

INTERNATIONAL
RECOMMENDATION

OIML R 71

Edition 1985 (E)

Fixed storage tanks - General requirements

Réservoirs de stockage fixes - Prescriptions générales



Foreword

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This publication – reference OIML R 71 (E), edition 1985 – which is under the responsibility of TC 8/SC 1 *Static volume measurement*, was sanctioned by the International Conference of Legal Metrology in 1984.

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TERMINOLOGY

1. Calibration

The set of operations carried out to determine the capacity of a tank up to one or several liquid levels.

2. Nominal capacity

The rounded value of the maximum volume of liquid a tank may contain under normal conditions of use.

3. Sensitivity of a tank in the vicinity of a liquid level h

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

4. Gauge hatch

The opening in the upper part of the tank to allow the liquid levels in the tank to be measured.

5. Vertical measurement axis

The vertical line which passes through the middle of the still well (guide pipe), if provided, belonging to the gauge hatch concerned, and corresponding to the position intended for automatic or manual level gauges.

6. 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 the dip plate is not provided.

It constitutes the origin for the measurement of liquid levels (zero reference).

7. Upper reference point

The point located on the vertical measurement axis, with reference to which the ullage is measured.

8. Ullage

The distance between the free surface of the liquid and the upper reference point, 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, under reference conditions.

10. High point

The highest point on the bottom of a vertical cylindrical tank having a practically horizontal bottom. This is the point which is covered last by the liquid when the tank is being filled.

11. 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.

12. Calibration table

The expression in the form of a table, of the mathematical function $V(h)$ which represents the relation between the height h (independent variable) and the volume V (dependent variable).

13. Graduated zone

For tanks for which a calibration table has been established, the range of volumes between the deadstock and the nominal capacity.

14. Smallest measurable volume

The smallest volume the measurement of which is authorized, for delivery or reception of the liquid, at any point of the graduated zone.

The smallest measurable height of a tank is the change in the level which corresponds to the smallest measurable volume.

15. Deadstock

Volume of liquid contained in the bottom of the tank up to the lowest dipping datum point.

16. Lower limit of accurate capacity

The capacity below which the maximum permissible error does not apply, taking account of the shape of the tank and the calibration method.

FIXED STORAGE TANKS

GENERAL REQUIREMENTS

1. General

1.1. Fixed storage tanks at atmospheric pressure or under pressure (hereinafter called « tanks ») are built for bulk liquid storage and may be used for measurement of volumes (quantities) of liquid contained. When used for that measurement, and when subjected to national metrological control, they shall comply with the general requirements of this Recommendation.

1.2. Tanks represent a category of simple measuring equipment, but the measurement of volumes (quantities) of liquid contained in a tank is a complex operation which, in addition to the tank, involves the use of other devices and measuring instruments which, in general, may not be directly connected to the tank (see Appendix 1).

2. Classification and description

2.1. Regarding their calibration and the establishing of calibration tables, the tanks may be classified according to the following criteria :

- shape,
- position with reference to the ground,
- means used for measuring levels or volumes (quantities) of liquid contained,
- kind of liquid(s) to be contained,
- conditions of use (supplementary influence quantities).

2.1.1. The most common shapes of the tanks are the following :

- cylindrical with vertical or horizontal axis, and with flat, conical, truncated, hemispherical, elliptical or dome-shaped bottom or ends,
- spherical or spheroidal,
- parallelepipedic.

Note : the vertical cylindrical tanks may have a fixed or floating roof (or a floating cover).

2.1.2. The position of the tanks with reference to the ground may be :

- on the ground,
- partially underground,
- underground,
- above ground.

2.1.3. The means used for measuring the levels or volumes (quantities) of liquid contained may be :

- a single graduation mark,
- a measuring device with a graduated scale (with a viewing window or an external gauge tube),
- a graduated rule (dipstick) or a graduated tape with dip-weight or sinker (manual measurement),
- an automatic level gauge (automatic measurement).

2.1.4. The main influence quantities which affect calibration are pressure and temperature. Pressure, including hydrostatic pressure, may alter the apparent volume by distorting the shell ; differences from the reference temperature will alter the volumes by expansion or contraction of the liquid and shell.

- a) With reference to pressure, the tanks may be :
 - at ambient atmospheric pressure,
 - closed, at low pressure,
 - closed, at high pressure.
- b) With reference to temperature, the tanks may be :
 - without heating,
 - with heating, but without thermal insulation,
 - with heating and thermal insulation,
 - with refrigeration and thermal insulation.

2.2. A vertical cylindrical tank, with fixed roof, is shown as an example in Figure 1 ^(*).

2.3. A horizontal cylindrical tank is shown as an example in Figure 2 ^(*).

3. Units of measurement

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

If, in any country, units of measurement outside the 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 the SI shall be applied.

4. Technical and metrological characteristics of tanks

4.1. The tanks shall be built in accordance with sound engineering practice.

With reference to their construction, position and conditions of use, the tanks shall comply with the legal requirements for storage of contained liquids, in relation to the characteristics of these liquids (potable, petroleum, chemical, etc.).

4.2. The tanks may be provided with devices necessary to prevent, as far as possible, the loss of liquid by evaporation.

4.3. The tanks, to be accepted for verification, shall comply with the following general requirements, aiming to ensure the accuracy of measurement of the volume of liquid contained.

- a) The shape, material, reinforcement, construction and assembly shall be such that the tank is sufficiently resistant to the atmosphere and the effects of the contained liquid and that, under the normal conditions of use, it suffers no permanent deformation which may alter its capacity.

Materials other than metals shall be specially approved.

^(*) BIML note : these figures, as well as those in Appendix 2, show very classical and even old methods of construction and installation of tanks. They are given in this Recommendation only for illustration and shall in no case prohibit the use of more modern construction and installation methods.

- b) The dipping datum point and the upper reference point shall be constructed so that their positions remain practically unchanged whatever the state of filling of the tank, the temperature, etc.

However, if it is impossible to ensure the constancy of the reference points, and this applies particularly to very large tanks, for example over 1 000 m³, the effects on the reference points as a function of filling, temperature and density shall be indicated in the calibration certificate so that corrections can be applied during the determination of volumes.

Examples for the position of gauge hatches and the construction of reference points are shown in Appendix 2.

- c) The shape of the tanks shall be such that the formation of air-pockets during filling, or of pockets of liquid after draining is prevented.
- d) To permit the application of the geometric methods of calibration, the tanks shall show no deformation, bulges, etc. which could prevent correct measurement of their dimensions and interpolation between measurements.
- e) The tanks shall be stable on their foundations ; this may be ensured by anchoring or by an adequate period of stabilization, the tank remaining full, so that its base will not vary greatly with time.
- For vertical cylindrical tanks, exceeding 2 000 m³, five gauge hatches may be provided, one of these as close as possible to the centre and the other ones evenly spaced near the side walls. The gauge hatch located in the part least exposed to the sun is the principal gauge hatch.
- f) The tanks shall be pressure tested and leakproof, the results being recorded in a document which shall be presented before calibration starts.

4.4. The tanks shall comply with the technical requirements concerning the installation and use of the level measuring devices which are provided for each tank.

4.5. If required by national regulations, the tanks shall be provided with a calibration information plate bearing :

- the identification number of the tank,
- the reference height H, in millimetres (except for tanks with an external gauge tube),
- the number of the calibration certificate followed (with a horizontal or vertical separation line) by the last two figures of the year in which calibration was carried out and preceded by the name or acronym of the institution which carried out the calibration.

It is recommended to mark on this plate also the nominal capacity, rounded down to the nearest cubic meter.

The calibration information plate shall be made of a metal which remains practically unchanged under normal conditions of use. The plate shall be fixed on an integral part of the tank, so located that it is readily visible and easily legible, not subject to deterioration, and in such a manner that it cannot be removed without breaking the seals which carry the verification marks.

It is recommended that this plate be located in the immediate vicinity of the gauge hatch.

Other forms of identification and records of data may be authorized by national regulations.

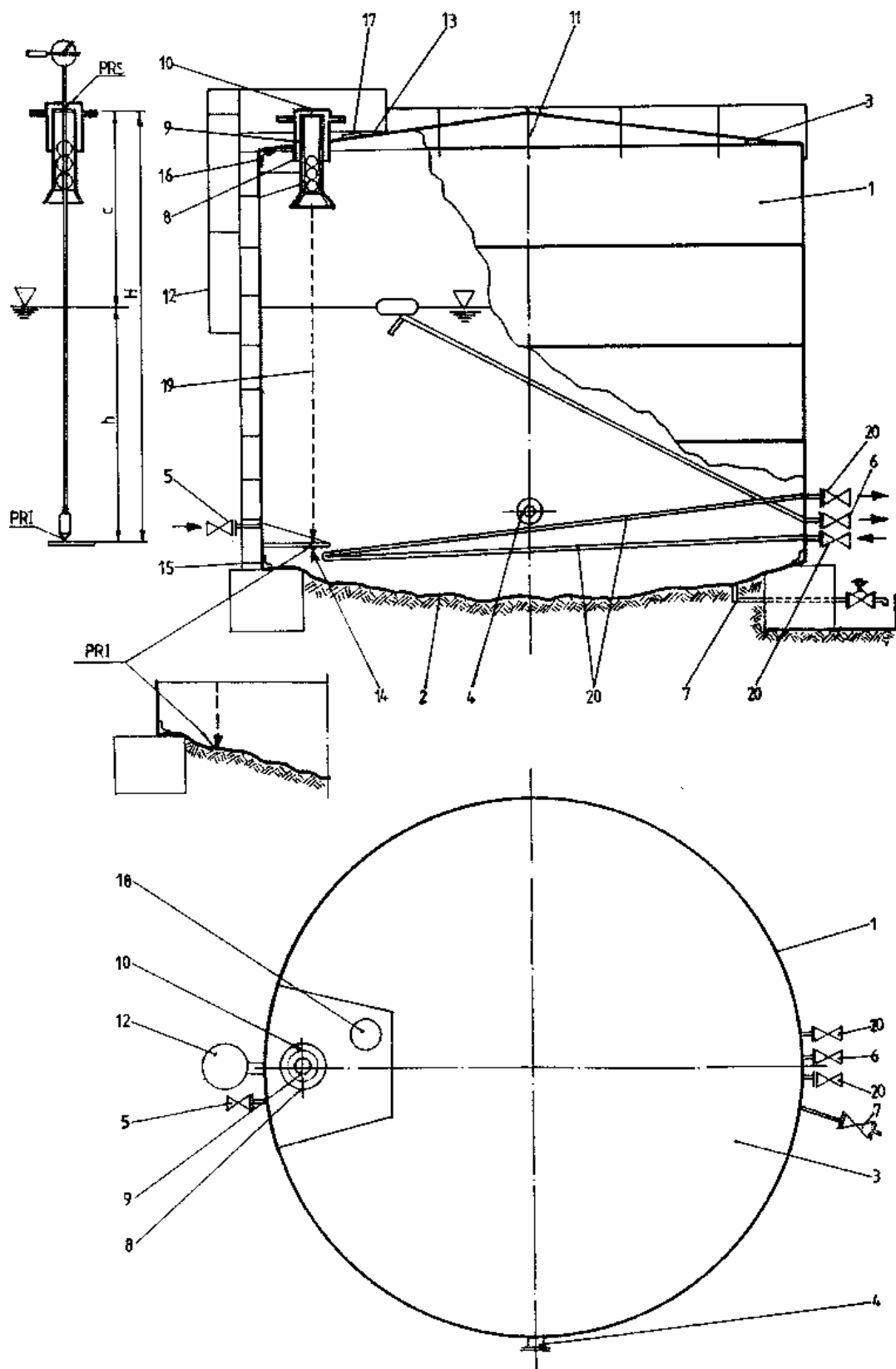


Figure 1. Diagram of a vertical cylindrical tank with fixed roof

1. Shell. 2. Bottom of the tank. 3. Roof. 4. Manhole. 5. Inlet line. 6. Outlet line. 7. Drain line. 8. Gauge hatch. 9. Guide pipe. 10. Lid of the guide pipe. 11. Handrail. 12. Access ladder with guard rail. 13. Measurement platform. 14. Dip plate. 15. Lower angle-irons. 16. Upper angle-irons. 17. Calibration information plate. 18. Opening. 19. Vertical measurement axis. 20. Heating coil. PRS : Upper reference point. PRI : Dipping datum point. H : Reference height. C : Ullage, h : Level of the liquid in the tank.

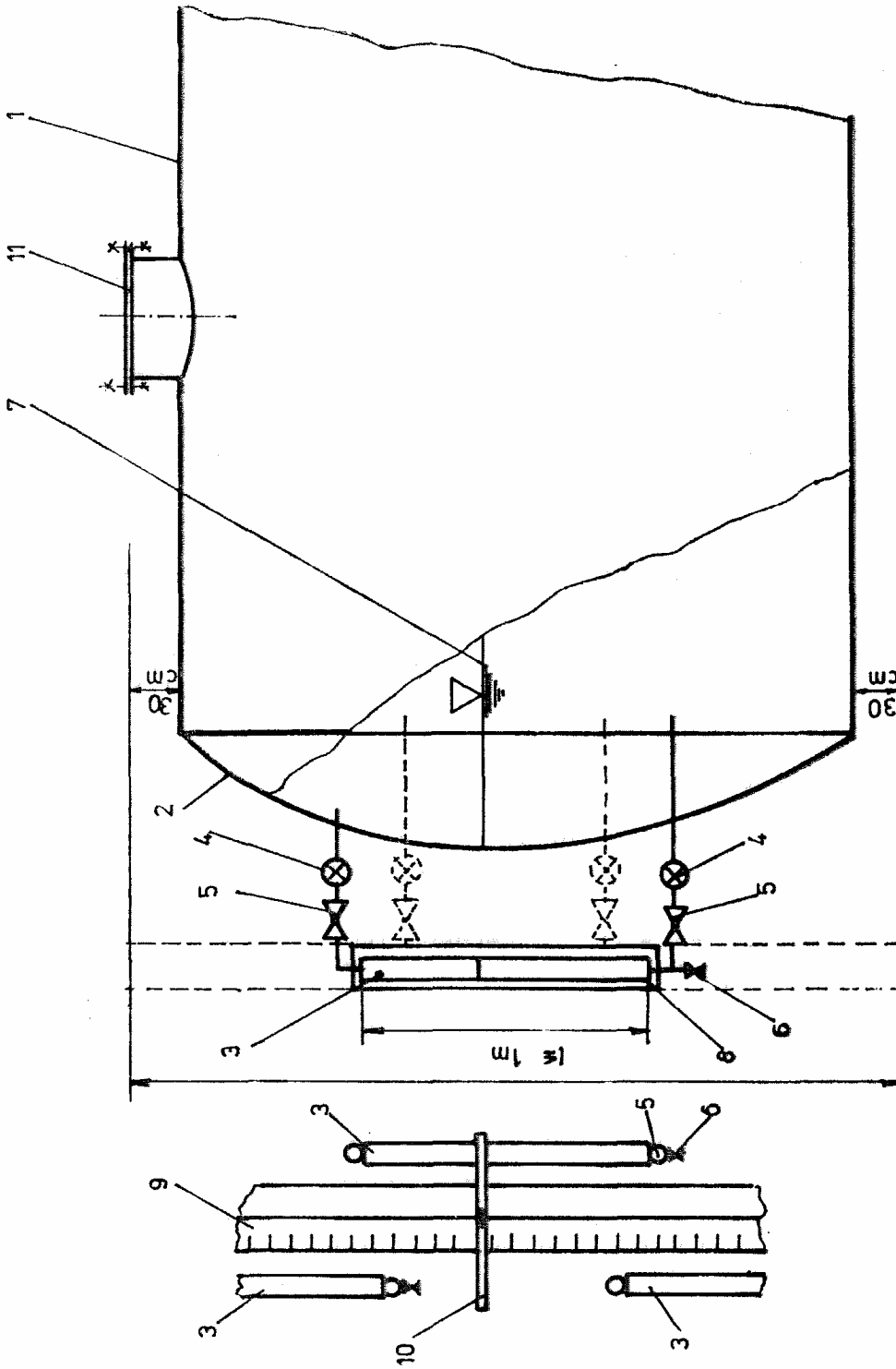


Figure 2. Diagram of a horizontal cylindrical tank with level tube

1. Cylindrical shell. 2. End. 3. Glass tube level gauge. 4. Isolating valve. 5. Safety shut-off valve. 6. Drain valve. 7. Level of the liquid in the tank.
8. Gauge glass protection. 9. Graduated scale. 10. Cursor. 11. Manhole.

4.6. The maximum permissible calibration error applies to the values between the lower limit of accurate capacity and the nominal capacity, shown in the calibration table.

The maximum permissible error, positive or negative, shall be equal to :

0.2 % of the indicated volume for vertical cylindrical tanks calibrated by geometric method,

0.3 % of the indicated volume for horizontal or tilted cylindrical tanks calibrated by geometric method and for any tank calibrated by volumetric method,

0.5 % of the indicated volume for spherical or spheroidal tanks calibrated by geometric method.

In case of particular technical difficulties, these maximum permissible errors may be increased.

The calibration table may be extended below the lower limit of accurate capacity ; the maximum permissible errors indicated above do not apply in this extended zone.

4.7. The tanks shall be presented for verification empty and well cleaned. They shall be degassed and prepared so that they do not present any risk to the operators.

5. Legal qualification of tanks

5.1. If, in any country, the tanks are subject to state metrological controls, the granting of the « legal » status to a tank and the retention of that status shall include all or part of the following operations :

- approval of design drawings in respect to the metrological characteristics of the tank,
- initial verification,
- periodic verification or recalibration in service.

These operations are carried out by or under the control of the national metrological authorities.

5.2. The approval of design drawings partially replaces pattern approval, which is normally required for ordinary measuring instruments. This approval must be obtained by the manufacturer before he starts construction ; for this purpose, he shall submit to the competent authority the design drawings of the tank, showing :

- the general layout,
- the method of fixing the tank on the ground (or underground),
- the position of the valves and of the inlet and outlet pipes, so that the way in which the tank can be completely emptied for the purpose of cleaning and periodic calibration can be deduced,
- the position and dimensions of deadwoods (positive and negative),
- the details concerning the floating roof or floating cover (if provided) including its mass,
- the details of fitting the liquid level measuring device in the tank,
- the position of the calibration information plate.

5.3. Initial verification is carried out in two stages :

- examination of the tank in situ,
- calibration.

5.3.1. During the in situ examination, the finished construction is checked, establishing its conformity with the approved drawings. One shall take into consideration : the uniformity of construction, any possible permanent deformations, the rigidity of the structure, stability, manholes, access to the gauge hatch, the possibility of carrying out calibration (if appropriate, additional work which would facilitate calibration, may be required), protected access ladder to the roof, handrail around the roof, internal fittings (deadwood), floating roof or floating cover, attachments for the fitting of the calibration information plate and, in particular, the workmanship and the fitting of the level measuring devices (according to points 4.1 to 4.5).

5.3.2. Calibration may be carried out when the team involved is provided with positive results of the in-situ examination and of the check of compliance with the requirements in points 4.3.f and 4.7.

Concerning calibration itself, the requirements in point 5.5 shall also be taken into account.

5.4. Periodic verification is carried out at the end of the period of validity of the certificate. That period is fixed by the national metrological authorities.

In addition, in-service recalibration is carried out after any accident or deformation of the tank, which could cause a change in its metrological qualities (including changing its position and modifications). The owner of the tank shall inform the national metrological authorities of any incident of this kind.

Periodic verification and in-service recalibration consist of :

- examination of the construction and of its external appearance,
- calibration.

5.4.1. During the examination of the construction and of its external appearance, it shall be ascertained that no modifications were carried out with reference to the drawings. If this is not the case, the problem may be solved in situ if it is of minor importance, or the drawings shall be amended and their approval renewed.

5.4.2. Recalibration may be carried out after it has been confirmed that :

- the result of the examination of construction and external appearance is satisfactory,
- the requirements in point 4.7 are complied with.

Concerning the calibration itself, the requirements in point 5.5 shall also be taken into account.

5.5. Calibration of tanks

The calibration of a tank may be carried out by one of the following methods :

- geometric,
- volumetric,
- a combination of the two.

The choice of the method or of the procedure is imposed by the nominal capacity of the tank, the shape, the position, the conditions of use, etc.

A list of ISO Standards and Draft Standards for different calibration methods is given in Appendix 3.

5.5.1. The geometric methods consist of direct or indirect measurement of external or internal dimensions of the tank, of the positive and negative deadwoods and of the floating roof or floating cover, if provided.

For geometric calibration one of the following methods is used :

- strapping, for vertical or horizontal cylindrical tanks, spheres and spheroids,
- optical method with a reference line and/or a reference plane for vertical cylindrical tanks,
- optical method by triangulation, for vertical cylindrical tanks, spheres and spheroids.

Note : the procedure of internal measurement by means of a tape with a tensioning device is generally not admitted for calibration of tanks containing liquids involved in international trade, except when no better method is applicable (for example, in the case of a thermally insulated tank).

The geometric methods may be used on tanks with a nominal capacity of about 50 m³ and greater, which have a regular geometric shape and show no deformation.

5.5.2. The volumetric method consists in establishing directly the internal capacity, by measuring, by means of a measurement standard, the partial volumes of a non-volatile liquid which are successively delivered into, or withdrawn from the tank. Water is a very suitable non-volatile liquid with the additional advantage of having a small coefficient of expansion.

The volumetric method is generally used for the calibration of the following categories of tanks :

- underground tanks, of any type,
- tanks on the ground or above ground, with a nominal capacity up to 100 m³,
- tanks of a shape not suitable for a geometric method.

5.5.3. The combination method consists in establishing, by means of the geometric method, the volumes corresponding to the shell of the tank and by means of the volumetric method the volumes corresponding to the bottom of the tank.

This method applies, under the same conditions as the geometric method, to tanks of which the lower part consists of a shape for which the volume cannot be determined with sufficient accuracy, by means of the geometric method.

5.5.4. The calibration operations include :

- consultation of drawings, examination of technical data, field measurements,
- calculation and interpretation of results,
- preparation of the calibration table or determination of the function V(h).

5.5.4.1. Before and during execution of measurements on site, the technical requirements regarding safety at work (danger of toxic gases, possible contamination from the stored product, for example leaded gasoline, conditions for working at heights, etc.) shall be observed, as well as the requirements laid down by the responsible authorities, concerning the risks of explosion and fire, relating specifically to the place at which the tank is installed, if appropriate.

5.5.4.2. The values of volumes are given in the calibration table with at least five significant figures.

If the calibration table is extended below the lower limit of accurate capacity, the values of the extended zone are given with a number of significant figures compatible with the expected calibration accuracy.

5.5.4.3. In the case of vertical cylindrical tanks, a calibration table is established for a reference density of the liquid contained.

This reference density shall be indicated in the calibration table. In addition, the table shall indicate the limits of variation of density, above and below that reference density, causing a relative variation in volume greater than 0.025 %.

5.6. Granting of the calibration certificate and application of the verification mark (according to national regulations).

5.6.1. The tanks which comply with all the requirements of this Recommendation shall be accepted for verification ; after calibration, the calibration certificate is issued and the markings on the calibration information plate are completed.

5.6.2. The calibration certificate shall include :

- the technical data concerning the tank :
 - reference height, H,
 - positions of the vertical measurement axes (gauge hatches, reference points including identification of the principal one),
 - level measuring means, if known,
 - nominal capacity and lower limit of accurate capacity,
 - smallest measurable volume corresponding to manual gauging or to the automatic level gauge, if the latter is known (see Appendix 4),
- the calibration table, for increments Δh ,
- the table of volumes corresponding to a vertical distance of 1 mm, for each zone for which the volume per millimetre varies (interpolation table),
- a statement that the values given in the certificate are valid for a reference temperature of 20 °C (or any other temperature officially accepted),
- the reference density, if appropriate (see point 5.5.4.3),
- the maximum permissible error on the determination of the values given in the calibration table (see point 4.6),
- the data concerning calibration, that is to say the method used and the regulation or standard which constitutes the legal and technical basis,
- the period of validity of the calibration certificate, if prescribed by national regulations,
- the corrections for the changes in certain parameters, such as :
immersion of the floating roof or floating cover, pressure, temperature, differences in density greater than those specified in point 5.5.4.3, etc.,
- the date of issue of the calibration certificate.

5.6.3. When required by national regulations, the legality of the verification is confirmed by applying a verification mark on :

- the calibration certificate,
- the calibration information plate,
- a place making it possible to identify the upper reference point, if appropriate,
- the graduated rule (dipstick), if provided,
- the device for sealing the level gauge, if provided.

APPENDIX 1

PROCEDURES TO BE FOLLOWED FOR THE DETERMINATION OF VOLUMES (QUANTITIES) OF LIQUIDS IN A TANK

In principle, the measurement of the volumes (quantities) of liquid contained in a tank requires the following procedures :

- a) measurement of the level of the free surface of the liquid ; whence the volume of the liquid in the tank V_{t_r} , at the temperature t_r , is determined, using the values given in the certificate or the calibration table,
- b) measurement of the mean temperature t_r ,
- c) taking of samples and preparation of a mean sample representative of the liquid contained in the tank; the density ρ_{t_ℓ} of the liquid at a temperature t_ℓ , very close to t_r , is determined in the laboratory,
- d) determination of the density ρ_{t_r} , on the basis of ρ_{t_ℓ} , by calculation or with the help of tables,
- e) calculation of the mass of the liquid, using the formula :

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

The procedures described in d) and e) may be replaced by the determination of the volume V_o and the density ρ_{t_o} , at the reference temperature t_o , by calculation or with the help of tables :

$$M = V_o \times \rho_{t_o}$$

It may sometimes be sufficient to calculate the value V_{t_o} at the reference temperature on the basis of the procedures described in a), b) and c) and with the help of tables. In some cases, for instance for products of moderate price or measured in small quantity, a calculation of V_t according to the procedure described in a) is sufficient.

Notes :

A) It is sometimes necessary to measure :

- the height of the layer of water deposited at the bottom of the tank,
- the quantity of suspended water,
- the quantity of solid impurities in suspension, etc.,

and to make the appropriate corrections.

B) If a device for determining directly the mass of the liquid contained in relation to the hydrostatic pressure is used, the procedures described in a) to e) are considerably simplified. It is sufficient to read the indication of the device (graduated in units of mass) and to know the horizontal section and its variations in relation to height.

C) In the case of a liquid under pressure without a gaseous phase, the pressure shall be measured and appropriate corrections for compressibility of the liquid and for elastic deformation of the tank shall be taken into account.

D) In the case of simultaneous presence of the gaseous and liquid phases, the liquid equivalent of the saturated vapour shall be determined, in addition to the corrections mentioned in C) above, and the result added to the volume of liquid.

APPENDIX 2

EXAMPLES OF LOCATION OF GAUGE HATCHES AND OF REALISATION OF THE REFERENCE POINTS

- Figure 3. Design details of a guide pipe in a horizontal cylindrical tank
- Figure 4. Design details of a guide pipe in a vertical cylindrical tank with fixed roof, of which the deflection when loaded is negligible
- Figure 5. Design details of a guide pipe in a vertical cylindrical tank with fixed roof, of which the deflection when loaded must be taken into consideration
- Figure 6. Design details of a guide pipe and level gauge in a vertical cylindrical tank with fixed roof, of which the deflection when loaded must be taken into consideration if the bottom of the tank is stable.
- Figure 7. Design details of a level gauge with still well in a spherical tank
- Figure 8. Design details of a level tube in a vertical cylindrical tank for wine (wine vat)
- Figure 9. Design details of a milk vat

Notes : 1. the dimensions are given in millimetres, unless otherwise indicated.
2. see note to points 2.2 and 2.3

DETAIL A

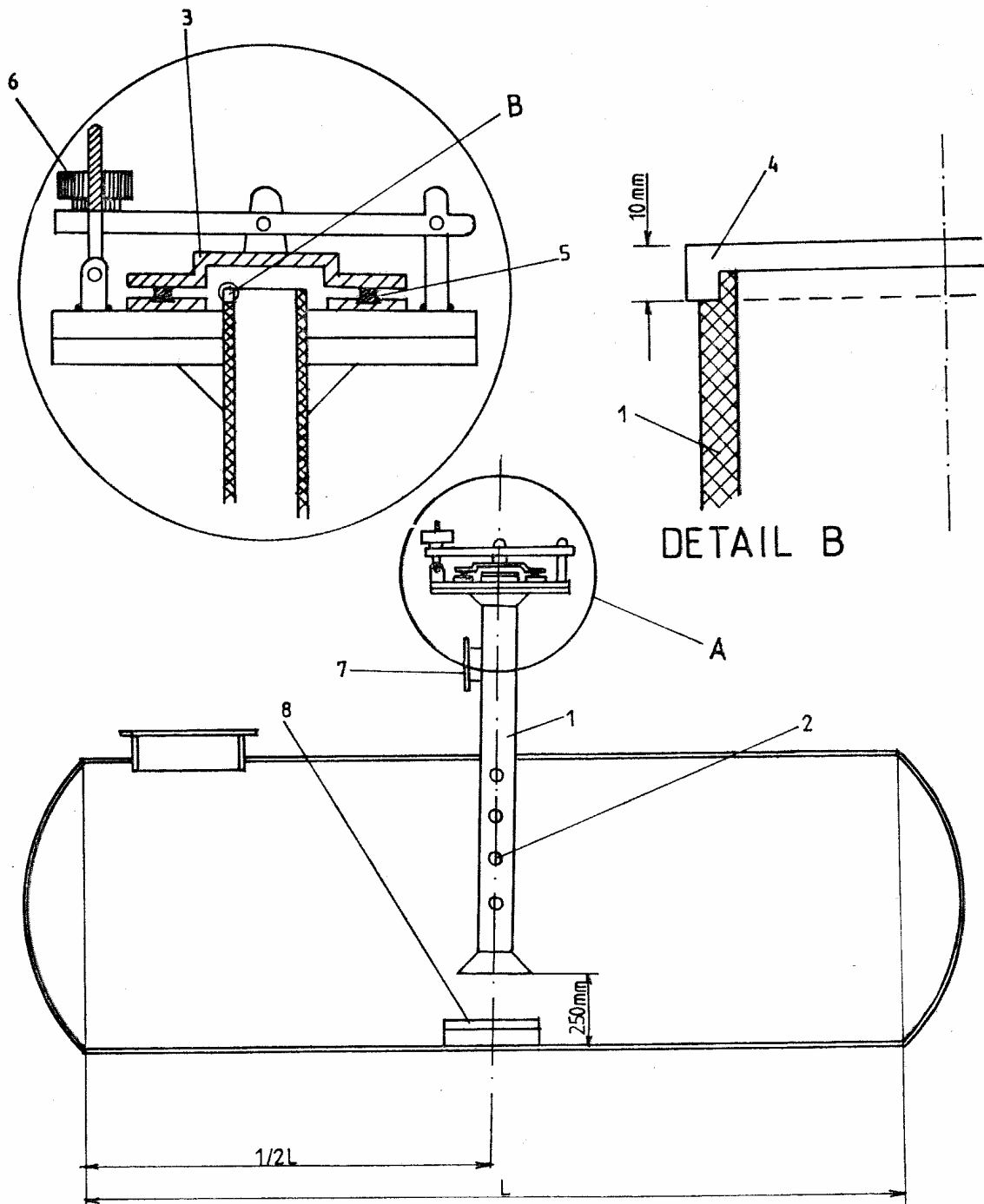


Figure 3. Design details of a guide pipe in a horizontal cylindrical tank

1. Guide pipe and still well ($\text{Ø}_{\text{int.}} = 100 \text{ mm}$).
2. Holes $\text{Ø} 25 \text{ mm}$ at 150 mm pitch.
3. Lid of guide pipe.
4. Fixed metal ring.
5. Rubber joint.
6. Set screw of the lid.
7. Calibration information plate.
8. Dip plate (another solution : fix the dip plate to the lower end of the guide pipe).

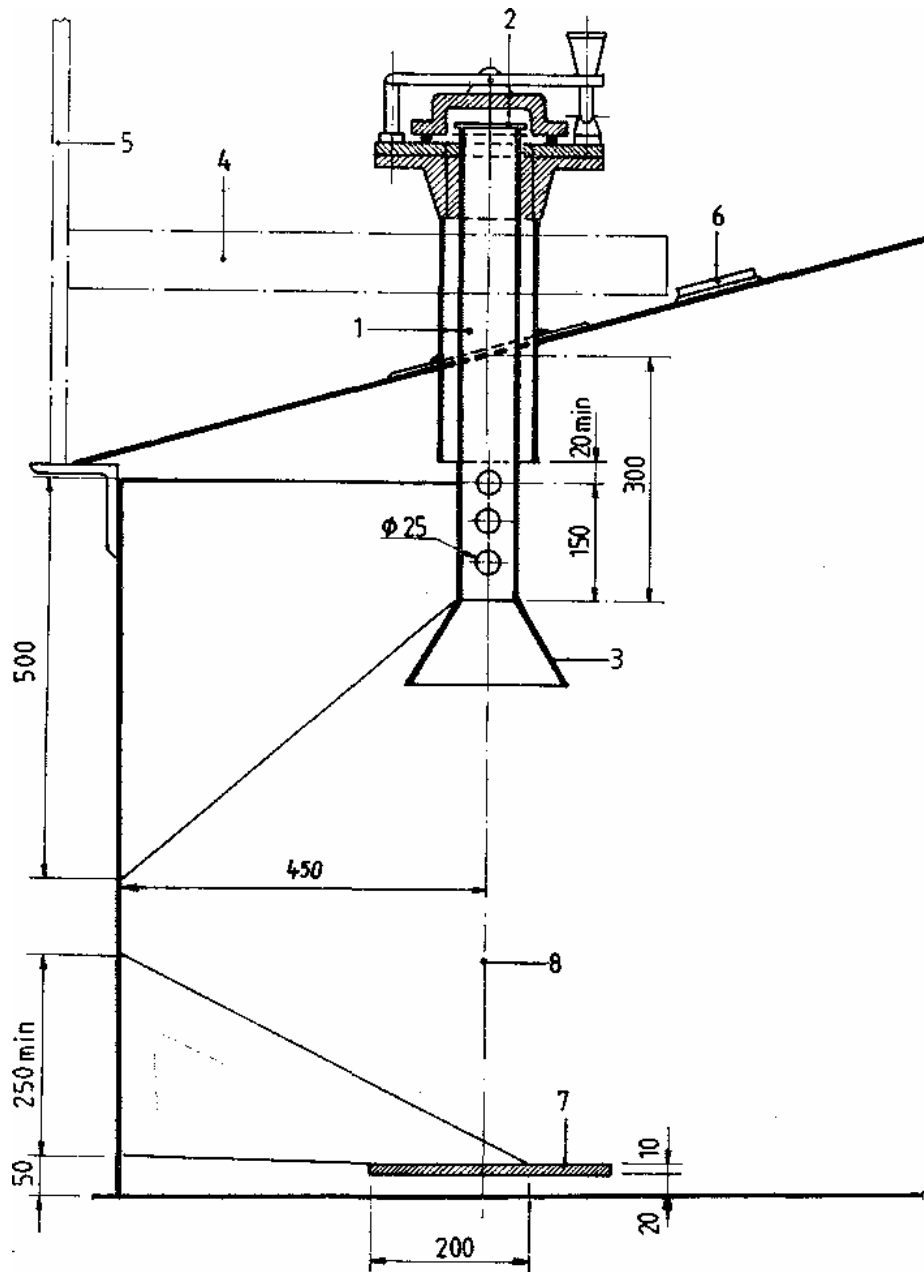


Figure 4. Design details of a guide pipe in a vertical cylindrical tank with fixed roof, of which the deflection when loaded is negligible

1. Guide pipe fixed to the upper part of the body by welded gussets.
2. Gauge hatch.
3. Funnel.
4. Platform.
5. Guard-rail.
6. Calibration information plate.
7. Dip plate (300 × 300 mm) fixed to the shell by welded gussets.
8. Vertical measurement axis.
9. Lid of guide pipe.

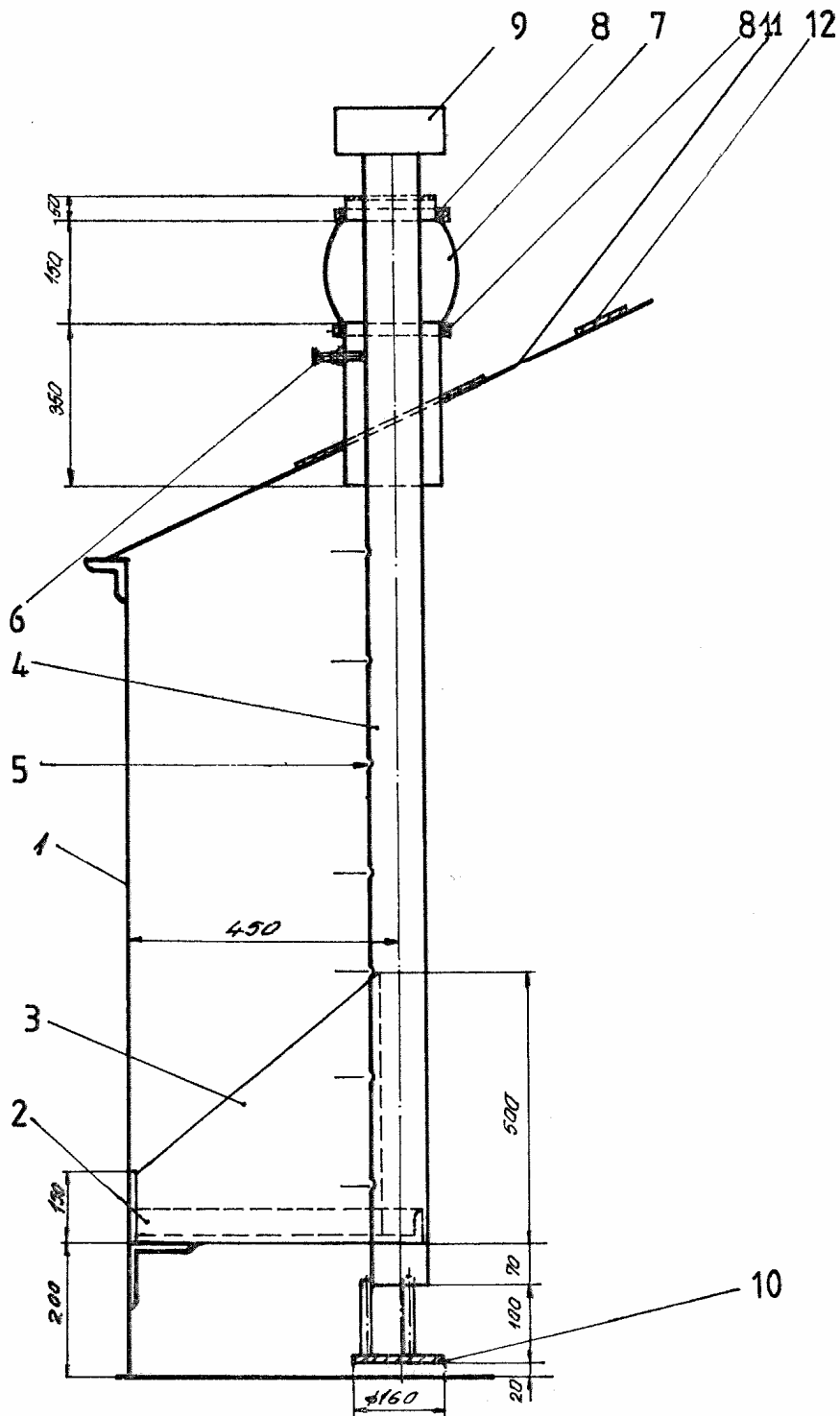


Figure 5. Design details of a guide pipe in a vertical cylindrical tank with fixed roof, of which the deflection when loaded must be taken into consideration

1. Cylindrical shell. 2. L-section. 3. Gussets. 4. Guide pipe and still well ($\text{Ø}_{\text{int}} = 100 \text{ mm}$) fixed to the lower part of the body by welded L-section 2 and gussets 3. 5. Holes $\text{Ø} 25 \text{ mm}$ at max. 300 mm pitch. 6. Screw ($\times 3$) to regulate the verticality of the guide pipe. 7. Flexible joint. 8. Screw collar. 9. Lid of guide pipe as in Figures 3 and 4. 10. Dip plate (10 mm thick) fixed to the guide pipe by welded 3/4 round iron. 11. Fixed roof. 12. Calibration information plate.

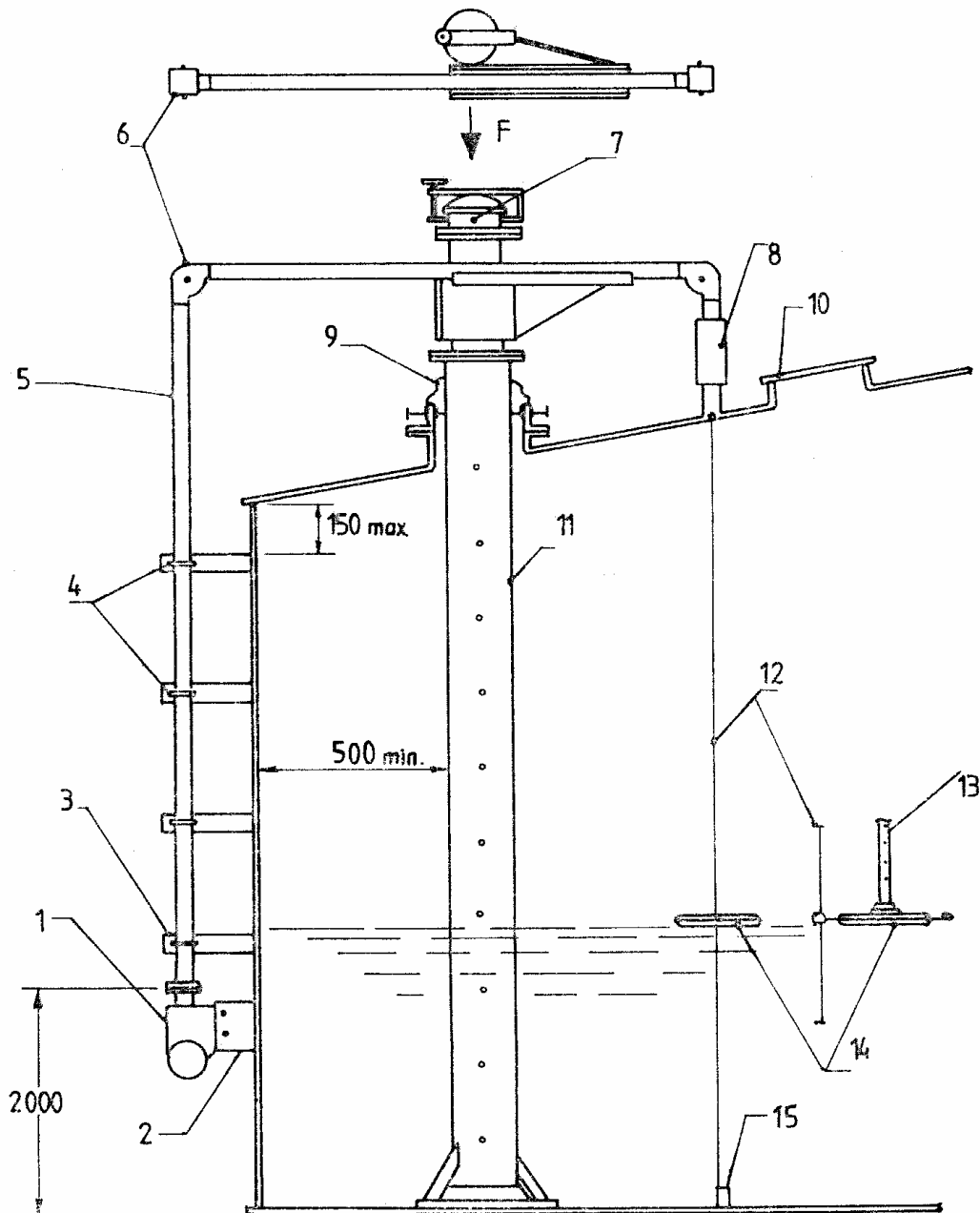


Figure 6. Design details of a guide pipe and level gauge in a vertical cylindrical tank with fixed roof, of which the deflection when loaded must be taken into consideration if the bottom of the tank is stable

1. Indicating device of the level gauge.
2. Support bracket.
3. Safety ring.
4. Sliding guides.
5. Protective tube for the level gauge tape.
6. Pulley for the tape.
7. Manual gauge hatch.
8. Flexible joint.
9. Seal.
10. Manhole.
11. Guide pipe and still well.
12. Tensioned wires for guiding the float.
13. Tape.
14. Float.
15. Guide wire bracket.

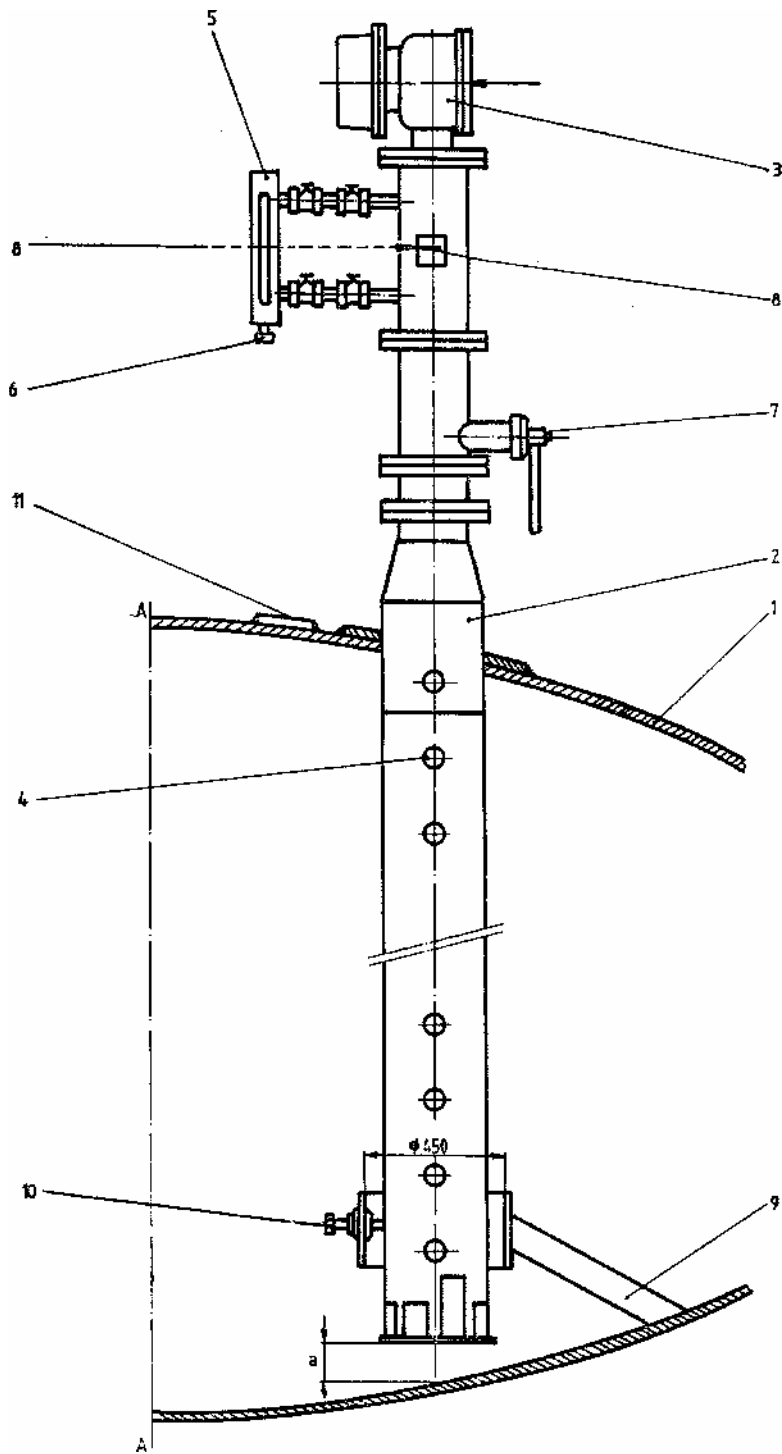


Figure 7. Design details of a level gauge with still well in a spherical tank

1. Metal wall (sphere).
 2. Pipe ($\text{Ø}_{\text{int}} = 300 \text{ mm}$) to be adjusted vertically (5 mm tolerance between the vertical determined by plumb bob and three generating lines at 120°).
 3. Indicating device of the level gauge.
 4. Holes $\text{Ø} 40$ at 200 mm pitch.
 5. Glass level indicator, with metal casing.
 6. Drain plug or valve.
 7. Spherical isolating valve.
 8. Mark of reference level (for in-service checking of zero adjustment of the level gauge).
 9. Three gussets at 120° .
 10. Three bolts for vertical alignment of the guide pipe.
 11. Calibration information plate.
- AA : Axis of the sphere, a : Minimum dimension compatible with the deformation of the sphere.

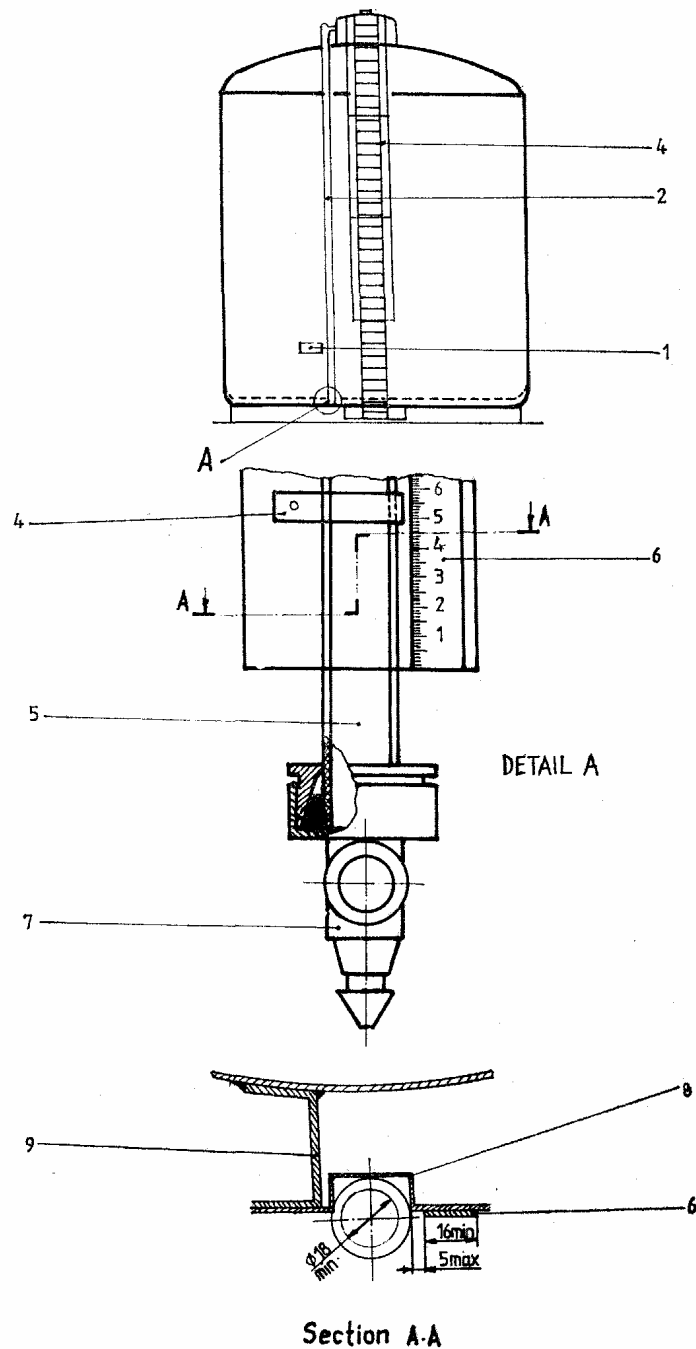


Figure 8. Design details of a level tube in a vertical cylindrical tank for wine (wine vat)

1. Calibration information plate.
2. Level indicating tube.
3. Ladder fixed alongside the level tube.
4. Fixing clamp of the level tube.
5. Vertical transparent level tube.
6. Millimetre rule.
7. Three-way valve.
8. Base support for the level tube and millimetre rule.
9. Fastening strap between the support 8 and the wall of the vat.

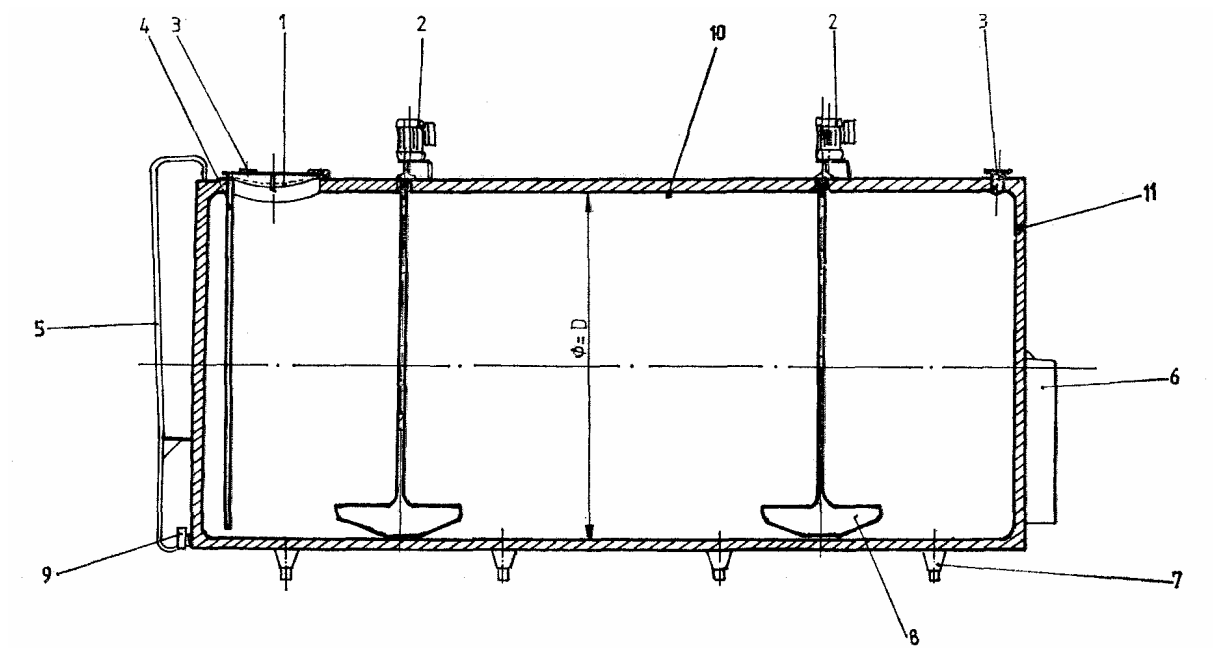


Figure 9. Design details of a milk vat

1. Manhole cover.
2. Stirring motor.
3. Air vent.
4. Gauge (dipstick).
5. Removable ladder.
6. Refrigeration cover.
7. Adjustable supports.
8. Stirrer.
9. Drain plug.
10. Cylindrical tank with circular or ellipsoidal section.
11. Thermal insulation.

APPENDIX 3

ISO STANDARDS AND DRAFT STANDARDS ON CALIBRATION METHODS

ISO/TC 28/SC 3

- DIS 4512 Petroleum and liquid petroleum products — Equipment — Tank gauging and calibration — Manual methods.
- DIS 4269 Petroleum and liquid petroleum products — Tank calibration — Liquid methods.
- DIS 7507-1 Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 1 : Strapping method.
- DIS 7507-2 Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 2 : Optical reference line method.
- DP 7507-3 Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 3 : Optical triangulation method.
- DP 7507-4 Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 4 : Electro-optical distance ranging method.
- DP ... Calibration of horizontal cylindrical tanks — Geometric method.
- DP ... Calibration of spheres and spheroids — Geometric method.
- DP ... Compressibility correction.
- DP 4267/1 Petroleum and liquid petroleum products — Calculation of oil quantities — Part 1 : Static measurement.

ISO/TC 28/SC 1 and 5

- DP 4273 Vocabulary of petroleum measurement terms.
- 5024-1976 Petroleum liquid and gases — Measurement — Standard reference conditions.
- DP 7394 Natural gas liquids and vapours — Conversion to equivalent liquid volumes.
- DIS 6578 Refrigerated hydrocarbon liquids — Static measurement — Calculations procedure.

APPENDIX 4

SMALLEST MEASURABLE VOLUME

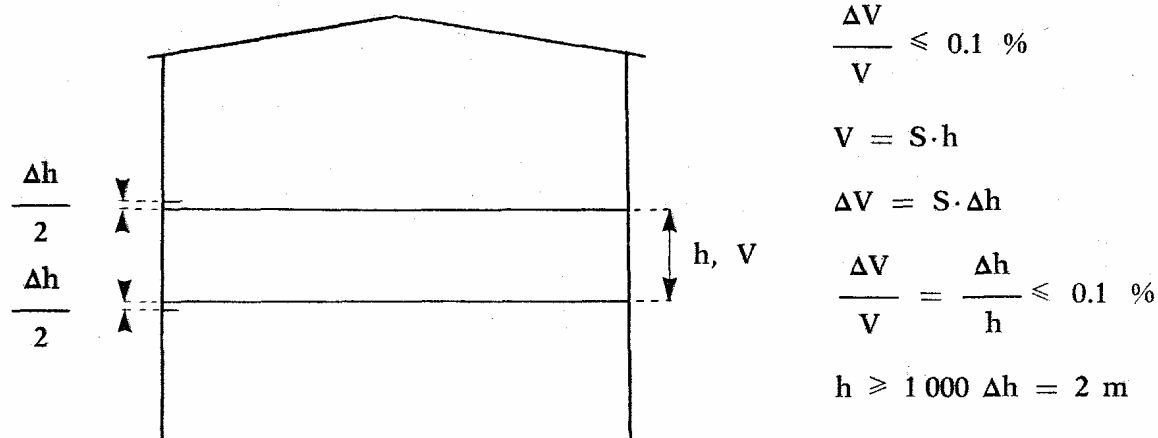
SMALLEST MEASURABLE HEIGHT

EXAMPLE

(with reference to point 5.6.2 of the Recommendation)

The smallest measurable volume is determined so that a change Δh in the level of the liquid, resulting from cumulative uncertainties on the measurement of the level at two successive points, does not lead to a relative error on the delivered or collected volume greater than a pre-established value, $\epsilon(h)$, generally smaller than the maximum permissible error on calibration.

For example, for a vertical cylindrical tank, by fixing $\epsilon(h) \leq 0.1\%$ and $\Delta h = 2\text{ mm}$, one obtains:



V = smallest measurable volume

h = smallest measurable height

Therefore, the Legal Metrology Service may specify the smallest measurable height of 2 m and, having established the calibration table, indicate in the certificate the smallest measurable volume, that is to say the volume corresponding to this smallest height, in the zone in which the diameter is the largest.

- Notes :
1. the values $\epsilon(h)$ and Δh are established by the Legal Metrology Service of each State,
 2. other methods of calculation of the smallest measurable volume may be used.

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