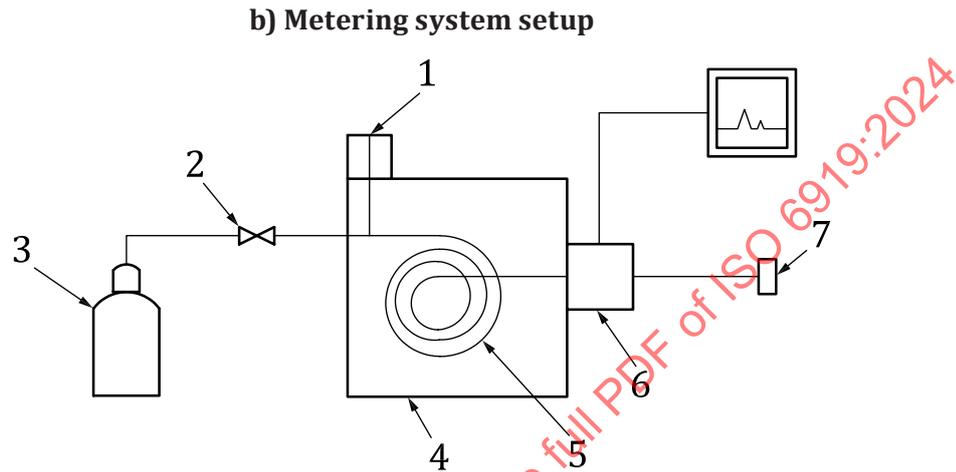


**Key**

- 1 flow meter

- 2 gas chromatography
- 3 LNG composition %: methane, ethane, propane, etc
- 4  $T$ , temperature
- 5  $P$ , pressure

NOTE 1 The parameters of the mass flow using a flow meter are quantity, temperature and pressure.  
 NOTE 2 The parameters of the gas chromatography include density, caloric value, Wobbe number, methane number, etc.



**Key**

- 1 sample injector
- 2 flow controller
- 3 carrier gas
- 4 column oven
- 5 column
- 6 detector
- 7 waste

SOURCE: Reference [3], reproduced with the permission of the authors.

**c) Gas chromatography principle**

**Figure 1 — Portable packaging of the combination system**

NOTE 1 There are two ways of transferring LNG for analysis after the sample has been vaporized properly: in a gas sample container (according to the definition in ISO 8943: the sample container used for the retention of the gas sample and for its transfer to an analysing instrument) or by direct piping to a gas analyser.<sup>[4]</sup>

NOTE 2 When an online gas chromatography is used, the data produced are normally used for the certificate of analysis and calculation of the heating value and density. The composite samplers are then used to produce the retained samples (available for buyer, seller, and independent lab, in case of a dispute). Alternatively, the composite samples can be used for the determination of the heating value (and used as backup of the online gas chromatography system).

## 5.3 Metrological requirements for measurement

### 5.3.1 Coriolis flow meter installation requirements

Installation and measurement using a Coriolis flow meter shall follow ISO 21903 and ISO 22192.

Fast-block valves shall be installed on both sides of the Coriolis MFM for zeroing on-site. A pressure relief device shall be installed in between the fast-block valves. The conditions of zero flow and the Coriolis MFM fully filled with LNG during the zeroing process shall be met.

### 5.3.2 Gas chromatography apparatus requirement

Installation and measurement using gas chromatography shall follow ISO 6974-1.

## 5.4 Measurement system verification

### 5.4.1 Coriolis flow meter system verification

The Coriolis flow meter system is required to undergo and pass an onsite verification to ensure that the metrological requirements in [5.3.1](#) are met.

Prior to installation, the Coriolis MFM shall be calibrated at the required flowrate to ensure that the error for the measurement of LNG falls within 1 % before it can be used for LNG bunkering. The calibration shall be traceable to a laboratory conforming to ISO/IEC 17025.

The Coriolis MFM's zero conditions shall be verified annually to ensure that the MFM is sufficiently stable to meet the maximum permissible error (MPE) of 1 %.

### 5.4.2 Gas chromatography system verification

Gas chromatography control charts can be used for determining whether the system is working satisfactorily.

## 5.5 Equipment maintenance and testing

The maintenance and testing of the systems and related components shall be performed in accordance with the manufacturers' guidelines and recommendations. Any additional maintenance and testing requirements arising from the risk assessment or otherwise, considering the system(s) as a whole, should be considered. The requirements of relevant authorities should also be taken into consideration.

The equipment used for measurement transporting LNG from TTS shall be visually inspected and/or tested as part of the pre-operation checks. Regular checks shall be conducted to ensure the quantity measurement system and all associated devices are in good working order.

Refer to ISO 20519 for requirements for LNG bunkering transfer systems and equipment used to bunker LNG fuelled vessels.

## 6 Measurement procedures

### 6.1 Coriolis mass flowmeter procedures

#### 6.1.1 General

The Coriolis mass flowmeter consists primarily of a fluid-conveying pipe fixed at both ends (measuring tube), an electromagnetic driver, a displacement sensor, a housing that provides structural support and protection to the measuring tube, and dedicated electronics (transmitter) to process the meter's output signal and thus calculate the mass flow rate. The Coriolis flowmeter working principle specified in ISO 10790:2015, Clause 6 shall be applied.

## 6.1.2 Quantity measurement procedures

**6.1.2.1** It is expected that the Coriolis MFM is sealed by parties authorized by the national weights and measures authority, after verification of the zero verification results, for custody transfer measurement in LNG bunkering.

**6.1.2.2** To prevent or minimize flashing, it is recommended that the difference between the discharge pressure and the vapour pressure (at the fluid temperature) be maintained at a factor of at least three times the pressure drop across the meter. The pressure drop may be reduced by an increase in meter size, taking into consideration the minimum flow rate ( $Q_{\min}$ ) of the meter. Increasing static pressure or reducing process temperature may also compensate for pressure drop and prevent flashing.

**6.1.2.3** A functional test in the field may be required to determine optimum process control to avoid boil off or LNG flashing entering Coriolis MFM.

**6.1.2.4** The following field conditions shall be met prior to the commencement of quantity measurement using a Coriolis MFM:

- a) carry out measurements in accordance with ISO 22192:2021, Clause 9;
- b) Cool the pipework or the hydraulic circuit and the Coriolis MFM to reach the cryogenic temperature. Keep the temperature stable and maintain that sub-cooled temperature over a period of at least 15 min prior to the commencement of measurement;
- c) ensure a gradual reduction in temperature to prevent excessive stress in the Coriolis MFM;
- d) ensure that the Coriolis MFM has sufficient thermal insulation so that the operating temperature is maintained;
- e) ensure that the minimum flow rate ( $Q_{\min}$ ), maximum flow rate ( $Q_{\max}$ ) and minimum measured quantity (MMQ) of the Coriolis MFM, are met;
- f) before commencing the measurement, inspect the Coriolis MFM system to ensure that the pipeline and bypass are secured and the meter, computer, indicator, pipeline and valves are in good operating conditions and are secured against unauthorized tampering and adjustment;<sup>[5]</sup>
- g) reset the totaliser of the Coriolis MFM;
- h) minimize stress on the Coriolis MFM caused by the pipeline;
- i) begin LNG bunker delivery to the receiving ship;
- j) monitor the discharge pressure and ensure that the delivery is in a single-phase flow condition during the transfer;
- k) ensure the operating flow rate is within the calibrated  $Q_{\min}$  and  $Q_{\max}$  range;
- l) ensure the temperature of the liquid in the Coriolis MFM is within the minimum and maximum temperatures recommended by the meter vendor;
- m) ensure sufficient and stable back pressure with good control during the bunkering delivery in order to avoid flow fluctuation, boiling or LNG flashing;
- n) after LNG delivery, take the reading indicated on the totaliser of the Coriolis MFM and print out the bunker measurement ticket; and
- o) indicate the unit of delivery quantity as mass in vacuum.

### 6.1.3 Quantity measurement documentation

Ship-owners/buyers are strongly advised to document agreed detailed specifications in their contract with bunker suppliers. Ship-owners/buyers are reminded that if no detailed specification is agreed upon, this can prejudice any subsequent claims in the event of a dispute.

Prior to the completion of the required procedure in accordance with [6.1.2.4](#), the documents listed below shall be approved by the LNG truck representative, chief engineer, or bunker surveyor (when engaged). All data shall be in the form of a permanent written record at the time the procedures are performed.

All stakeholders involved in the bunkering operation shall complete, maintain, and store traceable completed records of all steps involved in the bunkering operation. These documents shall contain terms which are consistent with this document.

A complete bunkering operation shall include the following documentation that bears the bunker supplier's name:

- a) Bunker requisition form (mass flow metering);
- b) Mass flow metering system seals checklist (see an example in [Annex E](#));
- c) Meter reading record form (delivery) (see an example in [Annex F](#));
- d) Bunker metering ticket (see an example in [Annex C](#)), which shall be printed at the end of delivery and filed for reference;
- e) Bunker delivery note (BDN) (see an example in [Annex B](#)).

The LNG truck representative shall prepare the documents for the chief engineer.

Bunker suppliers may have their own formats for the above documents, but the information as set out in such specific formats shall only contain terms which are consistent with this document.

### 6.1.4 MFM system failure and quantity dispute

#### 6.1.4.1 MFM system failure

In the event that there is an MFM system failure (as can be indicated by a critical alarm) occurring during a bunkering operation where the delivery cannot be continued, the pumping shall cease immediately and the meter's totalizer readings shall be recorded in the meter reading record form. A BDN shall be completed.

The final quantity delivered shall be the sum of the quantities recorded in the respective BDNs.

#### 6.1.4.2 Quantity dispute

If bunker supplier and buyer do not agree on the delivered quantity through the MFM system, it can be considered as a quantity dispute situation. Both parties shall proceed to resolve the quantity dispute situation by checking if the bunker delivery is conducted in accordance with this document. If the dispute situation is not resolved, the party making the claim shall issue a letter of protest, which shall be signed for receipt by the other party to ascertain compliance to this document.

## 6.2 Gas chromatography procedures

### 6.2.1 General

Set up the gas chromatography in accordance with the manufacturer's instructions.

### 6.2.2 Quality measurement procedures

LNG quality measurement is required to obtain the LNG composition, which is used to calculate the calorific value. The net calorific value ( $H_N$ ) and gross calorific value ( $H_G$ ) can be determined by computation on the basis of molar fraction of component  $X_i$ , molecular mass of component ( $M_i$ ) and the mass calorific value of component ( $H_{N,i}$ ,  $H_{G,i}$ ).

Re-gasified LNG sample is analysed by gas chromatography (GC) to determine its composition. The procedures for analysis should be carried out in accordance with ISO 6974-1:2012, Clause 6.

### 6.2.3 Quality measurement documentation

Test report documentation shall be in accordance with the procedures in ISO 6974-1:2012, Clause 8.

### 6.2.4 Calibration

Calibrate the equipment in accordance with the procedures in ISO 6974-1:2012, Clause 6.

## 6.3 LNG energy calculation

Volumetric gross heating value, mole weight and mass based gross heating value are calculated from the composition using the method referred to in ISO 6976.

Accurate measurement of LNG energy in custody transfer is important to minimize the financial risk in trading. LNG custody transfer energy content is calculated from the mass of the transferred LNG and the calorific value<sup>[6]</sup> using [Formula \(1\)](#).

$$E = M * C_v \quad (1)$$

where

$E$  is the LNG custody transfer energy content, expressed in kilojoules (kJ);

$M$  is the mass of the transferred LNG, expressed in kilograms (kg);

$C_v$  is the calorific value, expressed in kJ/kg.

The net total delivered energy should include the energy of the gas returned via the vapour return line and the gas consumed by the bunkering vessel, if applicable, during bunkering. The LNG bunker supplier and buyer may define assumptions or treatment for such vapour return quantities.

Refer to [Annex A](#) for details on the energy value calculation.

## 6.4 Measurement report

The measurement report shall include the following information:

- a) identification of the sample, including:
  - time and date of sampling (if available),
  - sample point (location) (if available), and
  - identification number for the cylinder (or vessel) used for the sample.
- b) information on the measurement method used, including:
  - a reference to the appropriate part(s) of the ISO 6974 series or other documented methods, and
  - any significant deviations from the referenced method.

c) analytical information, including:

- result of the analysis, expressed as a mole fraction,
- for analyses where ISO 6974-2 has been used, the expanded uncertainty of the analytical value (stating the coverage factor,  $k$ , used to expand the uncertainty;  $k$  is usually 2),
- date of the analysis, and
- information about any corrections made for contamination by air or other gases, if appropriate.

d) laboratory information, including:

- date of issuance of the report,
- name and address of the laboratory, and
- signature of the authorized signatory.

NOTE The results of analysis carried out using ISO 6974-1:2012 can be used in conjunction with additional information for the certification of a certified reference gas mixture (CRM). These reports can be reviewed by affected parties, signed, and retained with other custody transfer documentation.

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## Annex A (informative)

### Energy value calculation

**A.1** The net calorific value ( $H_N$ ), gross calorific value ( $H_G$ ), and density can be determined by computation on the basis of the composition of the gas and the reference data. The use of net or gross calorific values for energy content calculation shall be agreed between the LNG bunker supplier and buyer.

**A.2**  $H_N$  and  $H_G$  can be calculated in a number of ways; one example is using [Formulae \(A.1\)](#) and [\(A.2\)](#)<sup>[5]</sup>:

$$H_N = \frac{\sum x_i M_i H_{N,i}}{\sum X_i M_i} \quad (\text{A.1})$$

$$H_G = \frac{\sum x_i M_i H_{G,i}}{\sum x_i M_i} \quad (\text{A.2})$$

where

$x_i$  is the molar fraction of component  $i$ ;

$M_i$  is the molecular mass of component  $i$ , expressed in grams per mole (g/mol);

$H_{N,i}$  is the mass lower calorific value of component  $i$ , expressed in kilojoules per kilogram (kJ/kg);

$H_{G,i}$  is the mass higher calorific value of component  $i$ , expressed in kJ/kg.

The physical constants  $H_{G,i}$ ,  $H_{N,i}$  and  $M_i$  can be found in ISO 6578, ISO 6976, and GPA Standard 2145.

The energy of the transferred LNG can be calculated as shown in [Formulae \(A.3\)](#) and [\(A.4\)](#):

$$E_N = M \cdot H_N \quad (\text{A.3})$$

$$E_G = M \cdot H_G \quad (\text{A.4})$$

where

$M$  is the measured mass in vacuum of the delivered LNG, expressed in kg;

$E_N$  is the net energy of the transferred LNG, expressed in kJ/kg;

$E_G$  is the gross energy of the transferred LNG, expressed in kJ/kg.

The density of the LNG loaded shall be calculated by the revised Klosek-McKinley method described in ISO 6578. For the purpose of this calculation, the molar mass shall be determined in accordance with ISO 6976, as shown in [Formula \(A.5\)](#):

$$\rho = \frac{\sum (x_i \times M_i)}{\sum (x_i \times M_i) - \left[ k_1 + \frac{(k_2 - k_1)}{0,0425} \times x_n \right] \times x_m} \quad (\text{A.5})$$

where

- $\rho$  is the density, expressed in kg/m<sup>3</sup>;
- $k_1$  and  $k_2$  are the correction factors for volume reduction of liquid at temperature of T °C;
- $x_n$  is the mole fraction of nitrogen;
- $x_m$  is the mole fraction of methane.

**A.3** One of the following documents may be used to provide tables of physical constants and methods of calculation of factors, which are necessary to determine the net calorific value, gross calorific value, and density:

- ISO 6976
- ASTM D3588-98
- GPA Standard 2145
- GPA Standard 2172
- HM 21

**A.4** The determination of the amount of vapour returned involves measuring or assuming the composition, and calculating the resulting gas properties for the vapour return gas. The energy of the vapour return gas can be calculated in accordance with ISO 10976, as shown in [Formula \(A.6\)](#):

$$E_D = V \times \left( \frac{273,15 + T_s}{273,15 + T_{\text{vap}}} \right) \times \frac{P_{\text{vap}}}{P_S} \times H_{\text{vol}} \quad (\text{A.6})$$

where

- $E_D$  is the energy of gas displaced, expressed in megajoules (MJ);
- $V$  is the volume of liquid transferred to/from the ship, expressed in cubic metres (m<sup>3</sup>);
- $T_s$  is the reference temperature, typically standard temperature, i.e. 15 °C;
- $T_{\text{vap}}$  is the average temperature of the vapour in the ship's tanks before loading or after unloading, expressed in degrees Celsius (°C);
- $P_{\text{vap}}$  is the average pressure of the vapour in the ship's tanks before loading or after unloading, expressed in kilopascals (kPa) absolute;
- $P_S$  is the reference pressure, typically standard pressure, i.e. 101,325 kPa;
- $H_{\text{vol}}$  is the gross (superior) heating value of methane on a volume basis of the vapour at  $T_S$  and  $P_S$ , expressed in megajoules per cubic metres (MJ/m<sup>3</sup>).

**Annex B**  
(informative)

**LNG bunker delivery note**

[Figure B.1](#) illustrates a typical example of LNG bunker delivery note.

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## ISO 6919:2024(en)

(BUNKER SUPPLIER'S NAME)		BDN No. _____																
(BUNKER SUPPLIER'S ADDRESS AND TELEPHONE NUMBER)																		
(LICENSE NO.: _____)																		
<b>BUNKER DELIVERY NOTE</b>																		
Port	: _____	Date	: _____															
Delivery location	: _____	Vessel's name	: _____															
Truck no.	: _____																	
Alongside vessel	: _____	(Date/Time)	Vessel IMO No. : _____															
Commenced pumping	: _____	(Date/Time)	Gross tonnage : _____															
Completed pumping	: _____	(Date/Time)	Owner/Operator : _____															
			ETD : _____															
			Next port : _____															
<b>PRODUCT SUPPLIED</b>																		
<b>LNG Properties</b>		<b>LNG Composition</b>																
Methane number and calculation method	--	Methane, CH <sub>4</sub>	% (mol/mol)															
Lower calorific (heating) value	MJ/kg	Ethane, C <sub>2</sub> H <sub>6</sub>	% (mol/mol)															
Higher calorific (heating) value	MJ/kg	Propane, C <sub>3</sub> H <sub>8</sub>	% (mol/mol)															
Woobe Indices Ws/Wi	MJ/m <sup>3</sup>	Isobutane, iC <sub>4</sub> H <sub>10</sub>	% (mol/mol)															
Density at LNG temperature delivered <sup>a</sup>	Kg/m <sup>3</sup>	N-Butane, nC <sub>4</sub> H <sub>10</sub>	% (mol/mol)															
Vapour pressure after delivery <sup>a</sup>	bar <sup>e</sup>	Pentane, C <sub>5</sub> H <sub>12</sub>	% (mol/mol)															
Vapour temperature after delivery <sup>a</sup>	°C	Hexane, C <sub>6</sub> H <sub>14</sub> and heavier HCs	% (mol/mol)															
LNG temperature delivered <sup>a</sup>	°C	Nitrogen, N <sub>2</sub>	% (mol/mol)															
		Total sulfur, S	ppmv <sup>b</sup>															
<b>QUANTITY</b>																		
Net total delivered																		
_____ mT <sup>c</sup>		_____ m <sup>3</sup>																
_____ mmBtu <sup>d</sup>																		
<b>SUPPLIER'S CONFIRMATION</b>		<b>MASTER'S/CHIEF ENGINEER'S ACKNOWLEDGEMENT</b>																
We declare that the bunker fuel supplied conforms with Regulation 14(1) or 14(4) and regulation 18(3) of Annex VI of Marpol 73/78		We acknowledge receipt of the above product in the quantities stated.																
For _____		I confirm having received a copy of IMO material safety data sheet																
Company's name and stamp		_____																
Signature of PIC		Signature of Master/Chief Engineer/Time																
Full name in block letters		Full name in block letters																
Bunker tanker's/truck's stamp		Vessel's stamp																
<b>REMARKS</b>																		
Was any note of protest issued? Yes/No _____																		
The following rating is our satisfaction level of the bunkering operation (please circle)																		
<table style="width: 100%; border: none;"> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> <td style="text-align: center;">4</td> <td style="text-align: center;">5</td> </tr> <tr> <td style="text-align: center;">Very</td> <td></td> <td></td> <td></td> <td style="text-align: center;">Very</td> </tr> <tr> <td style="text-align: center;">Unsatisfied</td> <td></td> <td></td> <td></td> <td style="text-align: center;">Satisfied</td> </tr> </table>				1	2	3	4	5	Very				Very	Unsatisfied				Satisfied
1	2	3	4	5														
Very				Very														
Unsatisfied				Satisfied														
		_____																
		Signature of Master/Chief Engineer																
<sup>a</sup> to denote "NA" if not applicable <sup>b</sup> ppmv = parts per million volumes, molar mass of sulfur = 32.06 g/mol <sup>c</sup> mT = million tonnes, 1 mT = 1,000,000,000 kg <sup>d</sup> MMBtu = million British Thermal Unit, 1 MMBtu = 293 kWh = 1,005 MJ <sup>e</sup> 1 bar = 0,1 MPa = 10 <sup>5</sup> Pa; 1 MPa = 1 N/mm <sup>2</sup>																		

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**Figure B.1 — Example of LNG bunker delivery note**

**Annex C**  
(informative)

**Bunker metering ticket**

Figure C.1 illustrates a typical example of bunker metering ticket.

<p><b>[Name of LNG Truck]</b> System ID: 25095339</p> <p>BOL Number: 43</p> <p>Reset Time 19-DEC-2012 11:24:26</p> <p>Print Time 20-DEC-2012 4:27:18</p> <p>Bunker Begin Time 19-DEC-2012 23:40:59</p> <p>Bunker End Time 20-DEC-2012 2:52:49</p> <p>Mass In Air 1 582,682 t</p> <p>Mass Inventory -3 230,306 2 t</p> <p>Begin Fwd Inv Air 45 368,6094 t</p> <p>End Fwd Inv Air 46 951,293 t</p> <p>Begin Rev Inv Air 50 178,121 1 t</p> <p>End Rev Inv Air 50 178,125 t</p> <p>MID Cert#: T 10 265</p> <p>The mass vacuum to mass air conversion factor is: 0,998 925 IMPORTANT: Attach this ticket to BDN Report CE &amp; CO's Signs Original</p>	<p><b>BUNKER METERING TICKET</b> *****ORIGINAL*****</p> <p>TruckID: [Name of LNG Truck]</p> <p>F40001302SS</p> <p>BTN: 40 / Line 1</p> <p>Printout Time: 2013/AUG/18 10:19:09</p> <p>Start Time 2013/AUG/16 23:09:05</p> <p>End Time 2013/AUG/18 10:18:57</p> <p>Totalizer Loading at Operation Start: 44 390,227 T (in air)</p> <p>Totalizer Loading at Operation End: 51 521,341 T (in air)</p> <p>Totalizer Delivery at Operation Start: 43 302,181 T (in air)</p> <p>Totalizer Delivery at Operation End: 43 302,181 T (in air)</p> <p>Mass LOADED 7 131,114 T (in air)</p> <p>Signatures:</p> <p>Chief Engineer: .....</p> <p>Cargo Officer: .....</p> <p>***ATTACH THIS TICKET TO BDN***</p>
---	--

SOURCE: Reference [7], reproduced with the permission of the authors.

**Figure C.1 — Example of bunker metering ticket**

## Annex D (informative)

### LNG Bunker checklist TTS

#### D.1 General

The responsibility and accountability for the safe conduct of operations while a ship is performing an LNG bunkering is shared between the identified representatives in each LNG transfer mode. Refer to [Table D.1](#) for the representatives and the actions which shall be taken before the commencement of the LNG bunker operations.

**Table D.1 — Representatives for LNG transfer modes**

LNG transfer mode	Representatives	Actions to be taken before the commencement of LNG bunker operations
Truck-to-ship (TTS)	Ship's master, LNG bunker truck operator and, if applicable, terminal representative.	a) Agree in writing on the transfer procedures, including the maximum loading or unloading rates; b) Agree in writing on the action to be taken in the event of an emergency; c) Complete and sign the LNG bunker checklist accordingly; and d) Meet the port authority (e.g. port marine notices/circulars) and terminal requirements or regulations.
NOTE 1 A representative is an individual appointed by the bunker supplier to be responsible for the delivery and transfer of bunkers and the associated bunkering documentation.		
NOTE 2 "Terminal" is any organization responsible for the location of the bunkering.		

#### D.2 Guideline for completing the checklist

**D.2.1** The presence of the letters A, R or P in the Code column (see [Table D.2](#), [Table D.3](#), and [Table D.9](#)) indicates the following:

- A (Agreement) – Indicates an agreement or procedure that should be identified in the remarks column of the checklist (see [Table D.2](#), [Table D.3](#), and [Table D.9](#)) or communicated in some other mutually acceptable form.
- R (Re-check) – Indicates items to be re-checked at appropriate intervals, as agreed between both the parties, at periods stated in the declaration.
- P (Permission) – Indicates that permission is granted by authorities.

**D.2.2** All checks should be jointly completed by the bunker facility and the receiving ship by clearly indicating in the appropriate box. For the checks that are not applicable, the boxes are shaded in grey. The "if applicable" marked checks are not mandatory; users can skip these checks by indicating "N.A." in the remarks column. A copy of the completed checklist should be retained by both the bunker facility and the receiving ship.

**D.2.3** The joint declaration should not be signed until both parties have checked and accepted their assigned responsibilities and accountabilities. When duly signed, this document shall be kept on board of the LNG receiving ship which conforms to applicable regulations or company requirements.

### D.3 LNG bunker checklist TTS

The International Association of Ports and Harbors (IAPH)<sup>[8]</sup> has developed a TTS bunkering scheme to provide safety and operational checklists for the LNG bunkering.

Part A of the planning stage checklist [see a) and [Table D.2](#) below] should be completed in the planning stage of an LNG bunker operation. It is a recommended guideline for exchanging information (in advance), which is necessary for the preparation of the actual operation.

Part B of the pre-transfer checklist [see b) and [Table D.3](#) below] is mandatory and should be completed before the actual transfer operations start.

Part C [see c) and [Tables D.4, D.5, D.6, D.7](#) and [D.8](#) below] should be completed before actual transfer operations start.

Part D [see d) and [Tables D.9](#) and [D.10](#) below] should be completed after transfer operations have been completed.

a) Part A: Planning stage checklist

Planned date and time: \_\_\_\_\_

Designated LNG bunker location: \_\_\_\_\_

LNG receiving ship: \_\_\_\_\_

LNG supplying bunker truck: \_\_\_\_\_

A typical example of a planning stage checklist is given in [Table D.2](#).

**Table D.2 — Part A: Planning stage checklist**

	Check	Ship	LNG Truck	Terminal	Code	Remarks
1.	Competent authorities have granted permission for LNG transfer operations for the specific location and time.				P	
2.	The terminal has granted permission for LNG transfer operations for the specific location and time.				P	
3.	Competent authorities have been notified of the start of LNG bunker operations as per local regulations.					Day/time notification: ----- Day time notified: -----
4.	The terminal has been notified of the start of LNG bunker operations as per terminal requirements.					Day/time notification: ----- Day time notified: -----
5.	The requirements of competent authorities are being observed.					e.g. Port byelaws.
6.	Local terminal requirements are being observed.					e.g. Terminal regulations
7.	All personnel involved in the LNG bunker operation have the appropriate training and have been instructed on the specific LNG bunker equipment and procedures.	For the ship	For the truck	For the terminal		
8.	The bunker location is accessible for the LNG supplying tank truck and the total truck weight does not exceed the maximum permitted load of the quay or jetty.					
9.	The bunker operation area can be sufficiently illuminated.					
10.	All LNG transfer and gas detection equipment is certified, in good condition and appropriate for the service intended.					
11.	The procedures for bunkering, cooling down and purging operations have been agreed upon.				A	Reference to procedures:
12.	The system and method of electrical insulation have been agreed upon by ship and truck.				A	Method:

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**Table D.2 (continued)**

	Check	Ship	LNG Truck	Terminal	Code	Remarks
13.	The restricted area on the shore has been agreed upon by ship, truck and terminal.				A	Safety zone: ----- m (ft)
14.	Regulations with regards to ignition sources are observed.	For the ship	For the truck	For the terminal		
15.	All local requirements regarding firefighting equipment have been met, and the equipment is ready for immediate use.	For the ship	For the truck	For the terminal		If applicable
Registration in the planning stage involves representatives:						
Ship		LNG Truck		Terminal		
Name	Name		Name			
Rank	Position		Position			
Date	Date		Date			
Time	Time		Time			

b) Part B: Pre-transfer checklist

Planned date and time: \_\_\_\_\_

Designated LNG bunker location: \_\_\_\_\_

LNG receiving ship: \_\_\_\_\_

LNG supplying bunker truck: \_\_\_\_\_

A typical example of a pre-transfer checklist is given in [Table D.3](#).

**Table D.3 — Part B: Pre-transfer checklist**

	Check	Ship	LNG Truck	Terminal	Code	Remarks
16.	Part A is used prior to and in preparation of the actual operation.	For the ship	For the truck	For the terminal		If applicable
17.	Present weather and wave conditions are within the agreed limits.				AR	
18.	The LNG receiving ship is securely moored. Regulations with regards to mooring arrangements are observed. Sufficient fendering is in place.				R	
19.	There is a safe means of access between the ship and shore. When mandatory, there is a safe emergency escape route between ship and shore.				R	
20.	All mandatory firefighting equipment is ready for immediate use.	For the ship	For the truck	For the terminal		
21.	The bunker operation area is sufficiently illuminated.				AR	
22.	The ship and truck can move under their own power in a safe and non-obstructed direction.	For the ship	For the truck		R	
23.	Adequate supervision of the bunker operation is in place both on the ship and at the LNG tank truck and an effective watch is kept at all times.					
24.	An effective means of communication between the responsible operators and supervisors on the ship and at truck has been established and tested. The communication language has been agreed upon.				AR	Very high frequency/ ultra-high frequency Channel: _____ Language: _____ ----- Primary system: _____ ----- Backup system: _____

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Table D.3 (continued)

	Check	Ship	LNG Truck	Terminal	Code	Remarks
25.	The emergency stop signal and shutdown procedures have been agreed upon, tested, and explained to all personnel involved. Emergency procedures and plans and the contact numbers are known to the persons in charge.				A	Emergency stop signal: -----
26.	The predetermined restricted area zone has been established. Appropriate signs mark this area.				A	
27.	The restricted area is free of unauthorized persons, objects and ignition sources.				R	
28.	External doors, portholes and accommodation ventilation inlets are closed as per operations manual.				R	At no time should they be locked.
29.	The gas detection equipment has been operationally tested and found to be in good working order.					
30.	Material safety data sheets (MSDS) for the delivered LNG fuel are available.				A	
31.	Regulations with regards to ignition sources are observed.				R	
32.	Appropriate and sufficient suitable protective clothing and equipment is ready for immediate use.					
33.	Personnel involved in the connection and disconnection of the bunker hoses and personnel in the direct vicinity of these operations make use of sufficient and appropriate protective clothing and equipment.					
34.	A (powered) emergency release coupling is installed and is ready for immediate use.					If applicable
35.	The water spray system has been tested and is ready for immediate use.					If applicable
36.	Spill containment arrangements are of an appropriate material and volume, in position, and empty.					
37.	Hull and deck protection against low temperature is in place.					If applicable
38.	Bunker pumps and compressors are in good working order.				A	If applicable
39.	All control valves are well maintained and in good working order.					
40.	Bunker system gauges, high level alarms and high-pressure alarms are operational, correctly set and in good working order.					
41.	The ship's bunker tanks are protected against inadvertent overfilling at all times, tank content is constantly monitored and alarms are correctly set.				R	Intervals not exceeding ----- min
42.	All safety and control devices on the LNG installations are checked, tested and found to be in good working order.					
43.	Pressure control equipment and boil off or reliquefaction equipment is operational and in good working order.					If applicable
44.	Both on the ship and at the tank truck the emergency shutdown (ESD), automatic valves or similar devices have been tested, found to be in good working order, and are ready for use. The emergency shutdown systems are linked. The closing rates of the ESDs have been exchanged.				A	Emergency shutdown ship: ----- s Emergency shutdown truck: ----- s
45.	Initial LNG bunker line up has been checked. Unused connections are closed, blanked and fully bolted.					
46.	LNG bunker hoses, fixed pipelines and manifolds are in good condition, properly rigged, supported, properly connected, leak tested and certified for the LNG transfer.					
47.	The LNG bunker connection between the ship and the truck is provided with dry disconnection couplings.					If applicable
48.	The LNG bunker connection between the ship and the LNG bunker truck has adequate electrical insulating means in place.					
49.	Dry breakaway couplings in the LNG bunker connections are in place, have been visually inspected for functioning and found to be in good working order.				A	

Table D.3 (continued)

	Check	Ship	LNG Truck	Terminal	Code	Remarks
50.	The tank truck is electrically grounded and the wheels are chocked.					
51.	The tank truck engine is off during the connection and disconnection of the LNG bunker hoses.					
52.	The tank truck engine is switched off during purging or LNG transfer.					Unless the truck engine is required for the purging or transfer of LNG.
53.	If mandatory, the ship's emergency fire control plans are located externally.					Location: -----
54.	An International Shore Connection has been provided.					If applicable
55.	Competent authorities have been informed that bunker transfer operations are commencing and have been requested to inform other vessels in the vicinity.					Date /time of the notification -----

c) Part C: LNG transfer data

A typical example of agreed starting temperatures and pressures is given in [Table D.4](#).

Table D.4 — Agreed starting temperatures and pressures

Agreed physical quantity unit: <input type="checkbox"/> m <sup>3</sup> <input type="checkbox"/> kg <input type="checkbox"/> _____				
	Ship	Truck		
LNG tank: start temperature				°C <sup>a</sup>
LNG tank: start pressure				bar <sup>b</sup> / psi <sup>a</sup>
LNG tank: available (rest) capacity				m <sup>3</sup> / kg <sup>a</sup>
<sup>a</sup> Delete as appropriate.				
<sup>b</sup> 1 bar = 0,1 MPa = 10 <sup>5</sup> Pa; 1 MPa = 1 N/mm <sup>2</sup> ; 1 psi = 0,006 9 MPa.				

A typical example of agreed bunker operations is given in [Table D.5](#).

Table D.5 — Agreed bunker operations

Agreed physical quantity unit: <input type="checkbox"/> m <sup>3</sup> <input type="checkbox"/> kg <input type="checkbox"/> _____				
	Tank 1	Tank 2		
Agreed quantity to be transferred:				m <sup>3</sup> / kg <sup>a</sup>
Starting pressure at the manifold:				bar <sup>b</sup> / psi <sup>a</sup>
Starting rate:				physical quantity unit per hour
Max transfer rate:				physical quantity unit per hour
Topping off rate:				physical quantity unit per hour
Max pressure at manifold:				
<sup>a</sup> Delete as appropriate.				
<sup>b</sup> 1 bar = 0,1 MPa = 10 <sup>5</sup> Pa; 1 MPa = 1 N/mm <sup>2</sup> ; 1 psi = 0,006 9 MPa.				

A typical example of agreed maximums and minimums is given in [Table D.6](#).