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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).

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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.

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 °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)[8] 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:

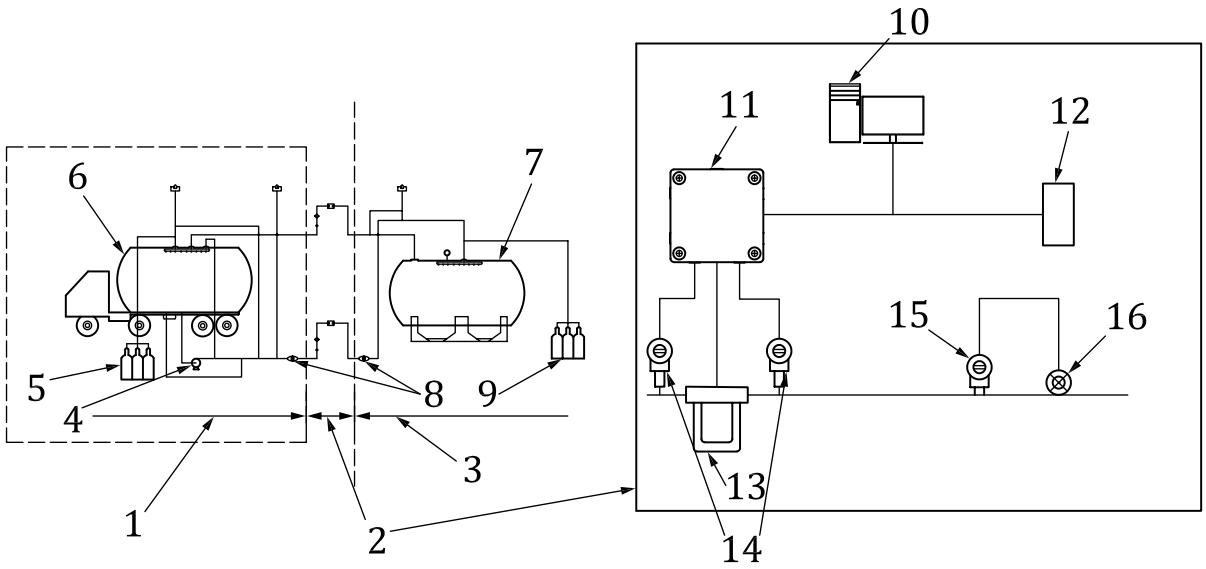
a) mass of bunker(s) transferred, expressed in kilograms (kg);

b) net or gross calorific (heating) value, expressed in joules per kilogram (J/kg);

c) density, expressed in kilograms per cubic metre (kg/m^3).

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[1] 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.

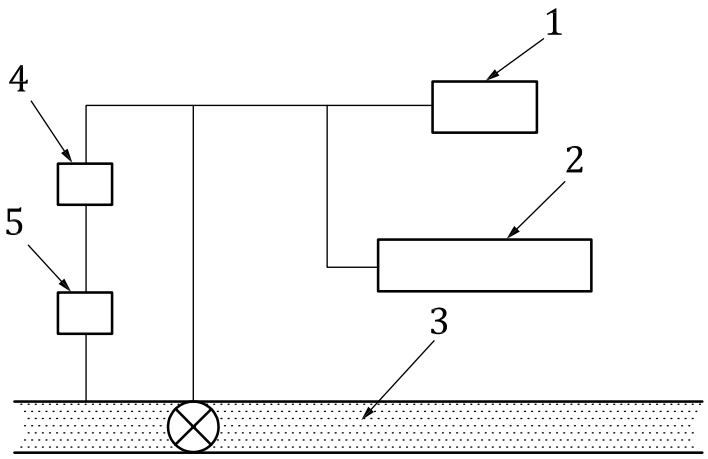


Key

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 value and actuator

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

a) Measuring supply flow



Key

1 flow meter

2 gas chromatography

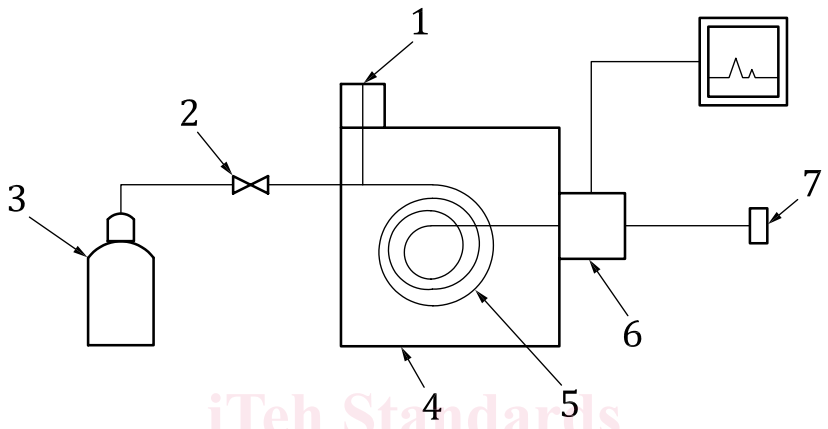
3 LNG composition %: methane, ethane, propane, etc

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.

b) Metering system setup



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.[4]

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.