INTERNATIONAL STANDARD

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

Part 1:
Strapping method

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

Partie 1: Méthode par ceinturage

Reference number
ISO 7507-1:1993(E)

Contents

Annexes

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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 7507-1 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, B, C, D and E form an integral part of this part of ISO 7507. Annex F is for information only.

Introduction

This International Standard 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:—[1)], *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 4: Internal electro-optical distance-ranging methods*

ISO 7507-5:—[1)], *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 5: External electro-optical distance-ranging methods*

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.

1) To be published.

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 1 For the reference method, the number of strappings required will be specified in the standard which calls up 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 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 3675:1993, *Crude petroleum and liquid petroleum products — Laboratory determination of density or relative density — Hydrometer method.*

3 Definitions

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

NOTE 2 Preferred terms only have been defined, and alternative terms are given with reference to the appropriate preferred term.

3.1 argument: The independent variable of a function.

NOTE 3 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

(1) The determination of the partial capacities of the lower portions of a tank.

(2) The quantity of liquid contained in a tank below the dip-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: Table, often referred to as a tank table or a tank capacity 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 datum-point: Point used as the datum in the preparation of a calibration table.

NOTE 4 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 which affects the capacity of the tank.

NOTE 5 Deadwood is referred to as "positive deadwood" when the capacity of the fitting adds to 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: Depth of a liquid in a tank.

NOTE 6 The term "innage" is synonymous.

3.10 dip-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 7 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. (See dip-plate.)

3.12 dip-plate: Striking-plate positioned below the dip-hatch. Its position should not be affected by bottom or wall movements.

3.13 dip-rod or **dip-stick:** Rigid length of wood or metal usually graduated in units of volume, for measuring quantities of liquid in a tank.

3.14 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.

3.15 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.

3.16 equivalent dip: Depth of liquid in a tank corresponding to a given ullage.

3.17 extrapolation: Process of obtaining the value of a function corresponding to a value of the argument greater or less than the extreme values given.

3.18 floating cover (screen): Lightweight cover of either metal or plastics material designed to float on the surface of a liquid in a tank.

NOTE 8 The cover rests upon the liquid surface. The device is used to retard evaporation of volatile products in a tank.

3.19 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.

3.20 function: When two variable quantities are interrelated, one quantity is said to be the function of the other.

NOTE 9 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.

3.21 gauge-hatch: See dip-hatch (3.10).

3.22 gauging: Process of taking all the necessary measurements in a tank in order to determine the quantity of liquid which it contains.

3.23 innage: See dip (3.9).

3.24 interpolation: Process of obtaining the value of a function corresponding to a value of the argument intermediate between those given.

3.25 Littlejohn grip: Quick-release clamp that may be fitted around a strapping tape at any convenient position throughout its length. A handle is attached to the Littlejohn grip so that the tape can be pulled to the correct tension.

3.26 open capacity: Calculated capacity of a tank or part of a tank before any allowance has been made for deadwood.

3.27 overall height: Vertical distance between the dip-point and the upper reference point.

3.28 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.

3.29 reference method: Application of the strapping method of tank calibration to the measurement of a reference circumference at one location for use in other methods of tank calibration, for example the optical-reference-line method (see ISO 7507-2).

3.30 reference point: Point to which all measurements subsequent to calibration are related.

3.31 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.

3.32 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.

3.33 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.

3.34 strapping tape: Specially designed and calibrated steel measuring tape graduated in units of length and used for taking measurements in tank calibration.

3.35 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.

3.36 sub-tabulation: Process of interpolation used to obtain the values of the function corresponding to regular fractional intervals between given values of the argument.

3.37 tank capacity table: See capacity table (3.5).

3.38 tank table: See capacity table (3.5).

3.39 tape positioner: Guide sliding freely on the strapping tape and used to pull and hold the tape in the correct position for taking measurements.

3.40 tensioning handles: Handles fastened to the strapping tape, used for pulling it into the correct position and applying tension.

3.41 ullage

(1) The capacity of a tank not occupied by the liquid.

(2) The distance between the surface of a liquid in a tank and some fixed reference point on the top of the tank.

NOTE 10 The term "outage" is synonymous.

3.42 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.

3.43 water bottom: Layer of water at the bottom of a tank, of such depth as completely to cover the bottom.

3.44 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

4.1.1 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.

NOTES

11 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.

12 Seriously distorted tanks are best calibrated using liquid calibration methods similar to the method described in annex C.

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 laid down 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 below 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, in any case, always be followed.

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

4.3.3 Where 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) Where 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) When justified, safety harness shall be worn by personnel working above ground level.

5 Equipment

5.1 Strapping tape

A strapping tape complying with the requirements given in D.1 shall be provided. The tape shall be well greased before use.

5.2 Spring balance

A spring balance, complying with the requirements given in D.2, shall be provided for measuring the tension applied to the tape.

5.3 Step-over

A step-over complying with the requirements given in D.3 shall be provided.

5.4 Tape positioners and cords

One or more tape positioners as described in D.4 shall be fitted to the strapping tape, and shall be supplied with plaited cords. Both upper and lower cords shall be long enough to cover the height of the tank.

5.5 Littlejohn grip

A Littlejohn grip complying with the requirements given in D.5 shall be provided 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 sub-divided into half-millimetres, or another device, such as an electronic thickness gauge, shall be provided to measure plate thickness, etc.

5.7 Paint thickness gauge

A suitable instrument for measuring the thickness of paint shall be provided.

5.8 Dip-tape and dip-weight

A dip-tape and dip-weight complying with the requirements given in D.6 and D.7 shall be provided. The dip-tape shall be long enough to reach from the dipping reference point at the tank roof to the dip-point on the tank bottom.

5.9 End-to-end rule

An end-to-end rule, 1 m in length, with graduations in centimetres and millimetres, shall be provided 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, etc.

See 4.3.6 for safety precautions.

5.11 Density and temperature measuring apparatus

Apparatus described in ISO 3675 shall be provided.

6 General requirements

NOTE 13 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 could differ by more than 10 °C between the empty part and the full part of the tank, the tank shall be completely full or empty. Do not make transfers of liquid during the calibration.

NOTE 14 The ambient temperature before and after calibration should also 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 15 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 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 datum-point, either by normal surveying methods or by other suitable means, and record it.

6.3 Measure the overall height of the upper reference point above the dip-point using the dip-tape and weight. Record this overall height, to the nearest sub-division on the dip-tape, in the empty and the full conditions as and when required.

7 Circumference measurements

7.1 Levels strapped

7.1.1 If the calibration is for referee purposes, measure the circumference by three strappings per course, at 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 levels as above, 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 1/5 to 1/4 above the lower horizontal seam;

— at 1/5 to 1/4 below the upper horizontal seam.

7.1.3 If the calibration is for reference purposes, measure the circumference at only one level as specified in the tank calibration method for which a reference circumference is required.

7.1.4 If for any reason it is impracticable, even with the use of a step-over (see 7.5), 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 below. The calibration tension specified on the tape shall be applied to the tape using the tensioning handles and spring balance, and transmitted throughout the length of the tape.

NOTE 16 A slight sawing motion imparted to the tape will achieve this, or the 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 tape as required.

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

7.2.2 If the tape used is not long enough to encircle the tank completely, choose the level of the 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 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 tape used is long enough to encircle the tank completely, choose the level of the 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 tape alongside. Then apply the tension to the spring balance and ensure that it is transmitted throughout the length of the tape. Take the reading directly from the tape opposite to the zero mark when the tension on the spring balance is as described in 7.2.1. Record the reading.

NOTE 17 When a tape sub-divided only for the first metre is used, take care when recording the circumferential measurement to subtract the reading shown on the sub-divided 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 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 m	**Tolerance** 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 so 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.

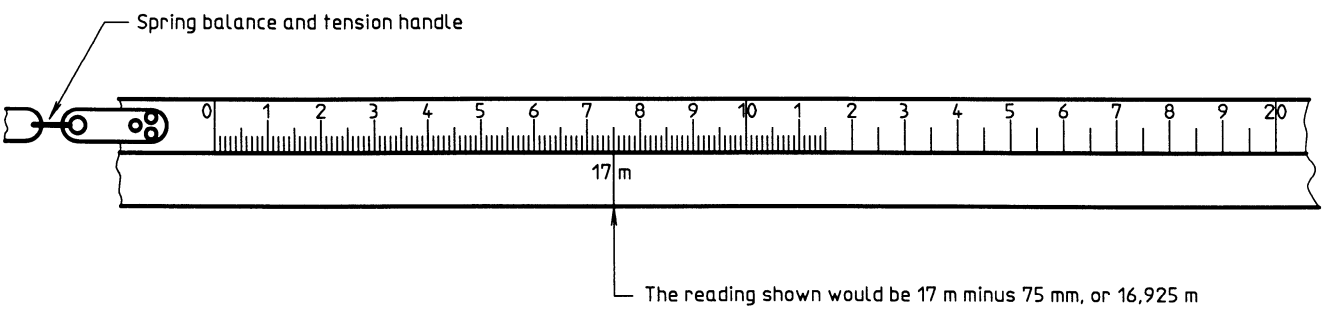

Figure 1 — Reading of tape sub-divided only for first metre

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, since 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 off the length between the points as measured on the tape to the nearest 0,2 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.

To assist in estimating fractions of a tape division, always take the reading from the same position on a graduation mark, e.g. from the right-hand edge.

7.5.2.2 With the tape still in position and under the tension used in strapping, apply the step-over to the tape on either side of each obstruction lying in the tape path. Take readings to the nearest 0,2 mm of the lengths of tape included between the scribing points (see last paragraph in 7.5.2.1). Record all step-over readings for subsequent use in calculation.

7.5.2.3 The step-over correction for the obstruction concerned shall be the difference between the readings obtained as in 7.5.2.2 and the step-over constant obtained as in 7.5.2.1.

7.5.2.4 Include all obstructions for which a step-over correction is detectable. In the case of vertical seams, provided that the tape path is entirely clear of other obstructions, obtain a calculated step-over correction as described in 16.1.2.

7.5.2.5 Total the step-over corrections for all obstructions and vertical seams at the level concerned and deduct the result, rounded off to the nearest 1 mm, from the gross circumference measured in accordance with 7.2 to 7.4.

8 Other measurements on tank shell plates

8.1 Plate and paint thickness

Measure the thickness of the plate, paint and any internal coating for each course, whenever possible, except that, if tanks are of butt-welded construction, plate thicknesses may be taken from the drawings. Record the plate and paint thickness for each course to the nearest 0,5 mm.

8.2 Heights of courses

Measure course heights externally and record the vertical distances obtained to the nearest 5 mm. Make due allowance for the effect of any horizontal seam overlap in order to give the distance between successive edges of the course as exposed internally in the tank.

NOTE 18 Seam overlaps may be obtained from the tank drawings or by difference between the measurement on successive courses.

Measure course heights at more than one position around the periphery. Average the results obtained and record them. The total of the separate course heights shall agree with the total height of the tank shell which shall be measured separately at a position as near to the dip-point as practicable and recorded. If possible, also measure the bottom-course height internally to ensure that any repairs to or renewals of the tank bottom plating have not resulted in the internal height of the bottom course being reduced.

9 Deadwood

Measure the dimensions of the deadwood, whenever possible, and the heights of the lowest and highest points of such deadwood measured in relation to the datum-point of the tank. Record these measurements to the nearest 5 mm.

When physical measurements cannot be obtained, take details of deadwood from the tank drawings.

10 Tank bottoms

NOTE 19 This clause should be read in conjunction with 17.2.

Calibrate the tank bottom by one of the following methods:

a) by filling with measured quantities of a non-volatile liquid (preferably clean water), as specified in annex C, to a minimum level that covers the bottom completely, immersing the dip-plate and eliminating the effect of bottom deformations; or

b) if liquid calibration is not possible or if the tank bottom has a regular shape, by carrying out a physical survey using a reference plane. Take care to ensure that the survey adequately describes the contours of the tank bottom. Use a minimum of three survey points per metre of diameter.

NOTE 20 Physical survey methods are used to determine the contents of the bottom by measuring down from a known truly horizontal plane across the tank bottom. Such a plane may be established by means of a dumpy level, a surveyor's level, a theodolite or water-filled tubes.

11 Measurement of tilt

Take measurements to determine the degree, if any, by which the tank is tilted.

NOTES

21 This can conveniently be done during an internal bottom survey or by suspending a plumb line from the top angle and measuring at a sufficient number of points the maximum offset at the bottom angle [see 16.2 g)].

22 Bottom-course heights should also be checked to ensure that tilt, if any, is genuine.

12 Floating-roof tanks

12.1 Carry out all calibration measurements exactly as for tanks with fixed roofs.

NOTE 23 These measurements should preferably include liquid calibration of the tank bottom, which should be continued to a depth sufficient for the roof to become fully floating (see annex C).

12.2 Carry out the following additional measurements:

a) The height of the lowest point of the roof above the datum-point when the roof is resting fully on its supports. If the roof is to be set at another working level, make the appropriate correction.

b) With the roof resting fully on its supports, paint four short horizontal white lines about 40 mm wide on the tank shell at approximately equidistant points and in such a position that, viewed from some definite point on the roof, their lower edges are just above four similar fixed reference points chosen along the periphery of the roof. Slowly pump liquid into the tank; when all roof reference points are seen to have moved equally upwards, regard the roof as fully floating. Read the dip reading of the liquid at this level and record it to the nearest 1 mm. Also measure and record the density and temperature of the liquid.

NOTE 24 The supporting legs can be utilized as a check as to when the roof is fully floating. This has the advantage that reliance is not placed solely on movement of the roof periphery. There can be considerable flexing of the roof surface just before it becomes liquid-borne. As soon as the weight of the roof is removed from a leg by flotation of the adjacent roof surface, this leg can be freely shaken without removal of its supporting pin.

From the above data, it is possible to derive the apparent mass in air of the roof if the quantity of displaced water is measured.

If facilities for liquid calibration are not available, measure the shape of the roof. Take sufficient measurements to enable the displacement of the roof to be calculated with reasonable accuracy and verified against the drawings.

c) If the apparent mass in air of the roof and its attached appurtenances is given by the maker or is indicated on a plate attached to the roof, record this value.

NOTE 25 The apparent mass in air of the floating roof includes half of the apparent mass in air of the ladder, and half the apparent mass in air of accessories attached to the underside of, and partially supported by, the roof, e.g. flexible or articulated drain lines or floating suctions.

Check the recorded apparent mass in air by calculation from the maker's drawings.

d) If calibration of the tank is required over the range between the lowest level of the tank roof and the level of the liquid at which the roof becomes fully floating, use either of the following procedures (but preferably the first) (see note 25):

1) When liquid is pumped into the tank as in 12.2 b), carry this out in batches. Measure the quantity of each of the batches, which should be similar but not necessarily identical in volume, accurately by a meter calibrated for custody transfer or from measurements made in a storage tank provided with an accurate capacity table. Record the quantities to the nearest litre together with the corresponding liquid depths above the dip-point. Record dips to the smallest graduation on the dip-tape. Choose the batch size such that increments of approximately 50 mm are obtained. Record the density and temperature of the liquid.

   From the above data it is possible to derive the apparent mass in air of the roof.

2) If facilities for liquid calibration are not available, measure the shape of the roof. Take sufficient measurements to enable the displacement of the roof, at various stages of immersion, to be calculated with reasonable accuracy and verified against the drawings.