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Refrigerated light hydrocarbon fluids — Calibration of membrane tanks and independent prismatic tanks in ships — Physical measurement

Hydrocarbures légers réfrigérés — Étalonnage des réservoirs à membrane et réservoirs pyramidaux — Mesurage physique

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Contents

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Annexes

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 approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 8311 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*.

Annexes A to F are for information only.

Introduction

Large quantities of light hydrocarbons consisting of compounds having 1 to 4 carbon atoms are stored and transported by sea as refrigerated liquids at pressures close to atmospheric. These liquids can be divided into two main groups, liquefied natural gas (LNG) and liquefied petroleum gas (LPG). Bulk transportation of these liquids requires a special technology in ship design and construction to enable shipborne transportation to be safe and economical.

Measurement of cargo quantities in ships' tanks for custody transfer purposes has to be of a high order of accuracy. This International Standard, together with others in the series, specifies methods of internal measurement of ships' tanks from which tank calibration tables can be derived.

This International Standard covers calibration techniques applicable to membrane type tanks, i.e. tanks in which the containment system comprises a relatively thin membrane of either stainless steel or high-nickel steel alloy supported by insulation and also, with some modifications, to tanks constructed of aluminium alloy or steel for low-temperature service that are independent, self-supporting and approximately prismatic in shape.

Annex A gives recommendations on safety precautions to be observed during the calibration.

Annex B gives an analysis of the sources of error for a typical membrane tank.

Annex C gives an example of a calibration table relating partial filling volume as a function of liquid level and annexes D, E and F give examples of trim, list and temperature correction tables.

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Refrigerated light hydrocarbon fluids — Calibration of membrane tanks and independent prismatic tanks in ships — Physical measurement

1 Scope

1.1 This International Standard specifies a method for the internal measurement of membrane tanks and independent prismatic tanks used in ships for the transport of refrigerated light hydrocarbon fluids. In addition to the actual process of measurement, it sets out the calculation procedures for compiling the calibration table and correction tables to be used for the computation of cargo quantities.

1.2 For membrane tanks, the procedures of this International Standard utilize the scaffolding used for the installation of the membranes to support the measuring equipment but, for independent prismatic tanks, other safe means of access to the required measuring positions have to be used.

2 Normative references

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

ISO 4512 : —[1], *Petroleum and liquid petroleum products — Equipment — Tank gauging and calibration — Manual methods.*

ISO 7507-1 : —[1], *Petroleum and liquid petroleum products — Volumetric calibration of vertical cylindrical tanks — Part 1 : Strapping method.*

3 Definitions

For the purposes of this International Standard, the following definitions shall apply.

3.1 calibration : The process of determining the total capacity or partial capacities of a tank corresponding to different levels.

3.1.1 bottom calibration : Measurements made to provide calibration of the bottom part of a tank to take account of undulation in the bottom plate.

3.2 calibration table (main gauge table) : A table, often referred to as a tank table or a tank capacity table, showing the capacity of, or volumes in, a tank corresponding to various liquid levels measured from the gauge reference point (see 3.6), with the ship on an even keel and upright.

3.3 chamfer : A slanting surface connecting the walls of a tank with its top or bottom surface (see figure 5).

3.4 deadwood : Any tank fitting or structure, including rounded corners or radiussed ends, which affect the capacity of the tank. 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.

3.5 gauging : All the measurements taken in a tank necessary to determine the quantity of liquid and vapour contained therein.

3.6 gauge reference point : The point from which the liquid depths are measured.

3.7 horizontal plane : A plane established parallel to the tank bottom.

3.8 liquid level : Height of the liquid surface measured from the gauge reference point. When the ship is in list or trim condition, the height is measured at a right angle to the tank bottom.

3.9 list : Transverse inclination of a ship.

3.10 longitudinal line : A line formed by a longitudinal plane crossing a horizontal plane.

3.11 longitudinal plane : A vertical plane running parallel to the centreline of the tank.

1) To be published.

3.12 measuring line : A line (longitudinal, transverse or vertical) on a three-dimensional rectangular grid with a pitch not greater than 5 m. Measurement for calibration purposes is taken along these measuring lines.

3.13 port : The left-hand side of a ship facing forward.

3.14 reference line : A standard line established by a string or laser. A calibration method using this line is adopted as an alternative to direct measurements, where it is considered impractical to take direct measurements.

3.15 reference offsets : Clearances or offsets between the tank bottom and a horizontal plane set over it, which are measured along all the vertical lines drawn on the fore and aft end walls.

3.16 reference plane : A plane parallel to a side wall, end wall or tank bottom which passes through a reference line.

3.17 section line : A line formed by a section plane crossing a horizontal plane.

3.18 section plane : A plane parallel with the fore and aft end walls of a tank.

3.19 starboard : The right-hand side of a ship facing forward.

3.20 trim : Longitudinal inclination of a ship.

3.21 vertical line : A line formed by a section plane on the side walls and formed by a longitudinal plane on the fore and aft end walls.

4 Precautions

This clause outlines the precautions to be taken during measurement in order to ensure that the required calibration precision is obtained.

4.1 Utmost care and attention shall be exercised in taking measurements, and any unusual occurrence during the measuring work which might affect the results obtained shall be recorded.

The calibration method described in this International Standard may be applied to ships whether afloat or in a dry dock or on a building slip. However, its use for ships in a dry dock is preferred, because trim or list, if any, will remain the same throughout the calibration procedure. The necessary adjustment shall be made to any measurement by optical level or laser transmitter if the ship's attitude has changed.

4.2 If unusual distortion is found in the tank, additional measurement shall be taken by the calibrator as considered necessary and sufficient to provide the required accuracy in the calibration table. Notes by the calibrator detailing the extra measurements and the reasons for them shall be included in the calibration report.

The calibrator shall provide detailed sketches of any abnormality of the tank or its fittings where such sketches will materially assist the interpretation of the recorded data.

4.3 If drawings for the tank are available, all measurements taken shall be compared with the corresponding dimensions shown on the drawings. Any measurement showing a significant discrepancy in this comparison shall be rechecked.

4.4 Measurements shall be taken twice to check whether they agree within the following tolerances; if they do not agree, measurements shall be continued until two consecutive readings agree, and their average shall be taken as the result.

Measurement	Tolerance
up to 20 m	± 2 mm
over 20 m	± 3 mm
for offset	± 0,5 mm

If the measurements have been interrupted, the last measurements taken shall be repeated. If the new measurements do not agree, within the required tolerance, with the earlier measurements, then the earlier set shall be rejected.

4.5 When measurements are made with a measuring tape, the tension specified in the tape calibration certificate shall be applied.

4.6 The measuring tape shall be supported, if necessary, so as to prevent it from sagging. If tape sag is unavoidable, the calibrator shall note this and a catenary correction shall be applied during calculation.

4.7 When measuring a membrane tank, care shall be taken to ensure that the membrane is in contact with the supporting material.

NOTE — In some cases it may be possible to ensure this contact by applying a vacuum to the space beneath the membrane.

4.8 The trim and list of the ship shall be kept unchanged while the optical level or laser transmitter is used.

5 Equipment

5.1 Dynamometer, to check the tension specified for a measuring tape.

5.2 End-to-end rule, graduated in centimetres and millimetres, to be used to measure deadwood, etc. A wooden rule shall be free of warping. The rule shall bear the identification of a recognized standardizing authority or certificate of identification.

5.3 Laser transmitter, emitting a low-power laser beam with a divergence of less than 4 mm at a distance of 35 m, which can be rotated through 360° vertically and horizontally.

5.4 Measuring tape, complying with the specifications given in ISO 4512, clause 20.

5.5 Optical level, having an erect image and a magnification of ×20 or greater, capable of being focussed to 1,5 m or less and with a spirit level sensitivity of 40 seconds of arc per 2 mm or less.

5.6 Steel rule, to be used to measure clearances, etc., graduated in millimetres. The rule shall bear the identification of a recognized standardizing authority or certificate of identification.

5.7 Thermometer, of suitable range, having an accuracy of ± 0,5 °C.

5.8 Tension handle, fastened to the measuring tape to apply tension to pull it into a straight line (see ISO 4512).

6 Measurement

6.1 Method

This clause and clause 7 set out a method of measurement and calculation applicable to tanks constructed using a membrane containment system.

Measurements of the distances between opposite walls of a tank shall be taken by tensioning the tape as specified on the tape certificate.

Tanks constructed of aluminium alloy or steel for low-temperature service, and of independent, self-supporting and approximately prismatic shape, may exhibit significant deformation or building inaccuracy. If such distortion has been identified, additional measurement, as indicated in 4.2, shall be carried out.

The decision to adopt an alternative method shall be made by the calibrator. The reasons for the decision shall be included in the field notes.

6.2 Determination of measuring positions

Tank calibration is basically the measurement of the tank length, width and height between known positions. These positions are determined by setting out a number of horizontal, longitudinal and section planes.

These planes intersect to form lines along which the measurements of length, width and depth shall be taken. The various planes shall be set out at intervals not greater than 5 m; the interval shall be adjusted so that the resulting measurements reflect any change of section and adequately describe any deformation. The positions at which measurements are to be taken shall be determined by the calibrator but shall not be more than 5 m apart.

6.3 Marking

Having determined the positions at which measurements are to be taken, mark the lines which run on the tank inner walls. Mark the section and longitudinal lines on the top and bottom plates, horizontal and vertical lines on the fore and aft end walls and horizontal and vertical lines on the port and starboard end walls.

6.4 Tank length measurement

Measure tank lengths along all the longitudinal lines at each level of the horizontal planes as described in 6.4.1 to 6.4.3.

6.4.1 Length measurement on the bottom plate

Measure distances between the fore and aft end walls along all the longitudinal lines marked on the bottom plate with a measuring tape stretched thereon.

6.4.2 Length measurement on the top plate

Measure distances on the top plate in a manner similar to that for the bottom plate (see 6.4.1). Care shall be taken to keep the measuring tape in contact with the top plate.

6.4.3 Length measurement in an intermediate horizontal plane

To avoid inaccurate measurement due to excessive sagging of the measuring tape, apply the reference line method using a string line (6.4.3.1) or laser beam (6.4.3.2).

As shown in figure 1, lengths in these imaginary planes can be obtained by applying offset corrections at both ends, a_2, a_3 ... a_{n-1} and b_2, b_3 ... b_{n-1}, to the length measured directly on the side wall.

6.4.3.1 String line

1) Mark P_1 and P_2, S_1 and S_2, on both side walls at equal distances from the end walls. Measure the lengths (L_P, L_S) between the fore and aft end walls with a measuring tape extended along both side walls, supporting the tape on the wall to prevent it from sagging.

2) Stretch strings between the opposite points P_1 and S_1, P_2 and S_2, and measure the offsets between the strings and the end walls (a_1, a_2 ... a_n and b_1, b_2 ... b_n) with a rule.

3) In measuring these offsets, take care to put the measuring rule at a right angle to the string.

6.4.3.2 Laser beam line

1) Mount a laser transmitter on one of the end walls with an appropriate clearance, then align the laser beam horizontally and approximately parallel to the end wall.

2) Mark P_1 on the port side wall where the laser beam strikes the wall, then rotate the beam through 180° and mark S_1 where the beam strikes the starboard wall.

3) Measure offsets between the centre of the beam and the end wall (a_1, a_2 ... a_n) with a rule.

4) Repeat the same procedure on the opposite end wall. Mark P_2, S_2 and measure b_1, b_2 ... b_n.

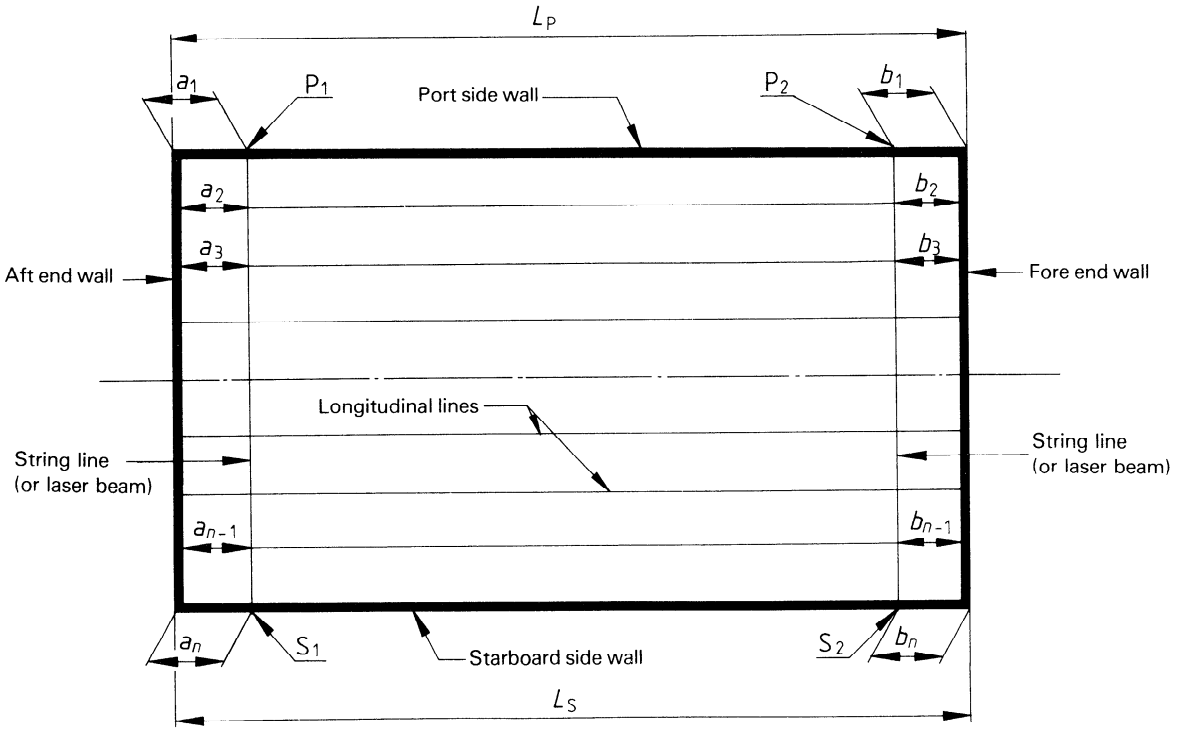

Figure 1 — Plan view of an intermediate horizontal plane

6.4.3.3 Average length

The purpose of the measurement using a string line (6.4.3.1) or laser beam (6.4.3.2) is to obtain the average length, L, of each intermediate horizontal plane, which is calculated from the equation

$$L = \frac{L_P + L_S - (a_1 + a_n + b_1 + b_n)}{2} + \frac{\sum_{i=1}^{n} (a_i + b_i)}{n}$$

Alternatively, another formula of equal or better precision may be used when it is considered adequate in the light of the shape of the tank.

6.4.3.4 Laser beam plane

As an alternative to the laser beam reference line method described in 6.4.3.2, the single beam laser may be replaced by a laser producing a laser plane. A rotating laser is set up adjacent to and approximately parallel with each inner surface. The plane will pass through the laser reference lines described in 6.4.3.2. Offset measurements are taken between the plane and the positions on the wall determined as described in 6.2.

6.5 Tank width measurement

Tank widths are measured along all the section lines set in each horizontal plane as described in 6.5.1 to 6.5.3.

6.5.1 Width measurement on an intermediate horizontal plane

Measure tank width in the same way as in the length measurement by actual measurement of w_f and w_a in combination with the string or laser beam method as shown in figure 2.

The average width, w, for each intermediate horizontal plane is given by the equation

$$w = \frac{w_f + w_a - (c_1 + c_n + d_1 + d_n)}{2} + \frac{\sum_{i=1}^{n} (c_i + d_i)}{n}$$

6.5.2 Chamfer portions

Measure the width on the end walls at the tank top as well as at the bottom of the upper chamfer. Likewise, measure the width on the end walls at the tank bottom and at the top of the lower chamfer.

6.5.3 Trapezoidal tank

If the tank width is less at one end, measure the width in the intermediate horizontal planes in the same way as in 6.5.1, as shown in figure 3.

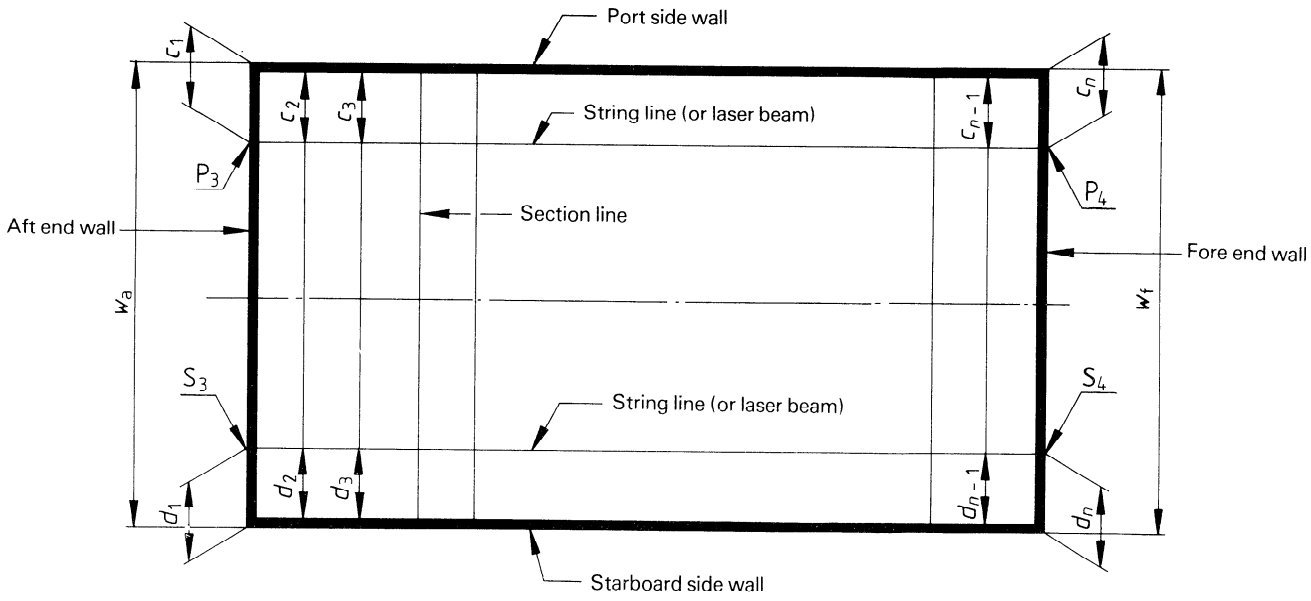

Figure 2 — Plan view of an intermediate horizontal plane

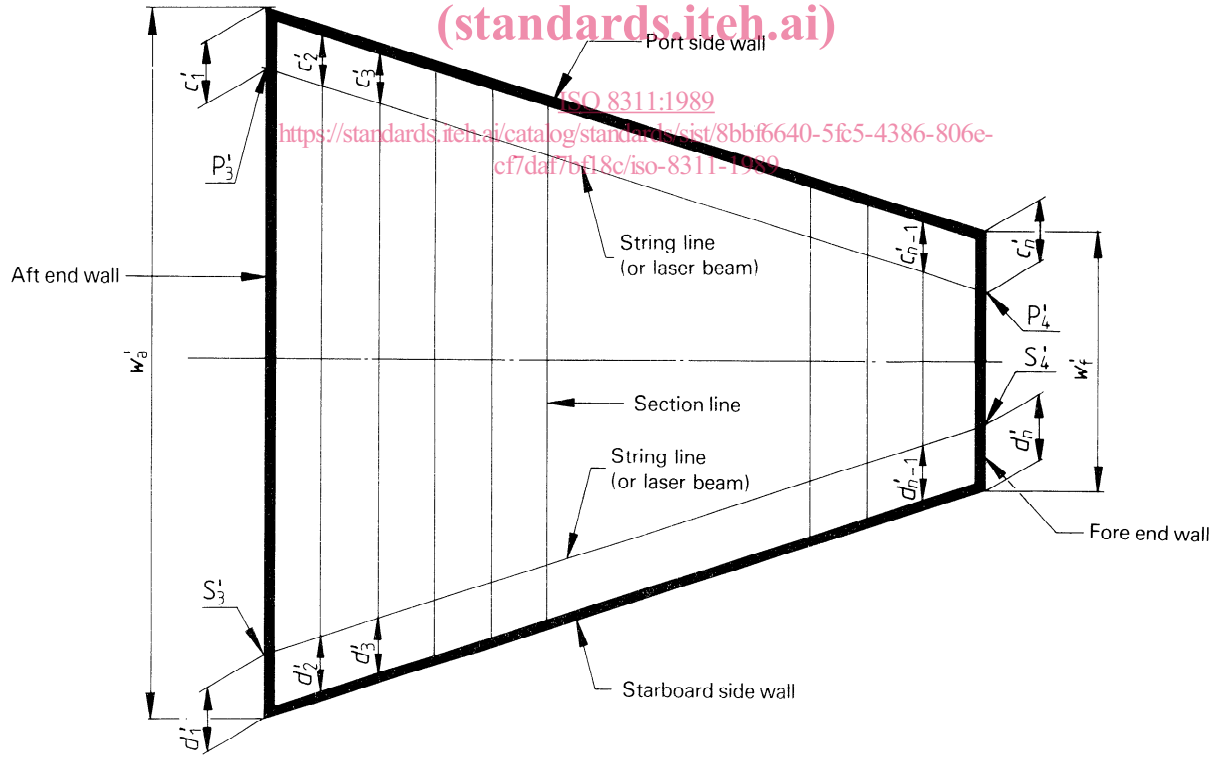

Figure 3 — Plan view of an intermediate horizontal plane (trapezoidal tank)