INTERNATIONAL STANDARD

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Petroleum and liquid petroleum products — Measurement of level and temperature in storage tanks by automatic methods —

Part 2: Measurement of level in marine vessels

Pétrole et produits pétroliers liquides — Mesurage du niveau et de la température dans les réservoirs de stockage par des méthodes automatiques —

Partie 2: Mesurage du niveau dans les citernes de navire

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 part of ISO 4266 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 4266-2 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 3, *Static petroleum measurement*.

ISO 4266-2, together with ISO 4266-1 and ISO 4266-3 to ISO 4266-6, cancels and replaces ISO 4266:1994, which has been technically revised.

ISO 4266 consists of the following parts, under the general title *Petroleum and liquid petroleum products — Measurement of level and temperature in storage tanks by automatic methods*:

— *Part 1: Measurement of level in atmospheric tanks*

— *Part 2: Measurement of level in marine vessels*

— *Part 3: Measurement of level in pressurized storage tanks (non-refrigerated)*

— *Part 4: Measurement of temperature in atmospheric tanks*

— *Part 5: Measurement of temperature in marine vessels*

— *Part 6: Measurement of temperature in pressurized storage tanks (non-refrigerated)*

Annexes A and B of this part of ISO 4266 are for information only.

Introduction

Marine ALGs are not normally used in fiscal/custody transfer applications because of the limitations described in annexes A and B. However, level measurement by marine ALGs may be used in fiscal/custody transfer when no other alternative, reliable measurement is available. The use of marine-vessel-based ALGs in fiscal/custody transfer normally requires mutual contractual agreement between the buyer and the seller and may be subject to government regulations.

Petroleum and liquid petroleum products — Measurement of level and temperature in storage tanks by automatic methods —

Part 2: Measurement of level in marine vessels

1 Scope

This part of ISO 4266 gives guidance on the accuracy, installation, calibration and verification of automatic level gauges (ALGs), both intrusive and non-intrusive, for measuring the level of petroleum and liquid petroleum products having a Reid vapour pressure less than 100 kPa, transported aboard marine vessels (i.e. tankers and barges).

This part of ISO 4266 gives guidance for buyers and sellers who mutually agree to use marine ALGs for either fiscal and/or custody transfer applications.

This part of ISO 4266 is not applicable to the measurement of level in refrigerated cargo tanks.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 4266. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 4266 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1998 (all parts), *Petroleum industry — Terminology*

ISO 4512:2000, *Petroleum and liquid petroleum products — Equipment for measurement of liquid levels in storage tanks — Manual methods*

ISO 8697:1999, *Crude petroleum and petroleum products — Transfer accountability — Assessment of on board quantity (OBQ) and quantity remaining on board (ROB)*

3 Terms and definitions

For the purposes of this part of ISO 4266, the terms and definitions given in ISO 1998, and the following, apply.

3.1
automatic level gauge
ALG
automatic tank gauge
ATG
instrument that continuously measures liquid height (dip or ullage) in storage tanks

3.2
dip
innage
vertical distance between the dipping datum point and the liquid level

3.3
innage-based ALGs
ALGs designed and installed to measure the liquid dip directly

3.4
still-pipe
vertical, perforated pipe built into a tank to contain the liquid-level-detecting element in order to reduce measurement errors arising from liquid turbulence, surface flow or agitation of the liquid, and to provide a stable mounting point for an ALG

3.5
ullage
outage
distance between the liquid level and the upper reference point, measured along the vertical measurement axis

3.6
ullage-based ALGs
ALGs designed and installed to measure the distance from the ALG reference point to the liquid surface

4 Precautions

4.1 Safety precautions

4.1.1 General

International Standards and government regulations, classification societies and ISGOTT on safety and material-compatibility precautions should be followed when using marine ALG equipment. In addition, the manufacturers' recommendations on the use and installation of the equipment should be followed.

4.1.2 Equipment precautions

4.1.2.1 All marine ALGs should be capable of withstanding the pressure, temperature and other environmental conditions likely to be encountered in marine service. When an ALG is installed in a corrosive service, any parts exposed to the liquid or vapours should be of durable, corrosion-resistant construction.

4.1.2.2 All ALGs should be sealed to withstand the vapour pressure of liquid in the tank. ALGs mounted on vessels with an inert gas system (IGS) should be designed to withstand the operating pressure of the IGS.

4.1.2.3 All marine ALGs should be specified and installed in accordance with the appropriate national and/or international (IMO, IEC, CENELEC, ISGOTT, ISO, etc.) marine electrical safety standards. ALGs should be certified for use in the hazardous-area classification appropriate to their installation.

All ALG equipment should be maintained in safe operating condition and the manufacturers' maintenance instructions should be complied with.

NOTE 1 The design and installation of ALGs may be subject to the approval of the national measurement organization and classification societies, who may have issued a general type approval for the design of the ALG for the particular service for which it is to be employed. Type approval is normally issued after an ALG has been subjected to a specific series of tests and is subject to the ALG being installed in an approved manner.

NOTE 2 Type-approval tests may include the following: visual inspection, performance, vibration, humidity, dry heat, inclination, fluctuations in power supplies, insulation, resistance, electromagnetic compatibility, and high voltage.

4.1.2.4 The ALGs should provide security to prevent unauthorized adjustment or tampering. For ALGs to be used in fiscal/custody transfer application, the ALG should provide facilities to allow sealing of the calibration adjustment.

4.2 General precautions

4.2.1 Accuracy and performance

The general precautions given in 4.2.2 to 4.2.10 affect the accuracy and performance of all types of marine ALGs and should be observed where they are applicable.

4.2.2 Speed of response

Marine ALGs should have sufficient dynamic response to track the liquid level during maximum tank filling or emptying rates.

4.2.3 Protection from mechanical damage

Marine ALGs should be designed to withstand damage caused by waves in the tanks due to ship movement. They should also be able to withstand damage from high velocity jets of water or oil used to wash the tanks.

NOTE 1 This protection may require mounting the ALGs in still-pipes.

NOTE 2 Alternately, this protection may require that the ALGs with a float or displacer-type level-sensing element be raised to a “store” position when it is not being used. Note that such ALGs cannot be used during tank washing.

4.2.4 Manual gauging

When an ALG is set or verified by manual gauging, the manual gauging should be performed to obtain the highest accuracy (see ISO 4512).

4.2.5 Minimum measurable level

The ALG should be able to measure levels as near to the bottom of the tank as possible. This may require provision of a sump in the tank bottom in vessels with double bottoms.

NOTE The minimum measurable level of certain types of ALGs may limit their ability to measure small volumes of ROB/OBQ.

4.2.6 Trim and list

For the best accuracy, the vessel should be on an even keel and upright. In situations where both trim and list exist, every effort should be made to eliminate at least one condition, preferably list.

Trim and list corrections are not required on vessel tanks of cuboid (i.e. rectangular prism) shape, provided that the ALG is located at the geometric centre of the deck area for the tank. Where the ALG is not so located, correction will be required. On vessel tanks that have curvature(s), such as the aft and forward wing tanks, trim and list corrections are recommended. Correction for trim, list and wedge is permissible by table or calculation, using the procedure described in ISO 8697.

4.2.7 Product temperatures

Product temperatures should be measured at the same time as the tank level is measured. The temperature should be representative of the tank contents and should be measured as described in ISO 4266-5.

4.2.8 Compatibility

All parts of the ALG in contact with the product should be compatible with the product, to avoid product contamination.

4.2.9 Entrained air and vapour

Sufficient time should be allowed before gauging a tank to permit the liquid to free itself of entrained air or gas vapours.

4.2.10 Vessel motion

During lightering or offshore operation, or when the vessel is at an exposed berth, vessel motion causes waves on the surface of the product. At least three readings should be taken in minimum time and the readings should be averaged. If the vessel is in heavy motion due to large swells or waves, at least five readings should be taken in a minimum time.

Some ALGs provide internal filtering algorithms as part of the readout to average the level readings over a time interval. The filtering time can be fixed or made adaptive to the encountered motion.

4.3 Use of marine ALGs in fiscal/custody transfer

Marine ALGs are not normally used in fiscal/custody transfer application because of the limitations described in annexes A and B. However, level measurement by marine ALGs may be used in fiscal/custody transfer when no other alternative, reliable measurement is available. The use of marine-vessel-based ALGs in fiscal/custody transfer normally requires mutual contractual agreement between the buyer and the seller and may be subject to government regulations.

5 Accuracy

5.1 Intrinsic error of ALGs

The measurement accuracy of all marine ALGs is affected by the inherent error of the ALG, i.e. the error of the ALGs when tested under controlled conditions as specified by the manufacturers.

5.2 Calibration prior to installation

Marine ALGs to be used in a fiscal/custody transfer application should, prior to installation (i.e. in the factory and in a testing laboratory), agree with a certified reference within 3 mm at a minimum of three points over the intended operating range of the ALG. The certified reference should be traceable to national standards.

The uncertainty of the certified reference should not exceed 0,5 mm, with correction applied. If the reference is a certified gauge tape, refer to ISO 4512 for tape calibration.

NOTE Metrological requirements for the uncertainty of the calibration reference may be more stringent.

5.3 Initial shipyard adjustment

The shipyard adjustment (i.e. setting) procedure should be performed in accordance with the ALG manufacturer's instructions. The procedure normally consists of setting the ALG so that it reads correctly at the minimum level and at the setting point where the zero adjustment took place. The distances from the zero adjustment point to the zero point for the tank capacity table should be referenced.

The setting of the ALG should also confirm that the remote readout reads the same level (within $\pm$ 1 mm) as the level transmitter (if the ALG is provided with a local deck readout).

5.4 Error caused by operating conditions

The total error of the measurement by an ALG, due to operating conditions, varies and it is difficult to quantify on a general basis.

5.5 Overall accuracy

5.5.1 General

The overall accuracy of level measurement by ALGs, as installed, is limited by the intrinsic accuracy of the ALG equipment, the effect of installation methods, and the effect of changes in the operating conditions.

NOTE Depending on the overall accuracy of the ALG as installed (“installed accuracy”), ALGs may be used in either fiscal/custody transfer or for operational purposes. The use of ALGs in fiscal/custody transfer requires the highest possible accuracy. The use of ALGs for operational purposes often permits a lower degree of accuracy.

5.5.2 Use of ALGs for fiscal/custody transfer purposes

The ALG should meet the calibration tolerance prior to installation (see 5.2).

The ALG should meet the calibration tolerance after installation and initial setting at the shipyard (see 5.3).

The ALG should meet the onboard verification tolerance (see clause 7).

6 Installation of marine ALGs

6.1 General

Marine ALGs should be installed in accordance with the ALG manufacturer's instructions.

6.2 Location of ALG

The ALG should be located to minimize the effect of surface turbulence and waves in the cargo tank. The location should be designed to avoid damage during tank washing. Mechanical, float-operated ALGs which cannot withstand waves or tank washing should be provided with the ability to “store” the float when the ALG is not in use.

For vessel tanks of cuboid (i.e. rectangular prism) shape, the ALG should be located at the geometric centre of the tank, which usually eliminates the need for trim and list corrections. On vessel tanks that have curvature side(s), such as the aft and forward wing tanks, the ALG should be located nearer to the inboard bulkhead to avoid interference with the curvature of the vessel's tank bottom.

Presently, the combination of vessel design and ALG technology limits the use of ALGs to the measurement of partially or fully loaded vessels. Therefore, other measurement locations are required to accommodate the measurement of small volumes (ROB/OBQ) (see ISO 8697).

6.3 Location of manual calibration check point

To permit accurate comparison of the product level measured between manual gauging and automatic tank gauging, a manual calibration check point should be provided close (i.e. within 1 m) to the ALG.

6.4 Gauging of inerted tanks

On tanks with an inert gas system (IGS), the ALG should be designed and installed so that it can be maintained and calibrated without depressurising the IGS.

7 Onboard verification of marine ALGs

7.1 General precautions

7.1.1 Check for smooth operation of level-sensing elements — at the shipyard

After mounting ALGs which use intrusive level-sensing elements and prior to calibration, the level-sensing elements should be checked to ensure free operation over the entire operating range. This check should be done slowly to simulate actual operation and to avoid damaging the ALG.

7.1.2 ALG technology-specific considerations

There may be additional technology-specific considerations which can affect ALG verification. Specific, additional steps may be needed to prepare the ALG prior to the verification. Technology-specific considerations include, for example, the effect of physical and electrical properties of the liquid and vapour in the tank, the need for checking free movement of the level sensor, and others (see the ALG manufacturers' documentation).

7.2 Verification by innage gauging or ullage gauging

Marine ALGs that measure the ullage level from the top down should be verified by manual ullage gauging. Marine ALGs that measure innage level from the bottom up should be verified by manual innage gauging.

7.3 Initial verification

After leaving the shipyard and before the maiden voyage, most vessels fill certain tanks with water to check the operation of the vessel's pumps, valves and lines. During this initial tank filling, the verification of the ALGs should be checked against manual tank gauging.

7.4 Subsequent verification

7.4.1 General

After completion of cargo loading at a load port, and prior to discharge at a discharge port, the normal practice is to check the reading of the ALG against manual tank gauging. The manual gauging levels are normally used for the cargo reports. To minimize the effect of vessel motion and adverse external conditions, verification should be performed with a stable liquid level. The liquid level at which the ALG is verified should be within the intended operating range of the ALG.

NOTE Where the reference gauge point for manual gauging is different from the ALG, apply the appropriate correction.

7.4.2 Agreement between ALG reading and manual gauge reading

If the reading by ALG and the reading by manual gauging agree within 6 mm, no further action should be required.

7.4.3 Use of average gauge readings

If the reading by ALG and the reading by manual gauging differ by more than 6 mm, the ALG reading and the manual gauging should be repeated three times (or five times if there are waves in the tank). The average of the manual gauge readings and the ALG readings should be compared. For best accuracy, the vessel should be on an even keel and upright. In situations where both trim and list exist, every effort should be made to eliminate at least one condition, preferably list.

7.4.4 Adjustment of the ALG

7.4.4.1 If the difference between the average ALG reading and the average of the manual gauge readings exceeds 6 mm, the ALG should be readjusted or reset to agree with manual gauging. These adjustments and the reasons for them should be recorded in the vessel's equipment maintenance log.

7.4.4.2 After adjustment, the reading by ALG should be compared with the reading by manual gauging as described in 7.4.3. If the difference between the average ALG reading and the average manual gauge reading is less than 6 mm, no further action should be required.

7.4.4.3 If the ALG cannot be adjusted to agree with the average manual gauge reading, a correction may be used. The correction value should be posted near the ALG readout and used to correct the ALG reading. This correction should be recorded in the vessel documents.

7.5 Verification by alternate methods

In practice, due to the operating constraints (e.g. closed or restricted gauging requirement), lack of properly located manual gauging point(s), or adverse sea conditions (e.g. swell, vessel motion), reliable manual gauging often cannot be obtained to verify ALG measurement. As an alternative method, onboard verification can be performed by comparing the level measured by the ALG against predetermined, stable reference(s) at the tank or ALG support pipe. The method and procedure, which may vary depending on the ALG type, should follow the ALG manufacturer's recommendation.

7.6 Schedule for regular ALG verification

Vessels which do not routinely confirm ALG accuracy (by comparison with manual gauging or by comparison with reference) should perform the verification on a quarterly basis as a minimum.

7.7 Record keeping

ALG verification records should be documented and the record should be ready for inspection by involved parties. The records should be kept for a minimum of one year and twenty voyages.

8 Data communication and receiving

8.1 Introduction

This clause gives recommendations for the specification of the communication between level transmitter(s) and receiver(s) or vice versa.

The communications method(s) should comply with the latest available International Standards that are applicable to the ALGs covered in this part of ISO 4266. In the event that no applicable International Standards are available, the data communication requirements should comply with the applicable national standard regulations and codes.

8.2 Use of remote readout in fiscal/custody transfer

The remote readout of an acceptable ALG may be used in fiscal/custody transfer providing that the whole system, including the remote readout, complies with the required calibration tolerances given in this part of ISO 4266.

NOTE Some readout equipment can be programmed to alarm at high or low levels. Some equipment can also look up the tank-capacity table, apply the appropriate coefficients of expansion and calculate the standard volumes.

8.3 Telemetry and readout equipment

The ALG should be designed and installed such that data transmission and receipt should

— not compromise the accuracy of the measurement, i.e. the difference between the levels displayed by the remote receiving unit and displayed (or measured) by the level transmitter at the tank should not exceed 1 mm,

— not compromise the resolution of the measurement output signal,

— provide proper security and protection of the measured data to ensure its integrity,

— provide adequate speed to meet the update time required for the receiving unit, and

— be electromagnetically immune.

Annex A
(informative)

Accuracy limitations of marine level measurement

Level measurement using marine ALGs is affected by the following inherent limitations, regardless of the ALGs used.

a) **Measurement of small volumes (ROB or OBQ).** Measurement of small volumes of ROB and OBQ by an ALG can be difficult.

b) **Accurate determination of trim and list.** Accurate determination of trim and list is difficult and the trim and list corrections affect the accuracy of the marine level measurement. Due to hog and sag, twists and bends, a multi-point draft may be required to be taken, then using trim a correction which is appropriate to that of the tank. If automatic correction for trim and/or list is provided as part of the ALG readout, the correction should be used in accordance with ISO 8697.

c) **Effect of vessel motion causing waves in the tanks.** Waves in the tanks make it difficult to measure an average level. Many ALGs read the instantaneous level at the point of measurement, whereas manual level gauging tends to measure the height of the wave crests, making calibration of ALGs difficult when waves are present in the tanks. Some ALGs provide internal filtering algorithms as part of the readout to average the level readings over a time interval. The filtering time can be fixed or made adaptive to the encountered motion.

d) **Change of the tank dimensions due to oil or water temperature.** The dimensions of a vessel's tanks change with the water and oil temperature and other factors. This affects the conversion from tank level to volume. The change in the vertical tank dimension also changes the reference height which affects the level accuracy of ALGs which are mounted on the top deck structure.

e) **Change of the tank dimensions due to hog or sag.** Hogging or sagging changes the reference height which affects the level accuracy of ALGs which are mounted on the top deck structure.

The limitations listed above may have significant impact on the overall accuracy of level measurement by all types of marine automatic level gauges.

Annex B
(informative)

Accuracy limitations of marine volume measurement

Volume measurement based on the level on board marine vessels is affected by the following limitations which are inherent in marine measurement.

a) **Tank capacity table accuracy.** Some vessel capacity tables are accurate with nearly empty or nearly full tanks but contain significant errors for partially full tanks.

b) **Clingage**: Clingage is the liquid film that adheres to the inside walls (tank bulkheads) when the tank is emptied. Clingage does not affect the level measurement but may affect the transferred volume.

c) **Sediment and water (S & W), and free water.** Marine measurement of crude oil involves the measurement of both oil and water. Measured S & W and free water is deducted from the gross volume. Accurate S & W measurement requires accurate sampling, sample handling, and laboratory analysis. Accurate free water determination is difficult, particularly the free water in the slop tank.

d) **Temperature measurement.** Temperature differences may exist because the tank bulkheads may be in contact with the ocean, making it difficult to determine an accurate average cargo temperature.

e) **Contents of the vessel's lines.** The volume of transferred oil is affected by the volumes of liquid in the vessel's lines and pumps. Accurate measurement requires that these volumes be quantified or estimated before and after the cargo transfer.

f) **Vessel Experience Factor.** Determination of vessel experience factor (VEF) from marine ALGs and from manual measurement may be different.

The limitations listed above may have significant impact on the overall accuracy of volumes determined by marine automatic level measurement (and by manual level measurement).

Bibliography

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[2] ISO 4268:2000, *Petroleum and liquid petroleum products — Temperature measurements — Manual methods*

[3] ISO 7507 (all parts), *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks*

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