

INTERNATIONAL
RECOMMENDATION

OIML R 80

Edition 1989 (E)

Road and rail tankers

Camions et wagons-citernes



Foreword

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TERMINOLOGY

The terminology used in this Recommendation conforms to the " International Vocabulary of basic and general terms in metrology " (1984 edition) and the " Vocabulary of legal metrology" (1978 edition). In addition, for the purposes of this Recommendation, the following definitions apply.

1. Nominal capacity (of a road or rail tanker)

The volume of liquid which a tank contains under rated operating conditions, at reference temperature.

2. Total contents

The maximum volume of liquid which a tank may contain up to overflowing, under rated operating conditions, at reference temperature.

3. Expansion volume

The difference between total contents and nominal capacity.

4. Calibration

The set of operations to determine the capacity of a tank, at one or several filling levels, whether marked or not.

5. Vertical measurement axis

The vertical line on which the levels of liquid are gauged.

Note : When the levels are measured by means of a sight glass and graduated rule, the vertical measurement axis passes virtually through the centre of the dome.

6. Reference point (P)

A point on the vertical measurement axis, with reference to which the ullage height is measured.

7. Reference height (H)

The distance, measured along the vertical measurement axis, between the reference point and the foot of the vertical measurement axis, on the inner surface of the tank, or on the dip plate.

8. Sensitivity of a tank in the vicinity of a filling level h

The change in the level, Δh , divided by the corresponding relative change in volume, $\frac{\Delta V}{V}$ for the contained volume V corresponding to the level h.

9. Ullage height (C)

The distance between the free surface of the liquid and the reference point, measured along the vertical measurement axis.

10. Calibration table

The expression, in the form of a table, of the mathematical function V(h) [resp. V(C)] representing the relation between the height h [resp. ullage height C] (independent variable) and the volume V (dependent variable).

ROAD and RAIL TANKERS

1. General

1.1. This Recommendation concerns tankers for the transport by rail or road of liquid products and used (in addition to their functions as carriers), as measuring instruments subject to national metrological controls, and tankers whose effective volumes must be known in order to determine their maximum permissible filling loads for reasons of transport safety.

1.2. A mobile tanker to be considered as a volume-measuring instrument shall comply with the requirements of point 4 of this Recommendation.

Note : The value of the nominal capacity of a tank cannot be used directly in official operations (commercial transactions), as the volume of the contained product varies with temperature (see Annex 1).

1.3. Tankers may be considered as measuring instruments for liquids of which the viscosity does not exceed $17 \text{ mPa} \cdot \text{s}$ at measurement temperature.

1.4. The verification methods and equipment described in this Recommendation are examples. In practice, other verification methods and equipment may be used, provided that they give results of equal accuracy.

2. Classification and description

2.1. Road tankers

2.1.1. Tankers may be classified according to the following criteria :

- method of mounting of the tank on the vehicle,
- ancillary installations,
- conditions of use (influence factors),
- capacity (in general, between 0.5 and 50 m^3).

2.1.1.1. As regards the method of mounting on the vehicle, the tanks may be :

- mounted directly and permanently on the chassis of a vehicle, trailer, or semi-articulated trailer, or be self-propelled,
- detachable, mounted temporarily on the vehicle by means of devices which ensure that the position of the tank when mounted on the vehicle remains unchanged.

2.1.1.2. As regards ancillary installations, tanks may be with or without installations for measuring partial volumes received or delivered.

2.1.1.3. The main influence factors which can have a major effect during calibration and use of road tankers are pressure and temperature.

a) As regards pressure, the tanks may be :

- at atmospheric pressure,
- under pressure (for liquefiable gases).

- b) As regards temperature, the tanks may be:
- without means for heating and with or without thermal insulation of the contents,
 - with means for heating and with or without thermal insulation of the contents.

2.1.2. Some road tankers are divided into compartments, each being considered as a separate tank and subject to the requirements of this Recommendation. In addition, some tanks may be lined (for example, for the transport of wine).

2.1.3. Each tank or tank compartment on a road tanker shall comprise :

- a shell and ends,
- a dome with reinforcing elements, as appropriate (for example, pressurized tanks or tanks for the transport of certain chemical products may not or shall not be provided with domes),
- discharge devices.

2.1.3.1. The shell is generally horizontal and cylindrical in form, and is mounted on the vehicle in such a way that it drains completely.

2.1.3.2. The dome, when fitted, serves as a manhole and as an expansion chamber, but it is provided mainly to increase the sensitivity of the tank. It is on the top of the tank. The dome may incorporate the following:

- a filling aperture, fitted with leak-proof cover,
- an orifice for the observation of filling,
- a venting device or double-acting safety valve.

The level index may be in the dome or in the upper part of the shell, provided that the sensitivity requirements are met (see Annex 2).

2.1.3.3. The discharge device shall comprise a discharge pipe with a stop valve at its end; the flow of liquid between the tank and the discharge pipe may be stopped by a foot valve. Some tanks may incorporate devices fitted at the lowest point for water separation.

2.1.3.4. In general road tankers shall be provided with a ladder giving access to the dome, and a platform for the operator affecting the measurement or checking the tank.

2.2. Rail tankers

2.2.1. Rail tankers are classified according to the following criteria:

- conditions of use (influence factors),
- capacity (in general, between 10 m³ and 120 m³).

The main influence factors which can have a major effect during the calibration and use of rail tankers are pressure and temperature.

a) As regards pressure, the tanks may be :

- at atmospheric pressure,
- under pressure.

b) As regards temperature, the tanks may be :

- without means for heating,
- with means for heating, being provided with heating coils (in general, for liquids with a viscosity greater than 10 mPa.s).

2.2.2. Each rail tanker shall comprise :

- a shell and ends,
- a dome, as appropriate,
- discharge devices.

In general, rail tankers for liquefiable gases shall not have domes and are subject to regulations covering the construction of pressure vessels.

2.2.2.1. The shell shall be horizontal and cylindrical in form, with a circular cross section terminating in spherical, ellipsoidal or dome-shaped ends. The vessel shall be mounted on a chassis, or directly on bogies by means of supports.

Where appropriate, tanks shall be fitted with breather valves and flame arresters.

The vessel is fabricated from rolled shells of molded construction.

2.2.2.2. The dome, when fitted, is on the top of the tank in the form of a vertical cylinder, and has a leak-proof cover.

The dome serves as a manhole, a filling aperture and a measurement aperture (see Annex 2).

2.2.2.3. The discharge orifice shall be at the lowest part of the tank, near the centre, whence the liquid shall enter a double discharge pipe, allowing for offloading on either side of the rails. Ball valves or similar shut-off device shall be fitted at the end of the discharge pipe.

The discharge orifice may be closed by a foot valve.

2.2.2.4. Tanks shall be provided with one or two access ladders and a platform for the operator effecting a measurement or checking the tank.

3. Units of measurement

The authorized units of measurements are those of the International System of Units (SI).

If units of measurement other than those of the SI are authorized by the state, these legal units of measurement may be used; official conversion factors between these units of measurement and those of the SI shall be used for international commercial transactions.

4. Technical and metrological characteristics

4.1. Road tankers

4.1.1. General requirements of construction

Shapes, materials, reinforcing elements and methods of shaping or assembly shall be chosen so that the tanks are sufficiently unaffected by atmospheric agents and the liquids they contain and are practically not subject to distortion under rated operating conditions.

4.1.1.1. The designs shall be functional, taking into account the tankers functions of storage and transport and the nature of the liquid it is intended to contain.

It shall therefore satisfy the national or international regulations concerning transport in general and the transport of dangerous liquids in particular, safety at work, the construction of pressure vessels and protection against fire.

As far as potable liquids are concerned, the structural characteristics of the tank (shape, material, etc.), shall have no adverse effect on the quality of the liquid transported; and the advice of the health authorities in this regard shall be sought.

The application of the above-mentioned requirements shall be compatible with the measurement function of the tank.

4.1.1.2. If required by national regulations, tanks shall be pressure tested.

The execution of the pressure test shall be the responsibility of the manufacturer, who shall present the results of these tests to the metrology officers concerned with pattern evaluation.

The vessel shall be leak tested using water at atmospheric pressure; after filling, the tank shall show no traces of leakage or dampness at the joints.

4.1.1.3. The reference height H of any tank or compartment shall not vary during filling by more than the larger of the following two values :

- 2 mm,
- H / 1 000.

4.1.1.4. The capacity of a compartment shall not change by more than 1/1 000 of its measured volume when the neighbouring compartments are filled or emptied.

4.1.1.5. Every tank or compartment shall be of such a shape that no air is trapped on filling and no liquid is retained on emptying in all normal positions of use of the equipment.

Spouts, mouldings or vent pipes and valves may be used in order to comply with the above requirements.

To ensure complete drainage the lower generatrix of the tank shall have a slope of at least 2° with the vehicle on level ground, in the most unfavourable position concerning the order in which the compartments are emptied.

A tolerance of 1/5 of the maximum permissible calibration error, for the volume of water remaining in the tank on the complete draining test, is allowed; this volume may remain in the tank for reasons of conditions of construction or mounting (for example, at the joints).

4.1.1.6. Anti-wave devices and reinforcing elements that may be fitted in the tank shall be of a shape and shall be provided with appropriate orifices so that filling, draining and checking the emptiness of the tank is not impeded.

4.1.1.7. The placing of deadwood inside the tank for the purpose of adjusting the capacity to a given value, or any other body which when removed or changed, could modify the capacity of the tanks, is prohibited.

4.1.2. Dome and level-gauging device

The dome, when fitted, shall be on the upper part of the body and shall be welded to the latter. In general, the level-gauging device shall be inside the dome.

4.1.2.1. The dome may have a cylindrical or parallelepipedic form, with vertical side-walls. If the dome is parallelepipedic in form it may be of the same length as the tank itself.

If the sidewalls of the dome are mounted so that they penetrate the tank shell, the formation of air pockets in the upper part of the shell shall be avoided by providing orifices or cutouts at the level of the upper internal generatrix.

4.1.2.2. The transverse section of the shell and dome shall have a vertical axis of symmetry.

The dimensions of the horizontal section of the dome shall be such as to allow inspection of the interior of the tank. A diameter of at least 500 mm is recommended.

4.1.2.3. The level-gauging device (see Annex 2) shall ensure a safe, easy and unambiguous readout, practically independent of tank tilt under rated operating conditions.

The index (indices), or the vertical measurement axis, shall be as near as possible to the centre of horizontal sections of the tank.

4.1.2.4. The shape of the tank shall be such that, in the zone where the level of the contained liquid is gauged, a sensitivity of at least 2 mm for 1/1 000 of the contained volume is attained.

4.1.2.5. The specification of the nominal capacity shall take into account the national or international regulations prescribing the maximum filling level of tanks (see Annex 3).

4.1.2.6. The use of ancillary devices to facilitate reading of the index (indices), or to stop the flow automatically when the level of the liquid reaches the index, are permitted, provided that no additional measurement errors are introduced.

4.1.3. Discharge device

The discharge device shall ensure complete and rapid discharge of the liquid contained in the tank; for this purpose, the discharge device shall be connected to the lowest part of the tank shell.

4.1.3.1. Each tank shall have a single drain orifice and a single stop valve.

For tanks of special construction for airports, the fitting of a device to collect water and impurities precipitated by a liquid contained in the tank is permitted. This device shall have a separate drain pipe, of small diameter, when the normal discharge pipe is not connected to the lowest part of the tank.

The collecting device may be mounted :

- over the whole of the lower part of the tank, or
- over a reduced area of the lower part.

In the first case the lower part of the collecting device, instead of the lower generatrix of the tank, shall meet the requirements concerning minimum slope, specified in point 4.1.1.5.

4.1.3.2. The discharge pipe shall be as short as possible and have an adequate slope towards the stop valve. A slope of at least 2° is recommended.

4.1.3.3. The discharge device may incorporate a supplementary safety valve (foot valve -see point 2.1.3.3 above).

4.1.3.4. Each compartment shall have means for being discharged independently. A discharge manifold is permitted only in special cases.

Special cases include, for example, tanks intended for the transport of large volumes where the total content is delivered to a single destination and the tank carries only one product. A plate shall then be fixed adjacent to the manifold, measuring about 90 mm × 150 mm and bearing the following inscription : "Check the state of fill of all compartments, before and after every measurement operation". The existence of a manifold shall be indicated in the calibration certificate.

4.1.3.5. Stop valves shall be readily accessible and shall be at the rear or on the appropriate side of tank.

4.1.4. Installations for pumping and metering

Tanks may be provided with:

- a pumping installation,
- a flow measuring assembly including a flow meter ^(*), with or without pump.

The connections between the stop valves of the tank and these installations shall be by means of detachable couplings, which shall be as short as possible and easy to assemble and take apart. This requirement does not apply to tanks of special construction (for example, tanks used for aircraft refueling), but in this case effective and controlled hydraulic isolation of the tank body from this equipment shall be ensured.

Pumping installations shall comprise, in addition to the pump itself, no more than one filter and very short pipes (no valves nor branch connections). The installation shall be constructed so that it can be drained completely by gravity, each time the tank is emptied, without the need for any special measures.

4.1.5. Other devices

4.1.5.1. The following devices are permitted :

- level warning devices,
- level indicators.

4.1.5.2. Tanks may be thermally insulated.

4.1.5.3. In order to determine the volume corresponding to an index, without introducing major additional errors, the tank may be equipped with a plumb line which indicates whether the slope of the tank has exceeded 2° with respect to the reference position. The plumb line shall have a minimum length of 300 mm. The plumb line may be replaced by a level indicator, if appropriate.

4.1.5.4. Access shall be provided to enable the operator conveniently to open and close the filling aperture, to observe the liquid level, to take samples of the liquid and to observe the emptying of the tank. Such access may be made possible by means of a ladder and a platform with a handrail.

4.1.6. Determination of volumes ; maximum permissible errors

4.1.6.1. The volume of the tank shall be determined up to the stop valve, unless otherwise explicitly indicated in the calibration certificate.

Where a manifold is fitted, it shall be considered always to be empty, and shall therefore not be included when calculating the volume of any compartment.

Where a tank is fitted with a collecting device the volume of this device shall be included in the volume of the tank.

4.1.6.2. The maximum permissible error of calibration shall be ± 0.2 % of the nominal volume.

4.1.6.3. The maximum permissible error in service shall be ± 0.5 % of the measured volume (including the errors of calibration, determination of liquid level, measurement of temperature, density, etc.).

(*) These assemblies are the subject of other International Recommendations.

4.1.7. Identification plate and seals

An identification plate, clearly visible and easily legible, shall be fitted to the vessel at a suitable height.

The plate shall not be of material which deteriorates under the rated conditions of use of the tank, and should allow the data to be easily inscribed.

The plate shall be fixed in such a way that it cannot be removed without breaking the seals carrying the mark of the Legal Metrology Service.

The following information shall be inscribed on the plate :

- name or trademark of the manufacturer,
- type and year of manufacture,
- serial number,
- pattern approval number, if appropriate,
- nominal capacity of the tank, or of each compartment, in legal units of measurement (the compartments are numbered, starting at the front end of the vehicle),
- reference temperature.

A free area of about 20 mm × 50 mm shall be left on the plate for the periodic verification marks, if appropriate.

4.1.7.1. On tanks with which dipsticks are used to measure the levels of the contained liquid, the plate shall bear the number of the certificate of initial calibration instead of the last two items (capacity and temperature). This number shall be obliterated at the time of the first periodic calibration. For the periodic verifications a support shall be provided for a plate carrying the following information :

- type, year of manufacture and serial number,
- number of calibration certificate,
- place and date of calibration.

This plate shall be changed after each periodic verification.

4.1.7.2. Where a tank has been modified and the modifications have been approved in accordance with the metrological regulations, the following action shall be taken :

- on the manufacturer's original plate, the value (or values) indicating the nominal volume shall be obliterated (or the figures erased),
- adjacent to the original plate, an additional plate shall be fixed under the same conditions as in point 4.1.7 and having the same dimensions ; it shall carry the following information :
 - year in which modified, and by whom,
 - approval number of the Legal Metrology Service,
 - nominal capacity (of each compartment, if appropriate),
 - reference temperature.

4.1.8. Other seals

It shall be possible to seal the fixing devices of detachable tanks so that they can be removed only by breaking the seals which carry the stamp of the Legal Metrology Service.

Heating coils, if provided, shall be sealed at their points of junction with the tank body.

4.2. Rail tankers

4.2.1. General requirements of construction

The International Union of Railways, the railway companies, the official services concerned with the transport of dangerous goods, and the authorities responsible for the supervision of the manufacture of pressure vessels lay down conditions for the construction of rail tankers intended for the transport of liquids contained in tanks, without overload and free from danger. These conditions shall be observed.

4.2.2. Technical and metrological requirements

A tank used as a measuring device shall comply with the following technical and metrological requirements.

4.2.2.1. The tank shall be practically immune to distortion or deterioration under the rated operating conditions, taking into account the ambient conditions and liquids to be contained.

4.2.2.2. Any tank shall have a shape such that no air is trapped on filling and no liquid is retained on emptying when the tanker rests on horizontal rails, even when the suspension is unequally deflected.

4.2.2.3. It must be possible to gauge the level of the contained liquid manually; the vertical measurement axis shall pass approximately through the centre of gravity of the tank and intersect the lower generatrix of the tank at a point having no orifice or obstacle within a radius of 10 cm.

4.2.2.4. The reference point P shall be clearly defined and realized.

4.2.2.5. The joint between the shell and the dome shall be such that the dipstick can be held in a vertical position during measurement.

4.2.2.6. The heating coils shall be positioned and fixed in such a way that they do not impede filling and draining of the tank : it shall not be possible to dismantle the heating coils without breaking the seals having the marks of the Legal Metrology Service.

4.2.2.7. The sensitivity over the total gauging range shall be at least 3 mm for 2/1 000 of the contained volume.

4.2.2.8. When the tank is leak tested with water at atmospheric pressure, it shall show no trace of leakage or dampness at the joints.

4.2.3. Determination of volumes ; maximum permissible errors

4.2.3.1. Unless otherwise specified, the volumes shall be determined with the central cover open and shall include the discharge pipework up to the lateral stop valves.

4.2.3.2. The maximum permissible error of calibration in the gauging range shall be ± 0.2 % of the given volume.

4.2.3.3. The maximum permissible errors in service shall be ± 0.5 % of the measured volume (including the errors of calibration, determination of level of liquid, measurement of temperature, density, etc.).

Where there are special technical difficulties (reheating, pressure, etc.) this maximum permissible error may be increased.

4.2.4. Calibration and identification plates ; sealing

Each tank shall have an identification plate, and may have a calibration plate (gauging plate).

The plates shall not be of a material that deteriorates under the rated operating conditions of the tank and should allow the data to be easily inscribed.

The letters and numbers shall be easily visible, legible, and practically indelible; a height of at least 3 mm is recommended.

The plates shall be fixed in such a way that they cannot be removed without breaking the seals having the marks of the Legal Metrology Service.

4.2.4.1. The identification plate shall be fixed to one of the tank ends and bear the following information:

- name or trademark of the manufacturer (if appropriate),
- registration number of the rail tanker,
- reference height H , in mm,
- total contents V_t in dm^3 ,
- dome height, in mm,
- number and year of issue of the calibration certificate.

4.2.4.2. In conformity with national regulations, a calibration plate (of one or two parts) may be fixed to the side of the tank or close to the dome, with the following information:

- institution which calibrated the tank and prepared the calibration table (gauging table),
- number of the calibration certificate,
- identification number of the rail tanker,
- reference temperature,
- number of heating coils, if appropriate,
- calibration table (function $V(h)$ or $V(C)$),
- date of calibration.

5. Legal qualification of road and rail tankers

5.1. General

When the road and rail tankers of a country are subject to statutory metrological control, the assignment of a " legal " quality to these instruments and the retention of that quality include, in conformity with national regulations, all or part of the following operations :

- pattern approval,
- initial verification,
- periodic verifications.

5.1.1. The following operations shall be carried out on road and rail tankers not used as measuring instruments, but for which it is necessary to know the total contents, and possibly the contents at certain filling levels, for the application of safety regulations :

- approval of drawings,
- calibration.

Drawings shall be approved in order to establish the method of calibration, taking account of the diversity of structural variants concerning the filling and emptying of tanks.

5.2. Road tankers

5.2.1. Pattern approval

The manufacturer shall present the following documents for the purpose of obtaining pattern approval:

- technical manufacturing specifications, and operation instructions,
- drawings representing:
 - a general assembly of the road tanker,
 - a general assembly of the tank, including the subdivision into compartments,
 - the auxiliary installations, as appropriate,
 - details of the dome and reinforcing elements, discharge device and identification plate,

5.2.1.1. The examination of a pattern of a road tanker includes the following operations :

- inspection of external and internal appearance, of dimensions and of general construction,
- leak test,
- check on invariability of capacity in service,
- check on correct filling,
- check on complete discharge,
- calibration,
- check on sensitivity and expansion volume.

5.2.1.1.1. The external and internal appearance, the dimensions and the general construction, are examined in accordance with the following requirements :

- | | |
|--|---|
| — various regulations | point 4.1.1.1, |
| — shapes, materials and general construction | points 4.1.1 and 4.1.1.5 to 4.1.1.7, |
| — dome and reinforcing elements | points 4.1.2, 4.1.2.1 to 4.1.2.3 and 4.1.2.6, |
| — discharge device | points 4.1.3 and 4.1.3.1 to 4.1.3.5, |
| — devices and auxiliary installations | points 4.1.4 and 4.1.5, |
| — pressure test | point 4.1.1.2, |
| — identification plate and sealing | points 4.1.7 and 4.1.8. |

The external and internal appearance is inspected visually, the dimensions are checked using rules, measuring tapes and caliper gauges.

5.2.1.1.2. The tank is leak tested by verifying, after completely filling the tank, that there are no leaks at the shell joints, walls, couplings and reinforcing elements.

5.2.1.1.3. The invariability of capacity under rated operating conditions is checked by determining first the variation of H during filling. The height H is determined by means of a rule with a cursor when the tank is empty and then when the tank is full. The difference between the two values shall not exceed the value stipulated in point 4.1.1.3.

The rule shall comply with the requirements of the OIML International Recommendation R 35 for the accuracy class I and have the following characteristics :

- scale interval : 1 mm,
- terminal zero scale mark,
- nominal length, as needed.

To check the variation in the capacity of a compartment according to the state of filling of the other compartments, the compartment located roughly in the middle of the tank shall be filled to its index, the other compartments remaining empty. The other compartments shall then be filled, this having the effect of raising the level in the compartment in the middle of the tank ; the level of the water in this compartment shall then be adjusted to the index, the volume of water drawn off being measured using a volumetric measure; this volume shall comply with the requirements in point 4.1.1.4.

5.2.1.1.4. The correctness of filling shall be checked as follows : the tank shall be filled to the index, with dome covers fitted, and the tanker shall then travel for 5 to 10 minutes, including a number of abrupt starts and stops. The tank shall be returned to its initial position and the level of Water shall again be noted; if it is not on the index the valves and venting devices are not functioning correctly, or have been incorrectly fitted. The tank may be calibrated only after this situation has been remedied.

5.2.1.1.5. The completeness of discharge shall be checked as follows : the tank, with its interior walls dry, is filled to approximately 10 cm above the lower generatrix. The tanker is placed on a horizontal road and the stop valve opened. On termination of free flow, any water remaining inside the tanks is collected in a volumetric measure. This volume of water shall not exceed the value stipulated in point 4.1.1.5.

The following procedure may alternatively be adopted: the dry tank is filled with water to a height of approximately 10 cm, measuring the volume used by means of a volumetric measure. With the tanker placed in a horizontal road, the stop valve is opened and the volume of water that is drained is measured using the volumetric measure. The difference between the two measured volumes shall not exceed the value stipulated in point 4.1.1.5.

5.2.1.1.6. The tank shall be calibrated in conformity with point 5.2.5. below.

5.2.1.1.7. The sensitivity and expansion volume shall be checked as follows :

- a) if the index corresponding to the nominal capacity is in a zone of constant horizontal section, filling of the tank is continued, after calibration, up to overflowing. By determining the expansion volume ΔV and the corresponding height Δh , conformity with the requirements of points 4.1.2.4 and 4.1.2.5 may be verified ;
- b) if the index is in a zone of variable horizontal section, the expansion volume is determined as in the first case, but the following procedure is adopted for checking the sensitivity : two levels are selected, one approximately 5 cm below the index, and the other approximately 5 cm above the index. The determination of Δh_1 and ΔV_1 between these levels shows whether the requirements stipulated in point 4.1.2.4. are met.

5.2.2. Initial verification

Initial verification shall comprise the following operations :

- inspection of external and internal appearance, and of general construction,
- leak test,
- calibration,
- check of sensitivity and of expansion volume.

Where a tank has been modified all the operations called for in point 5.2.1.1 shall be carried out.

5.2.2.1. The external and internal appearance and general construction shall be inspected visually; conformity with the approved pattern shall be verified.

5.2.2.2. The tank shall be leak tested in conformity with point 5.2.1.1.2.

5.2.2.3. The tank shall be calibrated in conformity with point 5.2.5 below.

5.2.2.4. The sensitivity and expansion volume shall be checked in the manner indicated in point 5.2.1.1.7.

5.2.3. Periodic verifications

The periodic verifications shall comprise the following :

- inspection of external and internal appearance, and of general construction,
- leak test,
- calibration,
- check of sensitivity and expansion volume.

5.2.3.1. The external and internal appearance, and general construction shall be inspected visually; the existence of the initial verification mark shall be checked.

The road tanker shall be presented for verification in a clean condition, both externally and internally.

No modification of construction is permitted between initial and periodic verifications.

The tank shall be inspected on the basis of the following :

- | | |
|---|---|
| — shapes, materials and general constructions | points 4.1.1, 4.1.1.6 and 4.1.1.7, |
| — dome and reinforcing elements | points 4.1.2.1, 4.1.2.3, 4.1.2.5 and 4.1.2.6, |
| — discharge device | points 4.1.3.1 and 4.1.3.3 to 4.1.3.5, |
| — devices and auxiliary installations | points 4.1.4 and 4.1.5, |
| — identification plate and sealing | points 4.1.7 and 4.1.8. |

5.2.3.2. The tank shall be leak tested and its sensitivity and expansion volume shall be checked as indicated, and the tank shall be calibrated as indicated in point 5.2.5. below.

However, where the result of the first calibration differs from the value indicated on the identification plate by less than 0.2 %, no further calibration is required.

5.2.4. Issue of the calibration certificate and application of the verification mark

Road tankers complying fully with the requirements of this Recommendation shall be accepted for verification ; on completion of the calibration, the calibration certificate shall be issued and the marking on the identification plate shall be completed.

5.2.4.1. The calibration certificate (Annex 5) shall include the following indications :

- name of authorized verification service,
- name and, if appropriate, address of holder,
- number of calibration certificate,
- manufacturer's name or trademark, type, year of manufacture and serial number,
- vehicle registration number, if appropriate,
- number of compartments and heating coils, if appropriate,
- identification of the reference point P and position of the vertical measurement axis, if appropriate,
- method of calibration used, number of calibration certificate for the standard installation used,
- convention relating to the filling of the discharge pipes and, if appropriate, indication of the presence of a manifold,

- maximum relative error of the determination of the values of volume indicated in the certificate ($\pm 0.2\%$),
- date of issue and limit of validity of the calibration certificate, if a limit is set ^(*),
- title, name and signature of the person responsible for the calibration,
- sketch indicating the meaning of the symbols P , V_n , V_t , C_n , and H in diagrammatic form,
- height of the coupling during verification (for semi trailers only),
- number and positions of the applied verification marks.

For each compartment, the calibration certificate shall indicate :

- the nominal capacity, V_n ,
- the total contents, V_t ,
- the ullage height, C_n , corresponding to the nominal capacity, in millimetres,
- reference height, H , in millimetres,
- mean volume per centimetre at the level of the nominal volume or calibration table, in legal units of measurement.

5.2.4.2. The legality of verification shall be confirmed by the application of the verification mark, as laid down by national regulation, on:

- the calibration certificate,
- the drawing showing the reference point or the device defining the index,
- the lead seals preventing removal of the identification plates,
- the identification plate,
- the sealing device for the dome cover,
- the sealing device for a detachable tank,
- the sealing device for the heating coils, if appropriate.

If, on the occasion of periodic verification, the seals applied at the time of the preceding verification are intact, a stamp is applied only on the place provided for on the identification plate, to confirm acceptance for verification.

5.2.5. Calibration

The tank shall be calibrated using the volumetric method, determining the volume of water which fills the tank by means of standard measuring instruments.

The following may be used for this purpose :

- a proving tank installation,
- a standard flowmeter installation.

These installations shall comply with the relevant metrological requirements, and shall bear a valid verification mark.

The road tanker shall be placed on a horizontal road and the complete calibration operation shall be carried out in an enclosed space.

5.2.5.1. Where the tank has an index, the level of the surface of the water shall be adjusted to this index, in the position indicated in the operation instructions.

Where a tank has no index, the level shall be determined by measuring the ullage height, using a length measure. For this purpose, the measure shall be positioned as indicated in the specifications, and this recorded in the calibration certificate. The zero scale mark shall coincide with the reference point.

The level of the water in the tank shall be measured only after the surface has settled and air bubbles have been eliminated.

^(*) A period of validity of 2 to 5 years is recommended.

A water indicating paste may be used, if necessary. The length measure used for the measurement of ullage height shall have the following characteristics :

- scale interval: 1 mm,
- maximum permissible error ± 0.3 mm,
- length as required.

The material of the length measures used shall be compatible with the transported liquid.

5.2.5.2. A tank with an index shall be calibrated by measuring the volume of water introduced into or drained from the tank, using a standard installation and recording the successive volumes and temperatures of the water introduced or withdrawn and the water temperature inside the tank, and calculating the total volume by addition. If the dome is of constant section, the mean change of volume per centimetre of dome height shall be calculated.

Where a centimetric calibration scale is required for the tank, in addition to the nominal capacity, the tank shall be calibrated over the whole zone. For this purpose the tank shall be filled to the upper limit of the zone and then emptied in stages, calculating the volume withdrawn for each centimetre of height down to the lower limit. Alternatively, the tank shall be filled in a single stage to the lower limit of the zone, and then filled by stages, calculating the volume for each centimetre of height.

The volumes of water which are introduced or withdrawn shall be chosen so that the maximum permissible errors (point 4.1.6.2) are not exceeded, taking into account the interpolations required to calculate the volumes corresponding to each multiple of 10 mm on the vertical measurement axis.

5.2.5.3. The water temperature should not vary by more than 2 °C during calibration. The water temperature shall be measured using a thermometer, of which the scale interval shall not exceed 0.5 °C and the error shall not exceed half the scale interval. The water temperature shall be measured in the standard installation and in the tank being calibrated.

5.2.5.4. To calculate the capacity of the tank at reference temperature, the following procedure shall be adopted :

- if the water temperature is within $t_R \pm 10$ °C (*) and in compliance with the conditions in point 5.2.5.3, only the correction for the standard shall be applied (in conformity with its calibration certificate),
- if the water temperature lies outside the above-mentioned limits the volume of the tank shall be calculated using the relation:

$$V_{t_R}^c = V_{t_R}^e \left[1 + \beta_e (t_e - t_R) + \beta_c (t_R - t_c) \right] \frac{\rho_{t_e}}{\rho_{t_c}}$$

where :

$V_{t_R}^c$ is the volume of the tank at reference temperature,

$V_{t_R}^e$ is the volume of water measured by the standard installation, and to which the correction for the standard has been applied,

β_e is the coefficient of cubic expansion of the material used in the construction of the standard measures ($^{\circ}\text{C}^{-1}$),

β_c is the coefficient of cubic expansion of the material used in the construction of the tank being calibrated ($^{\circ}\text{C}^{-1}$),

t_e is the mean water temperature in the standard installation ($^{\circ}\text{C}$),

t_c is the mean water temperature in the tank being calibrated ($^{\circ}\text{C}$),

ρ_{t_e} , ρ_{t_c} are the densities of water at temperatures t_e and t_c respectively.

(*) t_R is the reference temperature, for example 20 °C.

The value of the coefficient of cubic expansion is $3.3 \times 10^{-5} \text{ }^\circ\text{C}^{-1}$ for mild steel, $5.1 \times 10^{-5} \text{ }^\circ\text{C}^{-1}$ for stainless steel and $6.9 \times 10^{-5} \text{ }^\circ\text{C}^{-1}$ for aluminium.

5.2.5.5. The nominal volume should be calculated as the mean of at least two individual values, the differences between values taken two by two not exceeding 0.1 % of the volume. The nominal volume is indicated on the plate.

5.3. Rail tankers

5.3.1. Pattern approval

To obtain pattern approval the manufacturer shall present the following documents :

- technical manufacturing specifications and operation instructions,
- drawings representing :
 - a general assembly of the rail tanker,
 - a general assembly of the tank,
 - details of the dome and of the ullage measuring device, discharge device, identification plate and heating coils.

5.3.1.1. The examination of a rail tanker pattern shall include the following operations :

- inspection of external and internal appearance, of dimensions and of general construction,
- leak test,
- check on complete discharge,
- calibration,
- check on sensitivity.

5.3.1.1.1. The external and internal appearance, dimensions and general construction shall be examined in accordance with the following requirements :

- | | |
|--|-----------------------------|
| — various regulations | point 4.2.1, |
| — shapes, materials and general construction | points 4.2.2.1 and 4.2.2.2, |
| — dome | points 4.2.2.3 to 4.2.2.5, |
| — auxiliary equipment | point 4.2.2.6, |
| — identification plates and calibration plates | point 4.2.4. |

5.3.1.2. The tank shall be leak tested with water, checking that no leaks occur at the joints of the shell and at the walls, couplings and reinforcing elements.

5.3.1.3. The check on complete discharge shall be carried out as follows : with the internal walls dry, the tank is filled to approximately 10 cm above the lower generatrix. The stop valves are opened and, on termination of free flow, the volume of the water remaining inside the tank is collected and measured using volumetric measures. This volume of water shall not exceed 1/5 of the volume corresponding to the maximum permissible error of calibration.

The following procedure may alternatively be adopted: the dry tank is filled with water to a height of approximately 10 cm, the volume used being measured by means of volumetric measures. With the tanker placed on horizontal rails, the stop valve is opened and the volume of water that is drained is measured, using the volumetric measures. The difference between the two measured volumes shall not exceed 1/5 of the volume corresponding to the maximum permissible error of calibration.

5.3.1.4. The tank shall be calibrated in accordance with point 5.3.5.

5.3.1.5. The check on sensitivity of measurement shall be checked using the data read from the calibration table in order to verify that the requirements in point 4.2.2.7 are met.

5.3.2. Initial verification

Initial verification shall comprise the following operations :

- inspection of internal and external appearance, and of general construction,
- leak test,
- calibration.

5.3.2.1. The external and internal appearance and general construction shall be inspected visually : conformity with the approved pattern shall be verified.

5.3.2.2. The tank shall be leak tested in conformity with point 5.3.1.2.

5.3.2.3. The tank shall be calibrated in conformity with point 5.3.5.

5.3.3. Periodic verifications

The tank shall be periodically verified by the same procedure as that for initial verification.

5.3.4. Issue of the calibration certificate and application of the verification mark

Rail tankers complying with the requirements of this Recommendation shall be accepted for verification; following calibration, the markings on the identification plate and calibration plate shall be completed and, if it is the practice of the Legal Metrology Service, a calibration certificate shall be issued.

5.3.4.1. The calibration certificate includes the following information :

- issuing authority and certificate number,
- registration number of rail tanker,
- name and address of owner (if appropriate) and manufacturer,
- method of calibration (if appropriate), and place and date of tests,
- identification of the reference point, P, and of the vertical measurement axis,
- conventions concerning filling of the tank and discharge pipework,
- reference height, H, in millimetres,
- total contents, V_t , and corresponding ullage height, C_t ,
- capacity of tank body, V_c , up to the upper internal generator, and corresponding ullage height, C_c ,
- reference temperature (on which the table is based),
- maximum relative error in the determination of the values indicated in the certificate ($\pm 0.2\%$),
- limit of validity (*) of the certificate as regards the use of the tank as a measuring instrument,
- date of issue of the calibration certificate,
- title, name and signature of the person responsible for the calibration,
- sketch indicating the meanings of the symbols P, H, V_t , C_t and, if appropriate, V_c and C_c ,
- calibration table giving, in legal units of measurement, the volume of the liquid contained in the tank against the ullage height expressed in centimetres, within the range of level gauging stipulated in point 5.3.5,
- number and positions of verification marks.

(*) A period of validity of 5 to 10 years is recommended.

5.3.4.2. The legality of verification shall be confirmed by the application of the verification mark, as laid down by national regulations, on :

- the calibration certificate (if appropriate),
- the lead seals, preventing removal of the identification plate and calibration plate,
- the drawing showing the reference point,
- the sealing device for the heating coils, if appropriate.

5.3.5. Calibration

The tank shall be calibrated as indicated in points 5.2.5 and 5.2.5.1 to 5.2.5.4 taking into account the fact that it is a tank without index and that a centimetric calibration table has to be established over a range specified by the Legal Metrology Service and depending on the conditions of use (see example in Annex 6).

5.4. Calibration of (road or rail) tankers under pressure

Pressurised (road or rail) tankers used as measuring containers shall be calibrated as described in point 5.2.5 or 5.3.5, and, in addition, the increase in total volume of the tank due to the internal pressure shall be determined.

In order to determine this increase the tank shall be filled to overflowing, ensuring that there are no air pockets. The filling orifice shall then be closed by means of a cover with an hydraulic pump, pressure gauge and ball valve attached (see Annex 4).

The maximum service pressure (indicated on the pressure gauge) shall be applied by means of the hydraulic pump; then, using the ball valve and a suitable volumetric measure, the volume of water discharged shall be measured when the pressure gauge indicates zero.

The results shall be recorded on the calibration certificate in tabular or graphic form. The calibration certificate shall be issued and the verification mark shall be applied in the normal way as indicated in points 5.2.4 or 5.3.4.

5.5. Calibration of tankers not used as measuring instruments, but for which the total contents must be known in order to determine the maximum filling load

A difficulty arises in this instance from the special arrangement of the orifices for filling and draining.

The tank shall be completely filled with water, without air pockets, using means appropriate to the type of construction of the tank.

5.5.1. The tank may be calibrated by one of the following two methods:

- volumetric,
- gravimetric.

5.5.2. The volumetric method of calibration shall be, in general, as indicated in points 5.2.5 and 5.2.5.1 to 5.2.5.3.

It is sometimes advantageous to use an auxiliary tank and, if appropriate, a pump for filling the tank with water where proving tanks are used for the calibration. No additional errors shall be then introduced as a result of the transfer of liquid.

5.5.3. When calibrating gravimetrically the total contents shall be calculated from the weight of water contained in the tank when completely full.

The procedure shall be as follows :

- the tare weight of the vehicle is determined by double weighing (with the tank completely empty),
- the tank is filled to the point of overflowing, taking the precautions indicated in point 5.4, and the weight is determined by double weighing,
- the temperature t of the water in the tank is measured,
- the difference between the two weights is calculated, giving the mass M of the water contained in the tank,
- the volume V^t of the tank at temperature t , is calculated from the relation :

$$V^t = M K_1 (1 + K_1 K_2)$$

where :

K_1 is the volume of 1 kg of water at temperature t in cubic decimetres, determined directly or taken from Table 1,

$K_2 = 0.0012$ is a factor introduced to correct for air buoyancy,

- the volume V^{t_0} of the tank at the reference temperature is calculated from the relation:

$$V^{t_0} = V^t [1 + \beta (t_0 - t)]$$

where :

β is the coefficient of cubic expansion of the material used in the construction of the tank.

Note : The weighing operations to determine the total contents shall be carried out with the vehicle in the same state of loading insofar as the other equipment is concerned and apart from the tank itself.

The tank shall be weighed using a weighing instrument with adequate sensitivity, repeatability and maximum capacity, and with standard weights suitable for double weighing. The error of the weighing instrument shall not exceed ± 0.1 %.

The temperature shall be measured by means of a thermometer with a scale interval of 0.5 °C and an error not exceeding half a scale interval.

5.5.4. The calibration shall be confirmed by the issue of a calibration certificate and by marking the value of the total contents on the calibration plate. The verification marks shall be applied, as laid down by national regulations, on:

- the calibration certificate (if appropriate),
- the lead seals, preventing removal of the calibration plate,
- the calibration plate beside the figures indicating the total contents.

The calibration certificate shall remain valid for an unlimited period.

TABLE 1

Water temperature (*) °C	Volume of 1 kg of water (K ₁) dm ³
4	1.000 03
5	1.000 04
6	1.000 06
7	1.000 10
8	1.000 16
9	1.000 22
10	1.000 30
11	1.000 40
12	1.000 51
13	1.000 63
14	1.000 76
15	1.000 90
16	1.001 06
17	1.001 23
18	1.001 41
19	1.001 60
20	1.001 80
21	1.002 01
22	1.002 24
23	1.002 47
24	1.002 72
25	1.002 97

(*) IPTS 68

After WAGENBRETH and BLANKE, PTB Mitteilungen, December 1971.

ANNEX 1

SUMMARY OF OPERATIONS TO DETERMINE THE VOLUMES OR QUANTITIES OF LIQUID IN A TANKER CONSIDERED AS A MEASURING CONTAINER

The following operations are generally required for the measurement of the volume of liquid contained in a tank :

- a) gauging the level of the free surface of the liquid, to obtain the volume V_{t_c} at the temperature t_c of the product in the tank,
- b) measuring the mean temperature t_c ,
- c) taking a representative sample of the product, and determining the density ρ_{t_1} at a temperature t_1 very close to t_c , in the laboratory,
- d) determining the density ρ_{t_c} from ρ_{t_1} , by calculation or from tables,
- e) calculating the mass of the product using the relation :

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

The operations d) and e) may be replaced by the following :

- obtaining the volume and density at reference temperature (t_0) by calculation or from tables, and then determining the mass using the formula :

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

- obtaining the volume V_{t_0} at reference temperature (t_0) from tables, if the quantities are expressed as volume.

It should be noted that sometimes, for example when the product is inexpensive, the value of V_{t_c} is adequate for use in the calculation (operation a).

Notes :

- A) If the density has been determined earlier, operation c is not required.
- B) In addition there shall be no layer of water at the bottom of the tank and sometimes one must measure :
 - the volume of water in suspension,
 - the volume of solid impurities in suspension,and make the corrections which result from such suspensions.
- C) If the liquid is padded under pressure, without gaseous phase, the pressure shall be measured and the volume shall be corrected for the compressibility of the liquid and the elastic deformation of the tank due to this pressure.
- D) If the gaseous and liquid phases of the same product are present in the tank, the condensed volume of saturated vapour shall be determined and added to that of the liquid, in addition to the corrections mentioned in Note C above.

ANNEX 2

EXAMPLES OF DEVICES FOR MEASURING THE LIQUID LEVEL IN A TANKER

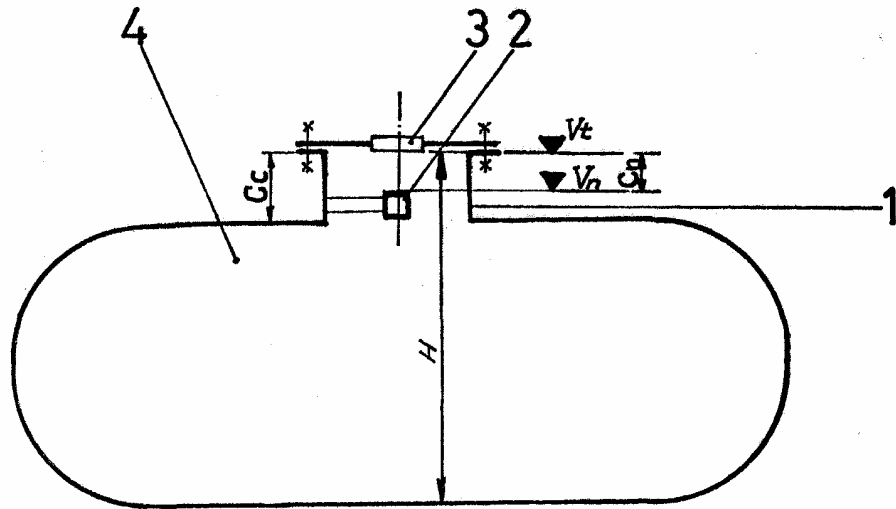


Figure 1

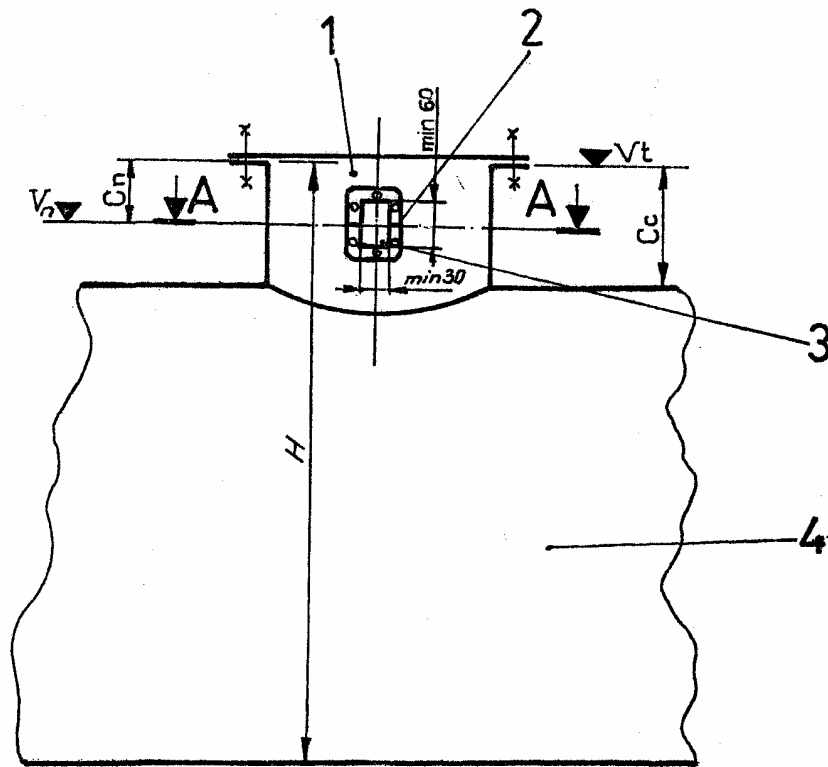
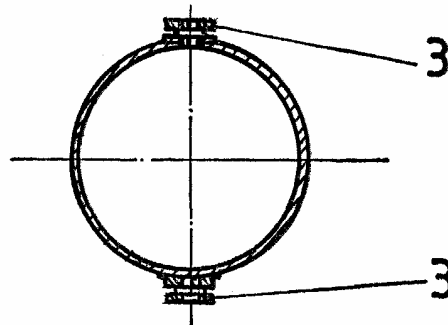


Figure 2

Section A-A



1. Dome
2. Level index
3. Observation window
4. Shell of the tank

Figure 3

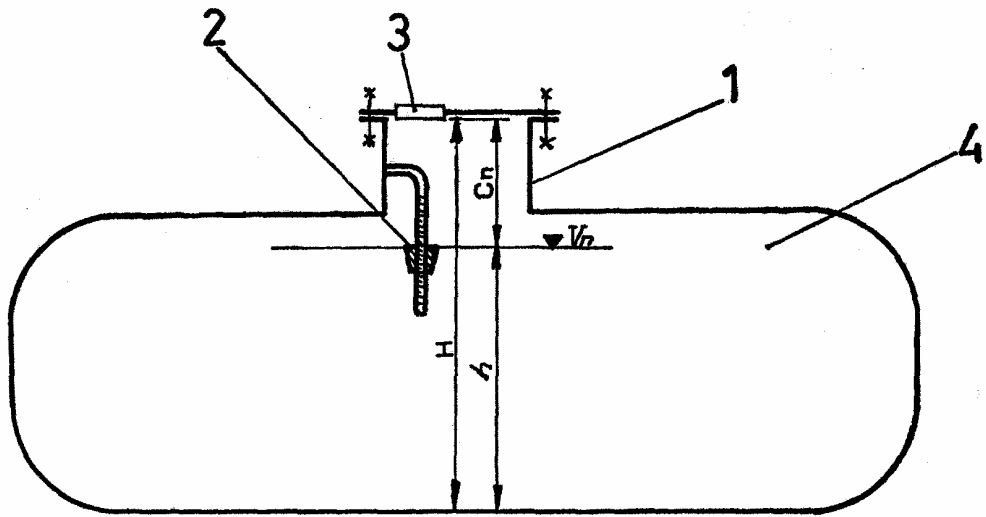


Figure 4

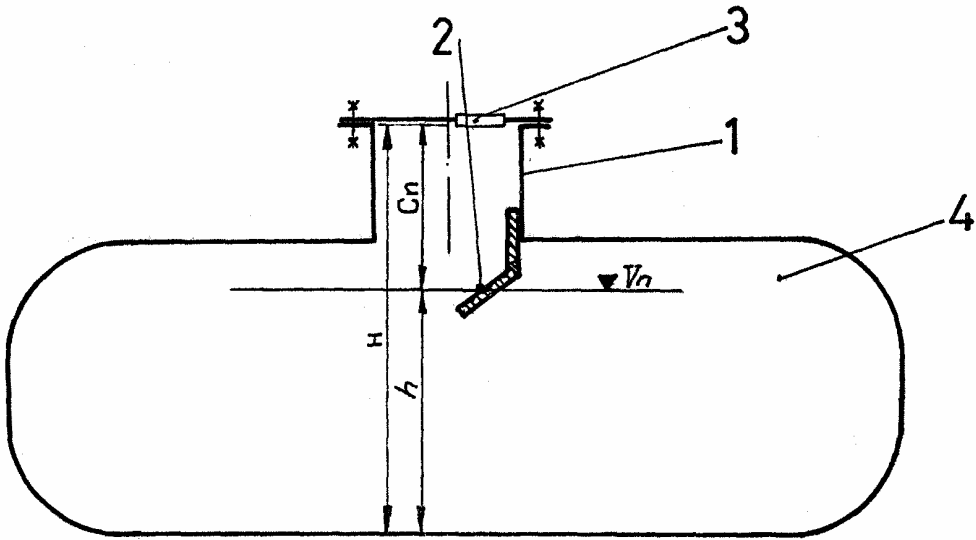
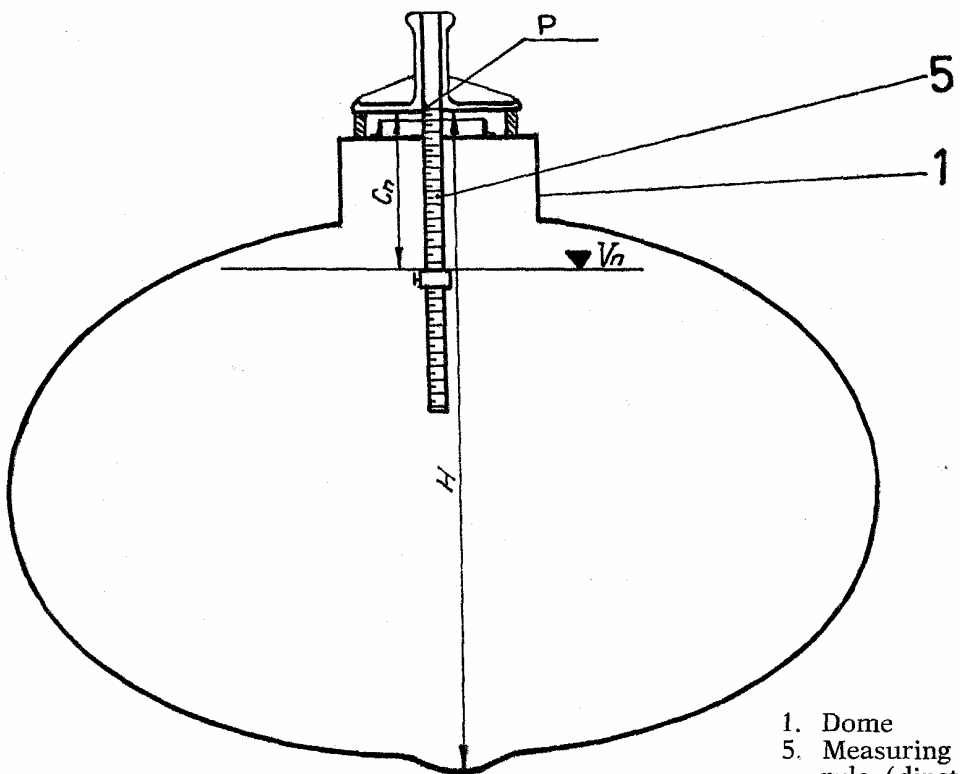


Figure 5



- 1. Dome
- 5. Measuring rule (dipstick)

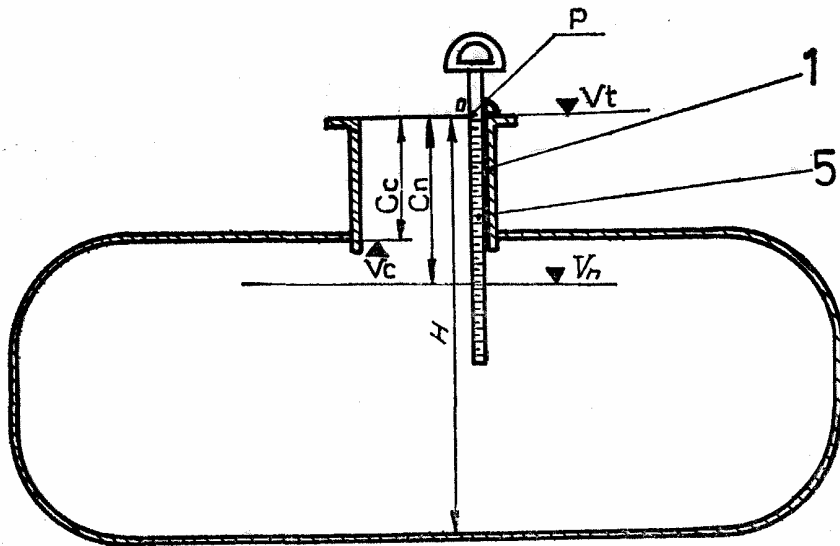


Figure 6

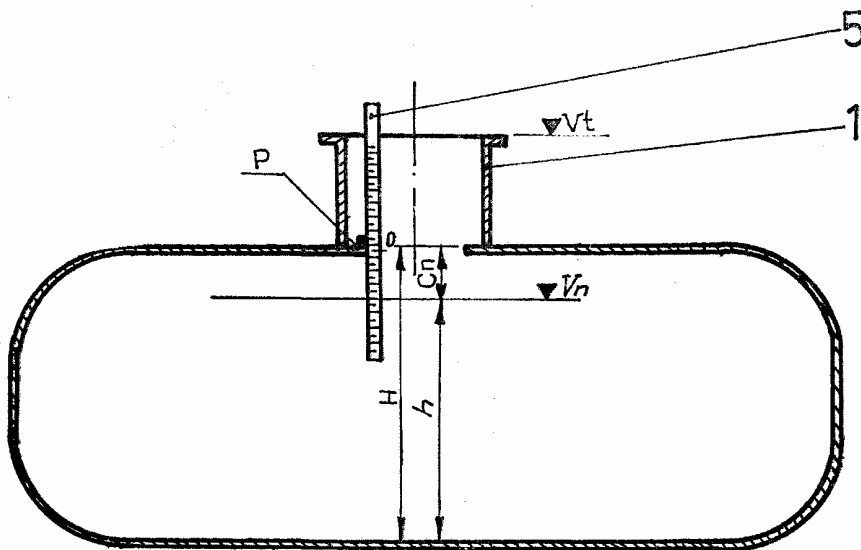


Figure 7

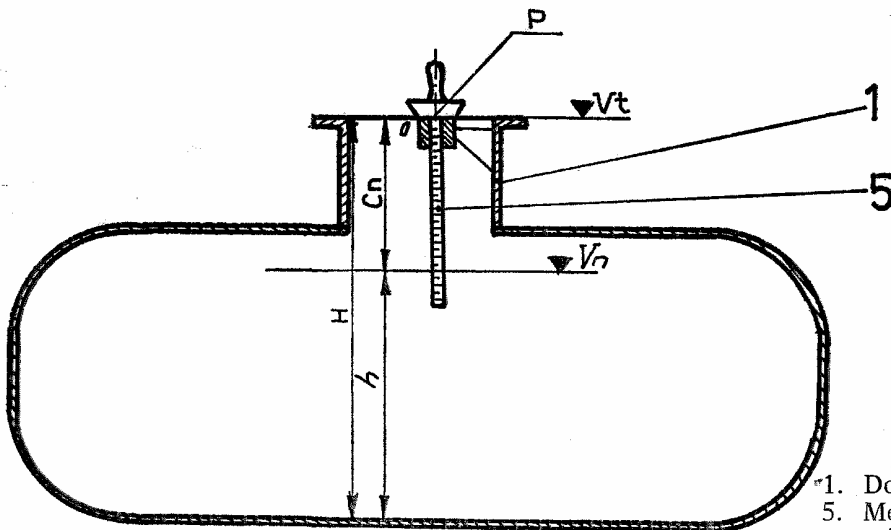


Figure 8

- 1. Dome
- 5. Measuring rule (dipstick)

ANNEX 3

MAXIMUM FILLING LEVEL OF ROAD TANKERS

National and international regulations prescribe the maximum filling level of road tankers used for the transport of dangerous goods.

Example : the European agreement concerning the international transport of dangerous goods by road (ADR) specifies that for inflammable liquids such as petrol (gasoline) the maximum level of filling is :

$$\frac{100}{1 + 35 \alpha} \% \text{ of total contents}$$

where α is the coefficient of cubic expansion of the liquid, calculated according to the formula :

$$\alpha = \frac{d_{15} - d_{50}}{35 \cdot d_{50}}$$

where :

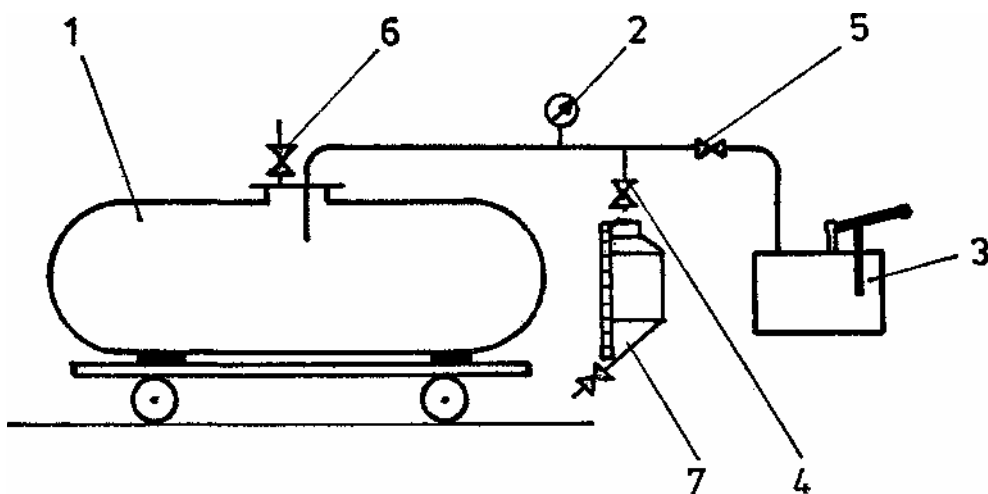
d_{15} and d_{50} are the densities of the liquid at 15 °C and 50 °C respectively.

Therefore, for petrol with $d_{15} = 0.700 \text{ kg/dm}^3$ the calculated expansion volume is approximately 3 % for a variation of 35 °C.

For potable liquids (milk, wine) an expansion volume of 0.5 % is considered reasonable for countries with temperate climates.

ANNEX 4

DETERMINATION OF THE EXPANSION VOLUME OF A TANKER UNDER THE INFLUENCE OF INTERNAL PRESSURE



- | | |
|-------------------|---------------------|
| 1. tank | 4. ball valve |
| 2. pressure gauge | 5. separation valve |
| 3. hydraulic pump | 6. vent |

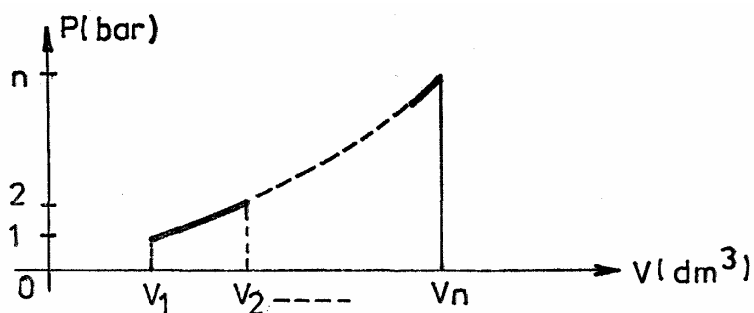
7. volumetric measure

While ensuring, by means of vent 6, that there are no air pockets, the pressure is increased by means of pump 3 up to P_{max} (indicated on pressure gauge 2). Valve 5 is then closed and, by opening valve 4, water is withdrawn and is measured using the volumetric measure 7; the volume is indicated on the graduated rule of the measure 7, and the pressure is read from the pressure gauge 2.

The results are recorded in tabular form :

Pressure (bar)	V (dm ³)
P_1	V_1
P_2	V_2
.	.
.	.
P_{max}	V_n

or in the form of a graph :



For example, for a tank of 30 m^3 and $P_{\text{max}} = 7 \text{ bar}$, the data in table A were obtained in successive steps. The final data are recorded in table B and presented in figure C.

Table A

P (bar)	ΔV (dm ³)
7 - 6	10
6 - 5	10
5 - 4	15
4 - 3	15
3 - 2	20
2 - 1	30
1 - 0	50

Table B

P (bar)	V (dm ³)
1	50
2	80
3	100
4	115
5	130
6	140
7	150

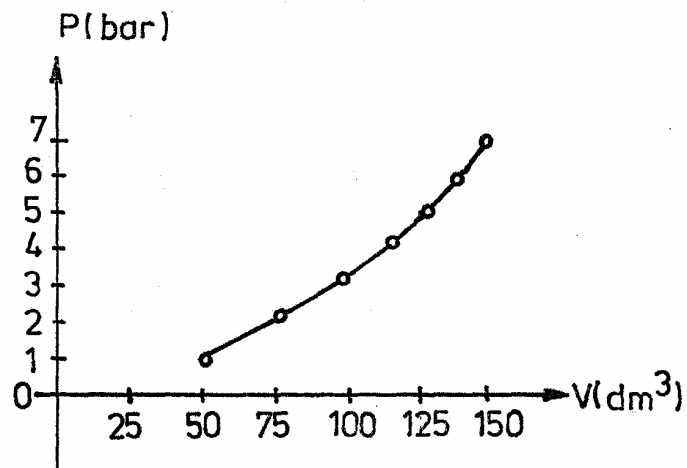


Figure C

ANNEX 5

EXAMPLE OF CALIBRATION CERTIFICATE

Calibration station
for road tanker:
.....

Country

Validity until

CALIBRATION CERTIFICATE No.

Equipment to be calibrated : Road tanker used for the transport of wine

Type, serial number,
manufacturer : Semi-trailer type No.
manufactured by

Characteristics : Made of stainless thermoinsulated sheet with 4 compartments ; the
liquid levels are gauged by a millimetre dipstick

Owner :

Calibrating method : Volumetric method. Calibration was carried out by in
conformity with OIML R 80 (National Regulation No.)

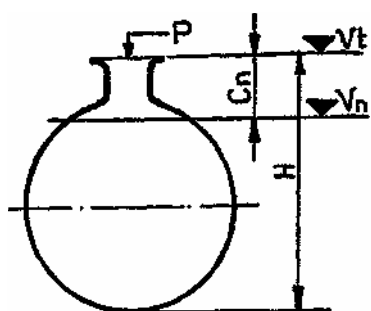
Calibration conditions : Temperature of water

The volumes mentioned in the attached table are calculated for the
temperature of 20 °C. The maximum error of calibration is ± 0.2 %
of the indicated volumes.

Notes : The tanker has a manifold which may cause errors. Before and
after each measurement the operator shall check the state of filling
of the compartments.

Coupling height of semi-trailer during calibration :

CALIBRATION TABLE



- P : reference point
- H : reference height
- V_t : total contents (to brim)
- V_n : capacity corresponding to normal filling in use
- C_n : ullage corresponding to a normal filling in use
- V : contained volume corresponding to the ullage C

Compartment No.	H mm	V_t dm ³	V_n dm ³	C_n mm
1	1 953	5 530	5 496	160
2	1 958	5 625	5 580	170
3	1 967	5 573	5 532	170
4	1 963	5 700	5 663	170

Compartment No.	Ullage (C), cm				
	19.0	18.0	17.0	16.0	15.0
	Contained volume (V), dm ³				
1	5 460	5 473	5 485	5 496	5 504
2	5 557	5 569	5 580	5 590	–
3	5 508	5 521	5 532	5 541	–
4	5 640	5 652	5 663	5 672	–

Calibrated at.....date.....

by

ANNEX 6

EXAMPLE OF CALIBRATION OF A RAIL TANKER

A standard installation is used with two proving tanks, each of 2 000 dm³, and a volumetric measure with a window and scale graduated from 1 to 550 dm³ (scale interval 1 dm³).

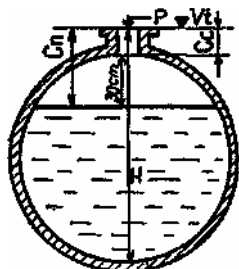


Fig. 1

- 1) During the first stage of calibration the values obtained for the data on the drawing (Fig. 1) are shown on the test sheet given below. The volume of the proving tank of 2000 dm³ was used 23 times to fill to $C_n = 45$ and then a further 20 dm³ by means of the 550 dm³ measure.
- 2) The second stage of calibration was carried out by means of the 550 dm³ measure, a measuring device, and an electric signal for each centimetre; the results and calculated values are shown on the test sheet given below.

CALIBRATION TEST SHEET

Calibration Station.....

Rail tanker No.

- First stage calibration

Date

$H = 3\,955\text{ mm}$ $C_c = 14.2\text{ cm}$

$C_n = 45\text{ cm}$

$V_n = 23 \times 2000 + 20 = 46\,020\text{ dm}^3$

Temperature of ambient air: + 17 °C

Temperature of water in the rail tanker (final) : + 17.5 °C

Mean temperature of water in the proving tanks : + 18 °C

- Second stage calibration

Date

Number of use of proving tank	Partial volumes (on scale) dm ³	Volume per cm dm ³	Volume total dm ³	C _i cm
1			46 020	45
2	195	195	46 215	44
	362	167	46 382	43
	512	150	46 532	42
3	147	147	46 679	41
	286	139	46 818	40
	416	130	46 948	39
	549	133	47 081	38
4	130	130	47 211	37
	263	133	47 344	36
	388	125	47 468	35
	516	128	47 597	34
5	127	127	47 724	33
	237	110	47 834	32
	350	113	47 947	31
	460	110	48 057	30
6	106	106	48 163	29
	213	107	48 270	28
	314	101	48 371	27
	418	104	48 475	26
	510	92	48 567	25
7	80	80	48 647	24
	154	74	48 721	23
	225	71	48 792	22
	291	66	48 858	21
	357	66	48 924	20
	415	58	48 982	19
	471	56	49 038	18
	509	38	49 076	17
	521	12	49 088	16
	531	10	49 098	15

Calibrated by:.....

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