INTERNATIONAL STANDARD

ISO 7507-2

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

Part 2: Optical-reference-line method

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

Partie 2: Méthode par ligne de référence optique

Reference number
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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.

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 7507-2 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 7507-2:1993), 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 forms part of a series on tank calibration, including the following:

ISO 4269:2001, *Petroleum and liquid petroleum products — Tank calibration by liquid measurement — Incremental method using volumetric meters*

ISO 7507-1:2003, *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 1: Strapping method*

ISO 7507-3:1993, *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 3: Optical-triangulation method*

ISO 7507-4:1995, *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 4: Internal electro-optical distance-ranging method*

ISO 7507-5:2000, *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 5: External electro-optical distance-ranging method*

ISO 8311:1989, *Refrigerated light hydrocarbon fluids — Calibration of membrane tanks and independent prismatic tanks in ships — Physical measurement*

ISO 9091-1:1991, *Refrigerated light hydrocarbon fluids — Calibration of spherical tanks in ships — Part 1: Stereo-photogrammetry*

ISO 9091-2:1992, *Refrigerated light hydrocarbon fluids — Calibration of spherical tanks in ships — Part 2: Triangulation measurement*

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*

This part of ISO 7507 describes a method for the calibration of vertical cylindrical tanks by measurement of one reference circumference by strapping and then determining the remaining circumferences at different levels from measurements of radial offsets from vertical optical-reference-lines. These circumferences are corrected to give the true internal circumferences.

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

Part 2: Optical-reference-line method

1 Scope

This part of ISO 7507 specifies a method for the calibration of tanks above eight metres 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.

NOTE The optical (offset) measurements required to determine the circumferences can be taken internally or externally.

The method specified in this part of ISO 7507 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).

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 4269:2001, *Petroleum and liquid petroleum products — Tank calibration by liquid measurement — Incremental method using volumetric meters*

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
optical-reference-line
vertical optical ray (virtual) that is established using the optical device at a given location

3.2
magnetic trolley
mechanical device that can be traversed up or down the tank shell wall to measure deviations in the tank shell relative to the optical-reference-line using a horizontal scale that is mounted on the trolley

3.3
station
location where the optical device and the magnetic trolley are placed for optical measurements

3.4
horizontal station
station where the optical device is located as it is moved around the tank circumference

3.5
vertical station
station where the magnetic trolley is located along the tank shell wall

3.6
reference circumference
circumference measured at the bottom course that forms the basis for subsequent computations

3.7
reference offset
distance of the shell wall (at each horizontal station) from the optical-reference-line measured at the bottom course where the reference circumference is measured

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 tank strapping, as follows, as specified in ISO 7507-1:

— strapping tapes;

— spring balance;

— step-over;

— littlejohn grip;

— dip-tape and dip-weight.

5.2 Optical-reference-line device, such as a precision optical plummet, a precision engineer's level with a pentaprism attachment, or a precision engineer's theodolite with a pentaprism attachment.

NOTE 1 These are optical instruments with a means of attachment to either a tripod, magnetic bracket or other stable means of support.

The instrument, when set on its support and levelled, either manually using bubble vials or automatically if an automatic levelling device is fitted, shall be capable of giving a vertical line of sight.

The instrument should preferably be of short focal length so that, when set up at a practical working height, it can be focused on the scale at the reference strapping level.

The instrument shall have a resolution of at least 1:20 000 and be equipped with a telescope with a magnification of not less than 20. The pentaprism attachment for use with an engineer's level or engineer's theodolite shall not introduce any significant collimation errors.

NOTE 2 Optical plummets can be fitted with a single optical train, i.e. a zenith plummet, a double optical train or a single superimposed optical train giving both upward and downward lines of sight, i.e. a nadir/zenith plummet. It is preferable that the plummet does not have any movable elements in its optical train, such as mirrors or pentaprisms, to ensure stability of the line of sight.

5.3 Magnetic trolley, of robust construction. Its design shall include the following features.

a) The magnet(s) shall be of sufficient power to ensure that the trolley does not lose contact with the tank shell in conditions of high wind or when ring joints have to be negotiated or when there are heavy layers of paint or scale.

b) The magnet(s) shall be adjustable for height so that the clearance between the magnet faces and the tank may be varied to suit the tank construction and condition.

c) A cord or wire cable shall be attached to enable it to be raised or lowered from the tank roof or, via a pulley system, from ground level.

d) A graduated scale shall be attached securely to the trolley at its centreline. When the trolley is in its operational mode, the scale shall be either perpendicular to the tank shell or horizontal.

e) The scale shall be attached to the trolley as closely as possible to the centreline of an axis in order to reduce errors caused by deformations in the tank.

NOTE Trolleys that are not magnetic can be used to maintain contact with the tank shell.

5.4 Graduated scale, made of steel and marked in millimetre increments. The length of the scale shall be as short as is practicable and shall be determined by the distance at which the optical equipment can be set up from the tank side. The scale shall be calibrated using standard methods and standard reference devices.

6 Procedure

6.1 Principle

This calibration method is based on the accurate measurement of a reference circumference using a calibrated measuring tape at one level on an accessible, non-obstructed course. Repeat measurements agreeing within specified tolerances are made to avoid any systematic error in the derived circumferences. The derived circumferences are calculated from the reference circumference, and measurements of offsets taken at the specified levels and at the reference circumference. These offsets are a measure of the deviation of the tank wall. They are measured at a specified number of vertical, optical-reference-lines spaced equally around the tank.

NOTE For examples see Figures 1 to 3.

6.2 Preparation of the 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.

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.

For floating-roof tanks where offset measurements may be taken internally, the roof shall be in its lowest position, resting on the legs.

6.3 Reference circumference

Reference circumference has a direct impact on the calibrated volume of entire tank. It, therefore, shall be measured as accurately as possible.

Determine the reference circumference using the reference method described in ISO 7507-1 and the following.

a) Take multiple measurements of the reference circumference either prior to the commencement or after the completion of the optical readings. If the first three consecutive measurements agree within the tolerances specified in Clause 7, take their mean average as the reference circumference and their standard deviation as the standard uncertainty. If they do not agree within the tolerances specified in Clause 7, repeat the measurements until two standard deviations of the mean of all measurements is less than the half of the tolerances specified in Clause 7. Use the mean as the measured reference circumference and the standard deviation as the standard uncertainty. Use standard procedures to eliminate obvious outliers.

b) Take the measurement of the reference circumference at a position where work conditions allow reliable measurements, and which is within the focal range of the optical instrument. Strap the tank, aiming at one of the following levels:

   1) 1/4 of the course height above the lower horizontal seam,

   2) 1/4 of the course height below the upper horizontal seam;

   and repeat the measurement to achieve measurements agreeing within the tolerances specified in Clause 7.

6.4 Offset readings

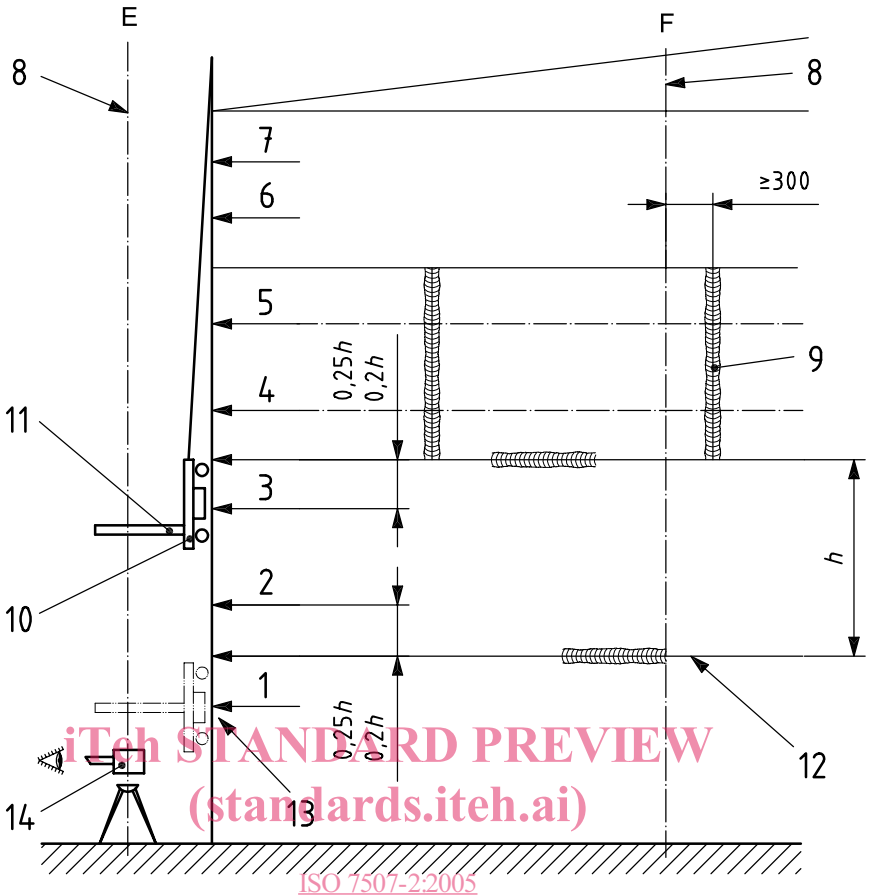
6.4.1 Set up the optical-reference-line device (5.2), magnetic trolley (5.3) and graduated scale (5.4) successively at the horizontal stations (see 6.4.2) that are equally spaced around the tank, as close as possible to the tank wall. Reference lines shall be chosen such that the trolley does not run over a vertical seam or its weld.

6.4.2 The minimum number of horizontal stations shall be as given in Table 1.

Table 1 — Minimum number of horizontal stations

Circumference m	Minimum number of horizontal stations
⩽ 50	10
> 50, ⩽ 100	12
> 100, ⩽ 150	16
> 150, ⩽ 200	20
> 200, ⩽ 250	24
> 250, ⩽ 300	30
> 300	36
NOTE 1 The number of horizontal stations divided by the number of plates in tank segments should not be equal to an integer (e.g. 1, 2, 3, etc.) in order to avoid systematic errors. NOTE 2 Using the minimum number of horizontal stations, especially for smaller tanks, can lead to larger-than-acceptable uncertainties.	

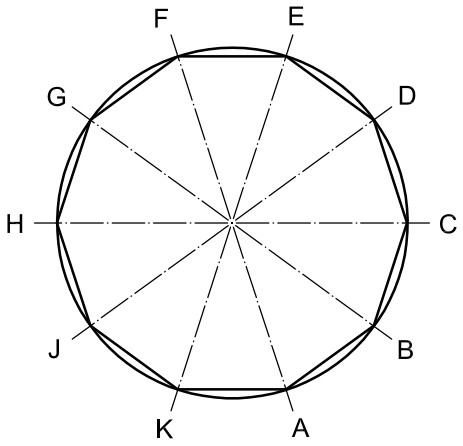
Dimensions in millimetres



Key

1 to 7	horizontal levels	11	graduated scale
8	optical-reference-line	12	weld seam (horizontal)
9	weld seam (vertical)	13	reference circumference taken close to location 1
10	magnetic trolley	14	optical equipment

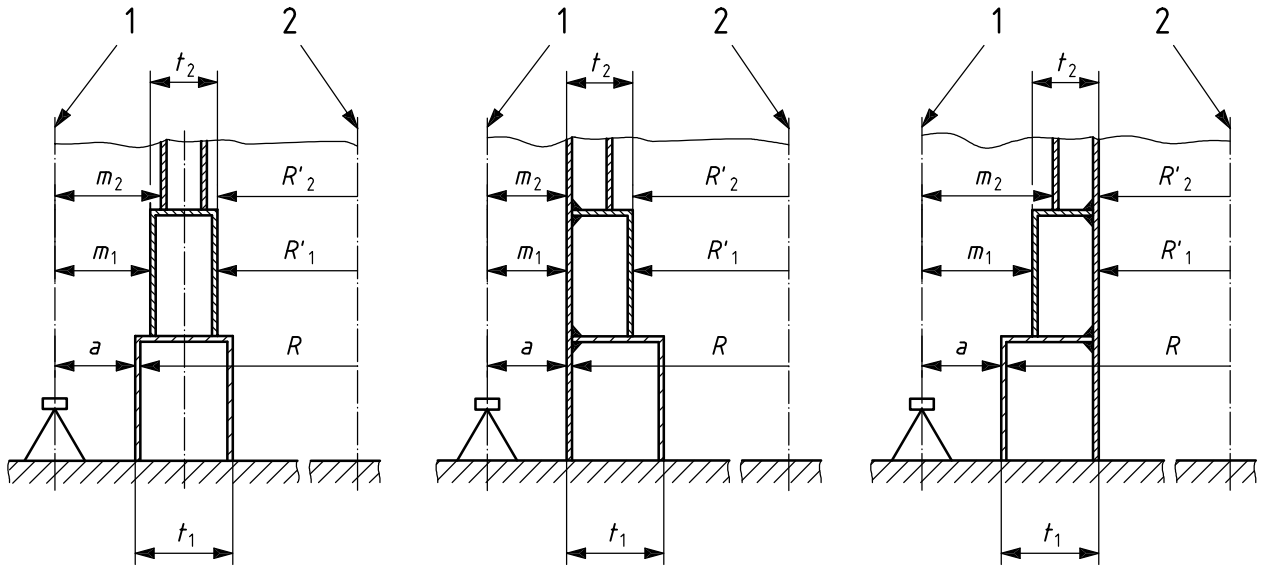
a) Tank elevation



b) Plan of horizontal stations

NOTE The horizontal stations are designated A to K in the plan view (see also 6.4.2). Of these, only E and F are shown in the elevation.

Figure 1 — Optical measurement of offsets from tank wall (typical case)



a) Centreline flush b) Outside flush c) Inside flush

Key

1 optical-reference-line
2 tank centreline

External reference circumference = C_{em}

External reference radius (bottom course) = $C_{em}/2\pi = R$

Outer radius of second course = R'_1, R'_2,

Course thicknesses = t_1, t_2, etc.

Reference offset = a

Reference radius = R

Individual course offsets = m_1, m_2, etc.

Internal reference radius = $R - t_1 = C_{em}/2\pi - t_1 = R_1$

Internal radius, second course, bottom = R'_{1i}

Internal radius, second course, top = R'_{2i}

Figure 2 — Determination of internal radius from offsets to external optical-reference-line