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**Refrigerated light hydrocarbon fluids —  
Liquefied natural gas — Procedure for  
custody transfer on board ship**

*Hydrocarbures légers réfrigérés — Gaz naturels liquéfiés — Procédure de  
transfert de garde à bord des navires*

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## Foreword

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

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 13398 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 5, *Measurement of light hydrocarbon fluids*.

Annex A forms an integral part of this International Standard. Annex B is for information only.

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## Introduction

Loading and discharging of LNG to/from an LNG carrier is a closed cycle operation performed by providing a vapour return line linking the tanks on board and on shore. This avoids displacement of vapour to the atmosphere. In addition, it may involve two or more shore tanks for easier cargo operation. Therefore, it is normal practice to implement the custody transfer on board the LNG carrier to ensure more accurate volumetric determination.

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# Refrigerated light hydrocarbon fluids — Liquefied natural gas — Procedure for custody transfer on board ship

## 1 Scope

This International Standard specifies methods of custody transfer of LNG on board ship, using a level gauge for determination of liquid level, thermometers for determination of liquid and/or vapour temperature and pressure gauges for determination of vapour pressure in cargo tanks.

## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6568:1981, *Natural gas — Simple analysis by gas chromatography.*

ISO 6578:1991, *Refrigerated light hydrocarbon liquids — Static measurement — Calculation procedure.*

ISO 8309:1991, *Refrigerated light hydrocarbon fluids — Measurement of liquid levels in tanks containing liquefied gases — Electrical capacitance gauges.*

ISO 8310:1991, *Refrigerated light hydrocarbon fluids — Measurement of temperature in tanks containing liquefied gases — Resistance thermometers and thermocouples.*

ISO 8311:1989, *Refrigerated light hydrocarbon fluids — Calibration of membrane tanks and independent prismatic tanks in ships — Physical measurement.*

ISO 8943:1991, *Refrigerated light hydrocarbon fluids — Sampling of liquefied natural gas — Continuous method.*

ISO 10574:1993, *Refrigerated light hydrocarbon fluids — Measurement of liquid levels in tanks containing liquefied gases — Float-type level gauges.*

## 3 Definitions

For the purposes of this International Standard, the following definitions apply.

**3.1 “boil-off” gas (BOG):** Vapour generated from LNG which is stored under nearly atmospheric pressure conditions at low temperatures (under the influence of heat transfer a certain amount of LNG will evaporate or “boil-off”).

**3.2 closing custody transfer:** Custody transfer implemented after loading and discharging LNG, at the loading and discharging ports respectively.

**3.3 custody transfer:** 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 volume and other data are determined to be a basis of payment of cost or assessment of the duty.

**3.4 custody transfer system on board ship:** A system consisting of a level gauge, thermometer and pressure gauge, which are used for measurement of liquid level, temperature and pressure of the cargo in tanks for the purpose of custody transfer.

**3.5 opening custody transfer:** Custody transfer implemented before loading and discharging LNG, at the loading and discharging ports respectively.

**3.6 thermal correction factor:** A factor used to correct the volume of LNG at an arbitrary temperature in a cargo tank to that at the reference temperature.

## 4 Gauging instruments

### 4.1 Level gauges

#### 4.1.1 The number of level gauges

Each cargo tank shall be equipped with two sets of level gauges, preferably of different measuring principle: e.g. a float level gauge and a capacitance level gauge.

#### 4.1.2 Installation

The level gauges shall be installed at the locations having little effect of sloshing of LNG, and they shall also be calibrated to indicate the depth of the liquid from the tank's lowest point irrespective of the shape of the cargo tank. The gauge reference point shall be set as low as possible to facilitate measurement of liquid level after discharge at the discharging port, and before loading at the loading port.

### 4.2 Temperature sensors

#### 4.2.1 The number of temperature sensors

To measure liquid and vapour temperatures of LNG, each cargo tank shall be equipped with five or more temperature sensors. These temperature sensors shall be supported by spare sensors, for emergency use, which are mounted adjacent the temperature sensors.

#### 4.2.2 Installation

Two sensors including spares shall be installed at the tank bottom and the tank top, in order to constantly measure the temperatures of liquid and vapour respectively. The remaining sensors including spares shall be installed at equally spaced distances between the tank bottom and top.

All the sensors shall be mounted such that they are not affected by the spray of LNG when the spray pumps are in operation.

### 4.3 Pressure gauges

The pressure gauges which measure vapour pressure in the cargo tanks shall be either of the type consisting of a transmitter and receiver or the type with local display.

#### 4.3.1 The number of pressure gauges

Each cargo tank shall be equipped with a pressure gauge of the transmitter type or of the local display type.

If a pressure gauge, of either type, has been mounted on the vapour header, this can also be used for the purpose of the custody transfer.

#### 4.3.2 Installation

A pressure gauge shall be set at an appropriate position on the vapour dome and/or the vapour header to accurately measure vapour pressure in the cargo tank.

A pressure gauge of the local display type or the pressure transmitter shall be mounted in an appropriate container to shelter it from direct spray of seawater.

### 5 Precautions

This clause outlines the precautions to be taken prior to berthing an LNG carrier at a loading or discharging port in order to ensure smooth and accurate custody transfer.

#### 5.1 Maintenance

To implement custody transfer with an expected precision, the custody transfer system shall always be maintained in good order and condition.

#### 5.2 Preliminary function test

The custody transfer system shall be functionally tested by means of an appropriate measure such as a test-run just before commencement of the custody transfer.

#### 5.3 Operation

The custody transfer system shall be operated by a skilled ship's officer.

#### 5.4 Use of a VHF radio

Unless the custody transfer system control panels are protected by a barrier there is a risk of electrical disturbance which may cause malfunctioning of the system. In this case VHF radios shall not be used near the system control panels when they are in operation.

#### 5.5 Precautions against malfunctioning of float level gauge

Floats which are wound home at the top of their housing during the voyage shall be put into serviceable condition by lowering the float on to the liquid surface to allow thermal stability before commencement of the custody transfer.

#### 5.6 Condition of the ship at the time of custody transfer

##### 5.6.1 Pipe lines

**5.6.1.1** Delivery lines to be used for loading and/or discharging shall be in volumetrically identical condition at the opening and closing of custody transfer.

**5.6.1.2** Vapour lines which are connected to the vapour header line shall be opened to make the vapour pressure in all cargo tanks the same.

### 5.6.2 Cargo facilities

In advance of the custody transfer, various cargo facilities such as spray pumps in cargo tanks, BOG compressors, etc., which may affect the results of the custody transfer shall be stopped.

### 5.6.3 Trim and list

Trim and list of the ship shall be kept unchanged while the custody transfer is performed.

## 6 Custody transfer

### 6.1 Method

This clause sets out the method of custody transfer by using a capacitance level gauge or a float level gauge.

It is recommended, in principle, to use the same method for opening and closing custody transfer. If the level gauge normally used is inoperative at the time of opening custody transfer, necessitating use of the alternative level gauge, the latter shall be used again at the time of closing custody transfer even when the level gauge normally used has been corrected.

### 6.2 Measurement of liquid level

Prior to measurement of the liquid level, observe the ship's draughts on the fore, aft, port and starboard side by draught marks or other suitable means. This will verify the ship's trim and list and whether trim and list corrections are required: make sure that the ship's vapour lines to the boilers and shore tanks have been closed.

#### 6.2.1 Capacitance level gauge (see ISO 8309)

The liquid level in each cargo tank shall be measured at least five times at appropriate intervals which have been programmed into the processor unit, or by manual operation where the system has no automatic scanning programme.

#### 6.2.2 Float level gauge (see ISO 10574)

**6.2.2.1** The liquid level in each cargo tank shall be measured at least five times.

**6.2.2.2** The liquid level in the cargo tank shall be kept higher than the floating point of the float level gauge, at the time of the opening custody transfer at the loading and the closing custody transfer at the discharging ports, respectively.

**6.2.2.3** Before measurements, the float shall be wound up to the top storage position and the maximum indication compared to that noted at the time of the last inspection to ascertain that the float level gauge is functioning properly.

#### 6.2.3 Determination of the corrected liquid level

**6.2.3.1** Where the capacitance level gauge is used for measurement of the liquid level in cargo tanks, apply the trim corrections and the list corrections as required to its arithmetic mean value to obtain the true level.

**6.2.3.2** Where the float level gauge is used, in addition to the above corrections, apply a thermal correction factor to correct the measurement error due to contraction of the float's suspending tape or wire.

If the liquid density of the LNG to be measured is different from that on which the immersion level of the float has been adjusted, apply the corrected immersion level to correct measurement error due to a change in the float's immersion level. See A.6.1 and A.6.2.

NOTE — The particular liquid density of the shipment is unknown at opening and closing custody transfer. The density may be estimated statistically for tentative determination of the true level, which, if the estimation seems to be inappropriate, should be corrected later once determination of the density becomes available by laboratory analysis of the shipment sample.

### 6.3 Measurement of temperature

#### 6.3.1 Timing of measurement

The temperature of liquid and vapour shall be measured immediately after completion of measurement of the liquid levels.

#### 6.3.2 Selection of temperature sensors (see ISO 8310)

**6.3.2.1** The temperature of the liquid shall be measured by using the temperature sensors deemed to be immersed in LNG in relation to the liquid level at the time of measurement. An arithmetic mean value through all the cargo tanks shall be calculated.

Determination whether a measured temperature is in the liquid or in the vapour phase shall be based on the relative position between liquid level and height of the temperature sensors in the cargo tank.

**6.3.2.2** The temperature of vapour shall be measured by using the temperature sensors deemed to be in the vapour phase in relation to the liquid level at the time of measurement. An arithmetic mean value through all the cargo tanks shall be calculated.

Determination whether a measured temperature is in the liquid or in the vapour phase shall be based on the relative position between liquid level and height of the temperature sensors in the cargo tank.

When measuring the vapour temperature, if a discrepancy of the measured value seems to be unreasonable or unusual in relation to the temperature gradient in the cargo tank, recalculate an arithmetic mean value disregarding the unsatisfactory temperature.

**6.3.2.3** If a float level gauge is used for determination of the liquid level in a cargo tank, the arithmetic mean value of vapour temperature in that cargo tank shall be calculated to provide corrections for thermal contraction of the tape or wire due to the difference between the vapour temperature and calibrated temperature of the float level gauge.

### 6.4 Measurement of tank pressure

#### 6.4.1 Timing of measurement

The pressure of cargo tanks shall be measured immediately after completion of measurement of the temperature.

#### 6.4.2 Method of calculation

If individual pressures are measured for the respective cargo tanks, an arithmetic mean value shall be calculated throughout all the cargo tanks. Despite the arrangement specified in 5.6.1.2, each pressure may not always be the same.

## 7 Calculation

This clause sets out the method of calculation of LNG, on the basis of volume, mass and thermal unit, which is loaded to or discharged from cargo tank on board. The calculation should be implemented on the basis of the components of the shipment which are obtained by gas chromatographic analysis of the representative samples.

**7.1** In accordance with the instructions noted in the tank gauge table, obtain the corrected liquid level in millimetres applying any necessary corrections to the apparent liquid level. Calculate the volume of LNG, in units of cubic

metres, expressed to three decimal places, in the cargo tanks corresponding to the above corrected liquid level before and after loading and/or discharging.

If the cargo tank is of the rigid and independent type and the temperature of LNG is not equal to the temperature to which the tank gauge table refers, on opening and closing custody transfer, the volume of LNG calculated on the basis of the tank gauge table shall be corrected to the actual temperature by multiplying the volume against the average liquid temperature by an appropriate factor listed in the table of thermal correction factors.

The volume of LNG in cubic metres loaded or discharged is then calculated as the volumetric difference obtained from the output of the opening and closing custody transfer measurements.

**7.2** The thermal value of LNG, loaded or discharged, shall be calculated in accordance with ISO 6578:1991, clauses 3, 5, 6, 8 and annexes.

**7.3** The density of LNG, loaded or discharged, shall be calculated in accordance with annexes of ISO 6578:1991.

**7.4** The mass of LNG, loaded or discharged, shall be calculated in accordance with ISO 6578:1991, clauses 5, 7 and annexes.

For a simple calculation, the following method may also be applied.

$$m = \frac{Q}{Q_m}$$

where

$m$  is the mass, in kilograms, of product transferred, after correction for vapour;

$Q$  is the gross thermal value of product transferred, in megajoules, after correction for vapour;

$Q_m$  is the gross thermal value of a mass basis, in megajoules per kilogram, of the liquid.

## 8 Sampling

In case the continuous method is applied, sampling of LNG is referred to ISO 8943.

## 9 Analysis

For analysis of the components in LNG see ISO 6568.

## Annex A (normative)

### Calculation procedures of correction tables

#### A.1 Trim correction for prismatic tank

Trim correction is utilized to correct the apparent liquid level measured in a trimmed condition of a ship to that in an even-keel condition. The correction will either be an addition to or subtraction from the apparent liquid level depending on the extent of the trim. Trim correction shall be calculated from volumetric differences between an even-keel and trimmed condition and shall not be simply based on an in-tank geometry of installation of the level gauge in a longitudinal direction.

##### A.1.1 Calculation procedure

**A.1.1.1** With the ship in an even-keel condition, calculate partial filling volumes of a liquid in a tank as a function of the liquid levels at 1 cm intervals and tabulate them against the liquid levels.

**A.1.1.2** For a trimmed condition of a ship, calculate in the same manner, partial filling volume of the liquid in the tank as a function of the liquid levels at 1 cm intervals and tabulate it against the liquid levels.

**A.1.1.3** At liquid levels of 0,1 m intervals in the even-keel table, compare the liquid volume with those in the trim table, and define a liquid level in the trim table of which volume is equal to the liquid level in the even-keel table. The difference in millimetres of the liquid levels thus defined is correction value.

**A.1.1.4** Repeat the comparative volume calculation as above for all the required trimmed conditions and tabulate the differences in the liquid levels in relation to the required trims in the trim correction table.

#### A.2 List correction for prismatic tank

List correction is utilized to correct the apparent liquid level measured in a listed condition of a ship to that in an upright condition. The correction will either be an addition to or subtraction from the apparent liquid level depending on the extent of the list. The list correction shall be calculated from volumetric differences between an upright and listed condition and shall not be simply based on an in-tank geometry of installation of the level gauge in a transverse direction.

##### A.2.1 Calculation procedure

**A.2.1.1** With the ship in an upright condition, calculate the partial filling volumes of a liquid in a tank as a function of the liquid levels at 1 cm intervals and tabulate them against the liquid levels.

**A.2.1.2** With the ship in a listed condition, calculate in the same manner partial filling volumes of the liquid in the tank as a function of the liquid levels at 1 cm intervals and tabulate them against the liquid levels.

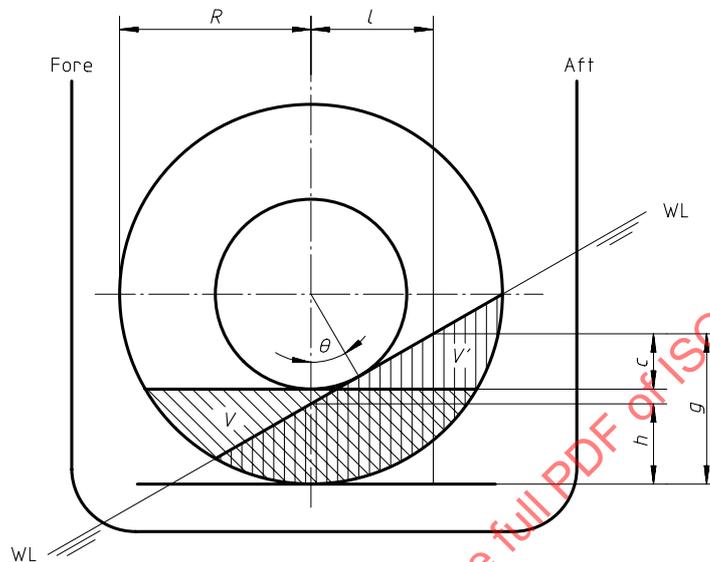
**A.2.1.3** At liquid levels of 0,1 metre intervals in the upright table, compare the liquid volume with those in the list table, and define a liquid level in the list table of which volume is equal to the liquid level in the upright table. The difference in millimetres of the liquid levels thus defines is a correction value.

**A.2.1.4** Repeat the comparative volume calculation as above for all the required listed conditions and tabulate the differences in the liquid levels in relation to the required lists in the list correction table.

### A.3 Trim correction for spherical tank

#### A.3.1 Calculation procedure

See figure A.1.



#### Key

$V$  is the volume of the liquid in an even-keel condition and the liquid level is represented by  $g - c$

$V'$  is the volume of the liquid in a trimmed condition and the liquid level is represented by  $g$

$c$  is the correction value for an apparent liquid level caused by a ship's trim and can be calculated by the following equation

$$c = R - (R - h) \cos \theta - g$$

where

$c$  is the correction value in millimetres;

$R$  is the radius, in millimetres, of a spherical tank;

$g$  is the observed level, in millimetres, in a trimmed condition;

$h$  is given by  $g - l \tan \theta$ ;

$l$  is the longitudinal distance, in millimetres, between the tank's vertical axis and the level gauge.

Figure A.1