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Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels — Metering of gas as fuel on LNG carriers during cargo transfer operations

Hydrocarbures réfrigérés et combustibles gazeux liquéfiés à base non pétrolière — Mesurage du gaz comme carburant sur les transporteurs de GNL pendant les opération de transfert de cargaison

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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 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).

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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.

The committee responsible for this document is ISO/TC 28, *Petroleum products and related products of synthetic or biological origin*, Subcommittee SC 5, *Measurement of refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels*.

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Introduction

Concerns over the emission of pollutants from ship exhausts prompted IMO to enact MARPOL Annex VI to the IMO Protocol of 1997 which sets limits on sulfur oxide and nitrogen oxide emissions. As for sulfur, as from 1 January 2012, the annex specifies a global cap mass fraction of 3,5 % on the sulfur content of fuel oil and special SOx emission control areas (SECAs) where the sulfur contents shall not exceed a mass fraction of 1,0 %. In order to comply with these requirements, the ships in general need to fit special facilities to limit SOx emissions unless they use low sulfur fuel oil.

However, liquefied natural gas (LNG) carrier is capable of utilizing BOG in ship's and shore tanks, and return gas during cargo transfer operation as fuel for their own power generation, if commercial value of such energy consumed on board is accountable as an element of custody transfer measurement.

This document provides the procedures needed for metering gas and assessing its calorific value and the requirements for metering devices.

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

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Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels — Metering of gas as fuel on LNG carriers during cargo transfer operations

1 Scope

This document specifies minimum requirements to quantify the boil-off gas (BOG) consumed on liquefied natural gas (LNG) carriers for their own functions, notably for power generation, during cargo transfer operations. BOG in this document refers to the low molecular gas returned from shore tanks to ships' tanks and the gas produced in ships' cargo tanks.

This document provides requirements for the metering of BOG and the subsequent calorific value calculations which can be taken into account when the energy transferred during cargo transfer is determined. This document also introduces performance requirements and calibration of the elements included in the BOG measurement system. A flowmeter of any type may be used to measure BOG as long as it meets the performance requirements specified in this document.

This document, with some modification, can also be applied to the measurement of BOG consumed by LNG carriers at sea.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

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

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

3.1
boil off
process of evaporation of a liquid resulting from heat ingress or a drop in pressure

[SOURCE: ISO 10976:2015, 3.1.6]

3.2
boil-off gas
BOG
vapour (3.14) produced by *boil off* (3.1)

Note 1 to entry: BOG in this document refers to the low molecular gas returned from shore tanks to ships' tanks and the gas produced in ships' cargo tanks during cargo transfer operation.

[SOURCE: ISO 10976:2015, 3.1.7 — Note 1 to entry has been added.]

3.3
closing custody transfer measurement
custody transfer measurement (3.4) implemented after loading or discharging cargo from the tank(s)

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3.4
custody transfer measurement
measurement of liquid level, liquid and vapour temperature, vapour pressure and analysis of the composition of LNG 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

3.5
custody transfer measurement system
CTMS
system that processes inputs from an ATG system, thermometers, pressure gauges, etc., and provides custody transfer measurement information on board, generating documents with regard to custody transfer of LNG

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

3.6
flowmeter
flow measuring device which indicates the measured flowrate

3.7
gas dangerous space or zone
space or zone defined by the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)

3.8
indicating device
displaying device
set of components of a measuring instrument intended to indicate the measured value

3.9
intrinsic error
inherent error
error of a measuring device when it is tested against a reference standard under controlled conditions as specified by the manufacturer

3.10
LNG carrier
LNGC
cargo ship specifically constructed and used for the carriage of LNG in bulk

3.11
maximum permissible error
MPE
extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications or regulations for a given measurement, measuring instrument, or measuring system

[SOURCE: ISO/IEC Guide 99:2007, 4.26, modified]

3.12
opening custody transfer measurement
custody transfer measurement (3.4) implemented before loading or discharging cargo from the tank(s)

3.13
uncertainty
non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used

3.14
vapour
fluid in the gaseous state that is transferred to/from or contained within the cargo tank

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3.15
verification
process of confirming the accuracy of an instrument by comparing to a source with known accuracy

4 Design requirements

4.1 General

Flowmeters shall be so constructed as not to leak gas in the atmosphere. In addition, all parts of a flowmeter in contact with BOG shall be chemically compatible with the product, to avoid both product contamination and corrosion of the flowmeter. Flowmeters installed in a gas dangerous space or zone shall be of gastight construction.

All electric components of a flowmeter for use in electrically classified areas shall meet the electrical area classification. They shall conform to applicable sections of the national and/or international electrical safety standards. All flowmeters shall be maintained in safe operating condition and manufacturers' maintenance instructions should be complied with.

4.2 Flowmeter

Flowmeters making use of any measurement principle may be used for the measurement of BOG. However, when selecting the flowmeter, consideration shall be given to the impact of the type of propulsion plant, constraints arising from the installation location and the nature of BOG flow on the meter's performance.

Regardless of the type of propulsion plant, flowmeters used for the measurement of BOG are always installed downstream of the low duty gas compressor and the gas heater on the fuel gas line to the propulsion plant. Typical installation and instrument specifications of flowmeters used for the measurement of BOG are shown in Annex A.

NOTE The consumption of BOG can be underestimated when the flow is below the minimum measureable flowrate.

4.3 Indicating device

Resolution of indicating device (totalizer) shall be better than or equal to 1 m^3 or 1 kg.

5 Accuracy requirement

Maximum permissible error of a flowmeter at the time of calibration at laboratory or factory (see 6.2) shall be ±2 % of reading throughout the expected operating range.

Maximum permissible error of the indicating device determined in accordance with 6.3 and 6.4 shall be ±1 % of the upper range limit of the expected operating range of the flowmeter. The accuracy of thermometers and pressure gauges associated with the flowmeters, if any, shall be better than or equal to ±0,5 °C and ±1 % of the reading throughout the expected operating range, respectively.

NOTE Maximum permissible errors shown on Table 1 and Table 3-1 in OIML R 140 are referred to.

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6 Calibration and accuracy verification

6.1 General

A flowmeter shall be calibrated and the uncertainty be established by the manufacturer before it is delivered for installation. The indicating device of the flowmeter shall be calibrated by the manufacturer or its authorized service representative after it is installed, and periodically, with the results verified.

NOTE The accuracy of flow measurement is affected by the inherent error of flowmeters, the error due to installation (e.g. stability, location, etc.) and the effect of changes in operating conditions.

All flowmeter calibration records shall be documented. Calibration and verification records shall be available for the parties involved in custody transfer of LNG. All adjustments to the flowmeters shall also be documented.

6.2 Calibration at laboratory or factory

A flowmeter and associating measuring device shall be calibrated at the manufacturer's factory or a laboratory against reference standards of which uncertainty is traceable to national standards. Uncertainty of a flowmeter may also be theoretically established in accordance with relevant international standards. In any case, the expanded uncertainty (k = 2) of the calibration shall not exceed 0,6 %.

6.3 Calibration and accuracy verification of indicating devices after installation

The indicating devices shall be calibrated by the manufacturer against reference standard of which uncertainty is traceable to a national standard and their accuracy be verified after installation of flowmeters on LNG carriers.

For the accuracy verification, at least three simulation signals that equally divide the measurable range should be input from a dedicated calibrator prepared by the manufacturer. The error of the indicating device at each test point shall be calculated using Formula (1). The largest E_d shall be regarded as the maximum error of the indicating device:

$$E_d = \frac{V_0 - V_e}{V_e} \times 100 \quad (1)$$

where

E_d is the error of the indicating device determined, %;

V_e is the expected value;

V_o is the output from the indicating device.

The maximum error of the indicating device shall not exceed the maximum permissible error specified in Clause 5.

The expanded uncertainty (k = 2) of the reference standard employed for the accuracy verification shall be one-third of the maximum permissible error specified in Clause 5 or 0,3 % whichever is greater.

6.4 Periodic accuracy verification of indicating devices

Accuracy of flow measurement of BOG shall be periodically verified. Periodic verification typically is scheduled to coincide with CTMS accuracy verification. The frequency should also take into consideration recommendations by the flowmeter manufacturer.

Periodic accuracy verification shall be performed in accordance with the calibration and accuracy verification procedure after installation described in 6.3. The maximum permissible error of indicating device described in Clause 5 shall also be applied to judge the results of periodic accuracy verification.

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The performance of flowmeters should be periodically verified in situ in accordance with the recommendation of the manufacturers and, if needed, the flowmeters should be recalibrated as referred in 6.2.

NOTE Crosschecking of the outputs among two or more flowmeters during operation or tracking the history may provide an indication of the performance of the flowmeters. However, it is recognized that such verification does not ensure the accuracy of the flowmeters to meet the requirement in Clause 5.

7 Metering and calculation

7.1 General

The quantity of BOG consumed by LNG carriers as fuel for their own use during the time between the opening and closing custody transfer measurements shall be measured by the flowmeters of which accuracy comply with the requirement in Clause 5. The energy of the BOG shall be calculated in accordance with 7.3.

7.2 Metering

The counter readings of the BOG flowmeters shall be reset to zero reading or recorded at the time of opening and recorded at the time of closing custody transfer measurements.

Prior to making measurements, confirm that the cargo tanks are in a static condition as referred to ISO 10976.

If an independent inspector is appointed for custody transfer measurement, the metering of BOG shall also be witnessed and verified by the independent inspector. The results of BOG metering may be taken into account in the total energy transferred (see Annex B).

7.3 Calculation of heating value

The energy of BOG consumed in LNG carriers during cargo operation shall be calculated in accordance with Formula (2) or (3):

a) in case a volumetric flowmeter is used:

$$E_E = \left(C_C - C_O\right) \times H_{vol} \tag{2}$$

b) in case a mass flowmeter is used:

$$E_E = \left(C_C - C_O\right) \times H_{mass} \tag{3}$$

where

E_E is the energy of BOG consumed in LNG carrier during cargo operation (MJ);

C_O is the counter reading at the time of opening custody transfer measurement;

C_C is the counter reading at the time of closing custody transfer measurement;

H_{vol} is the superior calorific value of BOG on a volume basis (MJ/m^3) at standard condition;

H_{mass} is the superior calorific value of BOG on a mass basis (MJ/kg) at standard condition.

NOTE H_{vol} and H_{mass} are assumed to be of pure methane, if not determined by analysis or such value as defined by the contractual agreement between parties.

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Gas density used for converting volume of BOG to mass, or vice versa, shall be 0,678 5 kg/m^3, 15 °C and 101,325 kPa (see ISO 6976:2016, 10.2), if not directly measured, or such value as defined by the contractual agreement between parties.

In case a volumetric flowmeter is used, $C_C - C_O$ shall be the volume at standard condition, i.e. 15 °C and 101,325 kPa.

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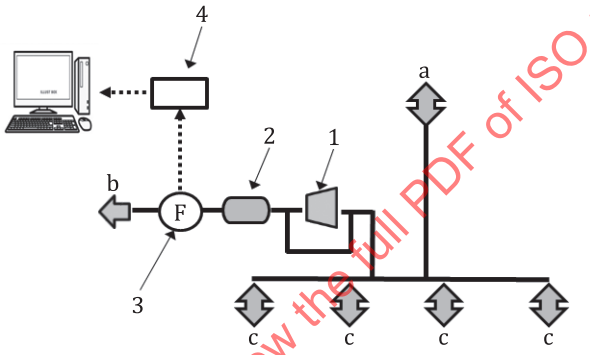
Annex A
(informative)

Typical installation of fuel gas flowmeters

A.1 General

Regardless of the type of ship's propulsion plant, flowmeter used for the measurement of BOG is always installed downstream of the low duty gas compressor and the gas heater on the fuel gas line to the propulsion plant or gas combustion unit. Figure A.1 shows the typical installation of flowmeters used for the measurement of BOG.



Key

1 gas compressor
2 gas heater
3 gas flowmeter
4 volume/mass flow calculator
a BOG to/from shore
b BOG to boiler, dual fuel diesel (DFD) engine or gas combustion unit (GCU)
c BOG to/from cargo tank

Figure A.1 — Typical installation

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Annex B
(informative)

Application of the energy of BOG consumed by LNG carriers to custody transfer measurement

B.1 General

The energy of BOG consumed in LNG carriers in ports (E_E) in accordance with 7.3 may be included in the calculation of heating value of the energy transferred.

B.2 Calculation of heating value of the energy transferred

The energy of LNG transferred to/from an LNG carrier is calculated using Formula (B.1) (see ISO 10976:2015, D.6):

$$E = \frac{1}{k} \times \left(E_L - E_D \pm E_E \right) \tag{B.1}$$

where

E is the energy transferred (MMBtu);

E_L is the energy of liquid (MJ);

E_D is the energy of gas displaced (MJ);

E_E is the energy of BOG consumed by the LNG carrier (MJ), where + is for an LNG loaded and – is for an LNG discharged;

$1/k$ is the factor to convert energy in MJ to energy in MMBtu: k = 1 055,12 when 60 °F is the reference temperature for the MMBtu value and 15 °C is the reference temperature for MJ; k = 1 055,056 when the reference temperatures for MJ and MMBtu are the same.

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