BRITISH STANDARD

BS ISO 7507-5:2000
ISO 7507-5:2000

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

Part 5: External electro-optical distance-ranging method

ICS 75.200

National foreword

This British Standard reproduces verbatim ISO 7507-5:2000 and implements it as the UK national standard.

The UK participation in its preparation was entrusted by Technical Committee PTI/12, Petroleum measurement and sampling, to Subcommittee PTI/12/1, Static and dynamic petroleum measurement, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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Summary of pages

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

Part 5: External electro-optical distance-ranging method

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

Partie 5: Méthode par mesurage électro-optique externe de la distance

Reference number
ISO 7507-5:2000(E)

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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.

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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 part of ISO 7507 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 7507-5 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee 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 method*

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

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

Annex A of this part of ISO 7507 is for information only.

Introduction

This International Standard forms part of a series on tank calibration methods including the following:

a) ISO 4269-1, *Petroleum and liquid petroleum products — Tank calibration by liquid measurement — Part 1: Incremental method using volumetric meters.*

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

c) ISO 7507-2, *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 2: Optical-reference-line method.*

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

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

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

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

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

The method is an alternative to other calibration methods such as the strapping method (ISO 7507-1), the optical-reference-line method (ISO 7507-2), the optical-triangulation method (ISO 7507-3), and the internal electro-optical distance-ranging method (ISO 7507-4).

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

Part 5: External electro-optical distance-ranging method

1 Scope

This part of ISO 7507 specifies a method for the calibration of non-insulated vertical cylindrical tanks having diameters greater than 5 m, by means of external measurement using an electro-optical distance-ranging method (EODR), and for the subsequent compilation of tank capacity tables.

This part of ISO 7507 is applicable to tanks with cone-up or cone-down bottoms as well as to tanks with flat bottoms.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 7507. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 7507 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 4512:—[1)], *Petroleum and liquid petroleum products — Equipment for measurement of liquid levels in storage tanks — Manual methods.*

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

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

IEC 60079-10:1995, *Electrical apparatus for explosive gas atmospheres — Part 10: Classification of hazardous areas.*

IEC 60825-1:1998, *Safety of laser products — Part 1: Equipment classification, requirements and user's guide.*

3 Terms and definitions

For the purposes of this part of ISO 7507, the terms and definitions given in ISO 7507-1 and ISO 7507-4 and the following apply.

[1)] To be published.

3.1
"at" station
station currently occupied by the EODR instrument

3.2
"back" station
station to the rear of the "at" station presently occupied by the EODR instrument

3.3
bisect
sighting of the centre of a target through the telescope of a EODR instrument

3.4
changing face
rotation of both horizontal and vertical circles of the EODR instrument by 200 gon

3.5
"forward" station
station forward of the "at" station presently occupied by the EODR instrument

3.6
misclosure
difference between the sum of the horizontal angles measured between the various stations of a complete traverse of the tank and the sum of the theoretical angles for the same traverse

3.7
station
position from which measurements of angles and slope distance are made

3.8
tribrach
device, set on a tripod, which, by adjusting three or more foot screws, is set in a horizontal plane and upon which surveying instruments are mounted

4 Principle

The tank and its surrounds are visually inspected and, having calculated the number of stations required, the siting of the measurement stations is chosen.

Tripods, together with their respective measuring equipment, are placed at the initial stations. To establish the position of the "at" station, angular and distance measurements are made from the initial "at" station to the initial "back" and "forward" stations. Angular and distance measurements to the top and base of the tank are then taken together with tangential angular measurements bisecting (3.3) the tank shell to the right and left of the station. These measurements are made at the required positions on each course. The tripods at the initial "back" and "at" stations are left in position to enable closure of the traverse on completion of the calibration.

From each of the subsequent, predetermined stations, angular and distance measurements to the top and base of the tank are then taken, together with tangential angular measurements bisecting (3.3) the tank shell to the right and left of the station.

In moving to each new station, the old "forward" station becomes the new "at" station and the old "at" station the new "back" station. The final measurements are made from an "at" station which was the initial "back" station; the final "forward" station is the initial "at" station.

These measurements, after any adjustments for misclosure, allow the calculation of three dimensional coordinates which are fitted into a matrix describing the tank mathematically. The circumferences at the various vertical positions on the tank shell are calculated from this information and the capacity table developed in accordance with ISO 7507-1.

5 Precautions

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

In addition, the laser emitted by the distance ranging unit shall conform to IEC 60825-1 for a Class 1 or Class 2 laser.

The EODR instrument and other electrical equipment shall have a level of electrical protection appropriate for the area classification of the location of the tank to be calibrated. (See IEC 60079-10.)

6 Equipment

6.1 Electro-optical distance-ranging instrument

The angular and distance-measuring parts of the instrument shall conform to 5.1 of ISO 7507-4:1995.

6.2 Single-corner cubic prisms, (for use as target prisms) mounted on a prism holder

NOTE The prism holder should be mounted on a ranging pole or a tribrach mounted on a tripod.

6.3 Tribrach

A minimum of five are required.

6.4 Tripod

A minimum of five are required.

6.5 Ranging pole

6.6 Self-adhesive retro-reflective tape

NOTE The external surface is coated with small reflective prisms or facets.

6.7 Ancillary equipment

This equipment shall include

a) a paint thickness meter, and

b) a plate thickness meter.

6.8 Equipment for bottom calibration

This equipment shall be on accordance with annex C of ISO 7507-1:1993.

7 General considerations

7.1 The EODR instrument shall be maintained so that the values of its measurement uncertainty do not exceed the values given in 6.1.

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

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

7.3 If the tank is calibrated whilst containing liquid, the contents shall remain static during the complete calibration. The dip (i.e. depth), temperature and density of the liquid shall be measured and recorded. However, if the temperature of the tank wall differs by more than 10 °C between the empty part of the tank and the full part of the tank, the tank shall either be completely full or empty. No transfers of liquid to or from the tank shall be made during calibration.

7.4 The EODR instrument shall be verified prior to calibration.

The accuracy of the distance-measuring unit, as well as the angular measuring unit, shall be verified using the procedures recommended by the manufacturer.

NOTE The appropriate procedures given in annex A of ISO 7507-4:1995 should be used for the verification of equipment in the field.

7.5 Calibration shall be carried out without interruption.

7.6 The overall height of the reference point on the dip-hatch above the dipping datum-point shall be measured using a dip-tape and dip-weight conforming to ISO 4512. This overall height, to the nearest 1 mm, shall be recorded.

8 Determination of the number of stations

The number of stations used in a calibration is dependent on the nominal tank circumference.

The number of stations shall be determined by the following equation:

$$N = \frac{C}{8}$$

where

N is the number of stations rounded up to the nearest even number;

C is the nominal circumference of the tank, in metres.

The minimum number of stations shall be not less than 8; an upper limit of 36 stations is acceptable unless circumstances require that more measurements be made.

NOTE If a tank is abnormally deformed, e.g. dented or non-circular, the number of tangential points and readings should be increased to take account of the areas of deformation.

9 Target-point positioning

Two sets of tangent measurements shall be taken at each station. In each set of tangents, measurements to two tangents per course shall be taken, one at 1/5 to 1/4 of the course height above the lower horizontal seam and the other at 1/5 to 1/4 of the course height below the upper horizontal seam. In addition, on the top course, the extreme top of the tank shell shall be bisected and, on the bottom course, the extreme bottom of the course shall be bisected.

A number of target points greater than the minimum number of target points recommended may be chosen depending on specific circumstances and tank conditions (see the note in clause 8).

10 Instrument set-up

10.1 Precalibration

Inspect the area surrounding the tank to optimize the position of the stations and allow firm and stable positioning of the tripods, (as illustrated in Figure 1). At each station, the "back" and "forward" stations shall be clearly visible from the "at" station. Ensure that there are no obstructions to clear lines of sight to the tank bottom, top and sides.

10.2 Set-up procedures

Set up the tripods at a height which is comfortable for all operatives. Drive the tripod legs well into the ground to make the tripods firm and stable.

Place tribrachs on the tripods.

Set each tribrach in the horizontal plane using the foot screws.

Place the EODR instrument on the tribrach at the "at" station and level horizontally.

If the EODR instrument is electronic and capable of automatic levelling, ensure that the instrument is levelled.

Place target prisms on the "forward" and "back" stations.

Place the retro-reflective tape (6.6) around the base and top of the tank.

11 Calibration procedure

11.1 Instrument start-up

Switch the instrument on and allow sufficient time to reach operating temperature in accordance with the manufacturer's recommendations.

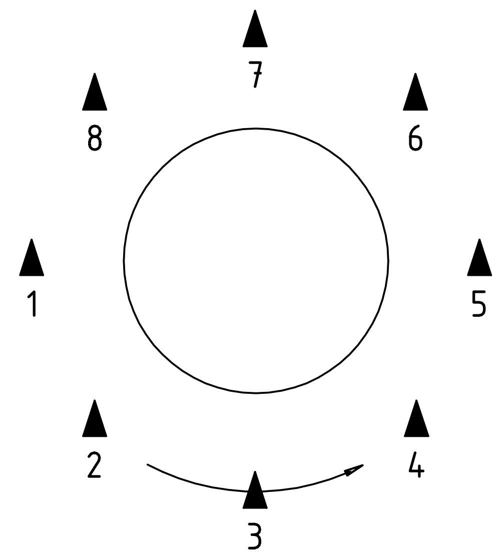


Figure 1 — Station positioning

11.2 Measurement procedure

11.2.1 Bisect the "back" station and measure the slope distance, horizontal and vertical angles. Record the measurements.

11.2.2 Change face.

11.2.3 Bisect the "back" station and measure the slope distance, horizontal and vertical angles. Record the measurements.

11.2.4 Change face.

11.2.5 Bisect the "forward" station and measure the slope distance, horizontal and vertical angles. Record the measurements.

11.2.6 Change face.

11.2.7 Bisect the "forward" station and measure the slope distance, horizontal and vertical angles. Record the measurements.

11.2.8 Change face.

11.2.9 Bisect the retro-reflective tape at the base of the tank, measure the slope distance, and horizontal and vertical angles. Record the measurements.

NOTE These measurements are made within ± 15° of a line normal to the tank shell wall from the station.

11.2.10 Change face.

11.2.11 Bisect the retro-reflective tape at the top of the tank and measure the slope distance, horizontal and vertical angles. Record the measurements.

NOTE These measurements are made within ± 15° of a line normal to the tank shell wall from the station.

11.2.12 Bisect the base tangent on the left-hand side of the tank (see Figure 2) and measure the horizontal and vertical angles. Record the measurements.

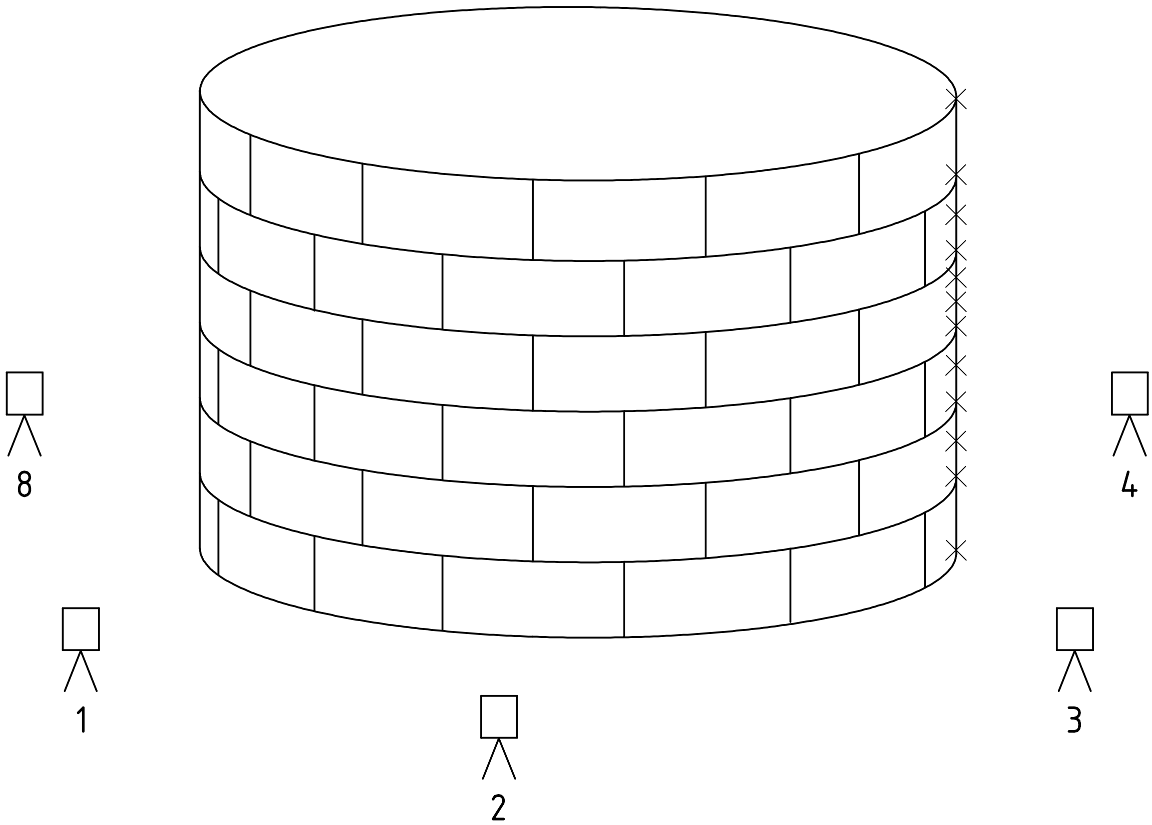
11.2.13 Bisect the tangent on the left-hand side of the tank at the 1/5 or 1/4 position on the first course and measure the horizontal and vertical angles. Record the measurements.

11.2.14 Bisect the tangent at the 3/4 or 4/5 position on the first course and measure the horizontal and vertical angles. Record the measurements.

11.2.15 Repeat the measurement procedures as detailed in 11.2.13 and 11.2.14 on each course, above the first course, until measurements have been taken on all courses.

11.2.16 Bisect the top tangent on the left-hand side of the tank and measure the horizontal and vertical angles. Record the measurements.

11.2.17 Repeat steps 11.2.12 to 11.2.16 for the right-hand side of the tank.



NOTE 20 % of plate height above or below weld.

Figure 2 — Tangential sights

11.3 Calibration procedures at subsequent stations

11.3.1 Replace the target prism on the "forward" station with the EODR instrument.

NOTE This station now becomes the new "at" station.

11.3.2 Transfer the target prims from the old "back" station to the old "at" station.

NOTE This station now becomes the new "back" station.

11.3.3 Set a tribrach on the new "forward" station.

11.3.4 Level the tribrach using the foot screws.

11.3.5 Place a target prism on the new forward station.

11.3.6 Repeat the procedures detailed in 11.3.1 to 11.3.6, repeating the measurement procedures as detailed in 11.2 at each station, until all stations have been "at" stations. The total number of "at" stations, at which measurements have been taken, shall be equivalent to the number of stations specified in clause 8.

11.3.7 The tripods, with tribrachs attached, at the first "back" and "at" stations, shall remain in place to enable the traverse loop of stations to be closed on completion of the calibration.

11.4 Establishment of dipping-reference-point position

11.4.1 Place the base of the ranging pole on the upper reference point and record the slope distance, and horizontal and vertical angles to the target prism fixed to the ranging pole.

NOTE These measurements should be taken from the most convenient station during the calibration procedure.

11.4.2 Place the ranging pole vertically below the dip-hatch with the base of the pole on the junction of the shell plating and bottom plating. Measure the slope distance, and horizontal and vertical angles. Record the measurements.

11.4.3 If, through necessity i.e. obstruction of the line of sight, the height of the ranging-pole height has to be altered, record the alteration in height to the nearest millimetre.

Any alteration in the height will require a compensating correction to be applied during the calculation of the upper-reference-point position.

12 Tolerances

The slope distances measured and recorded between two stations shall be within ± 2 mm (see 11.2).

13 Other measurements

13.1 The tank bottom shall be calibrated by one of the methods given in ISO 7507-1.

13.2 The following data shall be determined and processed in accordance with ISO 7507-1:

a) the density and the temperature of any liquid contained in the tank at the time of calibration;

b) the density and the working temperature of the liquid to be stored in the tank;

c) the height of each course;

d) the plate thickness of each course;

e) deadwood;

f) safe filling height and maximum filling height.

13.3 Measure the length of the ranging pole, to the nearest 1 mm, and record the value.

14 Calculation and development of capacity tables

14.1 Compute the internal radii of the tank.

NOTE A procedure for computation of radii from field measurements is described in clause A.2.

14.2 Using the computed internal radii, the capacity table shall be developed in accordance with ISO 7507-1.

The following corrections, described in ISO 7507-1, shall be applied in the development of the capacity tables:

a) hydrostatic head effect;

b) certified tank-shell temperature;

c) deadwood;

d) tilt, if necessary.

Annex A
(informative)

Computation of tank calibration tables

A.1 General

A.1.1 All calculations, other than the calculation of the radii at various levels on the tank shell, are made in accordance with the procedures in ISO 7507-1. This annex gives the general principles of the calculation procedure and the method by which circumferences at the various levels on the tank shell are derived.

A.1.2 All calculations should be made in accordance with accepted mathematical principles.

A.2 Computation of radii from field measurements

The field data obtained during calibration defines the position of each target point by a horizontal angle and a vertical angle, each point being related to one of the measurement stations positioned around the tank periphery.

These measurements are converted mathematically into coordinates in a three-dimensional matrix which describes the tank shell. They are normally expressed in the form (X,Y,Z); the X and Y coordinates define the horizontal position and the Z coordinate defines the vertical height.

The following equations provide a means of conversion:

$$X = D \cos \Theta \cos \phi$$

$$Y = D \sin \Theta \cos \phi$$

$$Z = D \sin \phi$$

where

D is the slope distance;

Θ is the measured horizontal angle;

ϕ is the measured vertical angle.

The X, Y and Z coordinates of the target points on the retro-reflective tape at the tank base and possibly the tank top are calculated initially. These points are fitted to a circle using a "least-squares polynomial approximation" method (see ISO 7507-3:1993, annex B), and geometry is used to find the intersection point of the base tangent, from each station, with this circle. The positions of the points above the base level are then determined by using the deviations in the tangent angles from the base tangent angle.

In order to calculate radii at the various measurement levels, the coordinates of each target point are adjusted so that the Z values of each of the target points which define a specific horizontal section or slice have a common and equal value. This adjustment is carried out by standard mathematical techniques which ensure that the adjusted positions of the target points in any particular slice are on a plane which is normal to the vertical axis of symmetry of the tank. Alterations in the Z value will require compensating alterations in the values of the X and Y coordinates at that point.

It should not be assumed that the tank is vertical.

The coordinates of the points are arranged in groups each with an equal Z value, i.e. they define a horizontal slice through the tank at the particular height, Z_i. A "least-squares polynomial approximation" method is employed to fit the points to a circle and hence produce the radius of each of the horizontal slices.

On completion of the calculation of the radii at each level on the tank shell, a circumference is calculated for that level. This circumference is used in the subsequent calculation of the tank calibration table described in ISO 7507-1.

If the tank construction drawings are available, calibration measurements should be compared with the corresponding dimensions shown in the tank construction drawings. Any measurements which show significant discrepancies should be checked.

If the calibration and drawing measurements do not agree, the reasons for the discrepancy should be determined and the calibration procedure repeated if necessary.

Bibliography

[1] ISO 7078:1985, *Building Construction — Procedures for setting out, measurement and surveying — Vocabulary and guidance notes.*

[2] ISO 8322-8:1992, *Building construction — Measuring instruments — Procedures for determining accuracy in use — Part 8: Electronic distance-measuring instruments up to 150 m.*

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