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Petroleum and liquid petroleum products — Direct measurement of temperature and level in storage tanks — Automatic methods

Pétrole et produits pétroliers liquides — Mesurages directs de la température et du niveau dans les réservoirs de stockage — Méthodes automatiques

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Contents

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

Annex A of this International Standard is for information only.

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Petroleum and liquid petroleum products — Direct measurement of temperature and level in storage tanks — Automatic methods

1 Scope

1.1 This International Standard gives guidance on the selection, specification, installation, operation and maintenance of mechanical and servo-operated automatic tank gauging systems measuring level and temperature in petroleum storage tanks which are at or near atmospheric temperature and pressure, or used under pressure, or for the storage of heated liquid petroleum products.

This International Standard does not apply to tank gauging systems using other sensing principles, such as radar and optical methods.

NOTE 1 Automatic level gauges may be used with either manual or automatic temperature measurement and automatic temperature measurement may be used with either manual or automatic level gauging.

The provisions of this International Standard are intended to ensure a sufficiently high degree of accuracy to meet the requirements of normal commercial operation.

This International Standard does not apply to level and temperature measurement systems for refrigerated hydrocarbon liquids, for which reference should be made to ISO 8309 and ISO 8310.

1.2 The provisions of this International Standard are intended to meet the requirements of accuracy necessary for custody transfer purposes. However, automatic level gauges are widely used for monitoring the movements of oil to and from storage tanks for stock control, for which a lower standard of accuracy may be acceptable.

1.3 The user of automatic tank gauging systems should consult the system manufacturer for details of any specific requirements not covered in this International Standard.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was 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 edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 79-0:1983, *Electrical apparatus for explosive gas atmospheres —Part 0: General requirements, (with Amendment No. 1:1987)*

3 Definitions

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

3.1 accuracy: Degree of closeness with which the indication of gauging equipment approaches the true value of the quantity measured.

3.2 analog signal: Representation of the proportional value of a variable in the form of a physically measurable quantity.

3.3 anchor weight: Weight to which the detecting element guide wires are attached to hold them taut and plumb.

3.4 bottom guide-wire anchor: Bar, welded to the tank bottom, to which the detecting element guide wires are attached.

3.5 automatic level gauge: Instrument that continuously measures liquid depths or ullages in storage tanks.

3.6 automatic temperature-measuring system: System that continuously measures the temperature of the contents of a storage tank.

3.6.1 electrical resistance spot thermometer: Thermometer that measures the temperature of a liquid at a particular point in a tank by electrical resistance.

3.6.2 electrical resistance averaging thermometer: Thermometer that measures the average temperature of a liquid over the whole or a large part of its depth or at discrete intervals throughout its depth.

3.7 calibration: Process or procedures of setting gauges or instruments so as to bring their reading into agreement with the true value of measurement.

3.8 condensate reservoir: Device situated at the base of a gauge to collect and drain off condensate formed within the tape conduit.

3.9 density: Mass of a substance divided by its volume (see ISO 3838).

3.10 detecting element: That part of the measuring equipment which responds to a specific property (e.g. liquid surface encounter or temperature) of the substance presented to it.

3.11 digital signal: Representation of the value of a variable in the form of a series of individually distinct pulses or states.

3.12 dip: Depth of a liquid in a tank.

NOTE 2 The term "innage" is synonymous (see ISO 7507-1).

3.12.1 dip-hatch: Opening in the top of a tank through which dipping and sampling operations are carried out (see ISO 7507-1).

3.12.2 dip-tape: Graduated steel tape used for measuring the depth of oil or water in a tank, either directly by dipping or indirectly by ullaging (see ISO 7507-1).

3.12.3 dip-tube: Vertical pipe built into a tank for manual gauging.

3.13 displacer: Surface-detecting element which is suspended from a level gauge and moves in a vertical direction to follow the change in liquid level. The displacer has a higher mass than the liquid it displaces.

3.14 error: Difference between a computed or measured quantity and its true value.

3.15 fixed-roof tank: Vertical cylindrical storage vessel with a cone- or dome-shaped roof, of either the non-pressure (freely-vented) type or the low-pressure type.

3.16 float: Detecting element floating on the surface of a liquid in a tank which moves in a vertical direction to follow the change in liquid level.

3.17 floating cover (screen): Lightweight cover of either metal or plastics material designed to float on the surface of a liquid in a tank.

NOTE 3 The cover rests upon the liquid surface. The device is used to retard evaporation of volatile products in a tank (see ISO 7507-1).

3.18 floating-roof tank: Tank in which the roof floats freely on the surface of its contents only in the vertical direction; the roof is restrained from rotation in the horizontal plane.

3.19 gauge head: Housing of the liquid level measuring element, which may include the local indicator, transmitter and associated equipment.

3.20 gauge well: Vertical cylindrical structure built into the roof of a floating-roof tank to contain and guide the detecting element.

3.21 guide pole: Vertical tube used in floating-roof tanks to prevent rotation of the roof.

The guide pole may also be used as the still pipe (3.34), the support pipe (3.35) or the dip-tube (3.12.3).

3.22 guide wire: Spring-tensioned solid wire or flexible cable used to guide the travel of an automatic gauge float.

3.23 indicator: Device which indicates the value of the measurement being made by the gauging equipment.

3.24 non-pressure tank: Storage tank designed for operation at atmospheric pressure.

3.25 operation checker: Externally operated device sometimes incorporated in a mechanical level gauge by which a sudden movement may be imparted to the tape in order to ensure that it moves freely.

3.26 pressure tank: Storage tank designed for operation at pressures above atmospheric.

Pressure tanks are divided into two main classes:

a) low-pressure tanks, used for volatile products which are liquid at ambient temperatures;

b) high-pressure tanks, used for liquids which are normally in the vapour phase at ambient temperature and atmospheric pressure.

3.27 receiver: System which receives signals from a transmitter.

3.28 remote transmission and telemetering systems: Separate or integral systems used in conjunction with level or temperature measuring devices to transmit local data readings to some point other than the point of measurement.

Such systems usually comprise a transmitter to convert the readings into a form suitable for transmission to a receiver which presents the readings at a remote location.

3.29 resistance thermometer (RTD)**:** Temperature-sensing element constructed from material whose electrical resistance changes with temperature in a predictable manner.

3.30 sampling hatch: Any hatch used for sampling; often the dip-hatch.

3.31 seal unit: Device that seals the gauge assembly from tank vapours.

3.32 sensitivity: Minimum change in the measured parameter required to produce a movement of the indicator.

3.33 servo-mechanism: Externally powered mechanism which is controlled by the detecting element.

3.34 still pipe; still well: Vertical 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.

3.35 support pipe: Still pipe used to support an automatic tank gauge near or by the bottom of the tank or from the lower part of the tank shell.

3.36 tank shell: Cylindrical part of a storage tank.

3.37 tape; measuring wire: Element connecting the liquid level-detecting element of a direct-detecting automatic level gauge with the gauge head mechanism.

3.38 thermowell: Tube installed in a tank to house the resistance thermometer or any other temperature-measuring device.

If vertical, the thermowell may be a perforated pipe.

3.39 ullage

(1) Capacity of a tank not occupied by the liquid.

(2) Distance between the surface of a liquid in a tank and some fixed reference point on the top of a tank.

NOTE 4 The term "outage" is synonymous (see ISO 7507-1).

3.40 ullage lip: Marine term for the reference point on the dip-hatch from which manual measurements are made.

3.41 ullage plug: Marine term for the manual dip-hatch usually fitted with a heavy-duty cover.

3.42 ullage reference point: Point clearly marked on the dip-hatch, or on a plate suitably located above or below the dip-hatch, and situated above the maximum level in the tank to indicate the point from which measurements of ullage are taken.

3.43 upper reference point: Point clearly defined on the dip-hatch directly above the dip-point to indicate the position at which dipping or ullaging shall be carried out (see ISO 7507-1).

NOTE 5 If the upper edge of the dip-tube is level, this may be taken as the reference plane.

4 Precautions for installation and operation

4.1 General precautions

4.1.1 Regardless of the equipment used for the measurement of liquid depth and/or temperature, it is recommended that the following general precautions be observed, where applicable.

a) Temperature measurements should be made at the same time as the level measurement.

b) These readings should be recorded at the time they are taken.

c) When determinations of the contents of a tank are made both before and after movement of a bulk quantity of liquid, the same general procedure should be followed in each case.

d) All materials in contact with the product or its vapour should be chemically compatible with the product so that the product is not contaminated nor the equipment affected.

e) Equipment installed in ships should be environmentally tested in accordance with the requirements of the appropriate approval body.

4.1.2 It is recommended that, for critical applications for LPG spheres, two level gauges be fitted, the primary gauge for indication and the secondary gauge for alarm, although both should be available for indication if required. They should be permanently installed and, if a remote control room is provided, both should be wired back to it (see also 8.1.2).

4.2 Safety precautions

4.2.1 The safety precautions given below constitute good practice, but the list is not necessarily comprehensive. It is recommended that the list be read in conjunction with the appropriate safety code. These precautions should be taken whenever they do not conflict with national or other regulations which should, in any case, always be followed.

4.2.2 All automatic level- and temperature-measuring equipment should be capable of withstanding the pressure, temperature and environmental conditions specified for the tank design.

4.2.3 All electrical components used in connection with automatic gauging equipment situated in a classified area should be appropriate to the classification of the area and should conform to the standards laid down in recognized codes (for example IEC 79-0).

4.2.4 All metal parts of gauging equipment mounted on tanks should be firmly connected to an electrical earth, so that the resistance is not greater than the value specified in the local safety code.

A float should be bonded to the tank by means of the tape, because the guide wires do not provide adequate bonding or grounding of the float since the sliding contact could be intermittent. The bonding should not affect the free movement of the float.

Where intrinsically safe equipment is employed, the earth for such equipment is normally kept separate from other earths.

4.2.5 All regulations covering entry into hazardous areas should be rigorously observed.

Before a tank which has contained hydrocarbon liquids or toxic material is entered, a gas-free certificate and work permit should be obtained.

The standard regulations regarding entry into tanks which have contained leaded fuels should be meticulously observed.

4.2.6 Plant and equipment should be adequately maintained, and it is recommended that a regular inspection be made by a competent person.

4.2.7 If radioactive materials are used, any applicable regulations covering the handling of these materials should be observed.

4.2.8 Floating-roof tanks are preferably gauged from the platform, but in exceptional circumstances it may be necessary to descend to the roof. Toxic and flammable vapours may accumulate above the roof, and if it is necessary for a gauger to descend to the roof he should at all times be kept under observation by another operator from the top platform. It is essential that the gauger be equipped with a safety-line and harness, and both the gauger and the observer should put on breathing apparatus before the gauger descends on to the roof in the following circumstances:

a) if the product in the tank contains hydrogen sulphide or volatile mercaptans;

b) if the roof is at rest on its supports or is not fully floating;

c) if the roof is out-of-round or when the roof-seal is known to be faulty;

d) in any other circumstances if vapours may be present in dangerous concentrations.

4.2.9 Rotating shafts may enter part of the gauge installation which is effectively connected to the vapour space. If an electrically energized transmitter is attached to the gauge, there should be a vented space between the gauge and the transmitter.

4.2.10 All conductors entering zone 0 areas (see IEC 79-0) should be protected against flashover, which could occur during lightning storms.

5 Selection, accuracy and installation of automatic level gauges

5.1 General

The measuring instruments are required to provide a local readout and/or be equipped with a transmission system providing remote readout. Automatic level gauges may be mounted either at the top of the tank or near to ground level. They may also be used for detection of oil/water interfaces.

To achieve reliability of operation, it is essential to adhere to the recommendations for installation given in this clause.

5.2 Selection of level gauge

5.2.1 Automatic level gauges in most common use fall into either of the following general classifications:

a) mechanically-operated gauges;

In this type of gauge the detecting element is normally a float and the power for actuation of the mechanism is derived directly from the change in level of the liquid.

b) electrically powered servo-operated gauges.

In this type of gauge the detecting element is a level sensor which follows the variations of level by means of a servo-mechanism.

5.2.2 Automatic level gauges may be used for:

a) custody transfer measurements and the determination of stock inventory, which require the highest possible accuracy;

b) stock control or plant operations, such as blending, where a lower degree of accuracy may be permissible.

The accuracy of custody transfer level gauges will, in general, be the subject of legal regulations which may include type approval.

5.2.3 The following factors should be considered in the selection of a level-gauging system:

a) required degree of accuracy;

Consideration should be given to manufacturer's quoted accuracies, competent test reports, statutory requirements and gauging applications.

b) changes in product characteristics;

Range of product characteristics likely to be encountered in normal service and the permissible effects of such changes of characteristic on the accuracy of the gauge; any future change in the use of the tank should likewise be considered.

c) number and type of tanks on which gauges are to be installed;

d) whether local and/or remote indicators;

e) whether individual or common readout;

f) operating conditions;

Range of operating pressures, operating temperatures, ambient temperature, surface turbulence and products to be measured.

g) whether automatic temperature measurement;

h) whether detection of the oil/water interface is required;

i) future extent of the installation;

j) availability of electric power;

k) ease of maintenance and availability of skilled maintenance personnel;

l) any relevant legal metrological requirements;

m) environmental conditions.

5.2.4 Choice of appropriate gauge will depend on:

a) minimum increment of liquid level indicated by the gauge;

If an analog presentation is used, the length of the space between two divisions corresponding to a 1 mm increment in liquid level should be not less than 1 mm; if a digital display is used, the final digit should be equal to the minimum increment;

b) accuracy tolerance in terms of liquid height;

c) use of a float;

Changes in density of the liquid in the tank will affect the float immersion and consequently affects the gauge reading.

d) required sensitivity to changes in liquid level;

e) changes in temperature;

Effect on the gauge mechanism, and on its mounting with respect to thermal expansion of the tank shell.

f) influence of any transmission system;

g) type, size and construction of the storage tank;

h) effects of tank distortions on the upper reference point.

5.3 Accuracy

5.3.1 The accuracy of automatic level gauges should be in accordance with the requirements of national standards or regulations.

NOTE 6 Recommendations relating to accuracy are included in the OIML Recommendation No. R 85.

5.3.2 The manufacturer should state the typical errors for the gauge in question and, in addition, should give the change in level reading for the gauge which will occur with changes in both product density and ambient temperature.

5.3.3 The accuracy of a gauge should not be significantly affected by the amount of tape or wire run out, and a counterbalancing mechanism may have to be incorporated in the design of mechanical-type gauges.

5.3.4 If a tape or wire is incorporated into an automatic gauging system, it is recommended that the tape or wire be of a suitable material with a coefficient of thermal expansion as near as possible to that of the material of the tank shell.

5.3.5 If an automatic level gauge is provided with a remote indication, every effort should be made to guarantee the integrity of the presented data. If the remote indication is used for several automatic level gauges, the refreshing time of each of the level-indications should be taken into consideration.

5.4 Location of level gauge

5.4.1 Automatic gauging equipment should be located separately from any facilities provided or used for sampling. The location of the gauge should take into account the facilities available for sampling.

5.4.2 The liquid-level-detecting element should be located such that no part of the element is less than 500 mm from the tank shell. In floating-roof tanks, the outer edge of the level-detecting element should be as close as possible to 500 mm from the tank shell.

5.4.3 The liquid-level-detecting element should be located in close proximity to the gauging hatch and should be accessible from the gauger's platform.

5.4.4 The allowable minimum distance between the liquid-detecting elements and the centreline of the dip-hatch and/or sampling-hatch depends on the type of equipment and installation concerned. However, care should be exercised in fixing these distances so that there is no interference between such elements, and that manual gauging or sampling can take place.

5.4.5 The liquid-level-detecting element of the tank should be far enough away from the inlet and outlet connections to minimize the effects of eddies, currents and turbulence arising from these sources. If this is not sufficiently effective, the detecting element should be protected by means of a still pipe. Where tank mixers are installed, the gauge manufacturer should be consulted.

5.4.6 Local reading indicators and tank side equipment should be easily accessible for reading and servicing.

5.5 Installation principles

5.5.1 Special attention should be given to the gauge-mounting point on the tank, so that the distance between this point and the datum plate does not change as a result of tank shell distortion caused by the hydrostatic head of the contents. Therefore the gauge should preferably be mounted on a support pipe of adequate construction, or on the lower part of the tank shell.

Whilst a support pipe mounting is preferred, especially for large tanks, the final choice will depend on the type of gauge and whether the tank is fixed-roof or floating-roof.

5.5.2 If gauging is not being installed initially, on new tankage, it is recommended that fittings to suit a preferred type of level gauge are included on the tank at the construction stage.

5.5.3 The datum plate used for manual reference dipping should be below the dip-hatch nearest to the automatic level-detecting element.

NOTE 7 A plate 500 mm × 500 mm × 8 mm of corrosion-resistant material with horizontal and diagonal supports placed not more than 700 mm above the bottom has been found suitable.

5.5.4 After the tank has been hydrostatically tested, a check should be made that the support pipe is plumb and/or that the guide wires are in their correct positions prior to adjusting the gauge.

5.5.5 Any special installation requirements specified by the manufacturer or by national or local authorities should be followed.

NOTE 8 Recommendations relating to installation are included in the OIML Recommendation No. R 85.

5.5.6 Drawings are included to provide illustrations of the principles that are recommended for installing level gauges and certain averaging thermometers. Details of the particular installation should be specified additionally for each application.

5.6 Support-pipe-mounted gauges

5.6.1 The support pipe used for mounting the gauge head should have a minimum of 200 mm nominal bore, or such other bore as recommended by the manufacturer. It should be fixed either to the lower part of the tank shell or to the bottom of the tank such that the recommendations in 5.5.1 are met.

The support pipe should extend to the tank bottom as far as practicable, however, care should be taken that the position of the support pipe is not influenced by movement at the mounting location. The support pipe should be provided with one or more rows of holes or slots which should extend above the maximum level of the liquid.

5.6.2 If the support pipe is mounted on the tank bottom, its mass should be distributed on the tank bottom so that it does not normally impose a load exceeding the equivalent of 3 m of product.

NOTE 9 Mounting of a strengthening plate under the support pipe is recommended.

5.7 Tank-shell-mounted gauges

5.7.1 The support bracket for the gauge head and pipework should be attached to the tank shell at a height, typically 2 m, at which the angular deflection of the tank shell from the vertical due to filling is likely to be at a minimum. Pipe support brackets other than the gauge head support should incorporate sliding guides to ensure that the gauge pipework is, as far as possible, independent of tank shell movements.

5.7.2 The tape conduits should be of the size specified by the manufacturer and should be in proper alignment at all points to avoid the tape touching or rubbing the inside of the conduit. If the horizontal tape conduit (extension arm) requires lateral guiding, one point for anchoring the guide is the top of the tank shell; another point is the still pipe used for manual gauging.

5.7.3 The tape conduits should be treated internally (e.g. by heavy galvanizing) to prevent the formation of rust or scale. If necessary, facilities such as a condensate reservoir should be provided to drain off any condensate which may form.

5.8 Installation on fixed-roof tanks (see figure 1)

5.8.1 The gauge mounting and any tape conduit on fixed-roof tanks should be so fitted that any deflection of the tank roof with a change in tank vapour pressure or wall deformation due to hydrostatic forces does not introduce error into the gauge reading.

5.8.2 Means of isolation between the gauge head and the tank atmosphere should be considered to permit the gauge head to be opened without loss of tank pressure.

5.8.3 All component parts of the gauge head, level detecting element and associated conduits should be capable of withstanding the designed tank pressure without leakage.

5.9 Installation on floating-roof tanks (see figure 2)

5.9.1 For new floating-roof tank installations, a support pipe should be installed in addition to the guide pole. For existing tanks, it may be necessary to use the guide pole as the support pipe.

The construction of the support pipe should not restrict vertical roof movement.

The function of the support pipe, stilling well and guide pole may be combined in one construction.

5.9.2 If a float well is required in the floating roof for the level-detecting element, it should be constructed according to the installation requirements of the manufacturer of the gauge. The well should permit measurement of the operational liquid levels and should be constructed in such a way that vapour losses are minimized.