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| **OIML TC 8 / SC 1**  **Recommendation: OIML R71 (1CD)** |  | Circulated to P- and O-members and liaison international bodies and external organisations for: | |  | |
| **Title:**  **Fixed storage tanks. General requirements** |  | discussion at (date and place of meeting): | |  | |
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|  | vote (P-members only) and comments by: | |  | |
| TITLE OF THE 1CD (English):  **OIML R 71**  **Fixed storage tanks. General requirements.**  **(Mark-up Version)**  *Note : Some text highlighted to encourage close review of certain sections*  *(Highlight will be removed before publication)* | | | | |

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|  | | International | | **OIML R 71** | | |
|  | | Recommendation | | Edition 20XX (E) | | |

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| Fixed storage tanks. General requirements |
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| Réservoirs de stockage fixes. Prescriptions générales |
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| OIML R 71 Edition 20XX |  |  |  |
|  |  | Organisation Internationale  de Métrologie Légale |
| International Organization  of Legal Metrology |

**Explanatory Note**

(to be removed before publication)

In October 2015, the CIML approved a project to revise OIML R 71. This project also expands the scope of R 71 to include horizontal tanks, spherical tanks, and pressurized tanks. A project to revise OIML R 71 *Automatic level gauges for measuring the level of liquid in stationary storage tanks* is being accomplished in parallel (at the same time) by TC 8/SC 1 Project Group 10.

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**Foreword**

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States. The main categories of OIML publications are:

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* **International Basic Publications (OIML B),** which define the operating rules of the various OIML structures and systems.

OIML Draft Recommendations, Documents and Guides are developed by Technical Committees or Subcommittees which comprise representatives from the Member States. Certain international and regional institutions also participate on a consultation basis. Cooperative agreements have been established between the OIML and certain institutions, such as ISO and the IEC, with the objective of avoiding contradictory requirements. Consequently, manufacturers and users of measuring instruments, test laboratories, etc. may simultaneously apply OIML publications and those of other institutions.

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Additionally, the OIML publishes or participates in the publication of **Vocabularies (OIML V)** and periodically commissions legal metrology experts to write **Expert Reports (OIML E)**. Expert Reports are intended to provide information and advice, and are written solely from the viewpoint of their author, without the involvement of a Technical Committee or Subcommittee, nor that of the CIML. Thus, they do not necessarily represent the views of the OIML.

This publication - reference OIML R 71, edition 20XX (E) - was developed by the OIML Technical Subcommittee TC 8/SC 1 *Static volume and mass measurement*. It was sanctioned for final publication by the International Conference of Legal Metrology in 20XX. This Edition supersedes the previous edition of   
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**Fixed storage tanks**

**General requirements**

## 1 Introduction

The revision of this Recommendation is being accomplished in parallel with the revision of OIML R 85 (2008) “Automatic level gauges for measuring the level of liquid in fixed storage tanks”.

The requirements for tanks and gauges were separated in a previous revision cycle of R71 and R85.

## 

## 2 Scope

**2.1** Fixed storage tanks at atmospheric pressure or under pressure (hereinafter called “tanks”) are built for bulk liquid storage and may be used for the measurement of quantities (volume or mass) of the contained liquid. When used for that measurement, they shall comply with the requirements of this Recommendation.

**2.2** In addition to the requirements for parts of the tank, such as the gauging hatch and datum plate, the tank calibration table should be accurately determined as it is a critical component of the measurement of the quantity (volume or mass) of liquid in the tank.**2.3 This Recommendation specifies the general requirements for all stationary storage tanks onshore. These tanks include:**

**a) Vertical, cylindrical tanks of either fixed-roof or floating-roof type, operating at atmospheric pressure or near atmospheric pressure;**

**b) Horizontal, cylindrical tanks operating at or near atmospheric pressure; and**

**c) Pressurized horizontal or spherical tanks -- special provisions for these types of tanks are found in Annex B.**

**2.4 Fixed storage tanks covered by this recommendation may be insulated or non-insulated and/or refrigerated, non-refrigerated, or heated type tanks. Cryogenic storage tanks (such as those used for storing cryogenic fluids) are excluded from this Recommendation.**

***Note: An accepted definition of cryogenic fluid: a fluid with a boiling point of less than 120 K (-153 deg C) under atmospheric pressure conditions, which has been liquefied by refrigeration. [Reference is OIML R81]***

## 3 Terminology

**3.1 Calibration of a fixed storage tank**

Set of operations carried out to establish, under specified conditions, the relationship between the liquid level in the tank and the volume of the liquid in the tank.

**3.2 Nominal capacity**

Rounded value of the maximum volume of liquid that a tank may contain under normal conditions of use.

**3.3 Gauge hatch (Dip-hatch)**

Opening in the top of a tank through which the dipping and sampling operations are carried out.

**3.4 Vertical measurement axis**

Vertical line which passes through the middle of the still well (guide pipe), if provided, belonging to the gauge hatch concerned, and corresponding to the position intended for automatic or manual level gauges.

**3.5 Dipping datum plate (see Annex A)**

Horizontal plate located along the vertical measurement axis of a vertical, cylindrical storage tank descending from the upper reference point. It provides a fixed contact surface at the bottom of the tank from which manual liquid depth measurements are made.

*Note: The term “datum plate” is synonymous.*

*[Convener note: definitions will be added (as appropriate) for similar components on horizontal tanks, spherical tanks, and pressurized tanks.]*

**3.6 Dipping datum point**

Intersection of the vertical measurement axis with the upper surface of the dipping datum plate, or with the bottom surface of the tank if a dipping datum plate is not provided (in most horizontal tanks). It constitutes the origin point for the measurement of liquid levels (zero reference or dipping reference point).

**3.7 Upper reference point**

Point located on the vertical measurement axis, with reference to which the ullage is measured.

**3.8 Reference height**

Distance between the dipping datum point and the upper reference point.

**3.9 Ullage**

Distance between the free surface of the liquid and the upper reference point, measured along the vertical measurement axis.

**3.10 Reference conditions** Conditions applicable for the calibration certificate.

**3.11 Automatic level gauge (ALG)**

Instrument intended to measure automatically and display the level of the liquid contained in a tank with respect to a fixed reference.

An automatic level gauge includes at least a liquid level sensor, a transducer, and an indicating device.

*Note: See OIML Recommendation R 85 for general requirements.*

**3.12 Deadwood**

Tank fittings, structure, piping and other equipment which affects the capacity of a tank.

Deadwood is referred to as “positive deadwood” when the capacity of the fitting adds to the effective capacity of the tank, or “negative deadwood” when the volume of the fitting displaces liquid and reduces the effective capacity.

**3.13 Calibration table**

Expression in the form of a table, of the mathematical function *V(h)* which represents the relation between the height *h* (independent variable) and the volume *V* (dependent variable).

**3.14 Lower limit of accurate capacity**

Capacity below which the maximum permissible error is exceeded, taking account of the shape of the tank and the calibration method.

**3.15 Dipping tape**

Material measure of length for measuring the liquid level.

*Note: See OIML Recommendation R 35 for general requirements.*

## 4 Classification and description

For the purposes of calibration and the establishment of calibration tables, the tanks may be classified according to the following criteria:

* Shape (4.1);
* position with reference to the ground (4.2);
* means used for measuring levels or volumes (quantities) of liquid contained (4.3);
* kind of liquid(s) to be contained (hydrostatic pressure; 4.4 );
* conditions of use (supplementary influence quantities; 4.4 ).
  + 1. **4.1 Shapes of fixed storage tanks:**

1. vertical, cylindrical storage tanks (the most common shape);
2. horizontal cylindrical shape with flat, conical, truncated, hemispherical, elliptical or dome-shaped bottom or ends;
3. spherical or spheroidal; and
4. parallelepipedic.

Only vertical, cylindrical tanks normally have a floating roof (or a floating cover).

4.2 The position of the tanks with reference to the ground may be:

* on the ground;
* partially underground;
* underground; or
* above ground.

4.3 The following means may be used for measuring the quantity of contained liquid:

* a single graduation mark – for horizontal cylindrical tanks;
* a measuring device with a graduated scale (with a viewing window or an external gauge tube) – for smaller-sized tanks with lower a lower measurement accuracy requirement;
* a graduated rule (dipstick), divided into units of volume or of length, or a graduated tape (dipping tape), divided into units of length, with a dip-weight or sinker (manual measurement) – for horizontal cylindrical tanks; or
* an automatic level gauge or gauging system (automatic measurement).

Tanks, where the quantity of liquid is determined by use of a graduated dipstick or dipping tape, divided into units of length or by use of an automatic level gauge, shall be accompanied by a calibration table. See also OIML R 35 [15] and OIML R 85 [16].

4.4 The main influence quantities which affect calibration are pressure and temperature. Pressure, including hydrostatic pressure, may alter the apparent volume by distorting the shell; differences from the reference temperature will alter the volumes by expansion or contraction of the shell.

*Note: With reference to pressure and temperature, the tanks may be:*

* *at ambient atmospheric pressure;*
* *closed, at low pressure (Reid vapor pressure less than 100 kPa);*
* *closed, at high pressure (Reid vapor pressure more than 100 kPa);*
* *without heating;*
* *with heating, but without thermal insulation;*
* *with heating and thermal insulation; or*
* *with refrigeration and thermal insulation.*

## 5 Units of measurement

The recommended units of measurement are those of the International System of Units (SI).

If, in any country, units of measurement outside the SI are allowed, the legal units of measurement of that country may be used. In international trade, the officially agreed equivalents between these units of measurement and those of the SI shall be applied.

## 6 Technical characteristics of tanks

**6.1** The tanks shall be built in accordance with good engineering practice. The construction, position and conditions of use of the tanks shall comply with the all legal requirements for storage of contained liquids, especially considering the characteristics of these liquids (such as potable liquids, petroleum products, chemicals, and etc.).

**6.2** The tanks may be provided with features necessary to reduce, as much as practical, evaporative losses. Installation and the use of these features shall not lead to significant measurement errors.

**6.3** In order to be accepted for fiscal / custody transfer applications, the tanks shall comply with the following general requirements, which aim to ensure the accuracy of measurement of the volume of liquid contained:

1. The shape, material, reinforcement, construction and assembly shall be such that the tank is sufficiently resistant to the atmosphere and to the effects of the contained liquid; under normal conditions of use, the tank will not suffer any significant deformation that may adversely affect the capacity of the tank;
2. The dipping datum point and the upper reference point shall be constructed so that their positions remain practically most stable, minimizing the impact due to tank filling and emptying, and due to variations in process and ambient conditions.

Examples for the position of gauge hatches and the construction of reference points on vertical, cylindrical tanks are shown in Annex C ;

1. Still pipes are frequently used as support for the reference point (upper end) and datum plate (lower end). The installation shall be such that the lower tip is fixed close to the bottom and the upper end is guided at the top of the tank. Perforations must be designed to allow free flow of liquid to ensure level and temperature measurement (see also   
   ISO 4266-1, Annex A, and Annex C);
2. The shape of the tanks shall be such that the formation of air pockets during filling, or of pockets of liquid after draining, is prevented;
3. The tanks shall be stable on their foundations; this may be ensured by anchoring or by an adequate period of stabilization, the tank remaining full, so that its base will not vary greatly with time.

**6.4** If a calibration table is obligatory, the tanks shall be provided with a data plate bearing an identification of the tank.

The data plate shall be made of a metal which remains practically unchanged under normal conditions of use. The plate shall be fixed on an integral part of the tank, so located that it is readily visible and easily legible, not subject to deterioration, and in such a manner that it cannot be removed without breaking the seals which carry the verification marks.

At least the following tank information shall be available on the data plate:

* date the tank was built;
* the builder of the tank;
* nominal capacity;
* maximum fill height; and
* reference height.

Other forms of identification and records of data may be authorized or required by national regulations.

**6.5** A dipping datum plate is not required when the tank bottom is sufficiently stable and the risk of sediment forming is not present.

## 7 Metrological characteristics of tanks

The maximum permissible calibration uncertainty applies to the values between the lower limit of accurate capacity and the nominal capacity, shown in the calibration table.

The maximum permissible uncertainty, calculated according to the GUM [1] for *k = 2*, shall be equal to:

* 0.2 % of the indicated volume for vertical cylindrical tanks;
* 0.3 % of the indicated volume for horizontal or tilted cylindrical tanks;
* 0.5 % of the indicated volume for other tanks.

The maximum permissible uncertainties indicated above do not include the uncertainty of the quantity below the datum plate, which is stated in the tank calibration table.

*Note: For ISO Standards dealing with tank calibration, see the referenced standards in Annex D .*

## 8 Metrological controls

**8.1** The granting of the “legal” status to a tank and the retention of that status shall include all or part of the following operations:

* initial verification;
* subsequent verification or recalibration in-service.

These operations are carried out by or under the control of the national authorities.

**8.2** In countries where type approval is mandatory, the approval of design drawings partially replaces the type approval process that is usually required for othermeasuring instruments. This approval must be obtained by the manufacturer before he starts construction. For this purpose, he shall submit to the competent authority the design drawings of the tank, showing:

* the general layout;
* the method of fixing the tank on the ground (or underground);
* the location of all valves and of the inlet and outlet pipes, so that the way in which the tank can be completely emptied for the purposes of cleaning and subsequent calibration is clear;
* the position and dimensions of all deadwoods (positive and negative);
* the details concerning the floating roof or floating cover (if provided) including its mass;
* the details for fitting the liquid level measuring device in the tank;
* the details for fitting the temperature and pressure sensors in the tank; and
* the position of the data plate.

If a type approval is not required, a similar procedure shall be applied during the initial verification of the tank.

### 8.3 Initial verification (carried out in two stages)

8.3.1 Examination of the tank (in situ)

During the in situ examination, the finished construction of the tank shall be checked for conformity to the “as-built” drawings. Conformity to all requirements shall be established and documented. The following shall be taken into consideration:

* the uniformity of construction;
* any possible deformations;
* the rigidity and stability of the structure;
* manholes;
* access to the gauge hatch;
* the ability of the tank to be calibrated ( any additional work that may be required to facilitate calibration shall be documented);
* any internal fittings and features in the tank (deadwood);
* details of the floating roof or floating cover; and
* attachments for the fitting of the calibration information plate.

The tanks shall be pressure tested, leak proofed, and cleaned. The results shall be recorded in a document which is presented before the calibration procedure starts.

**8.3.2** **Calibration**

The tank calibration shall be carried out in accordance with the applicable ISO Standards, or national standards as required. See 8.5.

* + 1. **8.4 Tank re-calibration and subsequent verification**

National authorities shall determine the frequency and the requirements of tank re-calibration.

Tank re-calibration shall also be carried out if a deformation of the tank causes a change in its metrological qualities (including a change to the reference gauge points, the floating roof, or any other changes).

Subsequent verification, when carried out, shall include an examination of the construction and of the external appearance of the tank. For tanks used in custody transfer service, the bottom course diameter, the bottom course plate thickness, and the tank tilt shall all be verified.

8.4.1 Examination of the construction and the external appearance of the tank shall be used to ensure that no modifications to the “as-built” drawings have occurred. If modifications have occurred, the problem may be solved in situ if it is of minor importance, or the drawings shall be amended and a new/updated approval shall be obtained.

8.4.2 Recalibration may be carried out after it has been confirmed that:

* the result of the examination of construction and external appearance is satisfactory; and
* the requirements in 6.4 are met.

Concerning the calibration itself, the requirements in 8.5 shall also be taken into account.

### 8.5 Calibration

For the calibration of a tank, one of the following methods shall be used:

* geometric (e.g. optical, strapping);
* volumetric;
* a combination of the two; or
* other accepted methods.

The choice of the method/procedure used to calibrate the tank shall be documented and is usually based upon the nominal capacity of the tank, the tank shape, the position of the tank, the conditions of use, and etc. Additional information on tank calibration is in Annex A.

For tank calibration, it is recommended that the following ISO Standards are used (as applicable):

* ISO 4512 [2];
* ISO 4269 [3];
* ISO 7507 [4] - [8] series; and/or
* ISO 12917 [9, 10].

If these ISO Standards are not applied (or cannot be applied), the calibration authority must decide and document which calibration method is appropriate/acceptable.

**8.5.1 Geometric Methods**

The geometric methods consist of direct or indirect measurement of the internal or external dimensions of the tank, of the positive and negative deadwood, and of the floating roof or floating cover, if provided.

*Note: The procedure of internal measurement by means of a tape with a tensioning device is generally not admitted for the calibration of tanks containing liquids involved in custody transfer and international trade, except when no better method is available (for example, in the case of a thermally insulated tank).*

The geometric methods may be used on tanks with a nominal capacity of about 50 m3 and greater, which have a regular geometric shape and show no deformation.

**8.5.2 Volumetric Method**

The volumetric method consists of directly establishing the internal capacity of the tank. This is done by measuring (by means of a measurement standard) the partial volumes of a non-volatile liquid which are successively delivered into or withdrawn from the tank. Water is a very suitable non-volatile liquid that has the additional advantage of having a small coefficient of expansion.

The volumetric method is generally used for the calibration of the following categories of tanks:

* underground tanks, of any type;
* tanks on the ground or above ground, with a nominal capacity up to 100 m3; and
* tanks of a shape that is not suitable for a geometric method.

8.5.3 Combination Method

The combination method consists in establishing, by means of a geometric method, the volumes corresponding to the shell of the tank and by means of the volumetric method, the volumes corresponding to the bottom of the tank.

This method applies, under the same conditions as the geometric method, to tanks of which the lower part consists of a shape for which the volume cannot be determined with sufficient accuracy, for example due to deadwood, by means of the geometric method.

**8.6 Granting of the calibration certificate and application of the verification mark   
(according to national regulations)**

8.6.1 Tanks which comply with all the requirements of this Recommendation shall be accepted for fiscal and custody transfer applications. After calibration, the calibration certificate is issued and the markings on the data plate are completed.

8.6.2 The calibration certificate shall be issued in accordance with the standard that is used for the calibration.

8.6.3 The legality of the verification is confirmed by applying a verification mark on:

* the calibration certificate; and
* the data plate.

### 8.7 Re-computation of calibration table

In addition to 8.4, the calibration table should be re-computed when encountering:

* a large change in density (specific gravity) of the liquid in the tank since this changes the liquid head correction; or
* encrustation.

## *[Convener’s note: Chapter 9 removed … most information that was in Chapter 9 has been moved into Chapter 4.]*

# **Annex A**

# Tank Features Related to Measurement on Vertical Cylindrical Tanks

# 

**(Mandatory)**

### *[Convener note: Old Sections A.1.1 – A.1.3 moved to Section 8.5]*

### 

### General recommendations

**A.1**  The recommended minimum diameter of a perforated or slotted still pipe is 20 cm. Smaller diameter still pipes may be used provided that sufficient space is available for taking manual tank samples with a sample bottle or a thief. If smaller diameter still pipes are used, the design and construction of the still pipe shall be checked for mechanical rigidity and strength.

**A.2**  The still pipe shall be guided at the top of the tank and not rigidly attached.

**A.3**  The lower lip of the still pipe should extend to within 30 cm of the tank bottom.

**A.4**  The still pipe shall have two rows of slots, or two rows of holes (i.e. perforations) located on the opposite sides of the pipe, which start at the lower end of the pipe and continue to above the maximum liquid level. Typical sizes of the slots are 2.5 cm in width and 25 cm in length. The typical diameter of the perforation is 5 cm.

*Note 1: In the event a smaller diameter still pipe is retrofitted inside a larger still pipe, the slots or perforations must be designed to allow free flow of liquid to ensure the accuracy of the tank measurement (level, sample, and temperature).*

*Note 2: In certain locations, still pipes without slots (“solid” or “non-perforated” still pipes) have been used to comply with local air pollution regulations. Solid still pipes can lead to serious errors in level and temperature measurements and may be responsible for tank overfills. They should not be used for measurement.*

*Alternatives to solid still pipes which meet air pollution regulations may be available.*

**A.5**  It is recommended that the still pipe be supported either:

1. at the bottom corner of the tank, where the shell plate is welded to the bottom plate, i.e. the stable point to which the datum plate is referred; or
2. on the bottom of the tank; or
3. by a non-rigid hinged bracket connected to the bottom course of the shell.

**A.6**  The upper end of the still pipe and the sliding guide should be designed to allow vertical expansion of the still pipe when the tank shell bulges or moves vertically. The construction of the pipe and the top guide should not restrict floating roof movement in the vertical direction.

The still pipe may be supported on the bottom of the tank if the tank bottom does not move in relation to the joint where the shell and bottom meet.

For tank construction considerations, the centerline of the still pipe should be located between 450 mm to 800 mm from the shell of the tank.

*Note: When a tank is filled, the bottom of the tank may be defected upwards by the angular defection of the shell in the area immediately adjacent to the bottom joint. Further from the shell, the bottom is usually defected downward. The amount of defection depends on the soil conditions and the foundation design. In most cases, the bulging of the shell ceases to cause bottom movement approximately 450 mm to 600 mm from the shell.*

After the tank has been hydrostatically tested, the still pipe should remain vertical.

**A.7**  A water draw valve, a drain, a sump, and a weir (baffle) may be needed in the tank to facilitate water draining. Locks, seals, or other means of positive isolation are recommended.

**A.8**  Proper light at or on the tank should be provided to allow the operator to take measurements at night, if required by operations.

**A.9**  A separate thermometer well, extended from the top of the tank to near the bottom may be desirable for temperature probe installation.

**A.10**  The shape of the tanks shall be such that pockets of liquid do not remain after the tank is drained.

**A.11**  The gauging platform should be stable such that the effect of the gauger’s weight will have only a negligible effect on the change of the reference gauge height.

**A.12**  If the storage tank is equipped with more than one gauging hatch, an official gauging hatch should be designated and used for opening and closing the gauge during a custody transfer tranaction. The upper reference gauge point should be clearly marked on the hatch.

**A.13**  If side sample taps are installed, they should be positioned to allow tank samples to be taken and for composing an overall representative sample.

**A.14** The tanks shall be stable on their foundations; this may be ensured by proper soil compressing, anchoring, and/or by an adequate period of stabilization (the tank remaining full, so that its base will not vary greatly with time).

**Appendix B**

**Special provisions for pressurized storage tanks:**

**spheres, spheroid and horizontal cylindrical tanks**

**(Mandatory and Informative)**

B.1 Gauging hatch

Except for measurement with the storage tank not-in-service, the gauging hatch is normally closed and pressure-tight.

B.2 Entry point for portable electronic gauging device

Provisions on the top of the tank and on the hatch should be made to allow insertion of a portable electronic gauging device when safe, to obtain level, temperature, water-oil interface, and tank samples.

B.3 Provisions for automatic level and temperature measurement instruments

Provisions shall be made on the hatch on top of tank to allow automatic level and temperature measurement equipment be used. An isolation valve or equal shall be provided.

A still pipe and a thermowell are recommended for large spherical and spheroid type tanks, in particular if unstable vapour/liquid interface is expected.

B.4 Tank calibration methods

Applicable pressurized tank calibration methods published in the ISO standards include:

ISO 12917-1:2002 Petroleum and liquid petroleum products -- Calibration of horizontal cylindrical tanks -- Part 1: Manual methods

ISO 12917-2:2002 Petroleum and liquid petroleum products -- Calibration of horizontal cylindrical tanks -- Part 2: Internal electro-optical distance-ranging method

# **Annex C Examples of the location of gauge hatches and of the realization of the reference points (Informative)**

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|  | | | | | | | | | | |
| **Figure 1 Diagram of a vertical cylindrical tank with fixed roof** | | | | | | | | | | |
| 1 | | Shell | 10 | | Lid of the guide pipe | | 19 | Vertical measurement axis | | |
| 2 | | Bottom of the tank | 11 | | Handrail | | 20 | Heating coil | | |
| 3 | | Roof | 12 | | Access ladder with guard rail | | PRS | Upper reference point | | |
| 4 | | Manhole | 13 | | Measurement platform | | PRI | Dipping datum point | | |
| 5 | | Inlet line | 14 | | Dip plate | | H | Reference height | | |
| 6 | | Outlet line | 15 | | Lower angle-irons | | C | Ullage | | |
| 7 | | Drain line | 16 | | Upper angle-irons | | h | Level of the liquid in the tank | | |
| 8 | | Gauge hatch | 17 | | Calibration information plate | |  |  | | |
| 9 | | Guide pipe | 18 | | Opening | |  |  | | |
|  | | | | | | | | | | |
| **Figure 2 Diagram of a horizontal cylindrical tank with level tube** | | | | | | | | | | |
| 1 | Cylindrical shell | | | 5 | | Safety shut-off valve | | | 9 | Graduated scale |
| 2 | End | | | 6 | | Drain valve | | | 10 | Cursor |
| 3 | Glass tube level gauge | | | 7 | | Level of the liquid in the tank | | | 11 | Manhole |
| 4 | Isolating valve | | | 8 | | Gauge glass protection | | |  |  |

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| **Figure 3 Diagram of a spherical pressurized tank** | | | | | |
| 1 | | Metal wall (sphere) | | | |
| 2 | | Pipe (Øint = 300 mm) to be adjusted vertically (5 mm tolerance between the vertical determined by plumb bob and three generating lines at 120°) | | | |
| 3 | | Indicating device of the level gauge | | | |
| 4 | | Holes Ø 40 mm at 200 mm pitch | | | |
| 5 | | Glass level indicator, with metal casing | | | |
| 6 | | Drain plug or valve | | | |
| 7 | | Spherical isolating valve | | | |
| 8 | | Mark of reference level (for in-service checking of zero adjustment of the level gauge) | | | |
| 9 | | Three gussets at 120° | | | |
| 10 | | Three bolts for vertical alignment of the guide pipe | | | |
| 11 | | Calibration information plate | | | |
| AA | | Axis of the sphere | | | |
| a | | Minimum dimension compatible with the deformation of the sphere | | | |
|  | | | | |  |
| **Figure 4 Design details of a guide pipe in a vertical cylindrical tank with fixed roof,**  **of which the deflection when loaded is negligible** | | | | |  |
| 1 | Guide pipe fixed to the upper part of the body by welded gussets | | 6 | Calibration information plate |  |
| 2 | Gauge hatch | | 7 | Dip plate (300 mm  300 mm) fixed to the shell by welded gussets |  |
| 3 | Funnel | | 8 | Vertical measurement axis |  |
| 4 | Platform | | 9 | Lid of guide pipe |  |
| 5 | Guard-rail | |  |  |  |

# **Annex D**

# **Bibliography**

***[Convener note: these references will all be checked and updated before publication of R71.]***

|  |  |  |
| --- | --- | --- |
| **Ref.** | **Standard or Recommendation** | **Abstract** |
| [1] | **OIML G 1: 2008** Guide to the expression of uncertainty in measurement (GUM) | This Guide establishes general rules for evaluating and expressing uncertainty in measurement. |
| [2] | **ISO 4512:2000**  Petroleum and liquid petroleum products -- Equipment for measurement of liquid levels in storage tanks -- Manual methods | This standard specifies the requirements for the equipment required to measure manually the liquid level or the corresponding volume of petroleum and petroleum products stored in tanks and containers. |
| [3] | **ISO 4269:2001**  Petroleum and liquid petroleum products -- Tank calibration by liquid measurement -- Incremental method using volumetric meters | This standard specifies a method for the calibration of tanks by addition of batches of liquid. The liquid is used as a volume-transfer medium, measured accurately by means of a meter.   * + 1. *Note: This International Standard is not applicable to the calibration of reference measuring instruments, proving tanks, or meter provers.* |
| [4] | **ISO 7507-1:2003**  Petroleum and liquid petroleum products -- Calibration of vertical cylindrical tanks -- Part 1: Strapping method | ISO 7507-1:2003 specifies a method for the calibration of substantially vertical cylindrical tanks by measuring the tank using a strapping tape.  This method is known as the strapping method and is suitable for use as a working method, a reference method or a referee method.  The operation of strapping, the corrections to be made and the calculations leading to the compilation of the tank capacity table are described.  This method does not apply to abnormally deformed, e.g. dented or non-circular, tanks.  This method is suitable for tilted tanks with a deviation of up to 3 % from the vertical, provided that a correction for the measured tilt is applied in the calculations. |
| [5] | **ISO 7507-2:2005**  Petroleum and liquid petroleum products -- Calibration of vertical cylindrical tanks -- Part 2: Optical-reference-line method | ISO 7507-2:2005 specifies a method for the calibration of tanks above 8 m in diameter with cylindrical courses that are substantially vertical. It provides a method for determining the volumetric quantity contained within a tank at gauged liquid levels.  The optical (offset) measurements required to determine the circumferences can be taken internally or externally.  The method specified in ISO 7507-2:2005 is suitable for tilted tanks with up to 3 % deviation from the vertical provided that a correction is applied for the measurement tilt, as described in ISO 7507-1.  This method is an alternative to other methods such as strapping  (ISO 7507-1) and the optical-triangulation method (ISO 7507-3). |
| [6] | **ISO 7507-3:2006**  Petroleum and liquid petroleum products -- Calibration of vertical cylindrical tanks -- Part 3: Optical-triangulation method | ISO 7507-3:2006 specifies a calibration procedure for application to tanks above 8 m in diameter with cylindrical courses that are substantially vertical. It provides a method for determining the volumetric quantity contained within a tank at gauged liquid levels. The measurements required to determine the radius are made either internally or externally. The external method is applicable only to tanks that are free of insulation.  ISO 7507-3:2006 is suitable for tanks tilted up to a 3 % deviation from the vertical, provided that a correction is applied for the measured tilt as described in ISO 7507-1. |
| [7] | **ISO 7507-4:1995**  Petroleum and liquid petroleum products -- Calibration of vertical cylindrical tanks -- Part 4: Internal electro-optical distance-ranging method | Specifies a method for the calibration of vertical cylindrical tanks having diameters greater than 5 m by means of internal measurements using an electro-optical distance-ranging instrument (EODR), and for the subsequent compilation of tank capacity tables. Not applicable to the calibration of abnormally deformed tanks or of noncircular tanks. Applicable to tanks tilted by ≤ 3 % from the vertical, provided a correction is applied for the measured tilt. Applicable to tanks with cone-up or cone-down bottoms, as well as to tanks with flat bottoms. |
| [8] | **ISO 7507-5:2000**  Petroleum and liquid petroleum products -- Calibration of vertical cylindrical tanks -- Part 5: External electro-optical distance-ranging method | This standard specifies a method for the calibration of non-insulated vertical cylindrical tanks having diameters greater than 5 m, by means of external measurement using an electro-optical distance-ranging method (EODR), and for the subsequent compilation of tank capacity tables. This method is applicable to tanks with cone-up or cone-down bottoms as well as to tanks with flat bottoms. |
| [9] | **ISO 12917-1:2002**  Petroleum and liquid petroleum products -- Calibration of horizontal cylindrical tanks -- Part 1: Manual methods | ISO 12917-1 specifies manual methods for the calibration of nominally horizontal cylindrical tanks, installed at a fixed location. It is applicable to horizontal tanks up to 4 m in diameter and 30 m in length.  The methods are applicable to insulated and non-insulated tanks, either when they are above-ground or underground. The methods are applicable to pressurized tanks, and to both knuckle-dish-end and flat-end cylindrical tanks as well as elliptical and spherical head tanks.  ISO 12917-1 is applicable to tanks inclined by up to 10 % from the horizontal, provided a correction is applied for the measured tilt. |
| [10] | **ISO 12917-2:2002**  Petroleum and liquid petroleum products -- Calibration of horizontal cylindrical tanks -- Part 2: Internal electro-optical distance-ranging method | ISO 12917-2:2002 specifies a method for the calibration of horizontal cylindrical tanks having diameters greater than 2 m by means of internal measurements using an electro-optical distance-ranging instrument, and for the subsequent compilation of tank-capacity tables.  This method is known as the internal electro-optical distance-ranging (EODR) method.  ISO 12917-2:2002 is applicable to tanks inclined by up to  10 % from the horizontal, provided a correction is applied for the measured tilt. |
| [11] | **ISO 9770:1989**  Crude petroleum and petroleum products -- Compressibility factors for hydrocarbons in the range  638 kg/m3 to 1 074 kg/m3 | Includes the contents of Manual of Petroleum Measurement Standards, Chapter 11.2.1M published August 1984 by API. The purpose is to correct hydrocarbon volumes metered under pressure to the corresponding volumes at the equilibrium pressure for the metered temperature. Contains compressibility factors related to meter temperature and density of metered material. |
| [12] | **ISO 8973:1997**  Liquefied petroleum gases -- Calculation method for density and vapor pressure | No abstract available |
| [13] | **ISO 5024:1999**  Petroleum liquids and liquefied petroleum gases -- Measurement -- Standard reference conditions | No abstract available |
| [14] | **ISO 6578:1991**  Refrigerated hydrocarbon liquids -- Static measurement -- Calculation procedure | Specifies the calculations to be made to adjust the volume of a liquid from the conditions at measurement to the equivalent volume of liquid or vapor at a standard temperature and pressure, or to the equivalent mass or energy (calorific content). Annexes A to H form an integral part of this standard. |
| [15] | **OIML R 35-1:2007**  Material measures of length for general use. Part 1: Metrological and technical requirements | This Recommendation applies to material measures of length for general use, hereinafter called “measures”.  It specifies the technical, metrological and administrative conditions which are mandatory for these measures and includes the requirements for digital readouts on the cases of tapes, whether electronic or mechanical. |
| [16] | **OIML R 85-1/2:2008**  Automatic level gauges for measuring the level of liquid in stationary storage tanks.  Part 1: Metrological and technical requirements.  Part 2: Metrological control and tests. | This Recommendation specifies the metrological and technical requirements and test procedures for automatic level gauges for storage tanks. The storage tanks include vertical, cylindrical storage tanks and pressurized storage tanks (spheres, spheroid, bullets). The storage tank may be refrigerated or heated.  The metrological purpose of tank level measurements is the application in conjunction with tank calibration tables for the determination of liquid volume received from, delivered to, or contained in stationary storage tanks. |