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

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

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

Partie 3: Mesurage du niveau dans les réservoirs de stockage sous pression (non réfrigérés)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 28, *Petroleum and related products, fuels and lubricants from natural or synthetic sources*, Subcommittee SC 2, *Measurement of petroleum and related products*.

This second edition cancels and replaces the first edition (ISO 4266-3:2002), which has been technically revised.

The main changes are as follows:

— terms and definitions in Clause 3 have been updated;

— in 4.3.2, the level that is measured and recorded simultaneously with the temperatures has been clarified;

— in 5.2, the information on calibration prior to installation has been updated;

— in Clause 6, the design requirements for still-wells have been clarified and the limitation of non-perforated still-wells removed.

A list of all parts in the ISO 4266 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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

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

1 Scope

This document gives requirements and guidance on the accuracy, installation, commissioning, calibration and verification of automatic level gauges (ALGs) both intrusive and non-intrusive, for measuring the level of petroleum and petroleum products having a vapour pressure less than 4 MPa, stored in pressurized storage tanks.

This document gives guidance on the use of ALGs in custody transfer application.

This document is not applicable to the measurement of level in caverns and refrigerated storage tanks with ALG equipment.

2 Normative reference

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

3 Terms and definitions

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

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

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

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

3.1
automatic level gauge
ALG
automatic tank gauge
ATG
instrument that continuously measures liquid height (i.e. dip or *ullage* (3.8)) in storage tanks

3.2
datum plate
datum point dip-plate
dipping datum plate
horizontal metal plate located directly below the gauging reference point to provide a fixed contact surface from which manual liquid-depth measurements are made

3.3
gauging reference point
reference gauge point
point clearly defined on the gauge hatch directly above the dipping datum point to indicate the position (and upper datum) from which manual dipping or ullaging should be carried out

3.4
innage automatic level gauge
innage ALG
automatic level gauge (3.1) designed and installed to measure liquid, with an integral reference point at or close to the tank bottom, referenced to the *datum plate* (3.2)

3.5
intrusive automatic level gauge
automatic level gauge (3.1) where the level-sensing device intrudes within the tank and makes physical contact with the liquid, e.g. float and servo-operated-type automatic level gauges

3.6
non-intrusive automatic level gauge
non-intrusive ullage automatic level gauge
automatic level gauge (3.1) where the level-sensing device can intrude within the tank, but does not make physical contact with the liquid

EXAMPLE Microwave or radar-type automatic level gauges.

3.7
still-well
stilling-well
still-pipe
guide pole
vertical, perforated pipe built into a tank to reduce measurement errors arising from liquid turbulence, surface flow or agitation of the liquid

3.8
ullage
outage
distance between the liquid level and the gauging reference point, measured along the vertical measurement axis

3.9
ullage automatic level gauge
ullage ALG
automatic level gauge (3.1) designed and installed to measure the *ullage* (3.8) distance from the upper automatic level gauge reference point to the liquid surface

4 Precautions

4.1 Safety precautions

Relevant international standards on safety and material-compatibility precautions should be followed when using ALG equipment. The manufacturers' recommendations on the use and installation of the equipment should be followed. It is presupposed that all regulations covering entry into hazardous areas are observed.

4.2 Equipment precautions

4.2.1 All of the ALG equipment should be capable of withstanding the pressure, temperature, operating and environmental conditions likely to be encountered in service.

4.2.2 ALGs should be certified for use in the hazardous-area classification which is appropriate to their installation.

4.2.3 Precautions should be taken to ensure that all exposed metal parts of the ALG should have the same electrical potential as the tank.

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

NOTE 1 The design and installation of ALGs can be subject to the approval of a national measurement organization, who will normally have issued a 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 can include the following: visual inspection, performance, vibration, humidity, dry heat, inclination, fluctuations in power supplies, insulation, resistance, electromagnetic compatibility, and high voltage.

4.3 General precautions

4.3.1 The general precautions given in 4.3.2 to 4.3.9 affect the accuracy and performance of all types of ALGs and should be observed where they are applicable.

4.3.2 Product temperatures and vapour pressure should be measured and recorded simultaneously, or as close as practical, while the tank level is measured. The temperature should be representative of the tank contents and should be measured as described in ISO 4266-6.

4.3.3 All data measured for bulk transfer should be recorded promptly when they are taken.

4.3.4 Whenever determinations of the contents of a tank are made before the movement of a bulk quantity of liquid (opening gauge) and after the movement of a bulk quantity of liquid (closing gauge), the same procedures should be used to measure the tank level.

4.3.5 All parts of the ALG in contact with the product or its vapour should be chemically compatible with the product, to avoid both product contamination and corrosion of the ALG.

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

4.3.7 Following the transfer of product, the tank should be allowed to settle before the tank level is measured.

4.3.8 Following a rapid change in the ambient conditions, the liquid surface can show temporary instability. The level-measuring equipment should be capable of either detecting this phenomenon or counteracting the effect of level instability.

4.3.9 ALGs should provide security to prevent unauthorized adjustment or tampering. ALGs used in fiscal/custody transfer application should provide facilities to allow sealing for calibration adjustment.

5 Accuracy

5.1 Intrinsic error of ALGs

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

5.2 Calibration prior to installation

The reading of the ALG to be used in a fiscal/custody transfer application should agree with a certified reference (e.g. a certified gauge tape) within ±1 mm over the entire range of the ALG. It is presupposed that the certified reference is traceable to national standards. The certified reference should be provided with a calibration record.

NOTE Metrological requirements for the uncertainty of the calibration reference can be more stringent than the certified reference.

5.3 Error caused by installation and operating conditions

The error caused by installation and operating conditions on the ALGs used in fiscal/custody transfer pressurized applications should not exceed ±3 mm, provided that the operating conditions are within the limits specified by the ALG manufacturer.

The accuracy of measurements using ullage ALGs is affected by vertical movement of the gauging reference point used to calibrate the ALG, or by vertical movement of the ALG top mounting point during tank transfers. Accuracy can also be affected by tank tilt, hydrostatic pressure and vapour pressure.

The accuracy of measurements by innage ALGs can be affected by vertical movement of the ALG bottom mounting point either during tank transfers or variation of pressure, or both.

Volume measurements using tanks are limited by the following installed accuracy limitations, regardless of the ALG used. These limitations can have a significant effect on the overall accuracy of both manual level gauging and of all types of automatic level gauges, and on the accuracy of the quantity of the content in the tank. These limitations include:

a) tank capacity table accuracy (including the effect of tank tilt and hydrostatic pressure);

b) changes of tank geometry due to temperature;

c) random and systematic errors in level, liquid, vapour density, pressure and temperature measurement;

d) operational procedures used in the transfer;

e) minimum difference between opening and closing levels (parcel size).

Consideration should be given to volume or mass measurements (or both) in pressurized tanks with respect to the amount of product present in the vapour space of the tank.

5.4 Overall accuracy

5.4.1 General

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

NOTE Depending on the overall accuracy of the ALG as installed ("installed accuracy"), ALGs can be used in fiscal/custody transfer applications. The use of ALGs in fiscal/custody transfer applications calls for the highest possible accuracy. The use of ALGs for non-fiscal/custody transfer applications often permits a lower degree of accuracy.

5.4.2 Use of ALGs for fiscal/custody transfer applications

The ALG should meet the pre-installation calibration tolerances (see 5.2).

Including the effects of the installation and changes in operating conditions (see 5.3), the ALG should meet the field verification tolerance (see 7.3.3).

The remote readout, if used, should meet the recommendations specified in Clause 9.

6 Installation of ALGs

6.1 General

ALGs that use technology other than those described in this document can be used in fiscal/custody transfer applications if they provide the required accuracy for the intended application. In such cases, comparable methods to those described in this document should be available that allow the ALG to be verified with the tank in service.

6.2 to 6.5 outline recommendations and precautions for the installation of ALGs.

6.2 Mounting location

6.2.1 The mounting location of an ALG can affect the installed accuracy. For fiscal/custody transfer application accuracy, the ALG mounting location should be stable, with minimal vertical under all practical operating conditions (e.g. due to changes in either the liquid head or vapour pressure, or both).

6.2.2 The ALG should preferably be mounted as close as practical to the vertical centreline axis of the tank.

6.2.3 The level-sensing element should be protected against excessive turbulence caused by the product inlet or outlet. If this cannot be achieved, then an installation with a perforated still-well should be considered.

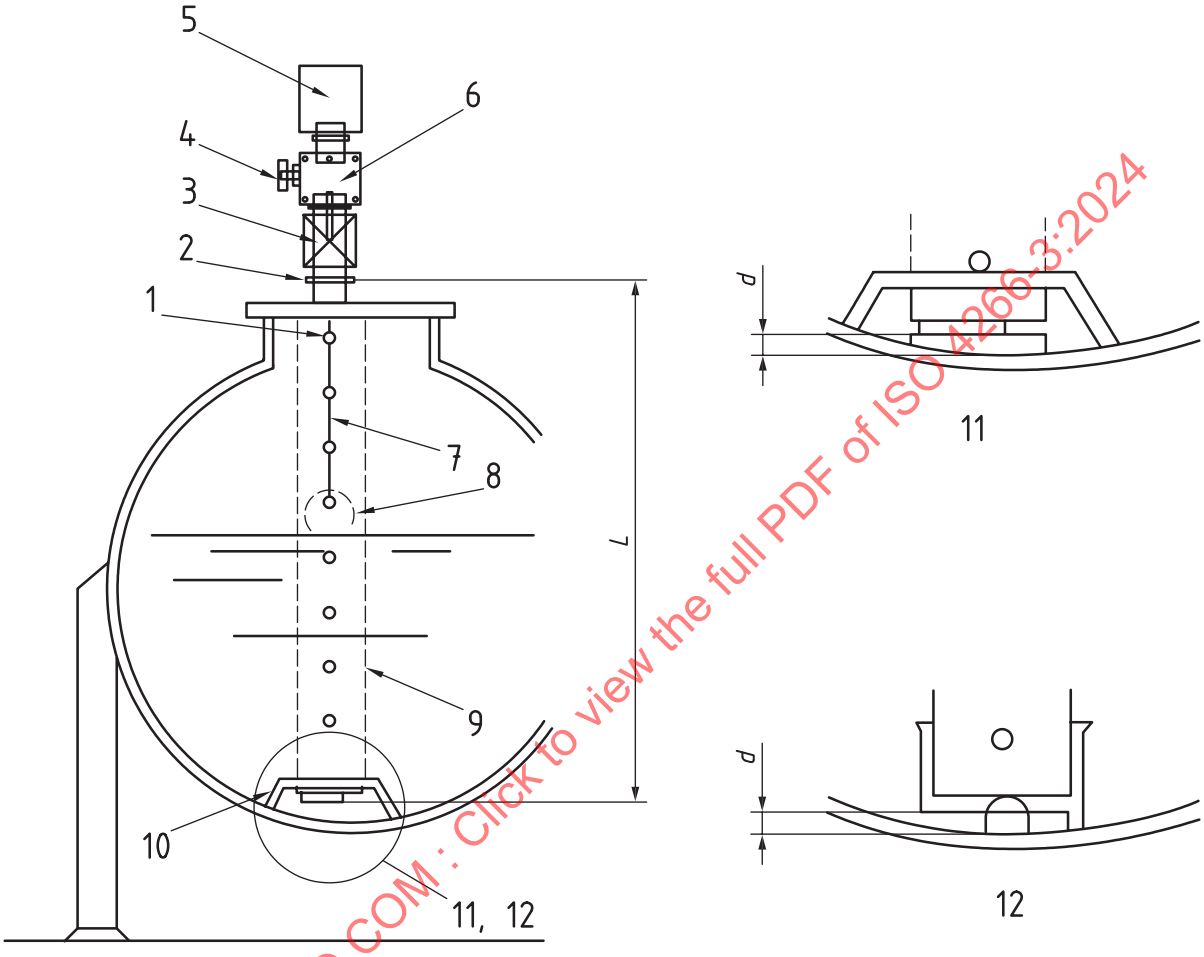
6.3 Manufacturer's requirements

The ALG and level transmitter should be installed and wired according to the manufacturer's instructions.

6.4 Installation

6.4.1 Installation of intrusive ullage ALGs mounted on still-wells

6.4.1.1 For fiscal/custody transfer application accuracy, the ALG should be mounted on a properly suspended perforated still-well. Figure 1 shows an example of this installation. The still-well protects the ALG level-sensing element from liquid turbulence and can provide the fixation point for the datum plate.



Key

1 upper hole above the maximum liquid level
2 reference flange
3 isolation valve
4 vent valve
5 gauge head
6 calibration chamber
7 tape or wire
8 level-detecting element
9 still-well
10 sliding guide with means to adjust verticality of still-well
11 datum plane connected to the still-well

12 datum plane fixed to the shell

d distance between the position of the datum plate and the tank bottom (see 7.1.1)

L distance between the datum plate and the reference flange on which the ALG assembly will be mounted (see 7.1.1)

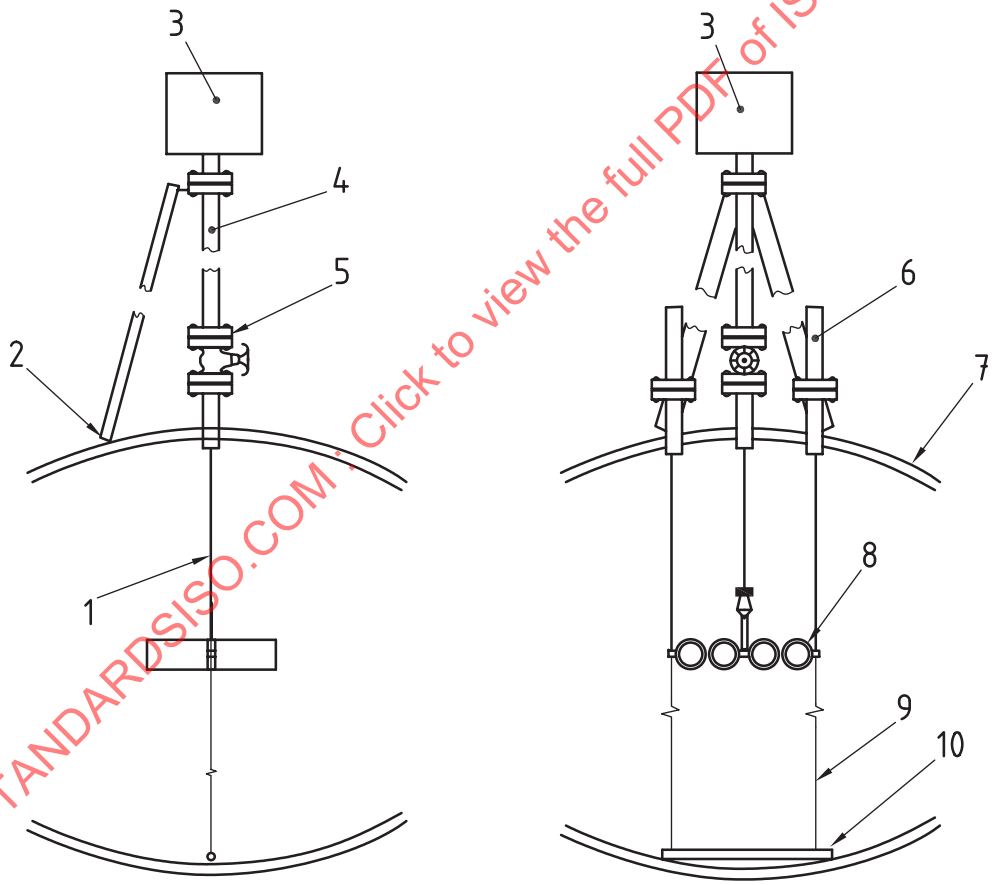
Figure 1 — Example of installation of an intrusive ullage ALG on a pressurized storage tank (with still-well)

6.4.1.2 For ease of maintenance and verification, the ALG should be installed such that it can be isolated from the tank (e.g. through an isolation valve).

NOTE When using ALGs for other purposes, a still-well is not required.

6.4.2 Installation of intrusive ullage ALGs using guide wires

6.4.2.1 For fiscal/custody transfer application accuracy and for operational accuracy, the ALG should be mounted on a properly installed nozzle. Figure 2 shows an example of this installation. The spring-tensioned guide wire protects the ALG level-sensing element from liquid turbulence.



Key

1 perforated stainless steel tape
2 support bracket
3 gauge head
4 two pipes and companion flange
5 tape or cable block valve
6 guide-wire spring assembly
7 tank roof

8 tubular float
9 stainless steel guide wires
10 anchor bar

Figure 2 — Example of installation of an intrusive ullage ALG on a pressurized storage tank (without still-well) using guide wires

6.4.2.2 For ease of maintenance and verification, the ALG should be installed such that the level-sensing element can be isolated from the tank (e.g. through an isolation valve). Adequate means (e.g. a calibration chamber equipped with an inspection hatch) should be provided for access to the level-sensing element.

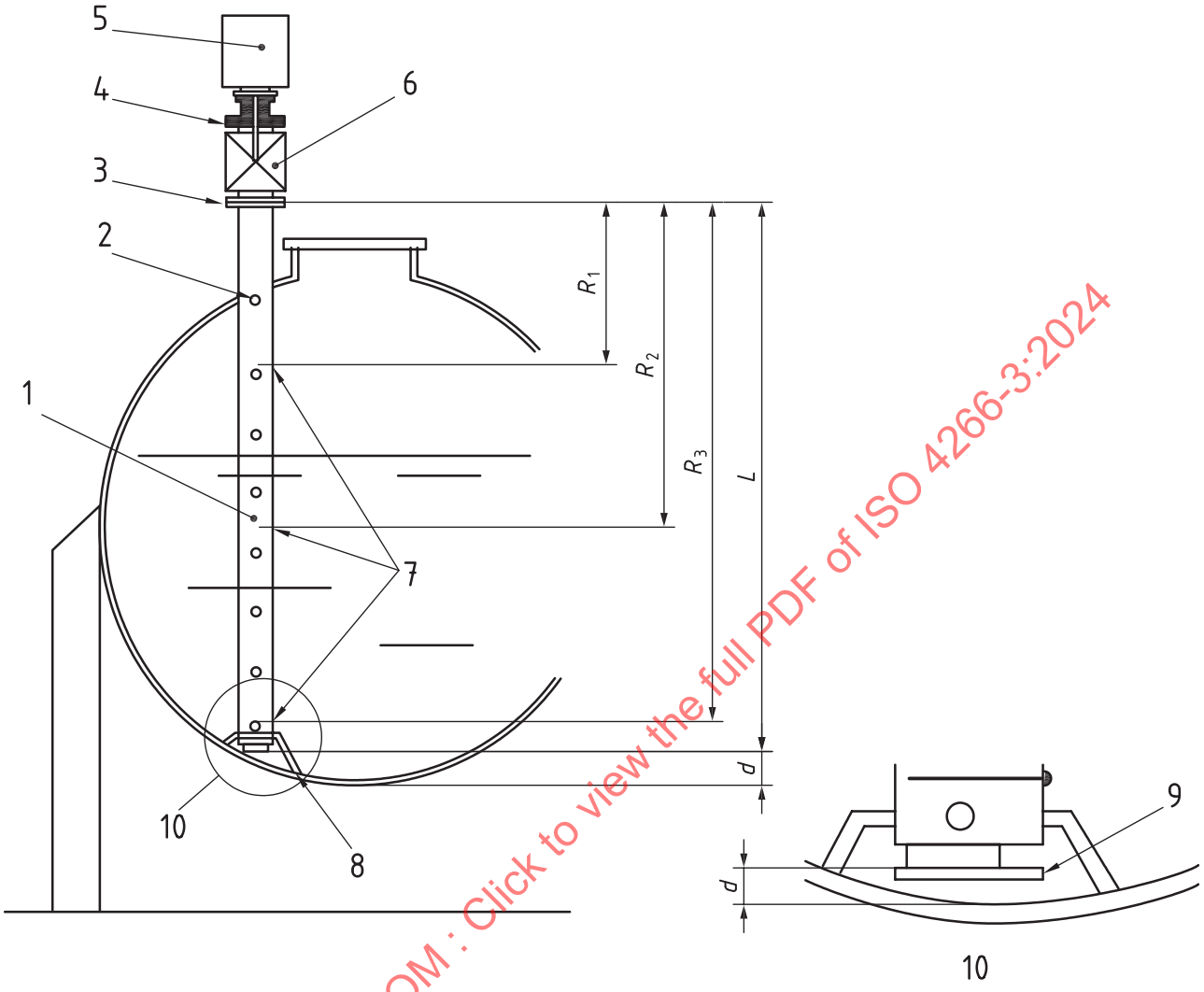
6.4.3 Installation of non-intrusive ullage ALGs (e.g. microwave or radar) mounted on still-wells

6.4.3.1 For fiscal/custody transfer application accuracy, and also for operational purposes, the ALG should be installed on a properly supported still-well. Figure 3 shows an example of this installation. The still-well should be designed to ensure that sufficient signal strength can be attained also under boiling conditions, which can occur during emptying a pressurized storage tank.

6.4.3.2 A datum plate which can serve as a reflector plate (shown in Figure 3 as an example), or similar device or means, should be provided close to the tank bottom to avoid any disturbance echo from the bottom. It is recommended that this plate be constructed in such a way that accurate manual measurement of the distance L (see 7.1.1) can be obtained, when practical.

6.4.3.3 When a permanent pressure seal that is transparent to the ALG is applied, it is possible that the construction of the ALG does not require the installation of an isolation valve for maintenance purposes.

6.4.3.4 Adequate means should be provided (e.g. verification pins positioned on various heights in the still-well) for maintenance and verification purposes. To also allow adjustment when the tank is full, the highest verification pin should be positioned above the maximum filling height.



Key

1	still-well
2	upper hole above the maximum liquid level
3	reference flange
4	pressure seal
5	gauge head
6	isolation valve (optional)
7	verification pins
8	sliding guide with means to adjust vertically of still-well
9	damping or deflector plate
10	d < 300 mm, preferably as small as possible
d	distance between the position of the datum plate and the tank bottom (see 7.1.1)
L	distance between the datum plate and the reference flange on which the ALG assembly will be mounted (see 7.1.1)
R_1, R_2, R_3	distances between the reference flange (on which the ALG assembly will be or is mounted) and the individual verification pins (or other similar verification means); (see 7.1.1)

Figure 3 — Example of installation of a non-intrusive ullage ALG on a pressurized storage tank (with still-well)

6.4.4 Location of ALG

The location of the ALG level-sensing element with respect to inlets and outlets should be such that its proper functioning is not hampered by the liquid flow.

6.4.5 Installation of ALGs other than those described in this document

Installation of ALGs other than those described in this document should be consistent with the criteria specified in Clause 6.

6.5 Still-well design

6.5.1 The still-well should be suspended from the top of the tank. The lower end of the still-well can be mounted in a receptor which permits vertical movement of the still-well due to hydrostatic deformation of the tank. If required, i.e. by the size of the tank, the construction should be such that the verticality of the still-well can be adjusted.

6.5.2 The diameter and thickness of the still-well should be designed to have sufficient rigidity and strength for the intended application, and be suitable for the type of ALG. If the still-well is constructed from more than one piece of pipe, it is important that the total pipe is internally straight and smooth (e.g. no burrs) after assembly.

6.5.3 The distance from the lower end of the still-well to the bottom of the tank should typically be less than 300 mm. In order to maximize the measuring range, this distance should be as short as possible.

6.5.4 The still-well perforations, slots or holes are typically 25 mm in diameter, their spacing between the perforations should be less than 150 mm, and the diameter of the still-well should conform to the ALG manufacturer's recommendations. Use of still-wells without perforations, slots or holes, can lead to serious level measurement errors and shall not be used for custody/fiscal measurement.

6.5.5 After the tank has been hydrostatically tested, the still-well should be checked to ensure that it remains vertical.

7 Initial setting and initial verification of ALGs in the field

7.1 Preparation

7.1.1 Checking for critical distances

Before pressurizing the tank or filling the tank with product, the following critical distances, if applicable to the type of ALG installed, should be determined (e.g. by physical measurement) with a maximum uncertainty of 1 mm, and recorded. Using the examples in Figures 1 to 3, and depending on the ALG type, these critical distances can include:

— the distance, d, between the position of the datum plate and the tank bottom (see Figures 1 and 3),

— the distance, L, between the datum plate and the reference flange on which the ALG assembly will be mounted (see Figures 1 and 3), and

— the distances, R_1, R_2 and R_3, between the reference flange (on which the ALG assembly will be or is mounted) and the individual verification pins (or other similar verification means). The pins should be located to cover the intended operating range of the ALG. To allow adjustment when the tank is full, the highest verification pin should be positioned above the maximum filling height.

NOTE Some ALGs require the orientation of the verification pins to be measured with a certain uncertainty as specified by the ALG manufacturer.

7.1.2 Checking for free movement of level-sensing element of intrusive ALGs

For intrusive ALGs, the travel of the level-sensing element through the normal range from the top to the bottom of the tank should be smooth and free, with no binding or friction. After mounting a new or repaired ALG and prior to setting, the sensing element (e.g. sensor float) and guiding mechanism (e.g. tape, cable, and the connecting elements) should be checked to ensure that the ALG level sensing element can operate freely and smoothly over the entire operating range. This check should be done slowly to simulate actual operation and to avoid damaging the ALG sensing element mechanism.

7.1.3 Checking for influences of changes in physical and electrical properties of the product (vapour/liquid)

Many technologies used for ALGs are in one way or another affected by a change in the physical properties (e.g. density, temperature, pressure) and/or electrical properties (e.g. dielectric constant) of the liquid and vapour. The ALG manufacturer should quantify the influence.

7.2 Initial setting

7.2.1 General

Setting of an ALG consists generally of setting a single point on the calibrated span to match the height of a "reference point." Generally, such a reference point can be one (or more) of the following:

— the reference point in a calibration chamber;

— the top of the isolation valve, or the point where a verification pin is located; or

— the tank datum plate.

The height of the reference point(s) above the datum plate should be defined and recorded together with any offset correction.

Adjustment and verification of ALGs, other than those described in this document, should be consistent with the accuracy verification criteria given in Clause 8.

NOTE Many ALGs are calibrated prior to installation (i.e. in the factory or testing laboratory) and the span cannot be adjusted in the field. Therefore, many ALGs are verified rather than calibrated in the field.

7.2.2 Setting of intrusive ullage ALGs

7.2.2.1 Setting an intrusive ullage ALG on an empty tank or setting an ALG which can measure the distance to the tank datum plate when the tank is in operation

a) Lower the level-sensing element to the datum plate (or the lower reference point).

b) Adjust the ALG reading to agree with the predetermined reference point. The adjustment should include the compensation value or correction factor for the effect of the product density and the displacer/float of the ALG in use.

NOTE 1 The correction factor or compensation value for the effect of buoyancy due to liquid density and the construction of the displacer/float is usually provided by the ALG manufacturer.

c) Raise the level-sensing element back to the upper reference point (see 7.2.1). Then lower the level-sensing element to the datum plate (or the lower reference point) and record the reading.

d) Repeat step c) three times to obtain three consecutive readings which should not exceed a range of 3 mm for both reference points. Set the ALG, if necessary, to agree with the predetermined reference points. The setting or adjustment should include the compensation value or correction factor for the effect of the product density and the displacer/float of the ALG in use.

If only one reference point is accessible, the ALG is set against the available reference point. It is recommended that the lowest reference point above the liquid surface be used to set the ALG.

NOTE 2 The correction factor or compensation value for the effect of buoyancy due to liquid density and the construction of the displacer/float is usually provided by the ALG manufacturer.

7.2.2.2 Setting an intrusive ALG with the tank in operation, and setting an ALG which cannot measure the distance to the datum plate when the tank is in operation

a) Raise the level-sensing element to the upper reference point (see 7.2.1) and record the ALG reading.

b) Lower the level sensing element back to the liquid surface.

c) Repeat steps a) and b) three times to obtain a total of three consecutive readings, which should not exceed a range of 3 mm. Reset the ALG, if necessary, to agree with the upper reference point. The setting or adjustment should include the compensation value or correction factor for the effect of the product density and the displacer/float of the ALG in use.

NOTE The correction factor or compensation value for the effect of buoyancy due to liquid density and the construction of the displacer/float is usually provided by the ALG manufacturer.

7.2.3 Setting of non-intrusive ALGs

7.2.3.1 Setting of a non-intrusive ALG on an empty tank

Compare the ALG measurement to the verification pins (or similar verification devices).

Take three ALG readings at each verification pin. The maximum spread of the ALG readings should not exceed a range of 3 mm. Set the ALG to the correct values for the location of the lowest verification pin.

7.2.3.2 Setting of a non-intrusive ALG with the tank in service

Compare the ALG measurement to a verification pin (or similar verification device). The tank should preferably be less than half-full, and the lowest available verification pin should be used.

Take three ALG readings at the lowest available verification pin. The maximum spread of the ALG readings should not exceed a range of 3 mm. Set the ALG to the correct value for the location of the lowest verification pin.

7.2.4 Other ALGs not described in this document

ALGs other than those described in this document should be set so that the ALG reading agrees with predetermined and stable reference point(s). The procedure, which can vary depending upon the ALG technology or design, should be consistent with the criteria given in 7.2.1 to 7.2.3 to meet the intent of the ALG setting.

7.3 Initial field verification

7.3.1 General

Several factors can result in level measurement errors and should be considered during ALG verification. These include:

— tank installation errors,

— changes in operating conditions, and

— errors intrinsic to the principle of operation of the ALG.

Following the adjustment of the ALG, the overall accuracy of the ALG is verified by:

— comparing the ALG readings against the recorded levels used during the verification procedure, or

— measuring the reference height, if the ALG permits such a measurement.

Depending on the results, the tank and ALG combination should be considered suitable for fiscal/custody transfer purposes if the calibration/verification tolerances given in Clause 7 are met.

7.3.2 Verification procedure

7.3.2.1 Rounding off

ALG readings should not be rounded off. The maximum resolution of the ALG should be used.

7.3.2.2 Procedure

The initial field verification is carried out by taking three consecutive ALG readings against one (or more) reference point(s) available with the tank in service. Follow the procedure described in 7.2 to obtain ALG readings. The verification should be performed with the tank in service.

The maximum spread of three consecutive ALG readings for each reference point is used to evaluate the repeatability of the ALG.

7.3.2.3 Resetting or readjustment of an ALG during initial field verification

Depending on the ALG type, the procedures described in 7.2 are used to obtain the ALG readings, except that the ALG should not be readjusted or reset during the initial field verification. If the ALG fails to meet the tolerance given in 7.3.3, the ALG may be readjusted or reset but it should then be reverified.

7.3.3 Tolerance of initial field verification

For ALGs in fiscal/custody transfer applications, the maximum spread between any two of the three consecutive ALG readings taken during the verification should not exceed 3 mm. In addition, the average ALG reading should agree with the known gauge distance of the reference point within 3 mm.

NOTE Verification of the ALG reading corresponding to the tank datum plate or bottom can provide information about possible deformation of the tank under operational conditions.

7.4 Record keeping

Full records should be kept of the initial setting and the subsequent verification of each ALG. Records of maintenance work should be kept.

8 Subsequent verification of ALGs

8.1 General

A verification programme should be established for ALGs used in fiscal/custody transfer applications. The ALG should be reverified according to the manufacturer's instructions.

8.2 Frequency of subsequent verification

ALGs used in fiscal/custody transfer applications should be verified on a regular basis. The ALG should initially be inspected and its calibration verified at least once per quarter. If operating experience confirms stable performance within the verification tolerance (7.3.3), the verification schedule can be extended up to a recommended maximum of once a year.