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Refrigerated light-hydrocarbon fluids — Calibration of spherical tanks in ships —

Part 1: Stereo-photogrammetry

*Hydrocarbures légers réfrigérés — Jaugeage des réservoirs sphériques
à bord des navires —*

Partie 1: Stéréo-photogrammétrie



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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 9091-1 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Sub-Committee SC 5, *Measurement of light hydrocarbon fluids*.

ISO 9091 consists of the following parts, under the general title *Refrigerated light-hydrocarbon fluids — Calibration of spherical tanks in ships*:

- *Part 1: Stereo-photogrammetry*
- *Part 2: Triangulation measurement*

Annexes A, B, C, D, E and F of this part of ISO 9091 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. The 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. 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, liquid calibration, physical measurement, optical measurement and stereo-photogrammetry 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. In view of its accuracy, the last-mentioned should be adopted as the referee method if calibration by another method is in doubt. Stereo-photogrammetry consists mainly of photographing targets on the tank wall and the analytical processing of the photographs in the laboratory.

This part of ISO 9091 specifically describes the method using a universal metric camera for the photographing and an analytical stereoplotter for the analysis.

Refrigerated light-hydrocarbon fluids — Calibration of spherical tanks in ships —

Part 1: Stereo-photogrammetry

1 Scope

1.1 This part of ISO 9091 describes a stereo-photogrammetric procedure for the internal measurement of spherical tanks in liquefied-gas carriers.

1.2 In addition to the actual process of measurement, this part of ISO 9091 also sets out the calculation procedures for compiling the calibration tables.

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 7078:1985, *Building construction — Procedures for setting out, measurement and surveying — Vocabulary and guidance notes*.

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 absolute orientation: The procedure of final correction of the stereoscopic models formed by inner and relative orientations, in which the scale in the stereoscopic model is converted to the actual length and the inclination of the model is adjusted to the actual condition of the tank.

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

3.3 calibration table (main gauge table): A 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.

3.4 datum point: The south pole to which the tank table is referred.

3.5 deadwood: Any tank fitting which affects the capacity of a 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.

3.6 equator: The largest horizontal circumference of a spherical shell.

3.7 floating mark: A mark seemingly occupying a position in the three-dimensional space formed by stereoscopic fusion of a pair of photographs and used as a reference mark in examining or measuring the stereoscopic model.

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

NOTE 1 In spherical tanks, this point may be either the zero of the level gauge or the south pole of the tank.

3.9 Inner orientation: The process of determining, mathematically, the interior perspective of the photographs at the time of exposure in an analytical stereoplotter. The calibrated focal length, the location of the calibrated principal point and the calibrated lens distortion are the principal factors used in the calculation.

3.10 list: Transverse inclination of a ship.

3.11 north pole: The zenith, or highest point, of a spherical tank shell (an imaginary point in most spherical tanks due to the pipe tower or other appurtenances).

3.12 pipe tower: A large-diameter pipe coaxial with the tank's north-south axis, containing pipes for loading and discharging, measuring instrumentation, the ladder, wiring and other in-tank facilities designed to protect them from the effect of sloshing of the tank contents.

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

3.14 relative orientation: The process of determining the relative position and attitude of a pair of overlapping photographs by mathematical analysis to create a stereoscopic model.

3.15 south pole: The nadir, or lowest point, of a spherical shell.

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

3.17 stereoscopic model: Three-dimensional model formed by intersecting homologous rays of a pair of overlapping photographs.

3.18 stereoscopic photograph: A set of photographs of an object taken from two different positions so that they may form a stereoscopic model of the object depicting it as if it were in three-dimensional space.

3.19 targets: Predetermined positions distinctively marked on the inside surface of the tank for the stereo-photogrammetry.

3.20 trim: Longitudinal inclination of a ship.

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 during photographing, and any unusual occurrence during the measurement or photographing which might affect the results obtained shall be recorded. The calibration method described in this part of ISO 9091 may be applied to ships whether afloat or in a dry dock. However, its use in a dry dock may be preferable, because trim or list, if any, will remain the same throughout the measurement. Keep trim and list of the ship unchanged while an optical level or any other levelling device is being used.

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

4.3 Measurements shall be taken in duplicate without interruption, and if they do not agree within the following tolerances, measurements shall be continued until two consecutive readings in duplicate agree within the specified tolerance:

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

4.4 The reference scale shall have a damping device at its bottom and shall not be touched whilst taking photographs.

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

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

4.7 Measurements in the analytical instrument shall be independently taken twice to check whether they agree within 0,01 mm on the scale of a negative or positive film and, if they do not agree, measurements shall be continued until two consecutive readings agree within 0,01 mm.

4.8 The targets shall be photographed when the tank is isothermal, either after dark or after the tank has been insulated.