INTERNATIONAL STANDARD

ISO 7507-1

Second edition
2003-12-15

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

Part 1: Strapping method

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

Partie 1: Méthode par ceinturage

Reference number
ISO 7507-1:2003(E)

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Published in Switzerland

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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.

International Standard ISO 7507-1 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 7507-1:1993). It also cancels and replaces ISO 7507-6:1997, the subject of which is now included in this part of ISO 7507.

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*

— *Part 6: Recommendations for monitoring, checking and verification of tank calibration and capacity table*

Introduction

This part of ISO 7507 forms part of a series on tank calibration including the following:

ISO 7507-2:1993, *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 2: Optical-reference-line 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 7507-6:1997, *Recommendations for monitoring, checking and verification of tank calibration and capacity table*

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*

The strapping method for the calibration of vertical cylindrical tanks has been used for many years and is a recognized method of determining the capacity of storage tanks from measurements of the circumference of a tank at various heights. The strapping method is also often used to establish a reference circumference at a selected height to use as a datum in other methods of tank calibration.

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

Part 1: Strapping method

1 Scope

1.1 This part of ISO 7507 specifies a method for the calibration of substantially vertical cylindrical tanks by measuring the tank using a strapping tape.

1.2 This method is known as the "strapping method" and is suitable for use as a working method, a reference method or a referee method.

NOTE For the reference method, the number of strappings required will be specified in the standard which refers to this part of ISO 7507.

1.3 The operation of strapping, the corrections to be made and the calculations leading to the compilation of the tank capacity table are described.

1.4 This method does not apply to abnormally deformed, e.g. dented or non-circular, tanks.

1.5 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.

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

ISO 3675:1998, *Crude petroleum and liquid petroleum products — Laboratory determination of density — Hydrometer method*

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

3 Terms and definitions

For the purposes of this document and subsequent parts of ISO 7507, the following terms and definitions apply.

3.1
argument
independent variable of a function

NOTE A table is entered with value(s) of the independent variable(s), the value(s) extracted from the table being known as the dependent value(s).

3.2
bottom calibration
procedure to determine the quantity of liquid contained in a tank below the calibration datum-point

3.3
calibration
process of determining the capacity of a tank, or the partial capacities corresponding to different levels

3.4
capacity
total volume of a tank

3.5
capacity table
tank table
tank capacity table
table showing the capacities of, or volumes in, a tank corresponding to various liquid levels measured from a stable reference point

3.6
course
one circumferential ring of plates in a tank

3.7
calibration datum-point
point used as the datum in the preparation of a calibration table

NOTE Course heights and the effective levels of deadwood are measured from this point, to which the bottom calibration is also related.

3.8
deadwood
any tank fitting that affects the capacity of the tank

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

3.9
dip
innage
depth of a liquid in a tank above the dipping datum-point

3.10
dip-hatch
gauge-hatch
opening in the top of a tank through which dipping and sampling operations are carried out

3.11
dip-point
point on the dip-plate which the dip-weight touches during gauging and from which the measurements of the oil and water depths are taken

NOTE The dip-point usually corresponds to the datum-point, but when this is not so, the difference in level between the datum-point and the dip-point has to be allowed for in the calibration table.

3.12
dip-plate
striking-plate positioned below the dip-hatch

NOTE The position of the dip-plate should not be affected by bottom or wall movements.

3.13
dip-tape
graduated steel tape used for measuring the depth of the oil or water in a tank, either directly by dipping or indirectly by ullage

3.14
dip-weight
weight attached to a steel dip-tape, of sufficient mass to keep the tape taut and of such shape as to facilitate the penetration of any sludge that might be present on the dip-point or the dip-plate

3.15
floating cover
screen
lightweight cover of either metal or plastics material designed to float on the surface of a liquid in a tank

NOTE The cover rests upon the liquid surface and is used to retard evaporation of volatile products in a tank.

3.16
floating-roof tank
tank in which the roof floats freely on the surface of the liquid contents, except at low levels when the weight of the roof is taken through its supports by the tank bottom

3.17
function
when two variable quantities are interrelated, one quantity is said to be a function of the other

NOTE In the context of tank calibration, the volume of liquid contained in a tank is said to be a function of the dip or of the ullage.

3.18
gauging
process of taking all the necessary measurements in a tank in order to determine the quantity of liquid that it contains

3.19
interpolation
process of obtaining the value of a function corresponding to a value of the argument intermediate between those given

3.20
Littlejohn grip
quick-release clamp that may be fitted around a strapping tape at any convenient position throughout its length

NOTE A handle is attached to the Littlejohn grip so that the strapping tape can be pulled to the correct tension.

3.21
open capacity
calculated capacity of a tank or part of a tank before any allowance has been made for deadwood

3.22
reference height
vertical distance between the dip-point and the upper reference point

3.23
overall height
total external height from the top of the shell to the base of the tank (plate)

3.24
referee method
application of the strapping method of tank calibration to give a calibration of a tank for custody transfer purposes or to provide a basis for assessing the accuracy of other methods of tank calibration

3.25
reference method
application of the strapping method of tank calibration to the measurement of a reference circumference for use in other methods of tank calibration

NOTE An example of such a method is the optical-reference-line method (see ISO 7507-2).

3.26
reference point
a point to which measurements in either calibration or gauging are related

3.27
step-over
device used in strapping for measuring the distance apart, along the arc, of two points on a tank shell where it is not possible to use a strapping tape directly because of an intervening obstruction, e.g. a protruding fitting

3.28
step-over constant
distance between the measuring points of a step-over as measured along the arc of the particular course of the tank concerned

3.29
step-over correction
difference between the apparent distance between two points on a tank shell as measured by a strapping tape passing over an obstruction and the true arc distance as measured by a step-over, i.e. the step-over constant

3.30
strapping tape
specially designed and calibrated steel measuring tape graduated in units of length and used for taking circumferential measurements in tank calibration

3.31
strapping method
method of tank calibration in which the capacities are calculated from the measurement of the external circumferences, due allowance being made for the thickness of the shell of the tank

3.32
tape positioner
guide sliding freely on the strapping tape, used to pull and hold it in the correct position for taking measurements

3.33
tensioning handles
handles fastened to the strapping tape, used for pulling it into the correct position and applying tension

3.34
ullage
outage
capacity of a tank not occupied by the liquid

3.35
upper reference point
point clearly defined on the dip-hatch directly above the dip-point to indicate the position at which dipping or ullaging shall be carried out

3.36
working method
application of the strapping method of tank calibration by a simplified procedure that may result in some loss of accuracy and is unsuitable for assessing other methods

4 Precautions

4.1 Introduction

This clause outlines the precautions that are applicable when tanks are being calibrated. The precautions necessary to ensure the safety of the operator are dealt with separately from those precautions which have to be taken to ensure the necessary precision required in the calibration of tanks.

4.2 General precautions

4.2.1 The utmost care and attention to detail shall be exercised when calibrating storage tanks.

4.2.2 All measurements shall be carefully observed and recorded as read, and any corrections which are required shall be recorded separately. If any unusual occurrences are noted during the operations, these occurrences shall be documented and the calibration shall be repeated, if necessary.

4.2.3 If the tank is only slightly distorted, sufficient additional measurements shall be taken to allow satisfactory calculation of its capacity table. If such additional measurements are required, the calibrator's notes shall include the reasons for the extra measurements.

It is also recommended that dimensioned sketches should be provided by the calibrator to show any abnormality of the tank or the fittings that affect calibration.

NOTE Seriously distorted tanks are best calibrated using liquid calibration methods similar to the method described in ISO 4269.

4.2.4 To ensure accuracy and repeatability of readings, lumps of paint, scale, etc., likely to interfere with measurement, shall be removed or the position of the measuring equipment adjusted accordingly.

4.2.5 If drawings for the tank are available, all relevant measurements shall be compared with the corresponding dimensions shown on the drawings. Any measurement which shows a significant discrepancy as a result of this comparison shall be reported and, if necessary, repeated.

4.2.6 If the calibration of a tank is interrupted, it may be resumed at a later date provided that:

a) if there is a change of equipment or personnel, sufficient check measurements shall be made to ensure that the results obtained prior to the change correspond within the tolerances given in this method;

b) all records of work done are complete and legible;

c) the liquid contents remain unchanged at substantially the same level;

d) the average liquid and atmospheric temperatures are within 10 °C of the average liquid and atmospheric temperatures recorded during the earlier working period.

4.3 Safety precautions

4.3.1 The safety precautions given in 4.3.2 to 4.3.6 constitute good practice, but the list is not necessarily comprehensive. It is recommended that the list should be read in conjunction with the appropriate sections of any applicable safety code. The precautions shall be taken whenever they do not conflict with legislative requirements, which shall always be followed.

4.3.2 All regulations covering entry into hazardous areas shall be rigorously observed.

4.3.3 If a tank being strapped contains a petroleum product, attention shall be paid to the normal safety precautions which apply to such tanks.

4.3.4 Before a tank which has been in use is entered, a safe-entry certificate issued in accordance with local or national regulations shall be obtained. All lines entering the tank shall be disconnected and blanked. The national or local regulations regarding the entry into tanks which have contained leaded fuels shall be meticulously observed.

4.3.5 Hand lamps shall be of a type approved for use in explosive atmospheres.

4.3.6 The safety of operating personnel shall be safeguarded by strict attention to the following.

a) Ladders shall be inspected before use, and extendable ladders used only within their safe operating range. The footing for each ladder shall be level and firm, and all ladders shall be securely lashed in position before being used.

b) When painters' cradles or bo'suns' chairs are used, blocks, falls, ropes, etc., shall be tested before erection, and any item of questionable strength or condition shall be replaced. Every care shall be paid to the securing of the equipment and its operational use.

c) If calibration cannot be carried out without the use of staging, properly constructed steel tube or timber scaffolding shall be erected. Loose bricks, drums, boxes, etc., shall not be used to form staging.

d) Where appropriate, safety harnesses shall be worn by personnel working above ground level.

5 Equipment

5.1 Strapping tape, conforming to A.1. The tape shall be well greased before use.

5.2 Spring balance, conforming to A.2, for measuring the tension applied to the tape.

5.3 Step-over, conforming to A.3.

5.4 Tape positioners and cords, conforming to A.4, fitted to the strapping tape, and supplied with plaited cords. Both upper and lower cords shall be long enough to cover the height of the tank.

5.5 Littlejohn grip, conforming to A.5, to hold the tape, without kinking, in order to facilitate application of the necessary tension.

5.6 Apparatus for thickness measurement, either a steel rule of convenient length graduated throughout its length in millimetres, with at least the first 10 mm subdivided into half-millimetres, and/or another device, such as an electronic thickness gauge.

5.7 Dip-tape conforming to A.6, long enough to reach from the dipping reference point at the tank roof to the dip-point on the tank bottom.

5.8 Dip-weight, conforming to A.7.

5.9 End-to-end rule, 1 m in length, with graduations in centimetres and millimetres, for measuring deadwood, etc. If a wooden rule is used, it shall be fitted with a brass ferrule at each end and shall be free from warp.

5.10 Ladders and staging: see 4.3.6 for safety precautions.

5.11 Density- and temperature-measuring apparatus, conforming to ISO 3675.

6 General requirements

NOTE If possible, measurements should be compared with the corresponding dimensions on the tank construction drawings and the roundness of the tank should be ascertained.

6.1 Fill the tank to its normal working capacity at least once and allow 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 can differ by more than 10 °C between the empty part and the full part of the tank, the tank shall be either completely full or empty. Do not make transfers of liquid during the calibration.

The ambient temperature before and after calibration should be recorded.

Obtain the required number of external circumference measurements, together with the subsidiary measurements, where necessary, to correct for deviation of the strap due to obstructions, as described in 7.2.

NOTE Additional measurements required to enable a table of capacities to be prepared and the procedures to be used in obtaining them are described in Clauses 8 to 12.

6.2 It is necessary to refer all tank dips to the dip-point, which may be in a different position from the calibration datum-point, e.g. a point on the bottom angle, used for the purpose of tank calibration. Check that the dip-plate has been securely mounted in a stable position so that it is not affected by movement of the tank bottom or walls. Determine any difference in level between the dip-point and calibration datum-point, either by normal surveying methods or by other suitable means, and record it.

6.3 Measure the height of the upper reference point above the dip-point using the dip-tape and dip-weight. Record this reference height, to the nearest subdivision on the dip-tape, in the empty and the full conditions, as appropriate.

7 Circumference measurements

7.1 Levels strapped

7.1.1 If the calibration is for referee purposes, measure the circumference by three or more strappings per course, at approximately the following levels:

a) for riveted tanks:

   1) 100 mm to 150 mm above the level of the top of the bottom angle of the tank, and 100 mm to 150 mm above the upper edge of each horizontal overlap between courses;

2) at the middle position of each course;

3) 100 mm to 150 mm below the lower edge of each horizontal overlap between courses and 100 mm to 150 mm below the level of the lowest part of the top angle.

b) for welded tanks:

three or more levels as indicated in a), but the upper and lower levels shall be 270 mm to 330 mm from the bottom angle, top angle or horizontal seams.

7.1.2 If the calibration is for the working method, the circumference may be measured, if preferred, by only two strappings per course, taking one at each of the following levels:

— at about 1/5 to 1/4 of the course height or the ring height above the lower horizontal seam;

— at about 1/5 to 1/4 of the course height or the ring height below the upper horizontal seam.

7.1.3 If for any reason it is impracticable to take a strapping at the normal level, take a strapping as close to this level as practicable, but not nearer the bottom or top angle or any seam than is specified in 7.1.1 a) or b). Record in the strapper's notes the level at which this circumference has been measured, with the reason for abandoning the normal level.

If the tape is not in close contact with the surface of the tank throughout its whole path, apply a step-over as in 7.5, so that a correction may be calculated to adjust the gross circumference for this effect.

7.2 Strapping procedure

7.2.1 Strap the tank by either of the methods described in 7.2.2 and 7.2.3. The calibration tension specified on the strapping tape shall be applied to the tape using the tensioning handles and spring balance, and transmitted throughout the length of the tape.

NOTE A slight sawing motion imparted to the strapping tape will achieve this, or the strapping tape can be eased round the tank by pulling it away from the shell by the cords attached to the tape positioners, sliding these along the strapping tape as required.

Place the strapping tape on its correct path which shall be parallel to the horizontal seams of the tank.

7.2.2 If the strapping tape used is not long enough to encircle the tank completely, choose the level of the strapping tape path and then measure the circumference in sections. Draw scribed lines not nearer than about one-third of a plate length from a vertical seam at such distances apart as will enable measurements to be made conveniently. When the tension on the spring balance at the end of the strapping tape is as specified in 7.2.1 for each separate section, record the individual readings. The external circumference of the tank shall then be the sum of the separate measurements.

7.2.3 If the strapping tape used is long enough to encircle the tank completely, choose the level of the strapping tape path and then pass the tape around the circumference and hold it so that the zero graduation is not nearer than about one-third of a plate length from a vertical seam. Bring the other end of the strapping tape alongside. Then apply the tension to the spring balance and ensure that it is transmitted throughout the length of the strapping tape. Take the reading directly from the part of the strapping tape opposite the zero mark when the tension on the spring balance is as described in 7.2.1. Record the reading.

If a strapping tape subdivided only for the first metre is used, take care when recording the circumferential measurement to subtract the reading shown on the subdivided portion from the reading indicated by the main graduation (see Figure 1).

7.3 Repetition of measurement

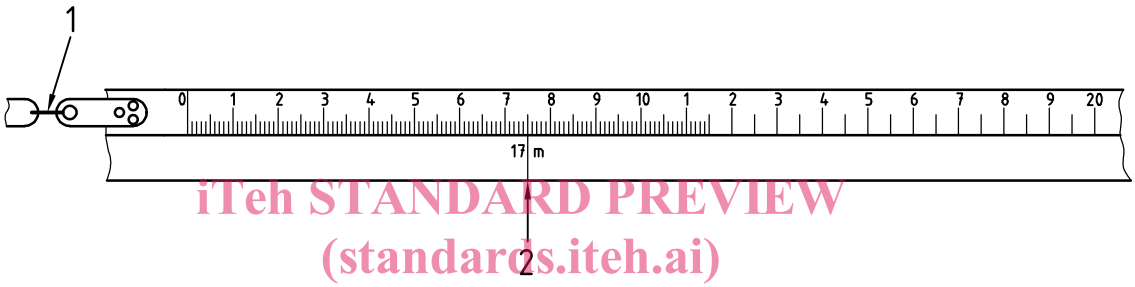
After a circumference has been measured as described in 7.2.2 or 7.2.3, release the tension and bring the strapping tape again to level and tension as in 7.2.1. Repeat and record the readings.

7.4 Tolerances

Measurements shall be read to the nearest 1 mm and shall be considered satisfactory if repetition as in 7.3 shows agreement within the following tolerances:

Circumferential measurement	Tolerance
m	mm
up to 25	2
above 25, up to 50	3
above 50, up to 100	5
above 100, up to 200	6
above 200	8

If agreement is not obtained, take and record further measurements until two consecutive readings do agree. Take the average of these two readings as the circumference. If consecutive measurements do not agree, determine the reasons for the disagreement and repeat the calibration procedure until agreement is obtained.



Key

1 spring balance and tension handle

2 reading shown would be 17 m minus 75 mm, or 16,925 m

Figure 1 — Reading of tape subdivided only for the first metre

7.5 Step-overs

7.5.1 Principle

If the tape path crosses obstructions such as projections, fittings, lapped joints, etc., which will cause it to deviate from a true circular path, an erroneous circumferential measurement will result. In order to avoid such an error, a step-over is used to measure the correction to be applied for such obstructions.

The constant for any one step-over will vary with the tank diameter and the course concerned, as it is determined on differently curved surfaces.

7.5.2 Use of step-overs

7.5.2.1 For each course, stretch the strapping tape as if in measurement of a circumference on the tank which is being calibrated (see 7.1). Apply the scribing points of the step-over to the tape near the middle of a plate where the tape is fully in contact with the tank surface.

Read the length between the points as measured on the tape to the nearest 1 mm.

Repeat the readings on four plates equally spaced around the course. Take the average of the results and record this as the step-over constant for the course concerned.