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Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels — General requirements for automatic tank thermometers on board marine carriers and floating storage

Hydrocarbures réfrigérés et combustibles gazeux liquéfiés à base non pétrolière — Exigences générales pour les thermomètres de réservoir automatiques à bord des transporteurs de cargaison en mer et des stocks flottants

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Foreword

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The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 8310 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 5, *Measurement of refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels*.

This second edition cancels and replaces the first edition (ISO 8310:1991), which has been technically revised.

Introduction

Large quantities of liquefied natural gas (LNG), liquefied petroleum gas (LPG) and other liquefied gases are usually transported by marine carriers dedicated for these applications and traded based on static measurement on board by automatic tank measurement. Such an automatic tank measurement may be a part of the custody transfer measurement system (CTMS) which involves determination of liquid/vapour interface, i.e. liquid level, average temperatures of liquid and vapour, and vapour pressure. The volumetric quantity of the liquid and gas is then computed with the tank capacity table based on which the delivered quantity in terms of energy content or mass is calculated.

In most cases, shore tank measurement is not used due to the active and dynamic conditions of the shore tank operations. In the absence of other means of acceptable measurement, custody transfer measurement usually takes place on board the carrier or floating production storage offshore (FPSO) and floating storage offshore (FSO). Liquid cargo density is very sensitive to temperature; therefore, obtaining accurate temperature readings is extremely important. For example, a change of 0,2 °C for liquid methane cargo results in a change in density of approximately 0,07 %.

This International Standard also discusses use of automatic tank thermometers on board marine vessels for other volatile, non-petroleum liquids in fully refrigerated conditions. Many of these non-petroleum liquids, such as di-methyl ether (DME) are measured in a similar manner to that used for fully refrigerated LPGs.

Values of temperature in this International Standard are in terms of the International Temperature Scale of 1990, ITS-90. Temperatures in degrees Celsius are denoted by the symbol *t*.

Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels — General requirements for automatic tank thermometers on board marine carriers and floating storage

1 Scope

This International Standard specifies the essential requirements and verification procedures for automatic tank thermometers (ATTs) consisting of platinum resistance thermometers (PRT) and an indicating device used for custody transfer measurement of liquefied natural gas, liquefied petroleum and chemical gases on board ships. Temperature detectors other than PRT are considered acceptable for use in the custody transfer service of liquefied gases if they meet the performance requirements of this International Standard and are approved by national regulations.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60751, *Industrial platinum resistance thermometers and platinum temperature sensors*

3 Terms and definitions

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

3.1
automatic tank gauge
ATG
automatic level gauge
ALG
instrument that automatically measures and displays liquid levels or ullages in one or more tanks, either continuously, periodically or on demand

3.2
automatic tank gauging system
ATG system
system that includes ATGs at the cargo tanks and control/display unit that processes and displays output signals from the ATG along with any other parameters required to determine the liquid level, i.e. liquid/vapour interface

3.3
automatic tank thermometer
ATT
automatic tank temperature system
instrument that continuously measures temperature in cargo tanks

NOTE 1 An ATT typically includes temperature sensors, such as PRTs, field-mounted transmitters for electronic signal transmission, and indicating device(s).

NOTE 2 ATTs on liquefied gas carriers are usually multiple-point ATTs which consist of three or more temperature sensors, such as PRTs, to measure the temperatures at selected heights in the cargo tank.

3.4
custody transfer measurement system
CTMS
system that processes inputs from an ATG system, an ATT, pressure gauges, etc. and provides custody transfer measurement information on board, generating documents with regard to custody transfer of liquefied gases

NOTE An ATT can be incorporated as part of a CTMS.

3.5
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)

3.6
indicating device
displaying device
set of components of a measuring instrument intended to indicate the measured value

3.7
inherent error
intrinsic error
error of a gauge when it is tested against a reference standard under controlled conditions as specified by the manufacturer

3.8
nominal resistance
expected resistance R_0 of a PRT at 0 °C, declared by the manufacturer and shown in the thermometer marking, usually rounded to the nearest ohm

3.9
nominal temperature/resistance relationship
relationship between temperature and resistance of a nominal PRT

3.10
platinum resistance thermometer
PRT
resistance temperature detector
RTD
temperature-responsive device consisting of one or more sensing platinum resistors within a protective sheath, internal connecting wires and external terminals to permit connection of electrical measurement instruments

3.11
uncertainty
non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used

4 Safety precautions

4.1 General

Nothing contained in this International Standard is intended to supersede any regulatory requirements or recommended operating practices issued by organizations such as the International Maritime Organization (IMO), International Chamber of Shipping (ICS), Oil Companies International Marine Forum (OCIMF), International Association of Classification Societies (IACS) and individual operating companies, nor is this International Standard intended to conflict with any safety or environmental considerations, local regulations, or the specific provisions of any contract.

4.2 Equipment precautions

4.2.1 General

All electric components of an ATT 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 ATTs shall be maintained in a safe operating condition and manufacturers' maintenance instructions should be complied with.

4.2.2 Mechanical rigidity

All ATTs shall be capable of withstanding the pressure, temperature, dynamic loads generated from rolling/pitching, and sloshing from environmental conditions likely to be encountered in the service.

Where a PRT is installed near a submerged pump or the end of a loading/unloading line in a cargo tank, appropriate measures shall be applied to prevent the ATT from being affected by the vortex or vaporization, i.e. boiling, of cargo caused by cargo loading or cargo unloading operations. In addition, all PRTs shall be mounted such that they are not affected by the spray of liquefied gas whenever the spray nozzles are in operation.

4.2.3 Gastight design

All parts of ATTs exposed to a gas dangerous space or zone shall be of gastight construction.

4.2.4 Compatibility with cargo

All parts of the ATT in contact with liquefied gases or their vapour shall be chemically compatible with the product, to avoid both product contamination and corrosion of the ATT.

4.2.5 Tolerance against low temperatures

ATTs shall be designed to measure the low temperatures encountered in refrigerated liquefied gas service. They shall also be designed to withstand the low-temperature thermal contraction of their components and of the tanks. Additionally, change in the height of PRT in the tanks by such thermal contraction shall be compensated for in an appropriate manner.

4.2.6 Type approval

The design and installation of ATTs shall be subject to the approval of a national metrology institute (NMI) or class society. For electrical considerations, refer to IACS Unified Requirements E10[10]. Type approval is normally issued after an ATT has been subjected to a specific series of tests.

5 Design requirements

5.1 General

The following design requirements apply to all types of ATTs on liquefied gas carriers, FPSOs and FSOs. These requirements, which may be in addition to the technical specifications by the ATT manufacturer, should be met where they are applicable.

5.2 Temperature sensors

Temperature sensors used for custody transfer measurement of liquefied gases on board ships shall be either three- or four-wire type PRTs as described in IEC 60751. The relationship of temperature and resistance of the PRTs is described by a temperature/resistance relationship (see Annex A).

Each PRT shall be subject to the following routine production tests:

a) insulation resistance at ambient temperature;

b) sheath integrity test;

c) dimensional test;

d) tolerance acceptance test.

NOTE See IEC 60751 for the details of the routine production test.

The manufacturer shall calibrate each PRT and establish its nominal resistance (R_0) and constants A, B and C in the temperature/resistance relationship.

Identification such as the serial number should be clearly and indelibly marked on each PRT.

5.3 Indicating device

Indicating devices with analogue inputs shall have a high-impedance input circuit so as to minimize error.

5.4 Installation

The number of PRTs in a tank depends on the capacity and the height of the tank; however, IGC Code requires a minimum of three. In the case of large LNG carriers, there may be five or more PRTs in each tank with each PRT supported by a secondary PRT mounted adjacent to the primary PRT (see 5.12).

At least one PRT shall be located above the maximum fill height so as to remain in the vapour space. The lowest PRT shall be located near the bottom of the tank so as to measure the temperature of the heel.

The indicating device of an ATT shall be installed in a location free from temperature variations, which can cause measurement errors. The indicating device may be integrated into the CTMS.

5.5 Provisions for routine maintenance and verification

Except for those components within the cargo tank itself, all parts of an ATT shall allow routine maintenance to be performed without compromising the integrity of the tank. This includes means of verification whereby the accuracy of an indicating device can be checked.

5.6 Provision against sudden malfunctions

ATTs shall be designed to minimize the frequency and severity of any malfunction. Electronics essential for the proper functioning of the system should ideally be accessible from the deck and be serviceable with tanks in operation.

5.7 Dynamic response

ATTs shall have sufficient dynamic response to track the temperature of liquid and gas in the tanks.

5.8 Measurable range

ATTs shall have sufficient measurable range in accordance with the intended cargoes to be loaded.

5.9 Data processing and reporting

An ATT or CTMS may calculate and report:

a) the average liquid temperature in each cargo tank;

b) the average vapour temperature in each cargo tank;

c) the average liquid temperature throughout all cargo tanks;

d) the average vapour temperature throughout all cargo tanks.

5.10 Compensation for variation of cargo temperatures

To ensure accurate discrimination of the liquid and vapour phases, the height of each PRT shall be compensated for any effect of thermal contraction/expansion of material used in a thermowell or protecting tube. The compensation may be carried out by the electronics in the ATT system or manually.

5.11 Sealing, security and unsealing

The ATTs shall be equipped with a means of preventing unauthorized adjustment or tampering. Specifically, ATTs used in fiscal or custody transfer applications shall provide security to allow sealing of the calibration adjustment. The security may include a physical seal and/or software password(s). Once the ATT has been sealed, it shall not be unsealed until the next scheduled inspection.

Should unsealing become necessary for some unavoidable reason, the inspection organization shall be informed of such action prior to unsealing.

5.12 Redundancy

Usually, liquefied petroleum and chemical gas carriers are equipped with one set of PRTs per tank.

Where a higher degree of reliability is desired, it is common practice to install two sets of PRTs in each cargo tank. One set shall be designated as the primary PRTs and the other as the secondary PRTs. In such a case:

a) each PRT shall be supported by a secondary PRT mounted adjacent to the primary PRT;

b) failure of a primary PRT shall not affect the secondary PRT, or vice versa;

c) secondary PRTs shall always be in operation; this provides a secondary PRT for comparison to the primary PRT and a means of monitoring the primary PRT for malfunction.

5.13 Data communication

The ATT system shall be designed and installed such that its data transmission device and indicating device:

a) does not compromise the accuracy of the measurement;

b) provides proper security and protection of the measured data to ensure its integrity;

c) provides adequate update speed.

6 Calibration and accuracy verification

6.1 General

The manufacturer of an ATT shall calibrate the ATT to meet the specification before it is shipped from the factory (see 6.3). The ATT is then calibrated by the manufacturer or its authorized service representative after it is installed (see 6.4) and periodically (see 6.5), with the results normally verified by a qualified third party.

The accuracy of temperature measurement by an ATT is affected by the inherent error of the ATT equipment, the error due to installation (e.g. stability, location, etc.) and the effect of changes in operating conditions. Accuracy is also subject to the uncertainty associated with the calibration. Chronological change of characteristics of a PRT is negligibly small in relation to the life of the ship.

6.2 Calibration reference

The calibration reference shall be traceable to a national metrology institute (NMI). The uncertainty of the reference standard shall not exceed ±0,05 °C. The ATT manufacturer shall establish the total uncertainty associated with the accuracy verification of the ATT.

6.3 Calibration and accuracy verification at factory

6.3.1 Calibration at factory

Output resistance of all PRTs shall be compared against a calibration reference under controlled conditions, e.g. in a temperature bath. Typical calibration points include:

a) approximately –196 °C (boiling point of nitrogen);

b) approximately –75 °C (generated by controlled bath);

c) approximately 0 °C (ice point of water);

d) approximately 100 °C (boiling point of water).

At least three calibration points shall be selected taking the operating range of the ATTs into account. The temperature of the room shall be controlled at the time of calibration.

The indicating device shall be calibrated by the manufacturer.

6.3.2 Accuracy of PRTs

The difference between the output from a PRT in terms of temperature (°C) and the solutions of the nominal temperature/resistance relationship (see A.3) shall be regarded as the PRT error at the calibration point.

The maximum PRT error shall be less than

a) $\pm(0{,}15 + 0{,}002 \mid t \mid)$ for LNG applications, or

b) $\pm(0{,}3 + 0{,}005 \mid t \mid)$ for other applications,

where $\mid t \mid$ is the modulus of temperature in °C without regard to sign.

At each calibration point, the maximum PRT error among all PRTs to be installed on the intended ship (E_S) shall be determined. If the overall error of ATT (E) is defined in accordance with 7.1.1 b), the resistance (R_0) and constants A, B and C unique to each PRT shall be calculated from the calibration results.

6.3.3 Factory acceptance test (FAT)

If the maximum PRT error (E_S) is verified by a qualified third party, at least 25 % of the total number of the PRTs, or statistically sufficient numbers, shall be randomly chosen and recalibrated with the repeatability less than the root-mean-square (RMS) of the uncertainties associating with the calibration.

Calibration of indicating devices may be verified by a qualified third party by applying the procedure described in 6.4.2.

6.4 Calibration and accuracy verification after installation

6.4.1 Calibration and inspection after installation

The installation of the PRTs, their connecting cables and associated connections shall be visually inspected. PRTs do not have to be recalibrated after installation.

Calibration of the indicating devices is made by the manufacturer or its authorized service engineers.

6.4.2 Site acceptance test (SAT)

The calibration results of the indicating device shall be verified by feeding simulation resistances from a precision decade box or other devices. The accuracy verification is carried out in the cargo control room or on deck depending on the location of the analogue/digital converter (see Figure 1). In either case, impedance of the cable from PRTs to the indicating device shall be negligibly small. The resistances to be fed shall be determined from the nominal temperature/resistance relationship (see A.3) or from the temperature/resistance relationship unique to each PRT. Typical simulation points include:

a) 0 °C;

b) –100 °C for LNG application or –50 °C for other applications;

c) temperature close to the boiling point of the intended cargo.

At each simulation point, the maximum indicating device error of the ATT (E_d) shall be determined.

6.4.3 Accuracy of indicating device

The maximum indicating device error of the ATT (E_d) shall be less than the following values:

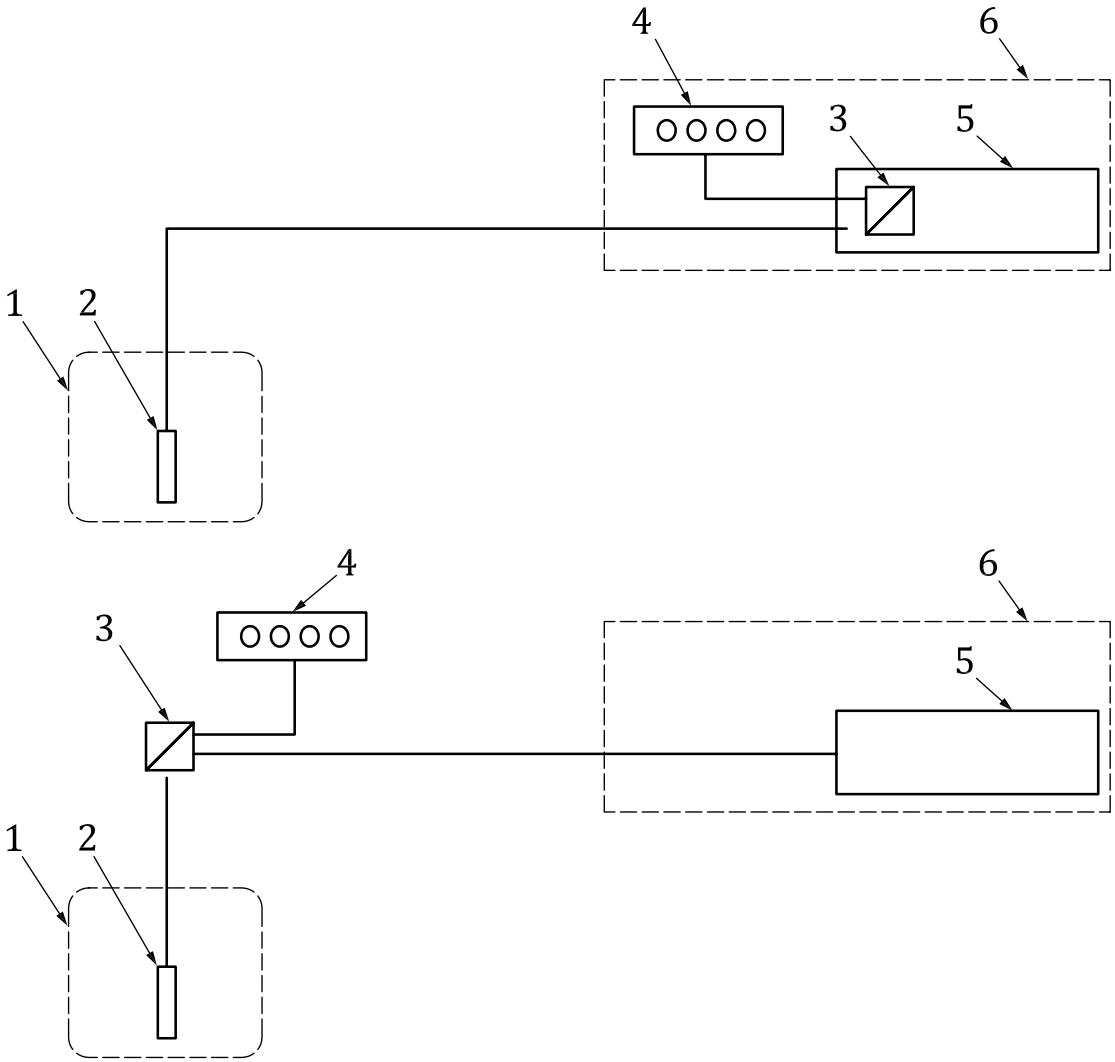
a) for LNG applications:

   1) 0,2 °C for temperatures below –145 °C;

   2) 1,5 °C for temperatures above –145 °C;

b) for other applications:

   1) 0,5 °C throughout the measurable range.



Key

1 cargo tank
2 PRT
3 analogue/digital converter
4 decade box
5 indicating device
6 cargo control room

Figure 1 — Accuracy test of indicating device

6.5 Periodic accuracy verification

6.5.1 General

Accuracy of an ATT used in custody transfer shall be verified periodically. This process normally involves verifying accuracy of the ATT and, if found to be needed, resetting/adjusting the ATTs against a calibration reference. Adjustment or calibration should normally be made by an authorized service engineer with results verified by a qualified third party.

Where there are primary and secondary ATTs in the cargo tanks, comparison of these ATTs during operations is not considered an ATT accuracy verification as defined in this International Standard. An ATT should not be adjusted simply due to an observation of a difference between the primary and secondary ATT.

Periodic recertification of ATTs in custody transfer application is normally required by local regulations and/or the parties to the sales and purchase contract of liquefied gases.

6.5.2 Method of periodic verification

Periodic accuracy verification shall be performed in accordance with the SAT procedure described in 6.4.2. The procedures to determine the overall error described in 7.1 shall also be applied for the determination of the overall error at the time of periodic accuracy verification.

NOTE The accuracy of PRTs does not have to be tested during periodic verification unless their temperature/resistance relationship is suspect (see 6.1).

6.5.3 Frequency of subsequent calibration and recertification

The frequency of periodic accuracy verification is sometimes agreed among the parties to the sales and purchase contract of liquefied gases, and may be subject to national or local regulations and International Standards. Periodic verification is typically scheduled to coincide with classification society inspections. The frequency should also take into consideration recommendations by the ATT manufacturer.

6.5.4 Customary verification

Cross-checking of the outputs from the primary and secondary PRTs during operation or tracking of the history may provide an indication of the performance of the ATTs. However, it is recognized that such verification does not constitute a means of ensuring that the accuracy of the ATTs meets the accuracy requirement set forth in 7.1.1.

7 Accuracy requirement

7.1 Overall error

7.1.1 The overall error of an ATT at the time of SAT (6.4.2) or periodic accuracy verification (6.5) shall be determined by either of the following procedures:

a) The root-mean-square (RMS) of the maximum PRT error (E_s) and the maximum indicating device error (E_d) shall be regarded as the overall error of the ATT (E). In the case of three-wire type PRTs, the resistance of the cable shall be included in E_s or E_d (see 6.4.2).

$$E = \sqrt{(E_s)^2 + (E_d)^2}$$

b) In cases where the error of each PRT is compensated by the ATT or CTMS software, the overall error of the ATT (E) may be regarded as the maximum indicating device error (E_d) of the ATT. In such a

case, the resistance (R_0) and constants A, B and C unique to each PRT stored in the ATT or CTMS software shall be verified.

7.1.2 The maximum overall error of the ATT (E) shall be less than the following values:

a) for LNG applications:

   1) 0,2 °C for temperatures of –145 °C and below;

   2) 1,5 °C for temperatures above –145 °C;

b) for other applications:

   1) 0,5 °C throughout the measurable range.

NOTE Maximum overall error of the ATT in custody transfer applications is normally subject to local regulations and/or requirements of the sales and purchase contract of liquefied gases.

7.2 Resolution

Resolution of ATTs shall be 0,1 °C or better throughout the measurable range.

8 ATT calibration records

All ATT calibration records shall be documented. Calibration and verification records shall be available for inspection by parties involved in custody transfer. All adjustments to the ATTs shall also be documented.

Annex A
(informative)

Information on platinum resistance thermometers

A.1 General

The platinum resistance thermometer is widely used for the custody transfer measurement of liquefied gases as a temperature sensor within an ATT. IEC 60751 provides the characteristics of a platinum resistance thermometer.

A.2 Characteristics of platinum resistance thermometers

IEC 60751 applies to platinum resistors whose temperature coefficient, α, defined as

$$\alpha = \frac{R_{100} - R_0}{R_0 \times 100\ ^\circ\mathrm{C}}$$

is conventionally written as $\alpha = 3{,}851 \times 10^{-3}\ ^\circ\mathrm{C}^{-1}$, where R_{100} is the resistance at $t = 100\ ^\circ\mathrm{C}$ and R_0 is the resistance at $t = 0\ ^\circ\mathrm{C}$.

A.3 Nominal temperature/resistance relationship

IEC 60751 gives the following relationship between temperature and resistance of the nominal PRT.

For the range −200 °C to 0 °C:

$$R_t = R_0\ [1 + A_t + B_t^2 + C\ (t - 100\ ^\circ\mathrm{C})\ t^3]$$

For the range of 0 °C to 850 °C:

$$R_t = R_0\ (1 + A_t + B_t^2)$$

where

R_t is the resistance at temperature t, in ohms (Ω);

R_0 is the resistance at $t = 0\ ^\circ\mathrm{C}$, in ohms (Ω).

The constants in these formulae are:

$$A = 3{,}908\ 3 \times 10^{-3}\ ^\circ\mathrm{C}^{-1}$$

$$B = -5{,}775 \times 10^{-7}\ ^\circ\mathrm{C}^{-2}$$

$$C = -4{,}183 \times 10^{-12}\ ^\circ\mathrm{C}^{-4}$$

IEC 60751:2008, Table 1 exhibits the resistance values of the nominal PRT at temperature t calculated from the above formulae and constants.

Bibliography

[1] ISO 4266-4, *Petroleum and liquid petroleum products — Measurement of level and temperature in storage tanks by automatic methods — Part 4: Measurement of temperature in atmospheric tanks*

[2] ISO 4266-5, *Petroleum and liquid petroleum products — Measurement of level and temperature in storage tanks by automatic methods — Part 5: Measurement of temperature in marine vessels*

[3] ISO 4266-6, *Petroleum and liquid petroleum products — Measurement of level and temperature in storage tanks by automatic methods — Part 6: Measurement of temperature in pressurized storage tanks (non-refrigerated)*

[4] ISO 6578, *Refrigerated hydrocarbon liquids — Static measurement — Calculation procedure*

[5] ISO 10976, *Refrigerated light hydrocarbon fluids — Measurement of cargoes on board LNG carriers*

[6] ISO 18132-1, *Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels — General requirements for automatic tank gauges — Part 1: Automatic tank gauges for liquefied natural gas on board marine carriers and floating storage*

[7] ISO 18132-3, *Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels — General requirements for automatic tank gauges — Part 3: Automatic tank gauges for liquefied petroleum and chemical gases on board marine carriers and floating storage*

[8] IEC 60092-101, *Electrical installations in ships — Part 101: Definitions and general requirements*

[9] IEC 60092-504, *Electrical installations in ships — Part 504: Special features — Control and instrumentation*

[10] IACS Unified Requirements E10, *Test Specification for Type Approval*

[11] ICS/OCIMF/IAPH. *International Safety Guide for Oil Tankers and Terminals*

[12] IMO. *International code for the construction and equipment of ships carrying liquefied gases in bulk (IGC Code)*. 1993 Edition

[13] International Group of Liquefied Natural Gas Importers (GIIGNL). *LNG Custody Transfer Handbook*

[14] ITS-90, *The International Temperature Scale of 1990*

[15] SIGTTO. *Liquefied Gas Handling Practices on Ships and in Terminals*. 3rd Edition

[16] SIGTTO. *Liquefied Gas Fire Hazard Management*. First Edition, 2004

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