

Calibration of spherical tanks for refrigerated light-hydrocarbon fluids in ships —

Part 2: Triangulation method

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Petroleum Standards Policy Committee (PTC/-) to Technical Committee PTC/12, upon which the following bodies were represented:

- Department of Trade and Industry (Gas and Oil Measurement Branch)
- Department of Trade and Industry (National Engineering Laboratory)
- Institute of Petroleum
- Royal Institution of Naval Architects
- Salvage Association

The following body was also represented in the drafting of the standard, through sub-committees and panels:

- Society of International Gas Tanker and Terminal Operators Ltd.

This British Standard, having been prepared under the direction of the Petroleum Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 15 May 1993

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National foreword

This Part of BS 7550 has been prepared under the direction of the Petroleum Standards Policy Committee. It is identical with ISO 9091-2:1992 *Refrigerated light hydrocarbon fluids — Calibration of spherical tanks in ships — Part 2: Triangulation measurement*, published by the International Organization for Standardization (ISO). ISO 9091-2 was prepared by Subcommittee 5, Measurement of light hydrocarbon fluids, of Technical Committee 28, Petroleum products and lubricants, in which the United Kingdom participated.

BS 7550 consists of the following Parts:

- *Part 1: Method of stereo-photogrammetry;*
- *Part 2: Triangulation method.*

Part 1 is identical with ISO 9091-1:1991.

Cross-reference

International Standard	Corresponding British Standard
ISO 8311:1989	BS 7627:1993 <i>Method for calibration by physical measurement of membrane tanks and prismatic tanks in ships for carriage of refrigerated light-hydrocarbon fluids</i> (Identical)

CAUTION. Attention is drawn to the Health and Safety at Work etc. Act 1974, and the need for ensuring that the method specified in this Part of BS 7550 is carried out with suitable precautions.

The procedure described in this Part of BS 7550 is intended to be carried out by appropriately qualified and experienced persons or other suitably trained and/or supervised personnel. Normal safety precautions should be observed throughout the use of the method. Attention is drawn to the additional safety precautions given in Annex A.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 20, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Introduction

Large quantities of light hydrocarbons consisting of compounds having one to four 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 by sea requires special technology in ship design and construction to enable such 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. The two parts of this International Standard, together with other standards in the series, specify methods of internal measurement of ships' tanks from which tank calibration tables can be derived.

For internal measurement, methods of liquid calibration, physical measurement, optical measurement and stereo-photogrammetry, etc. are in general use. Liquid calibration cannot be used for large spherical tanks designed to operate at near atmospheric pressure with refrigerated light hydrocarbons because the hydrostatic pressure exerted by the calibrating liquid may exceed the design pressure when filled higher than a certain level. This part of ISO 9091 covers a calibration technique applicable to spherical tanks equipped with a central pipe/instrumentation column.

1 Scope

1.1 This part of ISO 9091 specifies a triangulation method for the internal measurement of spherical tanks in liquefied gas carriers.

1.2 This part of ISO 9091 also sets out the calculation procedures for compiling the calibration tables to be used for the measurement of cargo quantities.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 9091. 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 9091 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:—, *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 1: Strapping method*¹⁾.

ISO 8311:1989, *Refrigerated light hydrocarbon fluids — Calibration of membrane tanks and independent prismatic tanks in ships — Physical measurement*.

3 Definitions

For the purposes of this part of ISO 9091, the following definitions apply.

3.1

base point

centre point of the theodolite set above the traverse point

3.2

basic pentagon

pentagon connecting base points

3.3

basic target

portable target mounted on a tripod with a tribrach

3.4

benchmark

point on which a staff is erected to determine the height of the theodolite above the south pole

3.5

calibration

process of determining the total capacity or partial capacities of a tank corresponding to different levels

3.6

calibration table; main gauge 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 the gauge reference point, with the ship on an even keel and upright

3.7

datum point

position used as the datum in the preparation of a calibration table

NOTE 1 This position may differ from the gauge reference point.

3.8 deadwood

Any tank fitting which affects the capacity of a tank.

3.8.1

positive deadwood

fitting whose capacity adds to the effective capacity of the tank

¹⁾ To be published.

3.8.2
negative deadwood

fitting whose volume displaces liquid and reduces the effective capacity

3.9
equator

largest horizontal circumference of a spherical tank

3.10
gauge reference point

point from which the liquid depth is measured

3.11
latitude

horizontal circumferences on the surface of the sphere parallel to the equator

3.12
longitude

vertical circumferences on the surface of the sphere passing through the north and south poles

3.13
list

transverse inclination of a ship

3.14
north pole

zenith, or highest point, of a spherical tank shell, an imaginary point in most spherical tanks due to the pipe tower or other appurtenances

3.15
pipe tower

large-diameter pipe coaxial with the tank's north-south axis, containing pipes for loading and discharging, measuring instrumentation, ladder, wiring and other in-tank facilities

3.16
port

left-hand side of a ship facing forward

3.17
south pole

nadir, or lowest point, of a spherical tank

3.18
starboard

right-hand side of a ship facing forward

3.19
target

position distinctively marked on the inside surface of the tank for the triangulation method (see 6.1)

3.20
traverse point

position on the inside surface of the tank above which a theodolite is set for determining the coordinates of a target

3.21
trim

longitudinal inclination of a ship

4 Precautions during measurement

4.1 Utmost care and attention shall be exercised in taking measurements and anything unusual occurring during the measurement which might affect the results shall be recorded. The calibration method described in this part of ISO 9091 may be applied to ships whether afloat or in dry-dock. However, its use in dry-dock may be preferable, because trim or list, if any, will remain the same throughout the measurement.

4.2 If any unusual distortions are found in the tank shell, additional measurements shall be taken by the calibrator to obtain sufficient data for correct calculation in the calibration table, and the calibrator's notes should be provided in connection with such extra measurements.

4.3 Duplicate measurements of angles shall be taken to check whether they agree within 16 s, and if they do not agree, measurement shall be continued until two consecutive readings agree. The average of the two shall be recorded.

If consecutive measurements do not agree, the reason for the disagreement shall be clarified and, if necessary, the entire calibration procedure shall be repeated.

If the measurement has been interrupted, the last angle measurement taken should be repeated. If the new angle values do not agree, within the required tolerance of 16 s, with the earlier measurements, then the earlier set should be rejected.

4.4 Measurement shall be carried out when the temperature fluctuation of the wall is limited to the minimum.

NOTE 2 Temperature fluctuations should be checked during measurement procedures.

4.5 Measurements shall not be carried out when there is any motion of the ship, or vibration of the tank.

If calibration is carried out before installation of the tank in the hull of the ship, the distance between predetermined points on the interior of the tank shall be measured after installation to ensure that no distortion of the tank has occurred. If distortion has occurred, the calibration shall be repeated.

4.6 The paint used to mark the targets shall be manufactured from materials which are resistant to liquids at cryogenic temperatures.

5 Equipment

5.1 Basic target

A target mounted on a tribrach indicating a base point.

5.2 End-to-end rule

A rule graduated in centimetres and millimetres, to be used to measure deadwood, etc. The rule should bear the identification of a recognized standardizing authority or certificate of identification.

5.3 Measuring tape

A tape bearing the identification of a recognized standardizing authority or a certificate of identification.

5.4 Optical level

An optical level having an erect image, a magnification of $\times 20$ or greater, capable of being focussed to 1,5 m or less and with a spirit-level sensitivity of 40 s per 2 mm or less.

5.5 Staff

A scale graduated in millimetres to be erected on a benchmark.

5.6 Steel rule

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

5.7 Subtense bar

A subtense bar having a length greater than 5 % of the distance between the base points with a length uncertainty of less than 0,01 % of its length.

5.8 Surface thermometer

A thermometer used to measure the temperature of the surface of the tank with an accuracy of $\pm 0,5^\circ\text{C}$ in order to convert the coordinates of the targets at the temperature at the time of measurement to those at the certified reference temperature.

5.9 Theodolite

A theodolite, recommended to have an erect image with a minimum circular reading of 1 s and a spirit plate level sensitivity of 20 s per 2 mm or less.

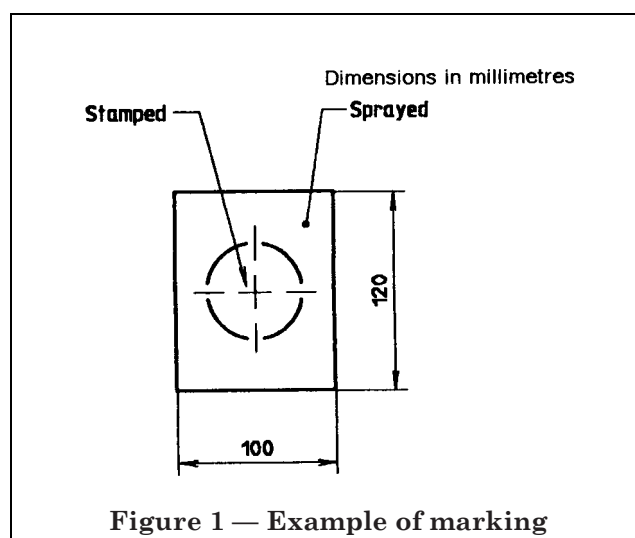
5.10 Tribrach

A levelling platform, mounted on the tripod, with three levelling screws and a clamping device to fasten the theodolite.

6 Preparation

6.1 Marking of targets

During construction of the tank and prior to the installation of the pipe tower, targets (see Figure 1) shall be stencilled on the inside surface of the tank shell at each intersection of latitude and longitude at 20° intervals. The marking error shall be less than 10 mm in both vertical and horizontal directions.



6.2 Basic pentagon

6.2.1 Determination of traverse points

Mark five traverse points so that each target can be measured from at least four traverse points without being obstructed by the pipe tower.

6.3 Marking of benchmark

Mark the benchmark at an arbitrary position near the south pole of the tank (see Figure 2).

6.4 Set-up of measuring instruments (see Figure 2)

6.4.1 Set staffs upright on the benchmark and on the south pole of the tank.

6.4.2 Set up a level (for the basic target) using a tripod and tribrach, on an arbitrary point at which the staff on the south pole can be observed through the opening of the pipe tower (see Figure 3).

6.4.3 Set up a levelled tribrach (for the base point) on a tripod at each of five traverse points (see Figure 4).

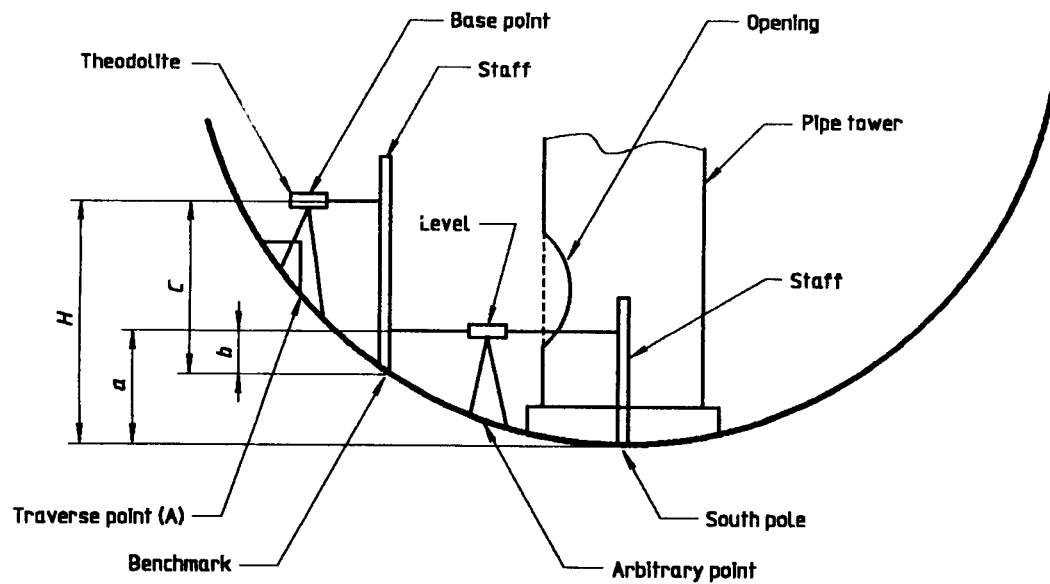


Figure 2 — Set-up of instruments for determining the height of the base point

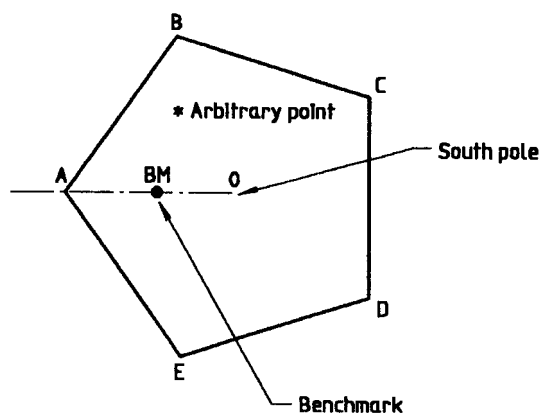


Figure 3 — Location of benchmarks and target