INTERNATIONAL STANDARD

ISO 7507-3

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

Part 3: Optical-triangulation method

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

Partie 3: Méthode par triangulation optique

Reference number
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Contents

Page

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 7507-3 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 3, *Static petroleum measurement*.

This second edition cancels and replaces the first edition (ISO 7507-3:1993), 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*

Introduction

This part of ISO 7507 describes the calibration of vertical cylindrical tanks by means of optical triangulation using theodolites. The circumference of the tank is determined at different levels by reference to a base line, which can be either a reference circumference measured by strapping or a base line between two stations of a theodolite measured by means of a tape or by an optical method. External circumferences are corrected to give true internal circumferences.

The method is an alternative to other methods such as strapping (ISO 7507-1) and the optical-reference-line method (ISO 7507-2).

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

Part 3: Optical-triangulation method

1 Scope

This part of ISO 7507 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 (Clause 10) or externally (Clause 11). The external method is applicable only to tanks that are free of insulation.

This 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.

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*

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
total station
theodolite with built-in distance meter that coincides with the optical axis of the instrument

4 Precautions

The general precautions and safety precautions specified in ISO 7507-1 shall apply to this part of ISO 7507.

5 Equipment

5.1 Equipment for measurement of angles

5.1.1 **Theodolite**, with angular resolution equal to or better than 0,2 mgon (1 mgon = 0,25 s).

Each theodolite shall be mounted on a tripod that is firm and stable. The legs of the tripod shall be steadied by means of magnetic bearers (or any equivalent system) when being used for the internal method. The theodolites shall be checked either periodically or prior to the tank measurements as described in Annex F.

Alternatively, a total station can be used along with a prism mounted on the other station. The total station shall meet the same requirements for the angular measurements as the theodolites. The distance measurement shall have a resolution equal to or better than 0,1 mm. The distance meter shall be calibrated together with the used prism with an extended calibration uncertainty on the order of 1 mm or better. It shall be possible to mount the prism on the tripod in the same position as the theodolite/total station.

5.1.2 **Laser-beam emitter**, low-power, equipped with a device, such as a fibre-optic light-transfer system and a theodolite-telescope eye-piece connection, by which the laser beam can be transmitted through a theodolite. The laser beam shall be coincident with the optical axis of the telescope.

5.1.3 **Weights**, heavy, to set round the theodolite stations to prevent movement of the tank bottom plate.

5.1.4 **Lighting**, for use inside the tank to allow measurements to be read accurately.

5.2 Stadia

Stadia, at least 2 m long, of a material whose thermal expansion is known.

The graduated length between two marks shall be calibrated. Extended calibration uncertainty should be on the order of 0,05 mm. It shall be possible to mount the stadia on the tripod in the same position as the theodolite.

NOTE The stadia is not used when the calibration is carried out using a total station.

6 Equipment set-up and procedure

6.1 Preparation of tank

For new tanks or for tanks after repair, fill the tank to its normal working capacity at least once and allow it to stand for at least 24 h prior to calibration.

6.2 Establishment of calibration conditions

If the tank is calibrated with liquid in it, record the depth, temperature and density of the liquid at the time of calibration. Do not make transfers of liquid during the calibration.

Measure or estimate the worst-case gradient of tank-shell temperatures at the time of calibration.

NOTE 1 The temperature gradient is used to estimate the uncertainties of the measured tank radii (see 13.2 and E.3.5.3).

NOTE 2 The highest temperature is usually found on the sunny side at the top of the tank, the lowest temperature on the shady side at the bottom of the tank.

6.3 Set-up of theodolites and/or total stations

6.3.1 Set up each theodolite or total station with care, according to the procedure and instructions given by the manufacturer. In addition, follow the procedures described in 6.3.2 and 6.3.3.

6.3.2 Set up the instrument so as to be stable.

For the internal method, steady the bottom of the tank near the theodolite or total station by installing weights or other heavy objects around the station if there is a risk of the station moving during the calibration. Mount the legs of the tripod on magnetic bearers (or any equivalent system) to prevent the legs from sliding on the tank bottom.

For the external method, drive the legs of the tripod fully home into the ground.

6.3.3 Set the bed plate of the instrument as near as possible to the horizontal.

NOTE This ensures verticality of the swivel axis of the theodolite or total station.

6.3.4 The calibration equipment shall be placed at the site for typically 1 h in order to reach ambient temperature before commencement of the actual calibration procedure.

7 Stadia set-up and procedure

7.1 Mount the stadia on the tripod with care according to the procedure and instructions given by the manufacturer. In addition, follow the procedures described in 7.2 and 7.3.

7.2 Mount the stadia horizontally and perpendicular to the aiming axis by adjusting the device on the stadia.

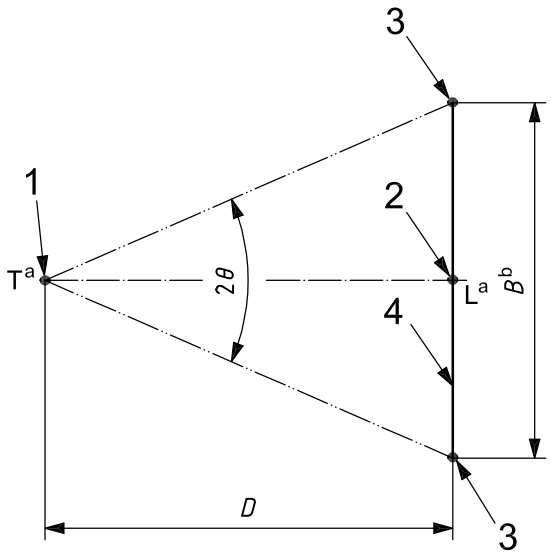
7.3 Once setting-up is complete, lock the stadia in position and verify that it is horizontal and perpendicular.

8 Measurement of horizontal distance between two theodolite stations using a stadia

8.1 This procedure for determining the distance using a stadia is not recommended if the distance between the stations is above 25 m.

8.2 Take the measurement prior to the commencement of the optical readings. Set up the stadia as described in Clause 7.

Measure the horizontal angle, 2θ, subtended at the theodolite (see Figure 1) by the two marks on the stadia, using the theodolite.



Key

1 theodolite 1
2 theodolite 2 (laser)
3 stadia mark
4 stadia

[a] Points T and L are interchangeable.

[b] B, the distance between the two reference marks on the stadia, equals 2 m.

Figure 1 — Measurement of distance between two theodolites

8.3 Compute the horizontal distance, D, between the two theodolite stations from Equation (1):

$$D = \frac{B}{2 \times \tan\theta} \tag{1}$$

where

B is the distance between the two reference marks on the stadia (corrected for thermal expansion, if necessary);

θ is half the angle subtended at theodolite, T, by the two reference marks.

8.4 Carry out the measurement of the angle 2θ and the computation of the distance, D, a minimum of five times while turning and re-pointing the theodolite in between, and calculate and record the average value. Two standard deviations of the mean of the distance, D, shall be less than half of the tolerance given in Table 3 or the entire procedure shall be repeated.

8.5 Re-determine the distance, D, after completion of all the optical measurements described in 10.13.

The average distances computed before and after the optical measurements shall agree within the tolerances given in Table 3. If they do not, repeat the calibration procedure until a set of measurements is obtained with the average values for D at the beginning and end within the tolerances.

8.6 The average of all measurements of distance, D, shall be used in further calculations.

9 Measurement of horizontal distance between two theodolite stations using a total station

9.1 This procedure for determining the distance between theodolite stations is not recommended if the distance between the stations is less than 10 m.

9.2 Set up the prism at the second tripod.

9.3 Carry out the measurement of the distance, D, a minimum of five times while turning and re-pointing the total station in between, and calculate and record the average value. Two standard deviations of the mean of the distance, D, shall be less than half of the tolerance given in Table 3 or the entire procedure shall be repeated.

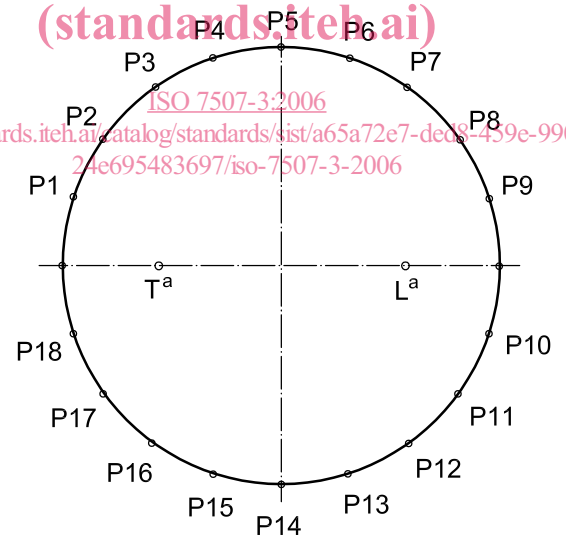
9.4 Re-determine the distance, D, after completion of all the optical measurements described in 10.13.

The average distances computed before and after the optical measurements shall agree within the tolerances given in Table 3. If they do not, repeat the calibration procedure until a set of measurements is obtained with the average values for D at the beginning and end within the tolerances.

9.5 The average of all measurements of distance, D, shall be used in further calculations.

10 Procedure for internal optical tank wall measurements

10.1 Set up two theodolite stations inside the tank as illustrated in Figure 2 and as described in 6.3.



[a] T and L are interchangeable theodolite and laser theodolite stations.

Figure 2 — Example of locations of theodolite stations and wall points for internal procedure

10.2 Locate the two stations approximately on a diametrical plane and at least one quarter diameter apart. Adjust the theodolites and measure the distance, D, between T and L as described in Clause 8 or Clause 9.

10.3 Set the reference axis, TL, optically on the horizontal planes (circles) of both instruments by sighting from each instrument the vertical graticule wires of the other instrument as described in 10.4 to 10.7.

10.4 Ensure that the laser is shut off in order to avoid exposure.

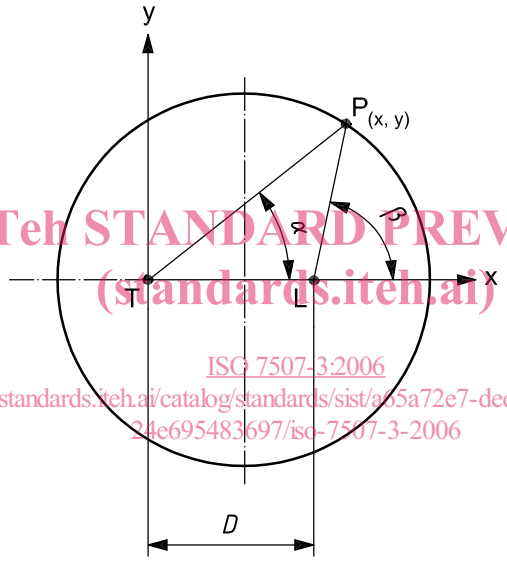
10.5 Adjust the theodolite, T, to set the telescope to infinity and illuminate the eyepiece of this telescope with a light source.

10.6 Sight the object lens of the theodolite, T, from the telescope of the laser theodolite, L, and continue focussing until the graticules become visible. Make the vertical graticule wires coincide by using the adjusting device on the laser theodolite, L.

10.7 Repeat the operation from the theodolite. Repeat the operation as many times as is necessary until the vertical graticule wires coincide perfectly.

10.8 The TL axis is now set. Record the relative locations of the two theodolites by taking readings on both horizontal scales as the horizontal reference angles.

10.9 Switch on the laser beam. This beam is then used to provide a series of points on the tank shell wall. Sight these points in turn using the other theodolite and take and record the horizontal-scale readings on both instruments. Do not locate measurement points closer to the reference angle (the line through T and L) than 10 gon (Figure 3, angle α or β, whichever is smaller).



Key

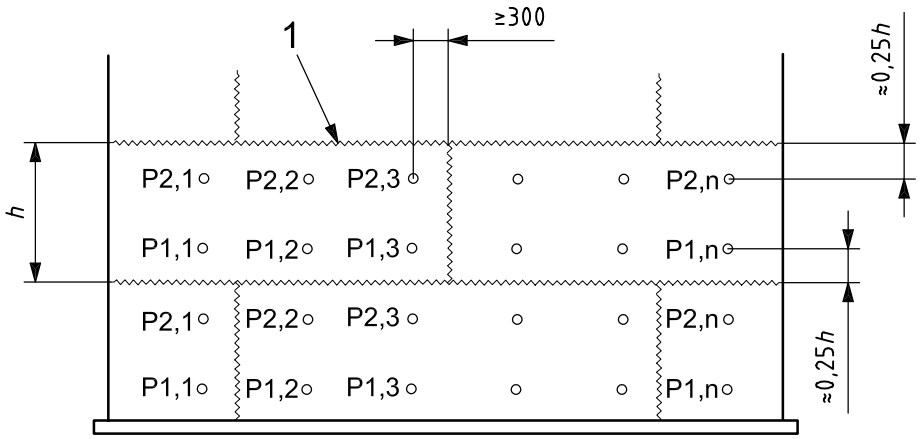
T theodolite station
L laser theodolite station
P arbitrary point on the tank

Figure 3 — Horizontal angles between sightings on points on the tank wall and the reference axis TL

10.10 The minimum number of points on the tank shell wall per circumference shall be as given in Table 1. These points shall not be closer than 300 mm from the vertical weld seam.

For each course, there shall be two sets of points: one set on a circumference at about 1/4 of the course height above the lower horizontal seam, and the other at about 1/4 of the course height below the upper horizontal seam as shown in Figure 4.

Dimensions in millimetres



Key

1 seam

Figure 4 — Location of sets of points on tank wall

10.11 Determine the horizontal angles, α and β, of all the points along a horizontal set, as shown in Figure 3, by the theodolite and the laser beam. Then move to the next level.

NOTE This ensures that each set of points on the tank wall is at the same level for a given circumference.

Table 1 — Minimum number of points per circumference for internal procedure

Circumference m	Minimum number of points
⩽ 50	10
> 50, ⩽ 100	12
> 100, ⩽ 150	16
> 150, ⩽ 200	20
> 200, ⩽ 250	24
> 250, ⩽ 300	30
> 300	36

To avoid systematic errors, the number of points divided by the number of plates in the tank segments should not be equal to an integer (e.g. 1, 2, 3, etc.).

For riveted tanks, it is recommended that at least three points are sighted in every tank plate at every height, one in the centre and two at the extremes of the plate width (near the vertical seams).

10.12 After completion of the optical measurement of all the points, re-determine the horizontal distance, D, between T and L (see 8.5 and 9.4) and repeat the calibration if necessary.

10.13 Check the axis, TL, by switching off the laser and repeating the operations described in 10.3 to 10.8. The original and final horizontal reference angles shall be within the tolerance specified in 12.2. If not, repeat the calibration procedures until a set of readings ending in such agreement is obtained. Record the average values of the horizontal reference angles.