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

Part 4: Internal electro-optical distance-ranging method

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

Partie 4: Méthode par mesurage électro-optique interne de la distance

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.

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 7507-4 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 methods*

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

— *Part 6: Recommendations for checking and verification of tank calibration and capacity tables*

Annexes A and B form an integral part of this part of ISO 7507. Annex C is for information only.

Introduction

The method described in this part of ISO 7507 is an alternative to other tank calibration methods such as the strapping method (ISO 7507-1), the optical-reference-line method (ISO 7507-2) and the optical-triangulation method (ISO 7507-3).

The parts of ISO 7507 form part of a series on tank calibration which also includes: 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: Stereophotogrammetry*, and ISO 9091-2:1992, *Refrigerated light hydrocarbon fluids — Calibration of spherical tanks in ships — Part 2: Triangulation measurement*.

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

Part 4:
Internal electro-optical distance-ranging method

1 Scope

1.1 This part of ISO 7507 specifies a method for the calibration of vertical cylindrical tanks having diameters greater than 5 m by means of internal measurements using an electro-optical distance-ranging instrument, and for the subsequent compilation of tank capacity tables. This method is known as the internal electro-optical distance-ranging (EODR) method.

1.2 This part of ISO 7507 is not applicable to the calibration of abnormally deformed (e.g. dented) tanks or of noncircular tanks.

1.3 This part of ISO 7507 is applicable to tanks tilted by $\leqslant 3$ % from the vertical, provided a correction is applied for the measured tilt as described in ISO 7507-1.

1.4 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 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 7507-1:1993, *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.*

IEC 825-1:1993, *Safety of laser products — Part 1: Equipment classification, requirements and user's guide.*

3 Definitions

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

3.1 reference target point: Fixed point clearly marked on the inside surface of the tank shell wall.

3.2 slope distance: Distance measured from the electro-optical distance-ranging instrument to a target point on any given course of the tank shell wall.

3.3 target point: One of a series of points on the inside surface of the tank shell wall to which slope distance, vertical and horizontal angles are measured by use of the electro-optical ranging instrument.

4 Precautions

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

In addition, the laser beam emitted by the distance-ranging unit shall conform to IEC 825 for a class 1 laser.

5 Equipment

5.1 Electro-optical distance-ranging instrument

5.1.1 The angular measuring part of the instrument shall have an angular graduation and resolution equal to or better than ± 0,000 2 gon[1], a repeatability equal to or better than ± 0,000 5 gon, and an uncertainty equal to or better than ± 0,001 gon.

5.1.2 The distance-measuring part of the instrument, used for direct determination of distances, shall have a graduation and resolution equal to or better than ± 1 mm, a repeatability equal to or better than ± 2 mm, and an uncertainty equal to or better than ± 2 mm.

5.2 Instrument mounting, consisting of a tripod which is firm and stable. The legs of the tripod shall be held firm, and steadied, by suitable devices such as magnetic bearers.

5.3 Laser beam emitter, having a low-power laser beam complying with IEC 825, which is either an integral part of the EODR instrument or a separate device. If the laser beam emitter is a separate device, it may be fitted with a fibre optic light transmitter system and a theodolite telescope eyepiece connection, by which the laser beam may be transmitted through a theodolite, or such that it may be fitted to a theodolite with its axis parallel to the axis of the theodolite. The laser beam may be coincident with the optical axis of the telescope.

NOTE 1 The laser beam emitter is used to position target points on the tank shell.

5.4 Stadia, a rigid bar, usually 2 m long, such that the graduated length between the two stadia marks remains constant to within ± 0,02 mm.

5.5 Equipment for bottom calibration (see 11.1).

1) 2π radians = 400 gons = 400 grades.

5.6 Auxiliary equipment, including:

a) heavy weights to be set around the instrument to steady the unit;

b) lighting within the tank, if required.

6 General considerations

6.1 The EODR instrument shall be maintained so that the values of its measurement uncertainty do not exceed the values given in this part of ISO 7507.

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

NOTE 2 The hydrostatic test applied to new tanks will satisfy this requirement in most cases.

6.3 Calibration shall be carried out without interruption.

6.4 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.

The appropriate procedures given in annex A shall be used for the verification of equipment in the field.

6.5 The tank shall be free from vibration and airborne dust particles.

NOTE 3 The floor of the tank should be as free as possible from debris, dust and loose scale.

6.6 Lighting, when required, shall be placed within the tank so as not to interfere with the operation of the EODR instrument.

7 EODR instrument setup within the tank

7.1 Instrument setup

7.1.1 The instrument shall be set up with care, according to the procedure and instructions given by the manufacturers.

7.1.2 The instrument shall be set up so as to be stable.

If necessary, the tank bottom in the vicinity of the instrument shall be made firm and steady by placing heavy weights in the area.

The legs of the tripod on which the instrument is mounted shall be steadied by use of suitable devices, such as magnetic bearers, to prevent slippage on the tank bottom.

7.1.3 The instrument shall be located at, or near, the centre of the tank.

NOTE 4 This will ensure that the measured slope distances, at any one horizontal level, do not vary significantly and minimizes the overall uncertainty of slope distance determination.

7.1.4 The instrument shall be set horizontal, thus ensuring that the vertical axis (standing axis) is vertical.

7.1.5 The instrument shall be free from external vibration.

7.1.6 The sighting lines from the instrument to the tank shell wall shall not be obstructed.

7.2 Preliminary procedures

7.2.1 Switch on the instrument and bring to operating temperature, allowing at least the minimum warm-up time recommended by the manufacturer.

7.2.2 After the instrument has reached its correct operating temperature, carry out the appropriate procedure given in annex A. Then select and clearly mark on the tank shell wall two reference target points.

NOTE 5 The two reference target points should be approximately 100 gon apart and preferably on the same horizontal plane as the instrument.

7.2.3 The slope distances to each of the two reference target points shall be measured. Two successive readings to each reference target point shall be taken. The two readings, at each point, shall agree within ± 2 mm. The average distance to each point shall be computed. The slope distances shall be recorded.

7.2.4 Wait 15 min and repeat 7.2.3. The repeated slope distances shall agree within ± 2 mm with the slope distances originally measured. The slope distances shall be recorded.

7.2.5 If the original and repeated average slope distances do not agree within ± 2 mm, determine the reason for the difference.

a) If the reason for differences is due to the instrument and or its stability, repeat the procedure from 7.1.

b) If the instrument was switched off during the determination of the differences, repeat the procedure from 7.2.1.

c) If neither a) nor b) is appropriate, repeat the procedure from 7.2.3.

d) Repeat the appropriate procedures until two successive readings agree within ± 2 mm.

8 Selection of target points

8.1 Select two sets of target points per course, 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.

The number of target points per set, on each course of the tank shell wall, is dependent on tank circumference. The minimum number of target points per set, as a function of tank circumference, is given in table 1 and illustrated in figure 1.

8.2 The target points shall be at least 300 mm from any vertical welded seam.

9 Calibration procedure

9.1 Sight all of the target points along the horizontal plane at each course location, and measure the slope distance, horizontal angle and vertical angle to each, as illustrated in figure 2.

9.2 Measure and record the slope distance, horizontal angle and vertical angle to each of the reference target points.

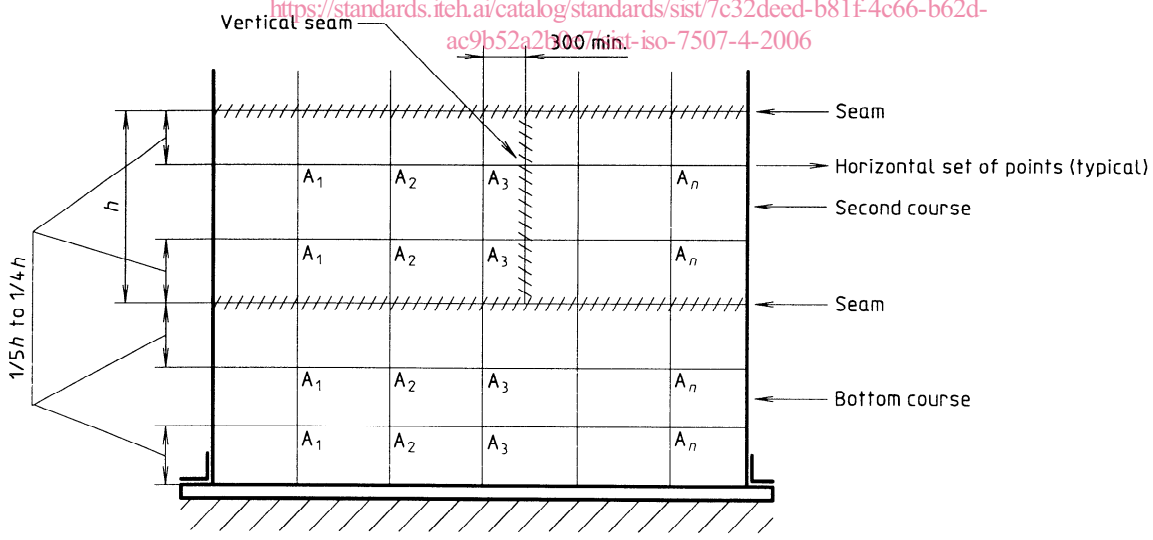
9.3 Complete the measurements to the target points on each course prior to moving to the next course.

NOTE 6 Measurements should begin at the bottom course and extend, course by course, to the top.

Table 1 — Minimum number of target points per set

Tank circumference, C m	Minimum number of target points
$C \leqslant 50$	8
$50 < C \leqslant 100$	12
$100 < C \leqslant 150$	16
$150 < C \leqslant 200$	20
$200 < C \leqslant 250$	24
$250 < C \leqslant 300$	30
$300 < C$	36
NOTE — A number of target points greater than the minimum number of points in table 1 may be chosen depending on specific circumstances and tank conditions.	

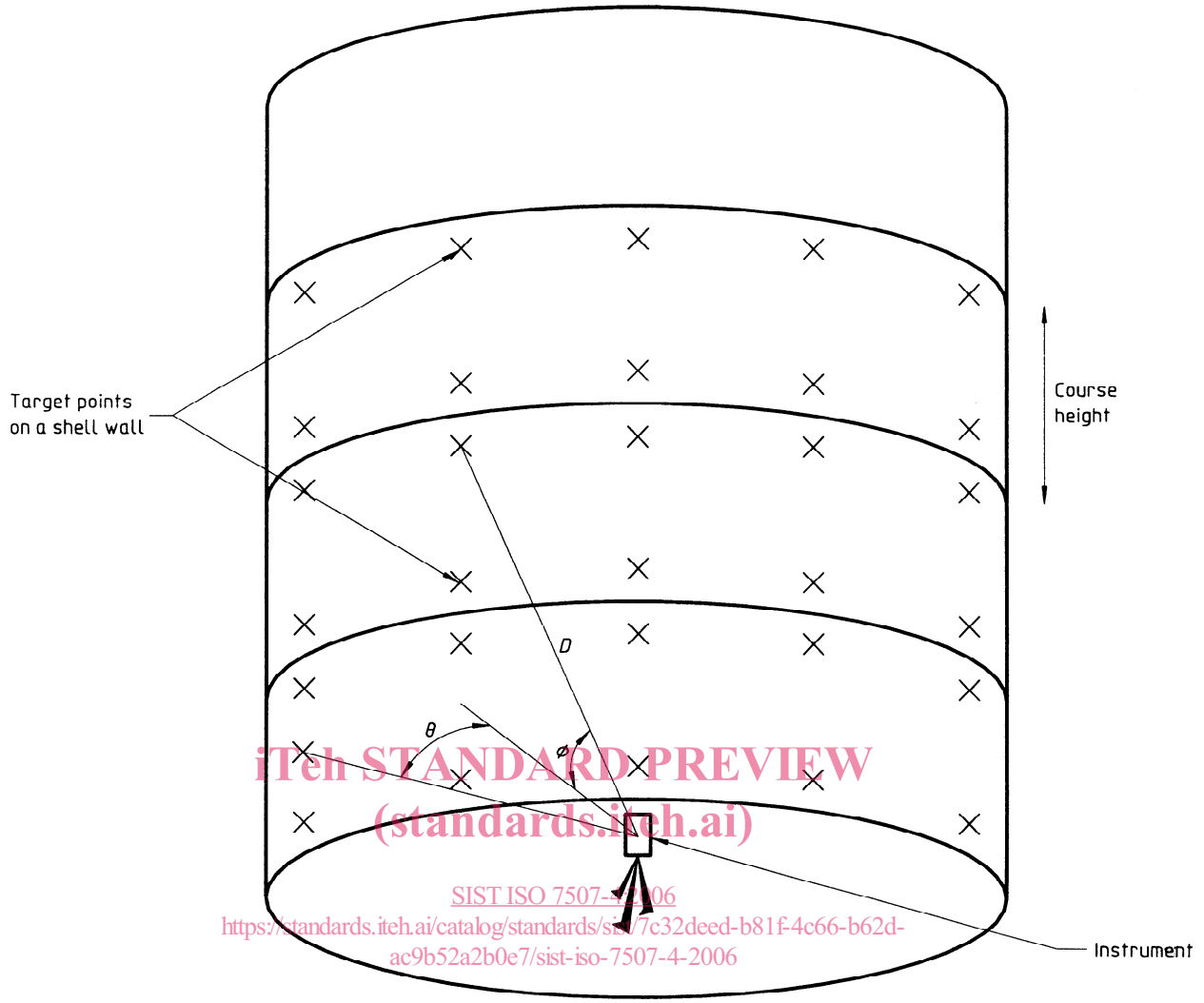
Dimensions in millimetres



h: Course height

A_1 to A_n: Target point at any given height

Figure 1 — Illustration of target positioning on tank shell wall



θ: Horizontal angle

ϕ: Vertical angle

D: Slope distance

Figure 2 — Illustration of calibration procedure

9.4 After all measurements on a course are completed, repeat the measurements to the reference target points.

9.5 If the repeated slope distances to the reference target points do not agree with the measurements taken during the setting up of the instrument, within the tolerance given in 10.1, then repeat 9.1 to 9.5.

9.6 If the horizontal and the vertical angles to the reference target points do not agree within the tolerance given in 10.2, repeat 9.1 to 9.5.

9.7 If statistical agreement is not obtained between the original and repeated measurements of slope distances, horizontal angles or vertical angles, then the reasons for such disagreement shall be determined, the cause eliminated and the tank calibration procedure repeated.

9.8 Carry out all measurements without interruption.