INTERNATIONAL STANDARD

ISO 7507-2

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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 — Étalonnage des réservoirs cylindriques verticaux —

Partie 2: Méthode par ligne de référence optique

Reference number
ISO 7507-2:1993(E)

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 7507-2 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Sub-Committee SC 3, *Static petroleum measurement*.

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 methods*

— *Part 5: External electro-optical distance-ranging methods*

At the time of publication of this part of ISO 7507, parts 4 and 5 were in course of preparation.

Annexes A and B form an integral part of this part of ISO 7507.

Introduction

This method describes 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.

This method is an alternative to other methods such as strapping (ISO 7507-1) and the optical-triangulation method (ISO 7507-3).

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

Part 2:
Optical-reference-line method

1 Scope

1.1 This part of ISO 7507 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 may be taken internally or externally.

1.2 Abnormally deformed, e.g. dented or non-circular, tanks are excluded from this part of ISO 7507.

1.3 This method is suitable for tilted tanks up to 3 % deviation from the vertical provided that a correction is applied for the measurement tilt, as described in ISO 7507-1.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 7507. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 7507 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 91-1:1992, *Petroleum measurement tables — Part 1: Tables based on reference temperatures of 15 °C and 60 degrees F.*

ISO 7507-1:1993, *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 1: Strapping method.*

3 Definitions

For the purposes of this part of ISO 7507, the definitions given in ISO 7507-1 apply.

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 listed in 5.1.1 to 5.1.5 below and specified in annex B:

5.1.1 Strapping tapes.

5.1.2 Spring balance.

5.1.3 Step-over.

5.1.4 Littlejohn grip.

5.1.5 Dip-tape and dip-weight.

5.2 Thermometer.

5.3 Tank bottom calibration equipment, as specified in annex A.

5.4 Optical-reference-line device, e.g. 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.

NOTE 2 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 collimation errors.

NOTE 3 Optical plummets may be fitted with either a single optical train, i.e. a zenith plummet, or 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.

5.5 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 perpendicular to the tank shell.

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

5.6 Graduated scale, made of translucent plastic 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.

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 4 For examples see figures 1 to 3.

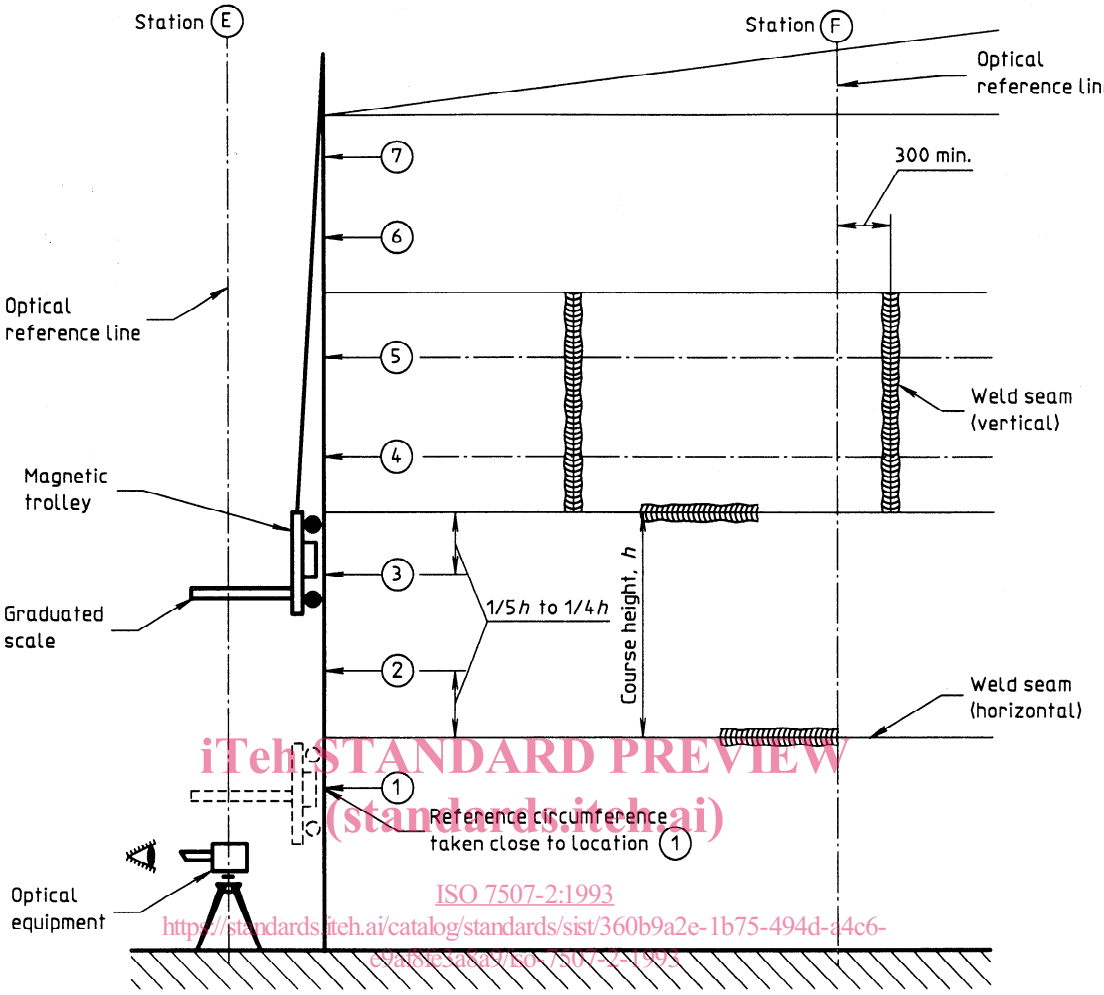
6.2 Preparation of tank

Fill the tank to its normal working capacity at least once and allow it to stand for at least 24 h prior to calibration.

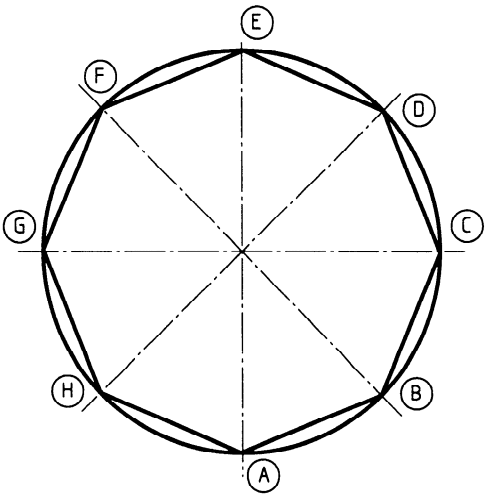
If the tank is calibrated with liquid in it, record the depth, temperature and density of the liquid at the time of calibration. However, if the temperature of the wall surface could differ by more than 10 °C between the empty part and full part of the tank, the tank shall be completely full or empty. 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.

Dimensions in millimetres



a) Tank elevation



b) Plan of optical-reference-line stations

NOTE — The reference line stations are designated A to H in the plan view (see also 6.4.2). Of these, only E and F are shown in the elevation. The horizontal levels are indicated by the numbers 1 to 7 (see 6.4.4).

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

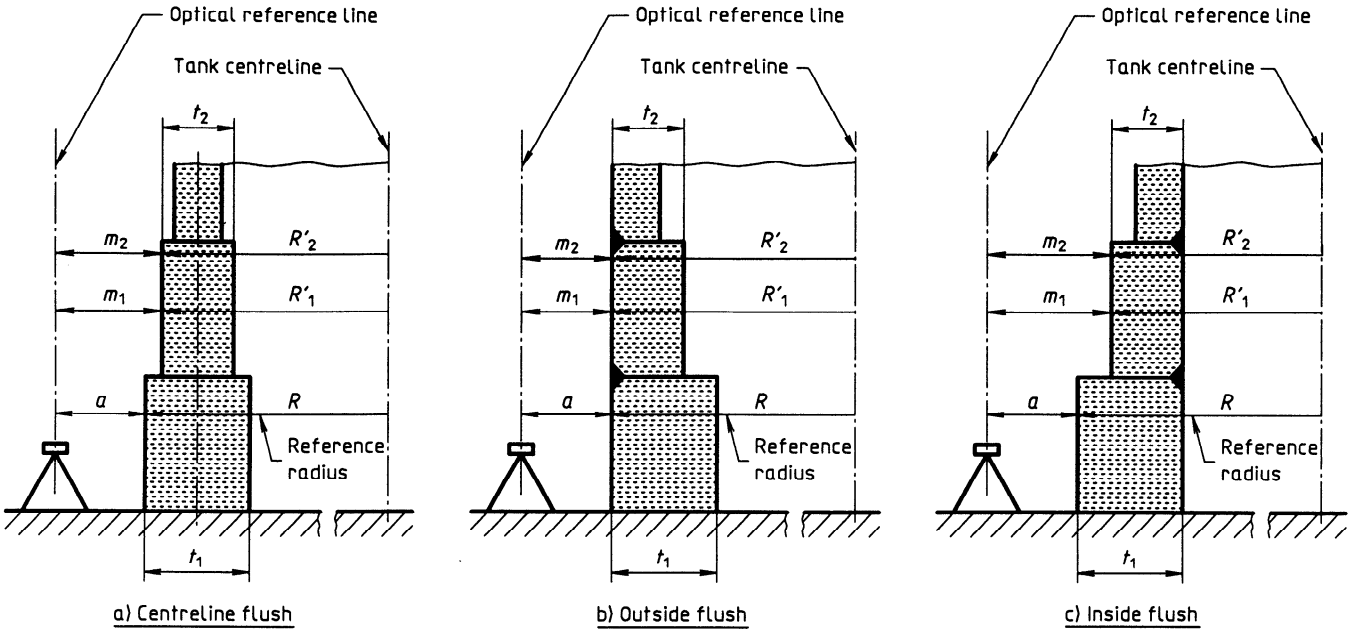
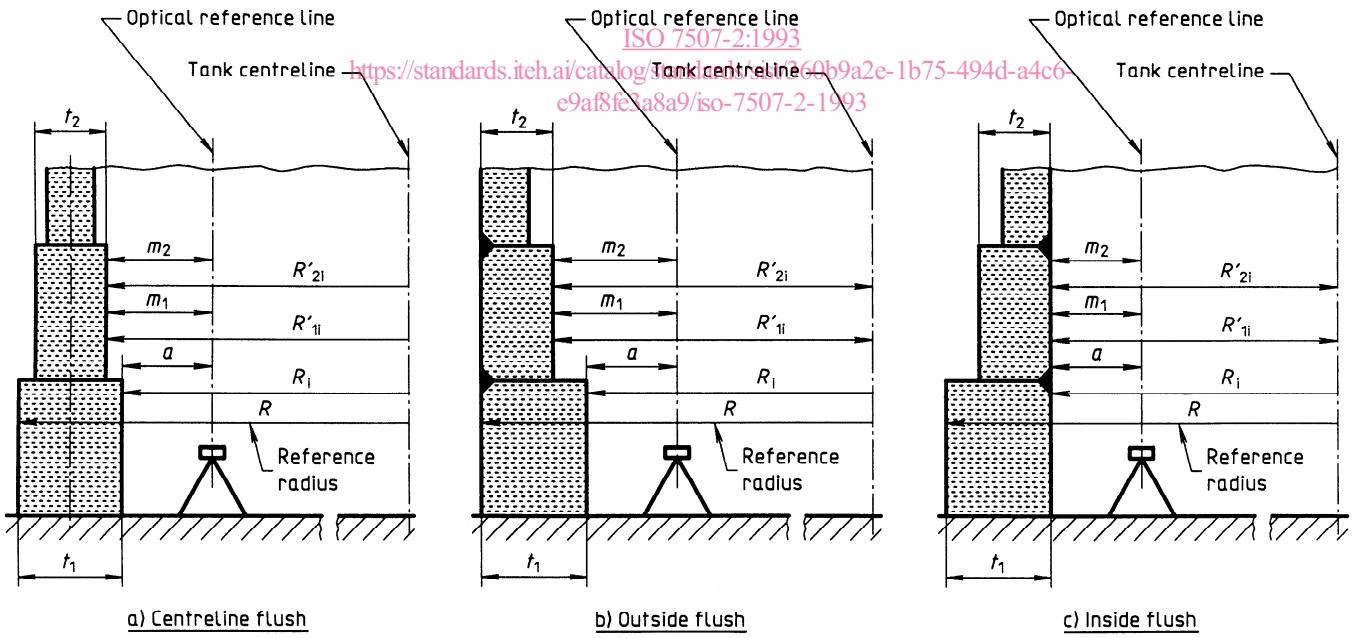


Figure 2 — Determination of internal radius from offsets to external optical reference line



Key:

External reference circumference	$= C$	Individual course offsets	$= m_1, m_2$, etc.
External reference radius (bottom course)	$= C/2\pi = R$	Internal reference radius	$= R - t_1 = C/2\pi - t_1 = R_i$
Outer radius of second course	$= R'_1, R'_2$	Internal radius, second course, bottom	$= R'_{1i}$
Course thicknesses	$= t_1, t_2$, etc.	Internal radius, second course, top	$= R'_{2i}$
Reference offset	$= a$		

Figure 3 — Determination of internal radius from offsets to internal optical reference line

6.3 Reference circumference

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

a) Take the measurement of the reference circumference prior to the commencement of the optical readings.

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 at one of the following levels:

   1) 1/5 to 1/4 of the course height above the lower horizontal seam,

   2) 1/5 to 1/4 of the course height below the upper horizontal seam

   and repeat the measurement to achieve measurements agreeing within the tolerances specified in 7.1.

   If the circumference cannot be measured on the outside, measure the inside diameters by a method that will provide a degree of precision equal to that obtained by using the external strapping method.

c) After completion of the optical readings, repeat the reference circumference measurement.

d) The measurements required in a) and c) shall agree within the tolerances specified in 7.1.

e) If agreement is not obtained, take further measurements of the reference circumference until two consecutive readings do so agree.

f) Record the arithmetic mean of two valid measurements as the reference circumference. If no agreement between the two readings is obtained, repeat the calibration procedure.

6.4 Offset readings

6.4.1 Set up the optical-reference-line device (5.4), magnetic trolley (5.5) and graduated scale (5.6) successively at the measurement stations (see 6.4.2) that are equally spaced around the tank, as close as possible, but not closer than 100 mm to the tank wall. No reference line shall be closer than 300 mm to a vertical seam.

6.4.2 The minimum number of optical-reference-line stations shall be as given in table 1.

Table 1 — Minimum number of stations

Circumference m	Minimum number of stations
up to 50	8
above 50, up to 100	12
above 100, up to 150	16
above 150, up to 200	20
above 200, up to 250	24
above 250, up to 300	30
above 300	36

6.4.3 Verify the verticality of the optical reference line prior to the commencement of readings by turning the optical instrument at the first station through 180°, whereby the difference between the two readings of the diametrically opposite positions shall be within 1 in 20 000. Also verify the verticality of the optical reference line at each station by frequently checking the levelling device.

6.4.4 Take a minimum of two radial measurements per course at each station, one at 1/5 to 1/4 of course height above the lower horizontal seam, the other at 1/5 to 1/4 of course height below the upper horizontal seam. Read the graduated scale to the nearest millimetre.

The graduated-scale reading shall be repeatable to within 1 mm radial distance.

6.4.5 At all stations, measure the reference offset and then take offset measurements progressively on each course as the trolley is raised up the tank wall. After the last offset measurement has been taken on the top course, lower the trolley to the bottom course and repeat the reference offset. The initial and final reference offset readings shall agree to within 1 mm.

If agreement is not obtained, take and record a further set of measurements until a set is obtained in which the initial and final reference offset readings agree to within 1 mm. Take the average of these two reference readings as the reference offset.

6.5 Tank bottom calibration

Calibrate the tank bottom preferably by filling with measured quantities of a non-volatile liquid (preferably clean water) as specified in annex A to a minimum level that covers the bottom completely, immersing the dip-plate and eliminating the effect of bottom deformations, or, alternatively, by a physical survey using a reference plane to determine the shape of the bottom.