

INTERNATIONAL
RECOMMENDATION

OIML R 95

Edition 1990 (E)

Ships' tank - General requirements

Bateaux-citernes - Prescriptions générales



Foreword

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States.

The two main categories of OIML publications are:

- **International Recommendations (OIML R)**, which are model regulations that establish the metrological characteristics required of certain measuring instruments and which specify methods and equipment for checking their conformity; the OIML Member States shall implement these Recommendations to the greatest possible extent;
- **International Documents (OIML D)**, which are informative in nature and intended to improve the work of the metrological services.

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International Recommendations and International Documents are published in French (F) and English (E) and are subject to periodic revision.

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TERMINOLOGY

For the purposes of this Recommendation, the following definitions apply.

1. Nominal capacity of a tank
The volume of liquid the tank contains under rated operating conditions, at reference temperature.
2. Total capacity
The maximum volume of liquid the tank may contain up to overflowing under rated operating conditions, at reference temperature.
3. Gauge hatch
An opening in the upper part of the tank to allow the height of the liquid level in the tank to be measured.
4. Vertical measurement axis
The vertical line through the position that will be used for manual or automatic measurement; it passes through the guiding device, if provided.
5. Dipping datum point
The intersection of the vertical measurement axis with the upper surface of the dip plate, or with the bottom surface of the tank if a dip plate is not provided. It constitutes the origin for the measurement of liquid levels (zero reference for innage height).
6. Upper reference point
The point on the vertical measurement axis, with reference to which the ullage height is measured.
7. Ullage height
The distance between the free surface of the liquid and the upper reference point, measured along the vertical measurement axis.
8. Innage height
The distance between the dipping datum point and the free surface of the liquid, measured along the vertical measurement axis.
9. Reference height, H
The distance between the dipping datum point and the upper reference point, measured along the vertical measurement axis.
10. Deadwood
The fittings of a tank and parts of the structure of the ship inside the tank, the volume of which must be added to or subtracted from the capacity of the tank in order to obtain the volume of liquid contained, when using the geometric method of calibration.
11. Calibration
A set of operations to determine the capacities of a tank at various filling levels.
12. Calibration table
The expression, in the form of a table, of the mathematical function $V(h)$ that represents the relation between the height h (independent variable) and the volume V (dependent variable) when the ship is on an even keel and has no list.
13. Graduated zone
The range of volumes between the dead stock and the total capacity.
14. Dead stock
The volume of the liquid contained in the bottom of the tank up to the dipping datum point, when the ship is on an even keel and has no list.

SHIPS' TANKS

GENERAL REQUIREMENTS

1. General

1.1. This Recommendation deals with ships' tanks used either for the transport and measurement of liquid products in bulk, or for the storage and measurement of the fuel oil used by the ship herself, that are subject to the control of the National Service of Legal Metrology.

Note: Ships used expressly for the transport of liquid products in bulk are normally known as "tankers".

1.2. The measurement of the quantities of liquids transported by a tanker is a complex operation and is generally less accurate than the measurement of liquid quantities in land-based tanks (see Annex 1).

1.3. This Recommendation lays down general requirements for tankers containing quantities subject to legal measurement. It applies to measurements made in wholesale transactions. When, in a particular country, barges and lighters are used for the reception and delivery of part loads and for their measurement, the additional errors that may then occur shall be taken into consideration. It is possible, in such cases, to specify a "minimum measurable height" (usually 500 mm) or a "minimum measurable volume", which shall then be mentioned in the calibration certificate.

2. Classification and description

2.1. Tanks may be classified according to the following characteristics:

- capacity,
- shape,
- use.

The shape of a tank may be:

- regular (or almost regular),
- irregular.

The tanks of regular shape are those of which the dimensions do not vary greatly in the horizontal and vertical cross-sections.

2.2. Maritime authorities have detailed requirements for the construction and inspection after completion of a tanker; the sketches in Figure 1 are given for information only.

In general, tanks are numbered fore-to-aft, with the qualifications "port" (P), "starboard" (S) or "centre" (C). If, in a particular country, a reverse order is adopted for some categories of ships, this fact shall be mentioned in the calibration report.

2.3. The ullage height and the innage height shall be measured along the vertical measurement axis by means of graduated dipsticks of suitable length or by means of diptapes or other devices.

The length measures shall have a scale interval of 1 mm and shall be of accuracy class I, according to OIML Recommendation R 35.

Automatic level gauges shall comply with the relevant requirements of OIML Recommendation R 85.

3. Units of measurement

The authorized units of measurement are those of the International System of Units, SI.

If, in any particular country, units of measurement other than SI are authorized, the legal units of measurement of that country may be used. In international trade the officially agreed equivalents between these units of measurement and those of SI shall be applied.

4. Technical and metrological characteristics

4.1. Tanks and their associated pipework should be constructed and arranged so that under the normal conditions of operation of the ship they can be easily and completely drained or filled without air pockets becoming trapped below the level of filling, thus corrupting the measurement of volume.

If exceptions are allowed, or if any precautions have to be taken to ensure correct measurement, they shall be mentioned in the calibration certificate.

4.2. The vertical measurement axis should pass, as a general rule, approximately through the centres of area of the horizontal cross-sections of the tank within the range in which the level of the free surface of the liquid may occur when measurements are made under the normal conditions of use.

If the above condition is not met because of the construction characteristics of the tank, one of the two following solutions shall be adopted:

- the calibration certificate shall indicate that the level of the liquid in the tank shall be determined only when the vessel has zero trim and list,
- corrections, corresponding to the different angles for trim and list, shall be applied for each tank.

4.3. If the tank is provided with a guiding device the latter's construction shall cause no systematic errors of measurement.

4.4. If the vertical measurement axis intersects the sloping side of the tank, a permanent horizontal dip plate shall be fitted at the dipping datum point. In all other cases a permanent horizontal dip plate may be located at the dipping datum point.

4.5. Every precaution shall be taken to ensure that the positions of the dipping datum point and of the upper reference point, in relation to the tank, remain practically unchanged. If this condition is not met, means shall be provided to measure the displacement of the ullage reference point from its nominal position, and this displacement shall be taken into consideration.

4.6. Tanks shall meet the technical conditions relating to the fitting and use of the equipment with which they are provided for measuring levels of liquid.

4.7. Tankers may be provided with:

- their own pumping installations,
- their own metering systems.

These installations shall comply with the requirements in point 4.1 of this Recommendation.

The metering systems shall be submitted separately to metrological control in accordance with the relevant OIML Recommendations ^(*).

4.8. Tanks shall be calibrated in such a manner and with instruments of such an accuracy that the relative errors of the volumes stated in the documents issued do not exceed:

- a) in general, plus or minus 0.3 % of the stated volume,
- b) exceptionally, plus or minus 0.5 % of the stated volume for tanks of irregular shape that cannot be calibrated using the volumetric method.

4.9. The calibration certificate shall indicate the maximum relative error that may arise when the tanks are used to measure the volumes of the liquids they contain, taking into account:

- a) the uncertainty of determination of the volumes indicated in the table, and
- b) the accuracy of the instrument used to determine the position of the free surface of the liquid in the tank.

Where point 4.8.a) applies the relative error in the use of the tanks shall not exceed plus or minus 0.5 % of the volume indicated in the table, and, where point 4.8.b) applies it shall not exceed plus or minus 0.8 % of that volume.

4.10. A calibration data plate shall be fixed on each tank near the gauge hatch. It shall bear the following markings:

- a) number of the tank,
- b) reference height H,
- c) number of the calibration certificate.

The plate shall be made of a material that is durable under normal conditions of use.

The characters shall be at least 4 mm high, easily visible and practically indelible.

The plate shall be fixed so that it cannot be removed without the seals bearing the marks of the Legal Metrology Service becoming damaged.

4.11. When presented for metrological control the tank shall be clean, dry, ventilated and free from toxic material (e.g. lead residues).

5. Legal qualification

5.1. When, in a particular country, ships' tanks are subject to the control of the Legal Metrology Service, the following operations may be required:

- approval of the drawings showing the metrological characteristics of the tanks,

^(*) At the time of printing of this Recommendation these are OIML Recommendations R 5, R 27, R 57, R 67 and R 77.

- initial verification,
- periodic verification.

These operations are performed by, or under the control of, the national metrological authorities.

5.2. In order to obtain approval of the drawings the manufacturer shall provide the competent authorities with drawings showing:

- a general assembly of the tanks,
- the positions of pipework for filling and emptying,
- the positions and dimensions of deadwood,
- details of the mounting of the devices for gauging the levels of the liquids in the tanks,
- the positions of the calibration data plates,
- the layout of the metering system and its main characteristics, if appropriate,
- the layout of the pumping circuit, if appropriate.

5.3. Initial verification comprises:

- examination of general appearance, and checking against drawings, of the:

pipework	point 4.1
vertical measurement axis	point 4.2
guiding device	point 4.3
dip plate	point 4.4
upper reference and dipping datum points	point 4.5
level gauging device	point 4.6
ancillary devices	point 4.7
calibration data plate	point 4.10
cleanliness of the tanks	point 4.11

- calibration.

5.4. Tanks are periodically verified at the end of the period of validity of the certificate. This period is fixed by the national metrology authorities; a period of 10 to 12 years is recommended. It is advisable to take advantage of the periodic refits of the ship for recalibrating the tanks.

The calibration certificate and the calibration table, as well as the sealing marks, are no longer valid when the tank has been subjected to deformation, repair or modification of such a nature that its metrological characteristics are modified.

Periodic verification is performed in the same way as initial verification (point 5.3).

5.5. Calibration of tanks

Tanks may be calibrated by one of the following methods:

- volumetric (liquid method),
- geometric (measurement method),
- a combination of the two.

The choice of the method or the procedure is determined by the capacities, the shapes, the positions, etc., of the tanks.

A list of ISO Standards and Draft Standards for various calibration methods is given in Annex 2.

5.5.1. The volumetric method consists of establishing directly the internal volume by the transfer of volumes of water or other suitable liquid to or from proving tanks or by means of metering systems specially calibrated for this purpose. The ship shall remain on an even keel and without list throughout calibration.

5.5.2. The geometric method consists of determining the volumes by calculation from the measured internal dimensions of the tank.

Tanks may be calibrated geometrically by:

- the classical method, by means of tape measures,
- an optical method.

5.5.3. The calibration operations include:

- measurement of the tank,
- calculation and interpretation of results,
- establishment of the calibration table.

The volumes indicated in tank calibration tables should be exclusive of pipeline volumes. If pipeline volumes are included in a calibration table, the calibration certificate shall include a statement to that effect.

5.5.3.1. The technical requirements concerning safety at work shall be complied with when measurements are made.

5.5.3.2. Values of volume shall be given in calibration tables to at least four significant figures, except, possibly, for volumes that are less than 1 000 times the unit used for the table.

5.5.3.3. In addition to volume tables with intervals of one centimetre or decimetre, a millimetre interpolation table may be provided.

5.6. Issue of calibration records and application of verification mark

5.6.1. Tanks that comply with the requirements of this Recommendation shall be accepted for verification and, when they have been calibrated, the records shall be issued and the markings on the calibration data plate shall be completed.

5.6.2. The calibration records include:

- the calibration certificate (technical and administrative data),
- a diagram showing the positions of tanks — see point 5.6.2.2,
- a diagram showing cross sections — see point 5.6.2.3,
- a diagram showing heaters and sumps, if appropriate — see point 5.6.2.4,
- the calibration table — see Annex 3,
- additional details concerning the automatic level gauges (location, corrections, etc.), if appropriate,
- volume correction table or formulas for trim and list, if appropriate,
- volume correction table or formulas for temperatures other than the reference temperature (i.e. 20 °C, 15 °C or 60 °F) in relation to the expansion coefficient of the metallic shell, as appropriate.

The calibration records may also include:

- a table giving for each tank the position of the centre of gravity of the product, depending on the filling level (innage),
- a table giving for each tank the moment of inertia of the free surface of liquid, depending on the filling level (innage).

These tables may be used to determine the stability of the ship.

5.6.2.1. The calibration certificate proper includes:

- the name and address of the competent authority issuing the certificate,
- the name and qualification of the inspector,
- the serial number of the certificate (which is reproduced on all other documents and on the calibration data plates),
- the date of issue of the certificate and the place of employment of the inspector,
- the identity of the ship (name, registration number, name and address of owner and year of construction),
- the method of calibration and a reference to the standard on which calibration was based (for instance ISO Standard),
- a list of attached documents, showing their nature,
- the limiting date of the certificate's validity,
- the identification of tanks provided with drainage sumps or heaters,
- the total capacity,
- the accuracy of the results given in the tables,
- the maximum error in the use of the tanks for determining the quantity of the liquid that they contain (with a mention of the minimum measurable heights or of the minimum measurable volumes, if appropriate — see point 1.3),
- a statement concerning pipeline volumes, if appropriate,
- the number and the locations of verification seals and stamps.

5.6.2.2. A drawing shall indicate the position of the tanks in the vessel and, for each tank, the reference height H, the total capacity, the position of the vertical measurement axis and its position in relation to the forward bulkhead of the tank and to the longitudinal bulkhead or plane.

5.6.2.3. A drawing shall give a schematic transverse cross-section of each tank showing, in particular, the radius of the bilge, the camber, the height of the trunk and the method of construction of the guiding device.

5.6.2.4. A drawing shall indicate the volume taken up by heaters and/or drainage sumps, for vessels having these heaters or sumps inside the tanks, and the volume of liquid that can be contained in the sumps between the sluice-valves.

5.6.2.5. For each tank, a calibration table with intervals of one centimetre or one decimetre shall be provided, with an indication of the reference height H and the limiting date of the certificate's validity and, if appropriate, a millimetre interpolation table, correction tables and the value of the reference temperature.

5.6.3. If provided for by national regulations, the legality of verification shall be certified by placing a verification mark:

- on each document forming part of the calibration records,
- on the calibration data plate,
- in a suitable place that serves to identify the upper reference point, if necessary.

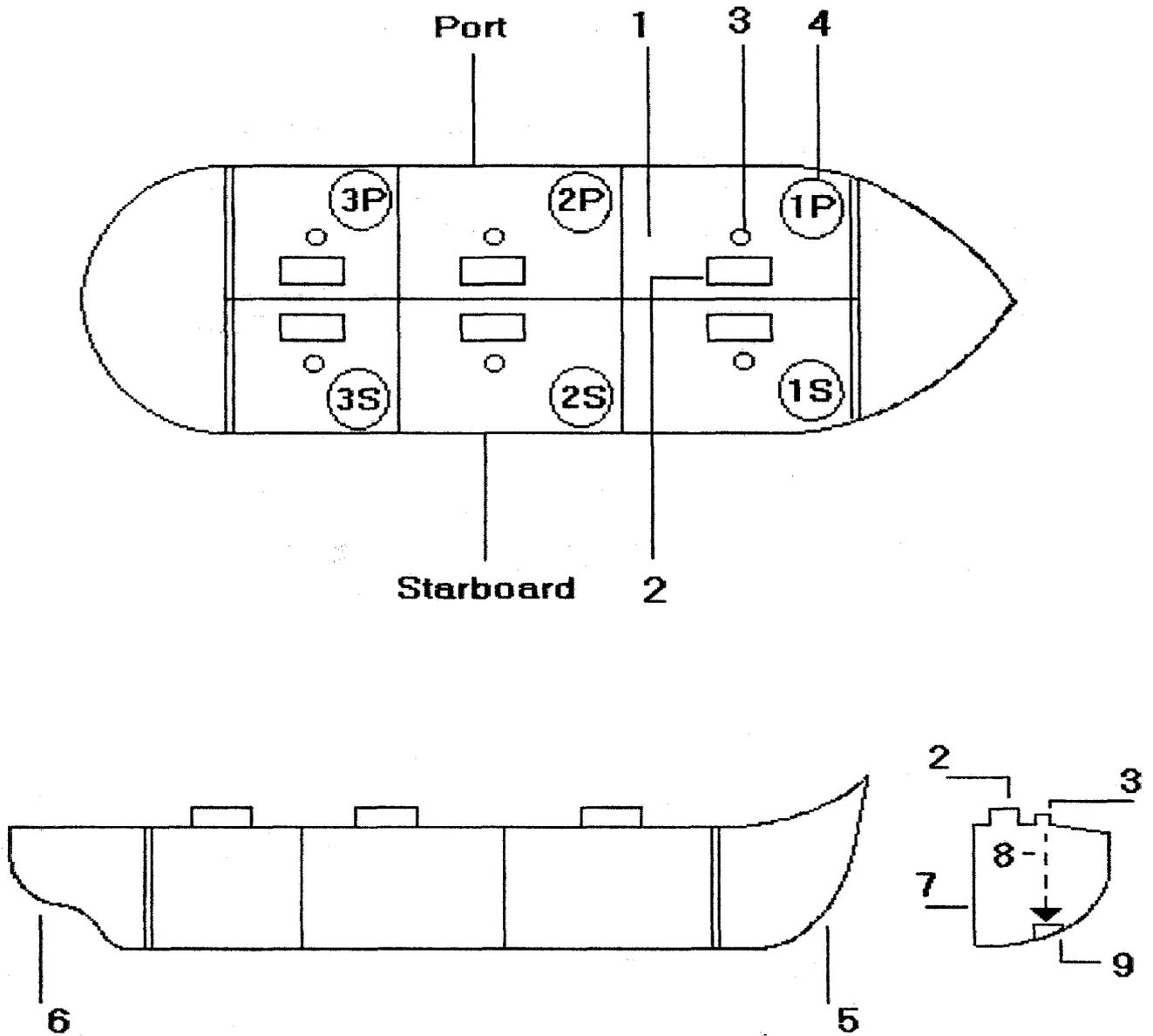


Figure 1

1. tank (compartment)
2. trunk inspection door
3. gauge hatch
4. number of the tank (compartment)
5. forward end (bow)
6. after end (stern)
7. longitudinal bulkhead
8. vertical measurement axis
9. dipping datum point

ANNEX 1

BRIEF REVIEW OF THE METHOD OF MEASUREMENT OF VOLUMES OR QUANTITIES OF LIQUIDS TRANSPORTED IN SHIPS' TANKS

1. The operations to determine the volumes or quantities of liquids in ships' tanks are the same as those for shore tanks (fixed storage tanks).

The following operations are necessary:

- a) measurement of the height of the level of the free surface of the liquid, from which, using the calibration table, the capacity C_{t_0} of the tank at reference temperature t_0 , up to this level, is determined,
- b) measurement of the mean temperature t_c , of the product in the tank,
- c) calculation of the capacity of the tank, at temperature t_c , and thus of the volume of liquid contained, V_{t_c} , at that temperature, using the formula:

$$V_{t_c} = C_{t_0} [1 + \beta (t_c - t_0)]$$

where β is the cubic coefficient of thermal expansion of the material of which the tank is built,

- d) taking of samples and preparing an average sample that represents the product contained in the tank; the density ρ_{t_1} of the product, at a temperature t_1 very close to t_c , is then determined in the laboratory,
- e) determination of the density ρ_{t_c} from ρ_{t_1} by calculation or using tables,
- f) calculation of the mass of the product using the formula:

$$M = V_{t_c} \times \rho_{t_c}$$

The operations d) and e) may be replaced by the determination of the volume V_{t_0} and the density ρ_{t_0} of the liquid at a reference temperature t_0 by calculation or using tables, and then:

$$M = V_{t_0} \times \rho_{t_0}$$

- g) if appropriate, application of corrections for:
 - the layer of water at the bottom of the tank,
 - the quantity of water in suspension,
 - the quantity of solid impurities in suspension.

Note: The error specified in point 4.9 of this Recommendation applies to the value V_{t_c} . In order to obtain the error in the determination of the mass of the product, the error in determining of the density ρ_{t_1} , and possibly the errors applying to the calculation of V_{t_0} and ρ_{t_0} , shall be added.

2. All these operations result in an increased uncertainty of measurement of the quantities of liquids in ships' tanks. It is recommended that the level (ullage or innage) be measured several times successively to reduce the resulting uncertainty.

3. The measurement of the quantities of liquids in ships' tanks is not an aim in itself; the final aim is a commercial transaction. The transported liquids are discharged at the port of destination and new phenomena occur:
 - losses due to evaporation,
 - quantities of the liquid remaining on board after discharge.

There is a risk of additional errors arising from partial loading or emptying of tanks (see point 1.3).

4. According to local customs, commercial transactions may be based either on the mass of the liquid or on the result of its weighing in air. For the relation between these two values, as regards petroleum products, see OIML Recommendation R 63, which refers to ISO Standard 91-1: 1982 (API Volume XII), and DIS 91-2 (API Volume XII).

ANNEX 2

ISO DOCUMENTS CONCERNING THE MEASUREMENT OF HYDROCARBON PRODUCTS IN SHIPS' TANKS^(*)

DIS 6578	Refrigerated hydrocarbon liquids — Static measurement — Calculation procedure
DP 7394	Natural gas liquids and vapors — Conversion to equivalent liquid volumes
ISO 8311	Refrigerated light hydrocarbon fluids — Calibration of membrane tanks and independent prismatic tanks in ships – Physical measurement
DP 8309	Refrigerated light hydrocarbon fluids — Measurement of liquid levels in tanks containing liquefied gases in bulk — Electrical capacitance gauges
DP 8310	Refrigerated light hydrocarbon fluids — Measurement of temperature in tanks containing liquefied gases — Thermocouple and resistance thermometers
TC 28/SC 5 WI 2-148 DOC n 44	Refrigerated light hydrocarbon fluids — Measurement of liquid level in tanks carrying liquefied gases in bulk — Float type level gauges
DP 9091/1	Refrigerated light hydrocarbon fluids — Calibration of spherical tanks in ships — Part 1: Stereo-photogrammetry
DP 9091/2	Refrigerated light hydrocarbon fluids — Calibration of spherical tanks in ships — Part 2: Triangulation method
ISO/TR 8338	Crude petroleum oil — Transfer accountability — Method for estimation on ships of total quantity remaining on board (ROB)
DP 8697	Crude petroleum oil — Transfer accountability — Method for estimation on ships of total on board quantity

^(*) Following 1990 ISO Catalogue and Annual Report of ISO/TC28 for 1989.

ANNEX 3
EXAMPLE OF CALIBRATION TABLE

Competent authority:

Limit of validity:

Inspector:

Appendix to calibration Certificate No.

“.....”

(type and designation of the vessel)

Tank No.

Table giving the volume in cubic decimetres (litres, cubic metres) of the liquid in the tank as a function of height, in centimetres, of the level of that liquid above the dip point, measured along the vertical measurement axis as indicated on the drawings No's

Total capacity:

Reference height H:

Height		Volume dm ³									
m	cm										
0	00		0	50		1	00		1	50	
	01			51			01			51	
	02			52			02			52	
	03			53			03			53	
	04			54			04			54	
	05			55			05			55	
	06			56			06			56	
	
	

(Layout of table with volumes in columns)

Height		Volumes in dm ³ corresponding to height in centimetres									
m	dm	0	1	2	3	4	5	6	7	8	9
0	0										
	1										
	2										
	3										
	4										
	5										
	6										
	.										

(Layout of a table with double-entry reading)

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