
**Petroleum and liquid petroleum
products — Calibration of vertical
cylindrical tanks —**

**Part 4:
Internal electro-optical distance-ranging
method**

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*Pétrole et produits pétroliers liquides — Jaugeage des réservoirs
cylindriques verticaux —*

Partie 4: Méthode par mesurage électro-optique interne de la distance

ISO 7507-4:2010

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 ISO 7507-4:2010

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 7507-4 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 2, *Measurement of petroleum and related products*.

This second edition cancels and replaces the first edition (ISO 7507-4:1995), which has been technically revised.

ISO 7507 consists of the following parts, under the general title *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks*:

- Part 1: *Strapping method*
- Part 2: *Optical-reference-line method*
- Part 3: *Optical-triangulation method*
- Part 4: *Internal electro-optical distance-ranging method*
- Part 5: *External electro-optical distance-ranging method*

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Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks —

Part 4: Internal electro-optical distance-ranging method

1 Scope

This part of ISO 7507 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 (EODR) instrument, and for the subsequent compilation of tank capacity tables.

The method 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 7507-1:2003, Clause 11.

This part of ISO 7507 also applies to tanks with floating roofs or internal floating blankets.

2 Normative references

The following referenced documents are indispensable for the application 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 7507-1:2003, *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 1: Strapping method*

IEC 60825-1:2007, *Safety of laser products — Part 1: Equipment classification and requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7507-1 and the following apply.

3.1

reference target point

fixed point clearly marked on a fixed point within the tank, e.g. on the inside surface of the tank shell wall

3.2

slope distance

distance measured from the electro-optical distance-ranging instrument to a target point on any given course of the tank shell wall

3.3

target point

one of a series of points on the inside surface of the tank shell wall to which slope distance, and vertical and horizontal angles are measured by use of the electro-optical ranging instrument

4 Precautions

The general precautions and safety precautions specified in ISO 7507-1 shall apply to this part of ISO 7507. In addition, the inside of the tank shall be clean. The laser beam emitted by the distance-ranging unit shall conform to IEC 60825-1.

5 Equipment

5.1 Electro-optical distance-ranging instrument

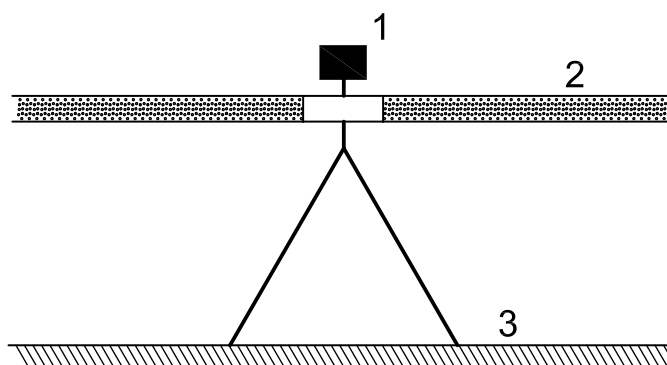
To achieve uncertainties of tank volumes acceptable in legal metrology, the angular measuring part of the instrument should have an angular graduation and resolution equal to or better than $3,142 \times 10^{-6}$ rad [$0,2 \text{ mgon}^1$] and the distance-measuring part of the instrument, used for direct determination of distances, should have a graduation and resolution equal to or better than 1 mm.

NOTE For analysis of the impact of uncertainty of the equipment on the uncertainty of the calibration table, refer to the examples in Annex C.

The accuracy of EODR equipment can be affected by variations of temperature. The manufacturer's guidance should be followed.

5.2 Instrument mounting

Instrument mounting shall be firm and stable. If a tripod is used, its legs shall be held firm, and steadied, by suitable devices such as magnetic bearers or an equivalent system. On floating-roof tanks or tanks with internal floating blankets, the supports of the EODR instrument should preferably rest on the tank bottom, while access to the instrument is through the roof or the blanket (see Figure 1). If this is not possible, mounting directly on the floating roof or blanket can be possible, but only if the stability of the instrument during the calibration procedure can be guaranteed.



Key

- 1 EODR instrument
- 2 floating roof
- 3 tank bottom

Figure 1 — EODR installation on floating roof

1) 2π radians = 400 000 mgon.

EODR measurements are restricted by

- a) minimum measurable distance;
- b) minimum incidence angle that still gives expected measurement uncertainty.

These limits are normally provided by the EODR equipment manufacturer.

If, for the given shape of the tank (height and diameter), the limits of incidence angles given by the manufacturer cannot be met from one position, either a higher uncertainty shall be accepted or the EODR equipment shall be placed in several positions. If this is not possible, this method might not be suitable for the given application.

NOTE Integration of measurements from multiple positions of the EODR, if required, is usually performed using procedures published by the instrument manufacturer. There are no standard calculations and, therefore, this part of ISO 7507 does not include equations for this case.

5.3 Laser beam emitter

The laser beam emitter used to position target points on the tank shell shall be either an integral part of the EODR instrument or a separate device whose axis is parallel to the axis of the EODR instrument.

5.4 Stadia

Stadia shall be a bar at least 2 m long with two marks. The graduated length between these marks shall be calibrated. Extended calibration uncertainty should be of the order of 0,05 mm. The stadia shall be made of a material whose thermal expansion is known.

5.5 Equipment for bottom calibration

Equipment for calibration of the tank bottom shall be as specified in ISO 7507-1:2003, Clause 10.

5.6 Auxiliary equipment

Auxiliary equipment shall include devices to steady the EODR unit, lighting, etc.

6 General considerations

6.1 The EODR instrument shall be maintained so that its performance can be traced to national and/or international measurement standards. The accuracy of the angular measuring unit shall be verified using the procedures described in Annex A. The distance-measuring unit is expected to hold its calibration and it is not normally necessary to verify it in the field. If verification is performed, the procedure given in Annex A shall be followed.

6.2 Tanks shall be calibrated only after they have been filled at least once with a liquid of density equal to or greater than that of the liquid that they will hold when in use.

NOTE The hydrostatic test applied to new tanks can satisfy this requirement in most cases.

6.3 The tank shall be free from vibration and air-borne dust particles. The floor of the tank should be as free as possible from debris, dust and loose scale.

6.4 Encrustation of the inner walls of the tank should be checked. If the estimated thickness, nature and distribution of the encrustation are deemed unacceptable, the tank should not be calibrated using this method.

6.5 Lighting, when required, shall be placed within the tank so as not to interfere with the operation of the EODR instrument.

6.6 Calibration should be carried out without interruption.

7 EODR instrument set-up within the tank

7.1 The instrument shall be set up with care, in accordance with the procedure and instructions given by the manufacturer.

7.2 The instrument shall be set up so as to be stable.

If necessary, the tank bottom in the vicinity of the instrument shall be made firm and steady by placing heavy weights in the area.

The legs of the tripod on which the instrument is mounted shall be steadied by use of suitable devices, such as magnetic bearers, to prevent slippage on the tank bottom.

7.3 The instrument should be located at, or near, the centre of the tank to ensure that the measured slope distances, at any one horizontal level, do not vary significantly and to minimize the overall uncertainty of slope distance determination.

NOTE Stability of the EODR instrument is likely to be more important than its position in the centre of the tank.

7.4 The instrument shall be free from external vibration.

7.5 The sighting lines from the instrument to the tank shell wall shall not be obstructed.

7.6 Select and clearly mark on fixed points inside the tank, e.g. on the shell wall, two reference target points. These should be approximately 1.571 rad (90 gon) apart and as near to the horizontal plane of the instrument as possible.

7.7 At least the minimum settling time recommended by the manufacturer should be allowed before the instrument is used.

7.8 The instrument shall be set horizontal, thus ensuring that the vertical axis (standing axis) is vertical.

8 Selection of target points

8.1 Two sets of target points per course shall be selected, one at approximately 1/4 of the course height above the lower horizontal seam, the other at approximately 1/4 of the course height below the upper horizontal seam.

The number of target points per set on each course of the tank shell wall is dependent on tank circumference. The minimum number of target points per set as a function of tank circumference shall be in accordance with Table 1, and is illustrated in Figure 2.

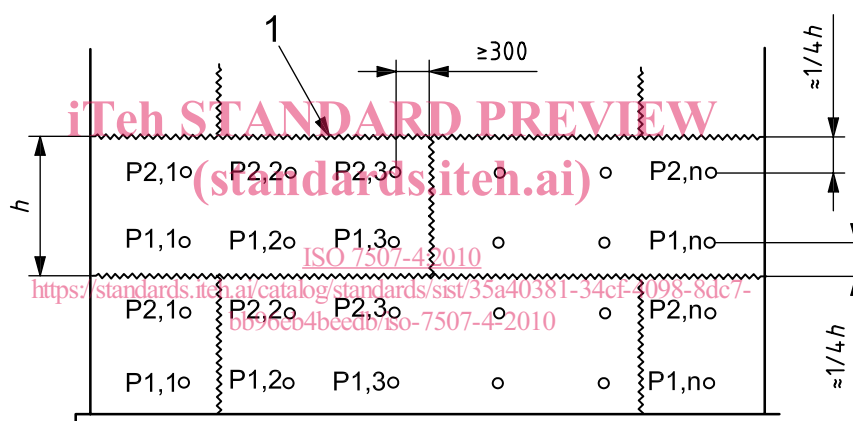
Where tank walls are deformed, the number of target points can be greater than the minimum given by this part of ISO 7507.

8.2 The target points shall be at least 300 mm from any vertical welded seam.

Table 1 — Minimum number of target points

Tank circumference m	Minimum number of points
≤ 50	10
$> 50, \leq 100$	12
$> 100, \leq 150$	16
$> 150, \leq 200$	20
$> 200, \leq 250$	24
$> 250, \leq 300$	30
> 300	36

A number of target points greater than the minimum number of points in Table 1 may be chosen depending on specific circumstances and tank conditions.

**Key**

1 seam

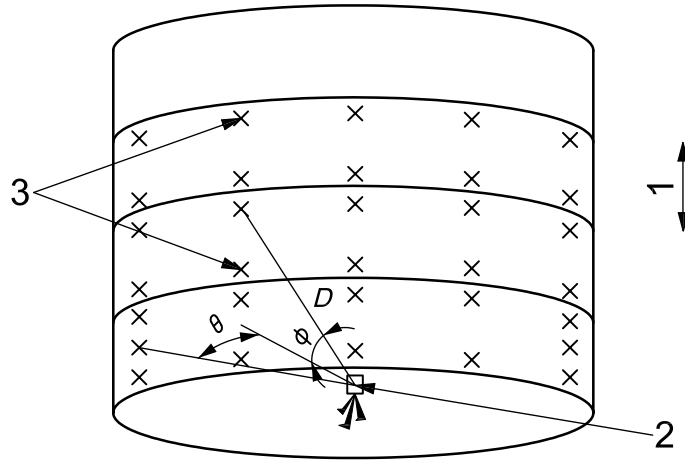
Figure 2 — Illustration of target positioning on tank shell wall

9 Calibration procedure

9.1 All measurements should be carried out without interruption and as quickly as possible.

9.2 Measure and record the slope distance, horizontal angle and vertical angle to each of the reference target points.

9.3 Sight all of the target points along the horizontal plane at each course location, and measure the slope distance, horizontal angle and vertical angle to each, as illustrated in Figure 3.



Key

- 1 course height
- 2 EODR instrument
- 3 target points on shell wall
- θ horizontal angle
- ϕ vertical angle
- D slope distance

Figure 3 — Illustration of calibration procedure

9.4 After all measurements on a course have been completed, repeat the measurements to the reference target points.

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9.5 If the repeated slope distances to the reference target points do not agree with the measurements taken during the setting up of the instrument, within 2 mm, repeat the procedure given in 9.1 to 9.4. Record the difference of the two measurements as uncorrected instrument drift, $e(R_{dr})$. Add the corresponding standard uncertainty, $u(R_{dr})$, calculated using Equation (1), to the resulting uncertainty of the tank radius (see Annex C):

$$u(R_{dr}) = \frac{e(R_{dr})}{2\sqrt{3}} \quad (1)$$

9.6 If the horizontal or vertical angles to the reference target points do not agree with the measurements taken during the setting up of the instrument, to within $1,571 \times 10^{-4}$ rad (0,01 gon), repeat the procedure given in 9.1 to 9.4. Record the difference of the two measurements as uncorrected instrument drift, $e(\theta_{dr})$ (horizontal angles) and $e(\phi_{dr})$ (vertical angles). Add the corresponding standard uncertainty, $u(\theta_{dr})$, calculated by using Equation (2) for horizontal angles, or Equation (3) for vertical angles, to the resulting uncertainty of the angular measurements (see Annex C):

$$u(\theta_{dr}) = \frac{e(\theta_{dr})}{2\sqrt{3}} \quad (2)$$

$$u(\phi_{dr}) = \frac{e(\phi_{dr})}{2\sqrt{3}} \quad (3)$$

10 Other measurements

10.1 Tank-bottom calibration and the overall height of the reference point at each dip-hatch shall be carried out in accordance with ISO 7507-1:2003, Clause 10 and 6.3, respectively.

10.2 The following data shall be determined and recorded:

- a) ranges of densities and the working temperatures of the liquids being stored in the tank;
- b) height of each course, in accordance with ISO 7507-1:2003, 8.2;
- c) thickness of each course of plating, not including the thickness of paint, in accordance with ISO 7507-1:2003, 8.1;
- d) safe filling height and maximum filling height, as determined by local practices;
- e) deadwood, in accordance with ISO 7507-1:2003, Clause 9;
- f) tilt of the tank as shown by the deviation from a vertical line, in accordance with ISO 7507-1:2003, Clause 9;
- g) average temperature of the tank shell. This should be measured around the tank (at least at four points), near the bottom of the shell and again as near to the top of the shell as possible. Average temperature shall be used to correct the measured radii.

10.3 The vertical height difference between the datum-point and the dip-point, if any, shall be measured by normal surveying methods and recorded.

NOTE In use, each measured tank dip is referred to as a dip-point; the position of the dip-point can differ from the datum-point used for the purpose of tank calibration (e.g. on the intersection of the tank shell and the tank bottom plate).

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11 Calculation and development of capacity tables

11.1 The internal radii of the tank shall be calculated in accordance with Annex B.

11.2 Once the internal radii have been computed, the development of the capacity table shall be carried out in accordance with ISO 7507-1:2003, Clause 14. The following corrections shall be applied in the development of the capacity tables:

- a) correction for hydrostatic head effect, in accordance with ISO 7507-1:2003, Annex A;
- b) correction to the certified tank shell temperature, in accordance with ISO 7507-1:2003, 16.1;
- c) correction for deadwood, in accordance with ISO 7507-1:2003, 17.1;
- d) correction for tilt, in accordance with ISO 7507-1:2003, 16.2.