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Revision of OIML International
Recommendation R 80-1**

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TITLE OF INTERNATIONAL RECOMMENDATION

Road and rail tankers

Part 1 – Technical and metrological requirements



EXPLANATORY NOTE

Background and brief initial history of the revision OIML R80 „Road and rail tankers“ and also the creation of a new working group within the scope of TC8/SC1 are exactly the same as described by Mr. Van Vijnngaarden from NMI in Explanatory note to Revision of R71.

Working group WG3 was established on TC8/SC1 meeting held in October 2003 in Vienna. Main purpose of this group is to revise Recommendation R80, Edition 1989, with regard to cover new technologies and to extend it in order to fulfil the requirements of OIML Certificate system.

Convenors of working group OIML TC8/SC1/WG3 are Slovakia and Germany (Mr Ivan Chren from SLM and Mrs Gudrun Wendt from PTB as Co-chair). The group started its work in May 2004 in Gotteszell (Germany), where the main principles of approach to the new technologies (e.g. electronic dipsticks in road tankers, volume conversion, tank inclination, etc.) and to the static measuring system classification were stipulated.

WG 3 met twice, in August 2004 in Banska Bystrica (Slovakia) and June 2005 in Gotteszell (Germany).

This second Committee Draft of OIML R80-1 contains the decisions made during the WG3 meetings mentioned as well as the SC1 meeting in Vienna in April 2005.

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Foreword

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

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

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

This publication – reference OIML R 80-1, edition..... (E) – was developed by the OIML subcommittee TC 8/SC 1 Static volume measurement. It was approved for final publication by the International Committee of Legal Metrology in and will be submitted to the International Conference of Legal Metrology in for formal sanction.

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Terminology

The terminology used in this Recommendation conforms to the " International Vocabulary of basic and general terms in metrology " (1993 second edition) and the " International vocabulary of terms in legal metrology" (2000 edition). In addition, for the purposes of this Recommendation, the following definitions apply.

T.1 Transportable measuring tank

Container suitable as a volume metering device for liquids fixed on a truck (or on railcar) or detachably connected to it, which may be subdivided into several measuring compartments.

Note: Hereby referred to as measuring tank or tank.

T.2 Static measuring system

A system, which is comprised of a measuring tank itself and its ancillary and additional devices. Static measuring systems can also be applied for the determination of converted volume of liquids.

Note: Hereby referred to as measuring system.

T.3 Ancillary device

A device intended to perform a particular function, directly involved in elaborating, transmitting or displaying measurement results.

Examples for ancillary devices:

- zero setting device,
- repeating indicating device,
- printing device,
- memory device,
- price indicating device,
- conversion device.

T.4 Additional device

A part or a device, other than an ancillary device, required to ensure correct measurement or intended to facilitate the measuring operations, or which could in any way affect the measurement.

Examples for additional devices:

- sampling device,
- gas indicator,
- sight glass,
- filter, pump,
- gas elimination device,
- device used for the transfer point,
- anti-swirl device,
- branches or bypasses,
- valves, hoses.

T.5 Nominal capacity (of the tank or compartment) (V_n)

Volume indicated (marked) on tank or its compartment.

Notes:

1. Value of nominal capacity usually corresponds to the volume of liquid which a tank or compartment contains at reference temperature when filled up to maximum permissible level or volume mark.
2. Value of nominal capacity can be limited by safety regulations.

T.6 Total capacity

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

T.7 Expansion volume

The difference between total and nominal capacity.

T.8 True volume (V_t)

Conventional true value of volume of liquid in a tank or compartment at working temperature t .

T.9 Indicated volume (V_i)

Value of volume provided by the volume metering system.

T.10 Error of indicated volume

Difference between the indicated volume (V_i) of the tank or compartment and true volume (V_t).

T.11 Calibration

The set of operations to determine the capacity of a tank or compartment, using methods satisfying the technical and metrological requirements, such as measurement at one or several filling levels by means of geometric size measurement, gravimetric, or volumetric method.

The gravimetric method determines the volume of liquid in the tank by means of weighing; the volumetric method determines the volume of liquid in the tank by means of metering the volume of liquid entered in or emptied from the tank.

T.12 Liquid level

The free surface of the liquid the volume of which is to be measured.

T.13 Reference point

A point clearly identified on the vertical measurement axis, with reference to which the liquid level is measured.

T.14 Reference point top (RPT)

A reference point in the upper part of the tank, under normal operating conditions above the liquid level.

T.15 Reference point bottom (RPB)

A reference point in the lower part of the tank, under normal operating conditions below the liquid level.

T.16 Reference height (H)

The distance, measured along the vertical measurement axis, between the reference point top and the reference point bottom.

T.17 Ullage height (C)

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

T.18 Liquid height (h)

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

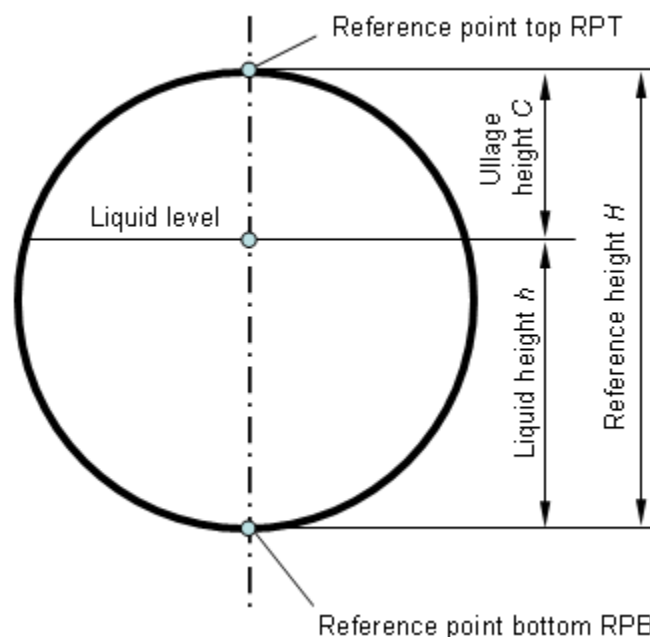


Fig. 1: Schematic view of a tank to determine T.14 – T.18

T.19 Sensitivity of a tank

The change in the level of liquid Δh divided by the corresponding relative change in volume $\Delta V/V$ for the contained volume V at the level h .

T.20 Calibration table

A table which shows the relation between of the liquid level and the volume contained in the tank (compartment) at that level under reference conditions (including the position of the tank).

T.21 Baffle

Internal device of the tank or compartment, e.g. a partition wall or obstacle inside the tank, intended to damp the movement of liquid during transport and to increase the mechanical stability of the tank.

T.22 Level sensor

Measuring device for the level of a liquid in a tank or compartment.

T.23 Measuring range of the level sensor

The range between the minimum and maximum possible indications of the level sensor. The lower limit is type and system dependent and shall be significantly less than the liquid level corresponding to the minimum measured quantity of the tank or compartment. The upper limit depends on the tank height and shall be above the maximum permissible filling height of the tank or compartment.

T.24 Inclination sensor

Measuring device for the pitch and roll angles.

T.25 Longitudinal axis and pitch angle

The symmetry axis of the tank parallel to the main direction of travel, when the tank is in normal position. The vertical angle by which this axis is rotated is referred to as pitch angle. It is positive if the front part of the tank is lifted.
(schema will be added later)

T.26 Transverse axis and roll angle

The horizontal axis of tank perpendicular to the longitudinal axis, when the tank is in normal position. The vertical angle by which this axis is rotated is referred to as roll angle. It is positive if the right part of the tank (in relation to travel direction) is lifted.
(illustration will be added later)

T.27 Damping tube

Mechanical device (usually in form of a tube with holes) intended to minimize or to eliminate the effect of surface waves on the level measurement and to protect the level sensor against mechanical damage.

T.28 Transfer point

Point at which the liquid is defined as being delivered or received.

T.29 Empty hose (Dry hose)

Hose connection that contains liquid products only during a transaction and usually is completely evacuated before the transaction is terminated. It is connected downstream the transfer point (the transfer point is located upstream of the delivery or receiving hose).

T. 30 Full hose (Wet hose)

Hose connection that is filled with liquid product prior to and after a transaction. In this case the transfer point is located close to the outlet of the full hose (the transfer point consists of a closing device located in the delivery or receiving line).

T.31 Collector (Manifold)

Collecting line connected via valves to the outlets of the measuring compartments and allowing delivery from any one or several compartments via common pipework.

T.32 Direct discharger

Tanker discharged by gravity, each individual measuring compartment having its own outlet. Frequently, the loading coupler is used as outlet.

T.33 Top loading

Loading of a measuring compartment from the top through the fill hole cover opened for this purpose.

T.34 Bottom loading

Loading of a measuring compartment from the bottom through a standardised dry adapter (e.g. API adapter) and the bottom valve that is integrated into the bottom of the measuring compartment and opened for this purpose.

T.35 Transaction

Delivery of liquid products from one or several measuring compartments to a recipient. The transaction can also be a receipt (e.g. milk collecting truck). A transaction is settled when the parties interested in the transaction have made their agreement known (explicitly or implicitly) as regards the amount of the transaction. This may be a payment, signing a credit card voucher, signing a delivery order, etc.

The parties interested in a transaction may be the parties themselves or their representatives (for example: the employee in a filling station, the driver of a tanker).

T.36 Reference position

Position for the discharge (or loading) of the measuring tank in accordance with the design drawing. It is the basis for the inclination correction function. The zero point of the inclination represents the zero point for both (longitudinal and transversal) inclinations.

T.37 Metering conditions

The conditions to which the volume of liquid is to be measured, at the point of measurement (example: temperature, viscosity, position of the tank).

T.38 Base conditions

The specified conditions to which the measured volume of liquid is converted (example: temperature, density).

T.39 Liquid detector

Device intended to detect the presence of liquid in the pipework or the tank and to check, before start-up and after shutdown, that all or part of the measuring system is either filled completely with liquid (full hose measuring systems) or completely empty of liquid (empty hose measuring system).

T.40 Liquid indicator

A device to indicate the presence of liquid in the pipework (example: sight glass).

T.41 Minimum measured quantity MMQ (V_{\min})

The smallest volume of liquid for which the measurement is metrologically acceptable for the tank or individually for each of its compartments. It shall be specified only for measuring systems suitable for measuring partial volumes.

Alternatively, the terms "minimum delivery" or "minimum receipt" may be used.

T.42 Minimum specified volume deviation (E_{\min})

Twice the absolute value of the maximum permissible error for the minimum measured quantity of a tank or compartment.

T.43 Influence quantity

Quantity which is not the object of the measurement but which influences the value of the measurand or the indication of the tank.

T.44 Disturbance

Influence quantity whose value lies within the limits defined by relevant requirements but outside the established rated operating conditions for the tank.

T.45 Critical change value

Maximum permissible change of the measured liquid volume due to the effects of a disturbance.

1 Scope

1.1 This Recommendation specifies the metrological and technical requirements applicable to static measuring systems for volume of liquids other than water subject to legal metrology controls. It also provides requirements for the approval of parts of the measuring systems.

It applies to tankers for the transport of liquid products by road and rail and used in addition to their functions as carriers as measuring instruments.

1.2 Tankers may be considered as measuring instruments for liquids of which the viscosity does not exceed 20 mPa·s at working temperature.

1.3 This Recommendation is also applicable for measuring partial volume received or delivered.

1.4 Essential metrological requirements of this Recommendation are in accordance with the relevant requirements of OIML R 117 “Measuring systems for liquids other than water” referring to measuring systems with liquid meters used for the same purpose.

1.5 In addition to the metrological and technical requirements included in this Part 1 (R 80-1) the methods of examination and testing are included in Part 2 (R 80-2) and a test report format is included in Part 3 (R 80-3).

2 Classification and description

2.1 General classification

2.1.1 Tankers may be classified according to the following criteria:

- volume measuring principle,
- ancillary installations,
- conditions of use (influence factors),
- capacity,
- method of mounting of the tank.

2.1.2 As regards the volume measuring principle, this may be:

- mechanical level gauging,
- electronic level gauging,
- automatic determination of the volume delivered/received including partial deliveries.

The mechanical level gauging can be based on

- a single or more volumetric marks,
- a graduated window in dome,
- an other measuring device with a graduated scale (with a viewing window or an external gauge tube or with any mean transferring the level position outside the tank),
- a dipstick or a dip tape.

Electronic level gauging may be based on

- floats/displacers with electronic level gauging,
- ultrasonic level gauging,
- radar/laser level gauging,
- other non-contact level gauging principle.

Automatic volume measurements are characterized by automatic volume determination.

Note: This may include

- complete automatic control and supervision of the deliveries/receipts,
- automatic taking into account of the influence of inclination, stage of emptying and/or waves.

2.1.3 As regards ancillary installations, tanks may be with or without

- installations for measuring partial volumes received or delivered,
- internal pumps,
- collectors,
- full hose installations.

2.1.4 The main influence factors that can have a major effect during calibration and use of tankers are pressure and temperature.

a) As regards pressure, the tanks may be:

- at atmospheric pressure,
- under pressure (e.g. for liquefied gases or beer).

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.

2.1.5 As regards the capacity of the tank, road tankers are usually between 0,5 m³ and 50 m³ and rail tankers between 10 m³ and 120 m³.

2.1.6 As regards the method of mounting, the tanks of road tankers 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 that ensure that the position of the tank when mounted on the vehicle remains unchanged.

2.2 Construction of tanks

2.2.1 If a tank is divided into compartments, each shall be considered as a separate tank and subject to the requirements of this Recommendation.

2.2.2 Tanks may be lined (e.g. for the transport of wine).

2.2.3 Each tank shall comprise a shell and ends and discharge devices.

2.2.4 The shape and the mounting of the tank as well as the installation of the discharge device shall be in such a way that the tank drains completely.

2.2.5 The discharge device shall comprise one or two discharge pipe(s) (allowing offloading on either side of the tanker), each equipped with a stop valve. The flow of liquid between the tank and the discharge pipe(s) may be stopped by a foot valve. If tank is equipped with two discharge pipes, suitable interlock facilities should prevent the use of both discharge pipes together. If necessary, a tank may incorporate devices fitted at the lowest point for water separation.

2.2.6 Tanks with mechanical or electronic level gauges shall comprise:

2.2.6.1 A dome with reinforcing elements serving as a manhole and as an expansion space and in some (non-fuel) applications 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.

2.2.6.2 For tanks with mechanical level gauges, a ladder shall be installed, giving access to the dome, and a platform for the operator performing the measurement or checking the tank.

2.2.6.3 For tanks with electronic level gauges

- access to the interior of the tank shall either be prevented by sealing or other means,
- or visual checking of the interior shall easily be possible according to 2.2.6.2.

2.2.7 Tankers for liquefied gases shall not have domes and are subject to regulations covering the construction of pressure vessels.

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

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 requirements

4.1 General

4.1.1 Accuracy classification and maximum permissible errors

Depending on the field of application the static measuring systems mounted on the road or rail tankers are classified into four accuracy classes specified in Table 1.

Table 1: Accuracy classes and maximum permissible errors

	Accuracy classes			
	0,5	1,0	1,5	2,5
Static measuring system (A)	0,5 %	1,0 %	1,5 %	2,5 %
Transportable measuring tank (B)	0,3 %	0,5 %	1,0 %	1,5 %

4.1.2 Conditions for applying maximum permissible error

4.1.2.1 Maximum permissible errors in line A of Table 1 apply to complete measuring systems, under rated operating conditions, without any adjustment between the various tests, for:

- type approval,
- initial verification ,
- subsequent verifications.

4.1.2.2 Maximum permissible errors in line B of Table 1 apply to:

- type approval of a measuring tank, under rated operating conditions, and
- verification of the tank as a preliminary stage for initial verification of the measuring system

4.1.2.3 For measured volumes greater than the minimum measured quantity up to twice the minimum measured quantity, the absolute value of maximum permissible error need not to be less than E_{min} .

4.1.3 Reference conditions

Recommended reference temperature is 15 °C or 20 °C for temperate and Nordic zones and 27 °C for tropical and subtropical zones. Recommended reference pressure is normal atmospheric pressure (1 bar).

The use of other values for justified reasons is allowed (for example reference temperature of 12 °C and higher pressure for liquefied petroleum gases).

4.1.5 Nominal capacity

Nominal capacity of a measuring tank or of its compartment shall be at least 500 litres.

4.1.6 Minimum measured quantity

4.1.6.1. Minimum measured quantity shall be defined only for tanks intended for partial deliveries.

4.1.6.2 The minimum measured quantity shall be specified for each compartment of a tank and shall not exceed a quarter (1/4) of its nominal capacity.

4.1.6.3 The minimum measured quantity shall be equal or greater than the larger of the two following values:

- volume corresponding to a level difference given in Table 2, in the range with the smallest sensitivity;
- volume calculated so that the change of it due to manufacturing tolerances of volume (between the actual tank geometry and the design specifications) does not exceed three-fifth (3/5) of the maximum permissible error specified in line A of Table 1 for each permitted inclination.

Table 2: Minimum level difference corresponding to MMQ (V_{\min})

	Accuracy classes			
	0,5	1,0	1,5	2,5
level difference	200 mm	171 mm	190 mm	200 mm

Note: The given level differences are based on an expanded uncertainty U_x for the corresponding accuracy classes given in 4.4.3.1 Table 5.

4.1.6.4 The minimum measured quantity of a measuring system shall be given in one of the following forms:

- 1×10^n , 2×10^n or 5×10^n litres, where n is a whole number,
- entire multiples of 100 litres.

4.2 Container of the measuring tank

4.2.1 Safety and other non-metrological requirements

4.2.1.1 National and international organisations, 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 road and rail tankers intended for the transport of liquids contained in tanks, without overload and

free from danger. Additional regulations for safety at work and protection against fire and explosion may exist. These conditions shall be observed.

4.2.1.2 In the case of tankers for potable liquids, the structural characteristics of the tank (shape, material, etc.) shall have no adverse effect on the quality of the liquid transported; 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.

4.2.1.3 The specification of the nominal capacity shall take into account the national or international regulations prescribing the maximum filling volume of tanks.

4.2.2 General requirements on construction of the container

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

4.2.2.2 The container must be tight. Proof by the safety tests carried out is generally sufficient.

4.2.2.3 The reference height H of a tank or each compartment shall not vary during filling by more than the greater of the two values given in table 3.

Table 3: Maximum permissible variation of the reference height in dependence of the accuracy class

	Accuracy classes			
	0,5	1,0	1,5	2,5
Maximum permissible variation of the reference height H (mm)	2 mm or $H/1000$	4 mm or $H/500$		

4.2.2.4 The capacity of a compartment shall not change by more than one-third (1/3) of the maximum permissible error specified in line B of Table 1 when the neighbouring compartment or compartments are filled or emptied.

4.2.2.5 The material of the tank shall be chosen so that the capacity of the tank shall not change by more than 1/3 of the maximum permissible error specified in line B of Table 1 when the temperature of the tank changes in the range of ± 10 °C from the reference temperature.

4.2.2.6 Tanks for liquids which are not measured at atmospheric pressure must be so designed that their capacity in the whole admissible pressure range does not change by more than 1/5 of the maximum permissible error specified in line B of Table 1.

4.2.2.7 Every tank or compartment shall be of such a shape that no air is trapped on filling and liquid is not retained on emptying in any admissible position of use of the equipment.

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

4.2.2.9 The complete drainage must be ensured

- by an adequate shape of the tank,
- by a slope of at least 2 % (1,2 °) of the lower generatrix of the tank with the vehicle on horizontal ground or
- by other means.

If complete drainage is not possible in all positions, which may be expected during use, monitoring facilities shall be provided to ensure complete emptying (for example, by additional liquid sensors in the compartment, or by monitoring the inclination).

4.2.2.10 Volume of liquid remaining in the tank or compartment after its complete draining shall not be greater than one-tenth of the absolute value of the maximum permissible error given in line B of Table 1 applied to the capacity of the tank or compartment. This volume may remain in the tank for reasons of conditions of construction or mounting (for example, at the joints).

4.2.2.11 Baffles 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 are not impeded.

4.2.2.12 The placing of dead wood 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.

4.2.2.13 Fixed internal elements in the measuring compartments (e.g. heating coils) are permitted if they have been present during the calibration and cannot be modified or dismantled.

4.2.2.14 The tank or compartment geometry should be such that waves at the liquid surface are rapidly damped.

4.2.2.15 To minimise inclination effects, the measuring tanks should be symmetrical both in the longitudinal and in the transverse direction and the level sensors should be installed centrally.

4.2.2.16 If correct measurement is not possible in all positions, which may be expected during use, the tank should be equipped with a device that indicates its measuring position with respect to reference position.

4.2.2.17 The interior of the measuring tank must be accessible for inspection purposes via a manhole, provided safety or other regulations do not exclude it.

4.2.2.18 The capacity of a measuring tank must not deviate by more than 10 % from the capacity specified in the design documents.

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

4.2.2.20 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.

4.2.2.21 If the sidewalls of the dome are mounted so that they penetrate the tank shell, and at the maximum permitted filling level air pockets could be formed, orifices or cut-outs at the level of the upper internal generatrix shall be provided.

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

4.2.2.23 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.

4.3 Additional devices

4.3.1 Discharge device

4.3.1.1 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.

4.3.1.3 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.

4.3.1.4 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.

4.3.1.5 Each compartment shall have means for being discharged independently. A discharge manifold is permitted.

Manifolds without automatic control or monitoring shall have suitable control facilities that prevent the refuelling from one compartment to another.

4.3.1.6 The existence of a manifold shall be indicated in the certificate on calibration.

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

4.3.1.8 If a tank consists of more than one measuring compartment, each compartment must be provided with a separate (manual or automatic) shutoff device in each delivery line. Unwanted mixtures of the products from different compartments shall be prevented by constructive or control measures.

4.3.1.9 In the vicinity of the lowest point of each delivery line liquid detectors or sight glasses (except automatic measuring systems) shall be installed, if necessary for checking emptiness.

4.3.1.10 Pipework whose filling quantity has an effect on the measurement result must not be flexible and must have been rigidly laid.

4.3.1.11 For full hose delivery, it shall be ensured by a separate gas separator or an equivalent function of existing components that the full hose is completely filled at the time of level gauging.

4.3.1.12 Control lines and control devices whose manipulation might falsify the measurement result shall be protected against tampering.

4.3.1.13 During a transaction, the change from full to empty hose and vice versa as well as the change between the full hose systems are admissible only if the filling levels are monitored in all measuring compartments so that manipulations are recognised.

4.3.1.14 Venting devices on the metering system shall be protected against dismounting and removal as well as against manipulations from outside.

4.3.1.15 The measuring tank must have supports in the longitudinal and in the transverse direction at least 500 mm in length to accommodate an electronic water-level to mark the reference plane for the normal position of the measuring tank.

4.3.2 Installations for external pumping and metering

4.3.2.1 If it is intended to connect the tank to separate pumping or metering devices it should be provided with the appropriate detachable couplings which shall be as short as possible and easy to assemble and take apart.

4.3.2.2 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 of any special measures.

4.3.2.3 For tanks equipped with an underneath manifold for measuring partial volumes delivered, the fitting of a diverting valve on each discharge pipe is permitted provided

- that any leakage of liquid through the diverting valve can be detected (for example: the underneath manifold ensures complete and rapid discharge of the liquid that it contains and a sight glass at its bottom end allows the checking of its emptiness), and
- that the installation and the control of the diverting valves is such that the product cannot flow back from one compartment to another.

4.3.2.4 Sampling device

The measuring system may include a sampling device intended to determine the properties of the liquid to be measured.

It is not necessary to take into account the quantity of the sample in the results of the measurement if this sample is less than one tenth of the absolute value of the maximum permissible error given in line B of table 1 applied to the capacity of the tank or compartment.

4.3.3 Other devices

4.3.3.1 Tank may be fitted with:

- level warning devices,
- level detectors,
- high level shutoff devices,
- etc.

4.3.3.2 The use of devices to facilitate reading of the index, 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.

4.4 Level gauging system

4.4.1 General requirements

4.4.1.1 The level gauging device shall ensure a safe, easy and unambiguous readout, practically independent of tank tilt under rated operating conditions.

4.4.1.2 The index (e.g. volumetric marks, scales), or the vertical measurement axis, shall be as near as possible to the centre of horizontal sections of the tank.

4.4.1.3 Hysteresis of the level sensor shall not exceed 1/3 of the sensitivity given in Table 4 for full compartment delivery or 1/3 of the expanded uncertainty given in Table 5 for partial delivery, otherwise their influence should be included into the uncertainty evaluation.

4.4.1.4 The level gauging system shall perform a valid height measurement only when the liquid surface has calmed down so that the result is reproducible.

4.4.1.5 Whenever the measurement range of the level sensor has been exceeded, this must be recognised and shall be regarded as a disturbance.

4.4.2 Requirements on level gauging for full compartment delivery

4.4.2.1 The shape of the tank shall be such that, in the zone where the level are gauged, a sensitivity equal or greater than values given in Table 4 is attained.

Table 4: Sensitivity of the tank in dependence of the accuracy class of the measuring system for full compartment delivery

	Accuracy classes			
	0,5	1,0	1,5	2,5
Minimum sensitivity of tank Δh pro $\Delta V/V$ in mm / ‰ (i. e. in mm for 1/1000 of measured volume)	1,5	1,0	0,5	0,3

4.4.2.2 It must be possible to gauge the level of the contained liquid manually. The gauging device should be positioned as close as possible to the curve connecting the centres of gravity of the horizontal cross sections of the compartment in the level measuring range.

When the lower end of the gauging device is close to the bottom of the tank, its axis should intersect the lower generatrix of the tank at a point having no orifice or obstacle within a radius of 100 mm.

4.4.2.3 The reference points RPB and RPT shall be clearly defined and realised.

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

4.4.3 Requirements on level gauging for partial delivery

4.4.3.1 The expanded uncertainty of the level measurement shall not exceed values given in Table 5.

Table 5: Level measurement uncertainty for partial delivery

	Accuracy classes			
	0,5	1,0	1,5	2,5

Level measurement uncertainty U_x in mm	0,7	1,2	2	3,5
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Expanded uncertainty of measurement U_x is stated in accordance with the “Guide to the expression of uncertainty in measurement” (GUM) as the standard uncertainty of measurement multiplied by the coverage factor $k=2$ which for a normal distribution corresponds to a coverage probability of approximately 95 %. Other values of expanded uncertainties U_x may be fixed in the type approval certificate of the measuring system.

4.4.3.2 The resolution of the indication the level measurement shall be in accordance with the values of Table 6.

Table 6: Resolution of the level indication

	Accuracy classes			
	0,5	1,0	1,5	2,5
Maximum value of the resolution for the level indication in mm	0,1	0,2	0,5	1,0

4.4.3.3 To dampen surface waves, the level sensor may be accommodated in a damping tube. In the area of the tank bottom, the tank roof and in-between, this tube shall be provided with openings for liquid exchange. The tube shall not affect the measurement, e.g. due to dirt or sedimentation occurring under regular operation.

4.4.4 Specific requirements for level gauging systems with float

4.4.4.1 The float shall not change its mass and volume due to the influence of the product measured. Neither must pressure lead to a change in its volume.

4.4.4.2 The cross-section of float in the range of immersion depth change shall be well-known.

4.4.4.3 The shape of the float shall be designed so that it does not retain liquid except the liquid layer caused by capillary effects. Additionally, no gas or air cushion shall form under the float.

4.4.4.4 Within the permissible density range of the measured liquid, the immersion depth of the float shall not change by more than the value given in Table 7. The permissible density range shall be specified in the type approval certificate. In measuring systems without corresponding correction the immersion depth change due to variation of liquid density, this influence should be included in the uncertainty evaluation of the level measurement.

Table 7: Change of float immersion depth

Maximal change of immersion depth in mm for	Accuracy classes			
	0,5	1,0	1,5	2,5
- partial deliveries	0,5	0,8	1,6	2,5
- full compartment deliveries	1,5	2,4	4,8	7,5

4.4.5 Specific requirements for level gauging systems on the basis of ultrasound transit time measurements

4.4.5.1 Within the permissible product parameters range (mainly density and modulus of elasticity), the measured height shall not change by more than the values given in Table 5. The permissible ranges of product parameters shall be specified in the type approval certificate.

4.4.5.2 The effects of the product parameters on the transit time of the ultrasound signal may be compensated for by suitable methods, e.g. by reference marks.

4.5 Calibration table

4.5.1 For the conversion of the result of the level gauging into volume, the electronic data processing system shall store a calibration table with pairs of level/volume values for each measuring compartment. Number and distance of these value pairs are selected according to the real tank geometry. Intermediate values are calculated by suitable interpolation. Extrapolation is not admissible.

4.5.2 The level range of the calibration table shall encompass all filling states occurring in practical operation. Filling of a measuring compartment to a level beyond the maximum permissible point of the calibration table shall be prevented or to be regarded as a disturbance.

4.5.3 The calibration table is experimentally determined for each compartment of the measuring tank by stepwise filling or discharge. This calibration is carried out with the measuring compartment in the normal position.

In tanks fitted with the correction device for inclination the volume effects of the inclination in the range of $\pm 4^\circ$ (pitch and roll angles) shall not exceed the minimum specified volume deviation.

4.5.4 If compliance with the requirements of 4.1.5.2 and 4.1.5.3, respectively, requires that a correction for inclination should be made, the inclined position of the measuring tank shall be measured during level detection using inclination sensors rigidly fixed to the tank. The inclination data are used to correct the measurement using a suitable algorithm.

4.5.5 The calibration table compiled during the calibration as well as the inclination correction data, if any, shall be stored in the system so that they are protected from manipulation.

4.6 Metrological requirements for ancillary devices

4.6.1 Volume conversion

4.6.1.1 The maximum permissible error for the conversion of the measured volume into a volume at base conditions or a mass is equal to $\pm (A - B)$, A and B being the values specified in Table 1. However, the magnitude of the maximum permissible error shall not be less than the greater of the two following values:

- one-half scale interval of the indicating device for converted indications,
- half of the value corresponding to the minimum specified volume deviation E_{\min} .

4.6.1.2 The total volume at base conditions may be determined using either of the following two methods:

Method A: The conversion is performed during the measurement. Each partial volume $\Delta V_{t,i}$ is converted to the partial volume $\Delta V_{0,i}$

$$\Delta V_{0,i} = \varphi(\Delta V_{t,i}, t)$$

The total volume at base conditions is then:

$$V_0 = \sum_i \Delta V_{0,i}$$

Method B: The conversion is done at the end of the measurement, using the weighted average temperature, which is calculated from the temperatures t_i of the partial volumes $\Delta V_{t,i}$:

$$t = \frac{\sum_i t_i \cdot \Delta V_{t,i}}{V_t}$$

The total volume at base conditions is then

$$V_0 = \varphi(V_t, t)$$

4.6.1.3 A suitable method shall be used for the conversion function $\varphi(V, t)$, which is usually part of national regulations. Annexes 3 and 4 (informative) show two examples of the use of such conversion functions.

Note: Calculations given in 4.6.1.2 and examples given in the Annexes 3 and 4 are in accordance with OIML R 63.

4.6.1.4 During a transaction, the temperatures of liquid flowing through the particular delivery line shall be measured in proportion to the volume or the time.

4.6.1.5 If averaging proportional to the volume is used, the partial volumes must not be greater than one fifth of the minimum measured quantity:

$$\Delta V_{t,i} \leq \frac{V_{\min}}{5}$$

4.6.1.6 If time proportional averaging is used, the time intervals must not be greater than the time needed to measure one fifth of the smallest measured quantity at maximum flow.

4.6.1.7 The total volume under measuring conditions is:

$$V_t = \sum_i \Delta V_{t,i}$$

4.6.1.8 The maximum permissible error for determination of the weighted average temperature is ± 1 °C for accuracy class 2,5 and $\pm 0,5$ °C for the other accuracy classes.

4.6.1.9 The data underlying the conversion (for instance the density ρ_0 at base conditions or the thermal expansion coefficient α_0) can be either firmly set or be adjustable in dependence on the product. They shall be protected from manipulations.

4.6.1.10 If the data according to 4.7.1.9 underlying the conversion can be adjusted in dependence on the product, the indication and, where appropriate, the printout must unambiguously reveal which values have been used or which liquid has been measured.

4.6.1.11 The measuring method - with temperature conversion of the volume or without conversion - for a given product shall be once selected at the time of verification. This selection may not be changed later. Similarly, for a given product, only one set of conversion data may be entered.

4.6.2 Indicating device

4.6.2.1 Reading of the indication shall be precise, easy and non-ambiguous. The customer shall be able to inspect it without particular measures.

4.6.2.2 The resolution of the indication shall be in the form 1, 2 or 5×10^n where n is whole number and shall not exceed one tenth of E_{\min} .

4.6.2.3 The continuous display of quantity during the period of measurement is only mandatory in the case of direct selling to the public.

4.6.2.4 The output of all measured and calculated values in the measurement state shall be possible. Additionally, when the converted volume of a product is indicated, it shall be possible to access all values underlying the conversion. However, it is not necessary to permanently indicate all values.

4.6.2.5 The kind of the indicated quantity (measurement or base condition) must be unequivocal.

4.6.2.6 The metering system may have several units for indicating the same measuring quantity. Each of these indications shall satisfy all requirements specified.

4.6.2.7 Additional information, which does not serve metrological purposes, may be additionally indicated but they must not give rise to false interpretation.

4.6.2.8 In the case of correction of a quantity, the non-corrected quantity shall not be displayed in normal operation. The non-corrected quantity shall, however, be available for test purposes.

4.6.3 Price calculation

Optionally, before or after the delivery, a unit price for a delivered product may be entered. The unit price is used to calculate the total price, which may be printed on the delivery note or invoice.

4.6.4 Printing device

4.6.4.1 Printing devices are necessary only for metering systems used for mineral oils and liquefied gas.

4.6.4.2 If the metering system is used in commercial transactions for direct sale to the public, the system must check before the delivery or receipt starts whether a printer is connected for this transaction, possibly also temporarily.

4.6.4.3 Data to be printed

If a delivery document is generated, it shall contain at least the following data:

- an identifier for the measuring system (e.g. serial number, or number plate of the semi-trailer),
- the product name or product group name,
- a unique number, which shall be incremented for each transaction,
- the volume V_t at metering conditions with the remark "at delivery temperature" and/or the volume V_0 at base conditions.

4.6.4.4 Printing of multiple results

If during a transaction more than one compartment is used for delivery/loading, all the results may be printed on the same delivery document. If more than one result is available for the same product, these results may be summed up.

4.6.4.5 Marking of data

If within one document data from verified parts of the system are printed together with

data from non-verified parts, the verified data shall be enclosed by special characters (e.g. an asterisk “*”).

The delivery document shall contain the following explanatory note:
Data from verified devices are enclosed in *asterisks*

The remark may either be printed at the time the document is generated, or pre-printed on the paper or the rear of the paper being used for the printout.

4.6.5 Memory device

4.8.5.1 Measuring systems may be fitted with a memory device to store measurement results until their use or to keep a record of commercial transactions, providing proof in case of a dispute. Devices used to read stored information are considered as included in the memory devices.

4.6.5.2 In the case of metering systems not used for direct sales to the public, the printing device may be replaced by a data memory. In this case, all data necessary for the printout shall be stored.

4.7.5.3 The medium on which data are stored must have sufficient permanency to ensure that the data are not corrupted under normal storage conditions.

4.6.5.4 There shall be sufficient memory storage for any particular application.

4.6.5.5 Unless otherwise specified, the measured data shall be stored for at least the billing period and the period for objection before being erased. If the capacity of the data memory is exhausted and if stored data cannot be erased because mentioned periods have not yet elapsed, it shall not be possible to start a new measurement.

4.6.5.6 If the measured data have been printed or transferred out at least once in a way acceptable for verification, they may be erased.

4.6.6 Automatic stop

4.6.6.1 If the system is able to stop the delivery or the loading, it is admissible to automatically terminate the delivery or the loading after a given difference or final quantity has been reached. It is not necessary to reach the given quantity exactly.

4.6.6.2 This option is not a volume pre-setting as described in OIML R117 and therefore must not be used for prepaid transactions.

4.7 Additional requirements for electronic components

4.7.1 General requirements

4.7.1.1 The electronic components of the measuring system shall be designed and fabricated such that the maximum permissible errors specified in 4.1 are not exceeded under rated operating conditions.

4.7.1.2 The electronic components of the measuring system shall be designed and fabricated in such a way that – if they are exposed to the disturbing influences defined in Annex A

- either the critical change values defined in 4.7.1.3 are not exceeded,
- or the disturbances are recognised as such and trigger the appropriate checking devices.

These conditions may be separately applied to

- every individual disturbance and/or
- every part of the measuring system.

4.7.1.3 The greater of the following two values shall be chosen as the critical change value for the measured volume of liquid:

- 1/5 of the maximum permissible error of the relevant measured quantity or
- the minimum specified volume deviation E_{\min} defined according to T. 42.

4.7.2 Power supply

4.7.2.1 If the transaction is not interrupted in case the power supply fails, the measuring system shall be provided with an emergency power supply device to safeguard all measuring and control functions during the failure.

4.7.2.2 If the transaction is interrupted in case the power supply fails, the requirements of 4.7.2.1 shall be met, or the data contained at the moment of the failure shall be saved and displayable for a sufficiently long time on an indicating device subject to legal control so that the current transaction can be completed. The absolute value of the maximum permissible error for the indicated volume in this case is increased to 5 % of the minimum measured quantity.

4.7.2.3 In the case 4.7.2.2, it is also sufficient to indicate the result of the measurement after re-establishing the power supply.

4.7.2.4 Alternatively, in the case of 4.7.2.2, the transaction may be terminated properly after re-establishing of the power supply, in which case the maximum permissible errors according to 4.1 apply.

4.7.3 Checking facilities

4.7.3.1 The checking facilities serve to detect a disturbance whose effects on the measured volume exceed the critical change value fixed in 4.7.1.3 and must have the following effect:

- automatic correction of the change in volume, or
- stopping only the faulty device when the measuring system continues to comply with the regulations without this device being in operation, or
- stopping the transaction.

4.7.3.2 For measuring systems with level gauging systems only checking facilities of type I or P are permitted. Type I is an intermittent automatic checking facility acting at least once at the beginning and at the end of each transaction, and type P is a permanent automatic checking facility operating during the whole duration of the transaction.

4.7.3.3 Checking facilities for the level sensors (type P), the temperature sensors (type P), the liquid indicators (type I) as well as for the inclination sensors (type I) shall be provided to ensure the availability of the sensor, its perfect operation, the correctness of data transmission as well as, where appropriate, compliance with the specified measurement range.

4.7.3.4 During type approval and initial verification it shall be possible to check that the checking facilities function correctly, e.g.

- by disconnecting the sensor or
- by interrupting the signalling circuit or
- by interrupting the power supply.

4.7.3.5 The checking facility for the functioning of the computer checks the values of all permanently stored instructions and data as well as all procedures for the internal transmission and storage of the data relevant to the measurement result and shall be of type I or P.

4.7.3.6 The checking facility for the correctness of the calculations carried out by the computer must be of type P. This check can be carried out, for example, with the aid of a parity bit, a checksum or double storage.

4.7.3.7 The checking facility for the indicating device will ensure that a failure or maloperation of individual elements is detected visually and/or automatically or cannot lead to erroneous interpretation. The automatic detection can, for example, take place by monitoring the current between the segments of LED displays or by measurement of the grid voltage of fluorescent displays. The visual check can, for example, be carried out by redundant LC segments (graphics LCD) or a black-and-white test.

4.7.3.8 It must be possible during initial verification to check the checking facility for the indicating device, for example, by disconnecting the whole or part of the indicating device (in the case of an automatic checking facility) or by a visual check of a manually or automatically triggered black-and-white test.

4.7.3.9 Checking facilities for ancillary devices (e.g. according to 4.6.2 to 4.6.5) must ensure that the particular ancillary device is available, if necessary, and that the transmission of the data is valid.

4.7.3.10 The checking facility for a printing device must also monitor the presence of paper.

5 Plates, documents and sealing

5.1 Identification plate

5.1.1 Each tank shall be provided with an identification plate, which is clearly visible and easily legible. The plate 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 plates shall be fixed in such a way that they cannot be removed without breaking the seals bearing with marks of the Legal Metrology Service.

5.1.2 The following information shall be inscribed on the plate:

- name or trademark of the manufacturer,
- type and year of manufacture (year may be given as a part of serial number),
- serial number of the tank,
- serial number of the level gauging system, if appropriate,
- pattern approval number, if appropriate,
- nominal capacity of the tank or of each compartment,
- accuracy class if other than 0.5,
- the minimum measured quantity of the tank or of each compartment,
- reference temperature if other than 15 °C for temperate and Nordic zones or 27 °C for tropical and subtropical zones.

5.1.3 A free area shall be left on the plate for the periodic verification marks, if appropriate.

5.2 Measuring system document

5.2.1 Upon initial verification of a measuring system a measuring system document shall be drawn up. This document shall contain at least:

- all statements given on the identification plate,
- sealing plan,
- pipework diagram,
- pneumatics diagram with the metrologically significant control lines marked,
- calibration parameter printout and calibration tables, if applicable,
- maximum rated diameter and maximum length of the full hoses, if available,
- extra sheets with descriptions of changes to the measuring system, repairs as well as any breaking of official seals including their confirmations,
- signatures for the software relevant to verification and its parameters, if applicable.

5.2.2 The measuring system document is part of the measuring system and shall be kept on the tanker.

5.3 Calibration plate on tanks with dipsticks scaled in non-volumetric units

In this case the measuring system documents may be replaced by a calibration plate for the tank or for each compartment which shall be fixed on the tank with the following information:

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

5.4 Calibration certificate

5.4.1 In conformity with national regulations a calibration certificate may be required.

5.4.2 In the case of road tankers, the calibration certificate shall include the following information:

- issuing authority and certificate number
- name and, if appropriate, address of holder
- 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 and 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, if appropriate, indication of the presence of a manifold
- uncertainty of the determination of the values of volume indicated in the certificate
- date of issue and limit of validity of the calibration certificate, if a limit is set
Note: A period of validity of 2 to 5 years is recommended.
- title, name and signature of the person responsible for the calibration
- sketch indicating the meaning of the symbols used
- height of 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
- the total contents
- the ullage height corresponding to the nominal capacity, in millimetres
- reference height, in millimetres
- mean volume per centimetre at the level of the nominal volume or calibration table, in legal units of measurement.

5.4.3 In the case of rail tankers, the calibration certificate shall include the following information:

- issuing authority and certificate number
- registration number of rail tanker
- name and, if appropriate, address of owner and manufacturer
- method of calibration, if appropriate, and place and date of the tests

- identification of the reference point and the vertical measurement axis
- conventions concerning filling of the tank and discharging pipework
- reference height, in millimetres
- total contents and corresponding ullage height
- capacity of tank body, up to the upper internal generator, and corresponding ullage height
- reference temperature (on which the table is based)
- uncertainty of the determination of the values indicated in the certificate
- limit of validity of the certificate as regards the use of the tank as a measuring instrument

Note: A period of validity of 5 to 10 years is recommended.

- date of issue of the calibration certificate
- title, name and signature of the person responsible for the calibration
- sketch indicating the meaning of the symbols used
- calibration table giving, in legal units, the volume of the liquid contained in the tank against the ullage height expressed in centimetres, within the range of level gauging
- number and positions of the applied verification marks.

5.5 Seals

5.5.1 All measuring systems shall be sealed in such a way that manipulations can be prevented and/or detected. The following locations for seals are recommended:

- indicating devices of the level gauging system,
- controller and interface units,
- terminal boxes with cables relevant to the measurements (e.g. for temperature and liquid detector),
- inclination sensors,
- temperature sensors,
- liquid detectors, except they need removal for cleaning,
- dipsticks on upper and lower fastening,
- identification plate of measuring system, operating instructions and pneumatic and pipework diagram, if applicable
- dome cover and man holes of tank compartments in measuring systems which can be filled from the bottom only,
- heating coils, if provided, shall be sealed at their points of junction with the tank body.

5.5.2 Seals are not applied to the pipework system.

5.5.3 The locations for seals must be so arranged that sealing and external administrative examination are possible without hindrance. They are fixed individually for each type of measuring system within the type approval certificate.

6 Metrological control

6.1 General

6.1.1 In conformity with national regulations, measuring systems, which are under legal metrological control shall be subject to all or a part of the following operations:

- pattern approval,
- preliminary examinations,
- initial verification,
- subsequent verifications.

6.1.2 The essential elements of a measuring system, mainly those listed below, may be subject to separate pattern approvals:

- measuring tank,
- level gauging device.

6.1.3 The results of metrological control may be used for purposes of safety control.

6.2 Pattern approval

6.2.1 Documentation

The application for pattern approval of a road or rail tanker shall include the following documents:

- a description giving the technical characteristics and the principle of operation (incl. level gauging system and ancillary devices, if any)
- drawings representing
 - a general assembly of the road or rail tanker,
 - a general assembly of the tank, including its compartments,
 - a general assembly and function of the level gauging system,
 - auxiliary and ancillary installations, as appropriate,
 - details of the dome, reinforcing elements and discharge device(s),
 - identification plate,
 - the location of seals and verification marks.

6.2.2 The body responsible for pattern evaluation decides about the number of specimens necessary for the pattern approval tests.

6.2.3 The examination of a pattern of a road or rail tanker includes the following operations :

- external inspection,
- leak test,
- pressure test, if required by national regulations,
- check on temperature dilatation of the tank,
- check on shape invariability (change of reference height),

- check on invariability of capacity in service (interference of neighbouring compartments),
- check on correct filling,
- check on complete discharge,
- calibration,
- check on sensitivity and expansion volume,
- check of ancillary devices and of the inclination correction (if any),
- check on rest volumes,
- performance tests of the electronic components.

6.2.4 The methods of examination and testing are described in Part 2 of R80 “Test methods” and shall apply to pattern approval and verification of the metering systems.

6.2.5 The performance tests of electronic components are described in Annex A and shall apply to metering systems with electronic devices.

6.2.6 For tankers with electronic level gauging, severity level I (mobile equipment) is applicable.

6.2.7 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.

6.2.8 Pattern approval certificate

6.2.8.1 The following information shall appear on the pattern approval certificate:

- name and address of the issuing authority and name of responsible person,
- name and address of the applicant,
- name and address of the manufacturer, if it is not the applicant,
- identification of the approved type (principal metrological and technical characteristics),
- pattern approval mark,
- date of issue and period of validity,
- information on the location of marks for pattern approval, initial verification and sealing (e.g. a picture or drawing)
- list of documents accompanying the pattern approval certificate
- specific remarks.

6.2.8.2 When applicable, the version of the metrological part of the evaluated software shall be indicated in the pattern approval certificate or in its annexes (technical file).

6.2.9 Modification of an approved pattern

6.2.9.1 The applicant of the pattern approval shall inform the body responsible for the approval of any modification or addition, which concerns an approved pattern.

6.2.9.2 Modifications and additions shall be subject to a supplementary pattern approval when they influence, or are likely to influence, the measurement results or the measuring system’s regulatory conditions of use. The body having approved the initial

pattern shall decide to which extent the examinations and tests described below shall be carried out on the modified pattern in relation to the nature of the modification.

Note: The manufacturer should present a written evidence (of this fact) issued by approval body, when introducing the product on market.

6.2.9.3 If the body having approved the initial pattern judges that the modifications or additions are not likely to influence the measurement results, this body shall allow the modified measuring systems to be presented for initial verification without granting a supplementary pattern approval.

6.2.9.4 A new or supplementary pattern approval must be carried out whenever the modified pattern no longer fulfils the provisions of the initial pattern approval.

6.2.9.5 The particular procedure of determining shall be described in the type approval certificate of the tanker.

6.3 Preliminary examinations

6.3.1 Preliminary examination of the tank

6.3.1.1 The tank shall be calibrated using geometric, volumetric or gravimetric method.

6.3.1.2 The expanded uncertainty of the determination of volume of liquid in tank shall not exceed one-third of the maximum permissible error according to Table 1. The expanded uncertainty shall be estimated according to the *Guide to the expression of uncertainty in measurement* (1995 edition) with $k = 2$.

6.3.1.3 Test liquid used for calibration is preferably water (if appropriate) or liquid for which the measuring system is intended or other suitable liquid with possibly low temperature dilatation. For gravimetric method, liquid which density is measured or well known with sufficient precision shall be used.

6.3.1.4 Test liquid used for calibration of tanks designated for transport of drinks or alimentary products shall be hygienically clean and non-toxic.

6.3.2 Preliminary examination of temperature sensors

The temperature sensors shall be tested in at least three points from the temperature range. Preferred test points are minimum (or value near 0 °C), reference and maximum temperatures.

6.3.3 Preliminary examination of inclination sensors

The inclination sensors shall be examined for a matrix-like pattern of inclinations of approx. $\pm 5^\circ$ in both (longitudinal and transverse) directions, as well as in the all possible (i. e. four) simultaneous inclination in both directions.

The direction of mounting shall be stated on the housing of the inclination sensor.

6.3.4 Preliminary examination of volume conversion devices

The function of the volume conversion shall be checked at least in two points for each used product or product group. The values may be taken from actual measurements or simulated. The function of hardware and software protection devices shall be checked.

6.3.5 Preliminary examination of floats

The immersion depth offset of the individual float shall be determined in relation to the reference immersion depth of a reference float of the same type and shall be documented for each float. Diameter and weight of the float shall be checked against the permissible tolerances specified in the type approval certificate. The floats need not be marked.

6.3.6 Preliminary examination of ultrasound level detectors

The ultrasound level detectors are checked with a reference pipe containing a well-defined echo mark. The permissible deviation is specified in the type approval certificate.

6.3.7 Preliminary examination of dipsticks for float systems

The dipsticks are checked with filling height simulators of different lengths, using the electronic unit connected to the dipstick. The permissible deviations are given in the type approval certificate. Linearity corrections may be necessary. The serial numbers of the dipsticks shall be documented together with the sound velocity and the linearity correction data.

6.3.8 Preliminary examination of dipstick pipes for ultrasound systems

The mechanical dimensions of the reference marks of the dipstick pipes shall be tested, for example by clamping the pipe into a gauge and comparing the distance of the reference marks from the reference edges of the gauge with the values given on the gauge. The permissible deviations are specified in the type approval certificate.

6.3.9 Preliminary examination of computer or controller

The software (modules) used as well as their signature shall be checked for compliance with the versions stated in the type approval certificate or supplements after subsequent software modifications.

The protection function (e.g. electronic sealing) for the data of legal relevance shall be checked.

6.3.10 Unless stated otherwise, all components having undergone a preliminary examination shall be marked and, if necessary, sealed.

6.4 Initial verification

6.4.1 General

6.4.1.1 All components of level gauging systems of relevance to metrology shall undergo a preliminary examination in accordance to 6.3. The use of simulators or computer-aided measuring facilities is permitted if authorised by the responsible authority.

6.4.1.2 All test equipment used shall have the required precision and must, to the extent possible, be linked to national standards. The tests of the test equipment shall be documented.

6.4.1.3 Initial verification shall comprise the following operations:

- external inspection,
- leak test,
- check of expansion volume,
- determination of rest volumes (in the pipe-work),
- check of level sensor (cut-off point),
- calibration (accuracy test),
- check of ancillary devices,
- check of the inclination correction.

6.4.2 External inspection

The following items are to be checked:

- external and internal appearance of the tank or compartment(s), damage(s),
- compliance (conformity) with the specifications of the type approval certificate, including the version of the software (modules) and signatures used, if appropriate,
- identification and preliminary examination certificates of the incorporated components,
- availability and identification of the calibration tables and of the inclination corrections, if any,
- stored values of the metrological relevant parameters (e.g. float correction values, product data, mode of volume conversion, etc.),
- functionality of the measuring system,
- availability and completeness of the measuring system document.

6.4.3 The tank shall be leak tested according to clause 4.2.2.2.

6.4.4 The tank shall be calibrated according to clause 4.5.

6.4.4.1 The expanded uncertainty of the determination of volume of liquid in tank for initial verification shall not exceed one-third of the maximum permissible error according to Table 1. The expanded uncertainty shall be estimated according to the *Guide to the expression of uncertainty in measurement* (1995 edition) with $k = 2$.

6.4.4.2 Specification of the minimum measured quantities

The minimum measured quantity shall be specified for each measuring compartment in accordance with 4.1.5 unless stated otherwise in the type approval certificates for the level gauging system or for the measuring tank. The minimum measured quantity according to 4.1.5.2 may be specified within the scope of the tank calibration. When it is determined within the scope of the tank calibration, it may be changed during the initial verification at the latest (for example if the measurement results exceed the error limits).

6.5 Subsequent verification

6.5.1 Subsequent verification is subject to national regulations.

6.5.2 Recommended actions after repairs

In case of a repair of the measuring system or its part by a recognised repair shop or under the supervision of the verification authority, the actions below are recommended:

6.5.2.1 Actions on replacement of an indicating device

- preliminary examination of new indicating device,
- entry of the new data into the measuring system document,
- single volume measurement by verification authority with quantity of about MMQ delivered from the random compartment, check of the indicated and corrected volume,
- comparison and evaluation of parameters.

6.5.2.2 Actions on replacement of dipsticks of float systems:

- preliminary examination of new dipstick of float system,
- entry of the new dipstick correction values into the level gauging system,
- entry of the new data into the measuring system document,
- single volume measurement by verification authority, quantity of about (1 to 2) MMQ delivered from the compartment fitted with new dipstick, check of the operating volume,
- comparison and evaluation of parameters.
-

6.5.2.3 Actions on replacement of a float

- preliminary examination of a new float,
- entry of the new float correction values into the level gauging system,
- entry of the new data into the measuring system document,
- single volume measurement by verification authority, quantity of about (1 to 2) MMQ delivered from the compartment fitted with new float, check of the operating volume,
- comparison and evaluation of parameters.

6.5.2.4 Actions on replacement of dipsticks for ultrasound systems

- preliminary examination of new dipstick for ultrasound systems,
- calibration of the relevant compartment by the manufacturer,
- initial verification.

6.5.2.5 Actions on replacement of a temperature sensor

- preliminary examination of a new temperature sensor,
- entry of the new sensor parameters into parameter list,
- entry of the new data into the measuring system document,
- temperature measurement by verification authority during delivery of a random quantity from the relevant compartment,
- recording and comparison of the delivery temperature with a temperature standard,
- comparison and evaluation of parameters.

6.5.2.6 Actions after compilation of a new calibration table for a measuring compartment (recalibration of a tank or compartment, e.g. after repair of the tank)
After a new calibration table has been compiled for one or several tank compartments, the verification of the measuring system is no longer valid.

6.5.2.7 For the following verification, all re-calibrated measuring compartments shall be tested as for initial verification. The re-examination of the pipe-work volumes may be dispensed with if these have not changed. Prior to the due date the compartments for which no new calibration tables have been compiled need not be subsequently verified due to the repair. After the repaired compartments have been checked, the measuring system shall be provided with a seal stating the original period of validity of the verification.

6.5.2.8 If the repair was carried out within the scope of a subsequent verification, the repaired compartments will be treated as in initial verification and the other compartments as in subsequent verification.

ANNEX A

PERFORMANCE TESTS FOR ELECTRONIC MEASURING SYSTEMS (Mandatory)

A.1 General

This Annex defines the program of performance tests intended to verify that electronic measuring systems may perform and function as intended in a specified environment and under specified conditions. Each test indicates, where appropriate, the reference conditions for determining the intrinsic error.

These tests supplement any other prescribed test.

When the effect of one influence quantity is being evaluated, all other influence quantities are to be held relatively constant, at values close to reference conditions.

A.2 Reference conditions

Recommended reference temperature is 15 °C or 20 °C for temperate and Nordic zones and 27 °C for tropical and subtropical zones. Recommended reference pressure is normal atmospheric pressure (1 bar).

The use of other values for justified reasons is allowed (for example reference temperature of 12 °C and higher pressure for liquefied petroleum gases).

A.3 Environmental classification (see OIML D 11)

For each performance test, typical test conditions are indicated which correspond to the climatic, mechanical and electromagnetic environmental conditions to which the tankers are usually exposed.

According to OIML D 11 the following classes are recommended

- Climatic environment: Class H2

This class applies to instruments or parts of instruments used in open locations with average climatic conditions, thus excluding polar and desert environments.

- Mechanical environment: Class M3

This class applies to locations where the level of vibration and shock is high or very high, e.g. for instruments mounted directly on machines, conveyor belts, etc.

- Electromagnetic environment: Class E2

This class applies to instruments used in locations with electromagnetic disturbances corresponding to those likely to be found in industrial buildings.

According to these classes, severity levels given by the following Table A.1 are recommended

Table A.1: Severity levels for the performance tests

Kind of performance tests	Test description	Influence quantity ²⁾	OIML D 11	Severity level
Climatic	A.4.1 Dry heat	I	10.1.1	3
	A.4.2 Cold	I	10.1.2	3
	A.4.3 Damp heat, cyclic (condensing)	D	10.2.2	2
Mechanical	A.4.4 Vibration (random)	I	11.1.1	2
Electrical, general	A.4.5.1 Electromagnetic fields of general origin	D	12.1.1/1	3
	A.4.5.2 Electromagnetic fields specifically caused by digital radio telephones	D	12.1.1/2	3
	A.4.5.3 Conducted radio-frequency fields	D	12.1.2	3
	A.4.6 Electrostatic discharge	D	12.2	3
	A.4.7 Power frequency magnetic field ¹⁾	D	12.3	5
	A.4.8 Bursts (transients) on signal, data and control lines	D	12.4	3
Electrical, power from external 12 V and 24 V road vehicle batteries	A.4.9.1 Voltage variations	I	14.2.1	C/F
	A.4.9.2 Electrical transient conduction along supply lines	D	14.2.2	IV
	A.4.9.3 Electrical transient conduction via lines other than supply lines	D	14.2.3	IV

¹⁾ This test shall only be prescribed where, as a result of the physical principle of the measuring instruments, a significant influence of power magnetic fields can be expected.

²⁾ I - Influence factor
D - Disturbance

However, the applicant for pattern approval may indicate specific environmental conditions in the documentation supplied to the metrology service, based on the intended use of the tanker. In this case, the metrology service shall carry out performance tests at severity levels corresponding to the corresponding environmental conditions. If pattern approval is granted, the data plate shall indicate the corresponding limits of use. Manufacturers shall inform potential users of the conditions of use for which the tanker is approved. The metrology service shall verify that the conditions of use are met.

A.4 Performance tests

The tests involve the electronic part of the measuring system or its devices (in the following called equipment under test EUT).

A.4.1 Dry heat

Test method: Dry heat (non condensing)

Object of the test: To verify compliance with the provisions in 4.7.1.1 under conditions of high ambient air temperature.

References: IEC 60068-2-2 (1974-01), -am1 (1993-02), -am2 (1994-05). Environmental testing. Part 2. Tests. Tests B. Dry heat. Section 4 - Test Bd: Dry heat for heat-dissipating specimen with gradual change of temperature [13].
IEC 60068-3-1 (1974-01), -1A (1978-01). Basic environmental testing procedures. Part 3: Background information. Section one: Cold and dry heat tests [14].
IEC 60068-1 (1988-06), -am1 (1992-04). Environmental testing. Part 1: General and guidance [15].

Test procedure in brief ⁽¹⁰⁾: The test consists of exposure of the EUT to the specified high temperature under “free air” conditions for a 2-hour period, after the EUT has reached temperature stability.
The change of temperature shall not exceed 1 °C/min during heating up and cooling down.
The absolute humidity of the test atmosphere shall not exceed 20 g/m³. When testing is performed at temperatures lower than 35 °C, the relative humidity shall not exceed 50 %.
The EUT shall be tested at the reference temperature after 1 hour conditioning,

- at the specified high temperature, 2 hours after temperature stabilization,
- after 1 hour recovery of the EUT at the reference temperature.

During tests, the EUT shall be in operation, simulated inputs are permitted.

Test severities:

One of the following severity levels shall be specified					
1	2	3	4	5	unit
30	40	55	70	85	°C

Number of test cycles: One cycle

Maximum allowable variations: All functions shall operate as designed and all the errors measured during the application of the influence factor shall be within the maximum permissible errors.

(10) This test procedure has been given in condensed form, for information only, and is adapted from the referenced IEC-Publication. Before conducting the test, the applicable publication should be consulted. This comment also applies to the test procedures hereafter.

A.4.2 Cold

Test method: Cold

Object of the test: To verify compliance with the provisions in 4.7.1.1 under conditions of high ambient air temperature.

References: IEC 60068-2-1 (1990-05), -am1 (1993-02), -am2 (1994-06). Environmental testing. Part 2.1 Tests. Tests A. Cold. Section three - Test Ad: Cold for heat-dissipating specimen with gradual change of temperature [16].

IEC 60068-3-1 (1974-01), -1A (1978-01). Basic environmental testing procedures. Part 3: Background information. Section one: Cold and dry heat tests [14].

IEC 60068-1 (1988-06), -am1 (1992-04). Environmental testing. Part 1: General and guidance [15].

Test procedure in brief : The test consists of exposure of the EUT to the specified low temperature under "free air" conditions for a 2-hour period, after the EUT has reached temperature stability.

The EUT shall be tested

- at the reference temperature after 1 hour conditioning,
- at the specified low temperature, 2 hours after temperature stabilization
- after 1 hour recovery of the EUT at the reference temperature.

During tests, the EUT shall be in operation, simulated inputs are permitted.

Test severities:

One of the following severity levels shall be specified				
1	2	3	4	unit
5	- 10	- 25	- 40	°C

Number of test cycles: One cycle

Maximum allowable variations: All functions shall operate as designed and all the errors measured during the application of the influence factor shall be within the maximum permissible errors.

A.4.3 Damp heat, cyclic (condensing)

Test method:	Damp heat, cyclic (condensing)
Object of the test:	To verify compliance with the provisions in 4.7.1.1 under conditions of high humidity when combined with cyclic temperature changes.
References:	IEC 60068-2-30 (1980-01), -am1 (1985-08). Basic environmental testing procedures. Part 2: Tests. Test Db and guidance: Damp heat, cyclic (12h + 12h cycle), test variant 1 [17]. IEC 60068-3-4 (2001-08). Environmental Testing. Part 3-4: Supporting documentation and guidance – Damp heat tests [18]
Test procedure in brief:	<p>The test consists of exposure of the EUT to cyclic temperature variations between 25 °C and the upper temperature of 55 °C, maintaining the relative humidity above 95 % during the temperature changes and during the phases at low temperature, and at 93 % at the upper temperature phases.</p> <p>A 24 h cycle consists of:</p> <ul style="list-style-type: none">- temperature rise during 3 h- temperature maintained at upper value until 12 h from the start of the cycle- temperature lowered to lower value within 3 h to 6 h, the rate of fall during the first hour and a half being such that the lower value would be reached in 3 h- temperature maintained at lower value until the 24 h cycle is completed. <p>The stabilizing period before and recovery after the cyclic exposure shall be such that all parts of the EUT are approximately at their final temperature.</p> <p>The power supply is turned off when the influence factor is applied.</p>
Test severities:	Upper temperature severity level 2: 55 °C
Number of test cycles:	Two cycles
Maximum allowable variations:	After the application of the influence factor and recovery, all functions shall operate as designed and all errors shall be within the maximum permissible errors.

A.4.4 Vibration (random)

Test method: Random vibration

Object of the test: To verify compliance with the provisions in 4.7.1.1 under conditions of random vibrations.

References: IEC 60068-2-47 (1999-10) Environmental testing Part 2-47: Test methods. Mounting of components, equipment and other articles for vibration, impact and similar dynamic tests
IEC 60068-2-64 (1993-05), with correction 1 (1993-10) Environmental testing- Part 2: Test methods, test Fh: Vibration, broadband random (digital control) and guidance

Test procedure in brief: The EUT shall, in turn, be tested in three, mutually perpendicular axes, mounted on a rigid fixture by its normal mounting means.
The EUT shall normally be mounted so that the gravitational force acts in the same direction as it would in normal use.
The power supply is turned off when the influence factor is applied.

Test severities:

	The following severity level shall be specified	
	2	unit
Total frequency range	10 -150	Hz
Total RMS level	7	m.s ⁻²
ASD level 10 –20 Hz	1	m ² .s ⁻³
ASD level 20 –150 Hz	- 3	dB/octave
Number of axes	3	-
Duration per axis	2 minutes	

Maximum allowable variations: After the application of the influence factor, all functions shall operate as designed and all errors shall be within the maximum permissible errors.

A.4.5 Radio frequency, immunity tests

A.4.5.1 Radiated, radio frequency, electromagnetic field of general origin

Test method:	Radiated electromagnetic fields
Object of the test:	To verify compliance with the provisions in 4.7.1.1 under conditions of electromagnetic fields.
References:	IEC 61000-4-3 (1995-03) consolidated Edition 2.1 (2002-09) with amendment 1 (2002-08) Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques, Section3: Radiated, radio-frequency, electromagnetic field immunity test
Test procedure in brief:	<p>The EUT shall be exposed to electromagnetic field strength as specified by the severity level and a field uniformity as defined by the referred standard.</p> <p>The EM field can be generated in different facilities, however the use of which is limited by the dimensions of the EUT and the frequency range of the facility..</p> <p>The frequency ranges to be considered are swept with the modulated signal, pausing to adjust the RF signal level or to switch oscillators and antennas as necessary. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the preceding frequency value.</p> <p>The dwell time of the amplitude modulated carrier at each frequency shall not be less than the time necessary for the EUT to be exercised and to respond, but shall in no case be less than 0,5 s. The sensitive frequencies (e.g. clock frequencies) shall be analyzed separately (Usually, these sensitive frequencies can be expected to be the frequencies emitted by the EUT).</p> <p>During tests, the EUT shall be in operation, simulated inputs are permitted.</p>
Test severities:	<p>Severity level 3:</p> <p>10 V/m for the following frequency ranges:</p> <ul style="list-style-type: none">- 80 – 800 MHz IEC 61000-4-3 (1995-03) only specifies test levels above 80 MHz. For frequencies in the lower range the test methods for conducted radio frequency disturbances are recommended (test A4.5.3)- 26 – 800 MHz However, for EUT having no mains or other input port available the lower limit of radiation test should be 26 MHz, taking into account that the test specified in A4.5.3 cannot be applied (refer to Annex H of IEC 61000-4-3). In all other cases both A.4.5.1 and A.4.5.2 shall apply- 960 – 1400 MHz <p>Modulation: 80 % AM, 1 kHz sine wave</p>

Maximum allowable variations: a) for interruptible measuring systems
either significant faults do not occur or checking facilities detect a malfunctioning and act upon it in accordance with 4.6.3 when significant faults occur
b) for non-interruptible measuring systems,
no significant faults occur.

A.4.5.2 Radiated, radio frequency, electromagnetic field caused by digital telephones

Test method: Radiated electromagnetic fields

Object of the test: To verify compliance with the provisions in 4.7.1.1 under conditions of electromagnetic fields.

References: IEC 61000-4-3 (1995-03) consolidated Edition 2.1 (2002-09) with amendment 1 (2002-08) Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques, Section 3: Radiated, radio-frequency, electromagnetic field immunity test

Test procedure in brief: The EUT shall be exposed to electromagnetic field strength as specified by the severity level and a field uniformity as defined by the referred standard.

The EM field can be generated in different facilities, however the use of which is limited by the dimensions of the EUT and the frequency range of the facility..

The frequency ranges to be considered are swept with the modulated signal, pausing to adjust the RF signal level or to switch oscillators and antennas as necessary. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the preceding frequency value.

The dwell time of the amplitude modulated carrier at each frequency shall not be less than the time necessary for the EUT to be exercised and to respond, but shall in no case be less than 0,5 s. The sensitive frequencies (e.g. clock frequencies) shall be analyzed separately (Usually, these sensitive frequencies can be expected to be the frequencies emitted by the EUT).

During tests, the EUT shall be in operation, simulated inputs are permitted.

Test severities: Severity level 3:
10 V/m for the following frequency ranges:
- 800 – 960 MHz
- 1400 - 2000 MHz
Modulation: 80 % AM, 1 kHz sine wave

Maximum allowable variations: a) for interruptible measuring systems

either significant faults do not occur or checking facilities detect a malfunctioning and act upon it in accordance with 4.6.3 when significant faults occur

b) for non-interruptible measuring systems,
no significant faults occur.

A.4.5.3 Conducted radio frequency fields

Test method:	Conducted electromagnetic fields
Object of the test:	To verify compliance with the provisions in 4.7.1.1 under conditions of electromagnetic fields.
References:	IEC 61000-4-6 (2003-05) Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques, Section 6: Immunity to conducted disturbances, induced by radio frequency fields
Test procedure in brief:	<p>Radio frequency EM current, simulating the influence of EM fields shall be coupled or injected into power ports and I/O ports of the EUT using coupling/decoupling devices as defined in the referred standard.</p> <p>The performance of the test equipment consisting of an RF generator, (de-)coupling devices, attenuators, etc. shall be verified</p> <p>During tests, the EUT shall be in operation, simulated inputs are permitted.</p>
Test severities:	<p>Severity level 3:</p> <p>10 V (e.m.f.) for the RF amplitude (50 Ω)</p> <p>Frequency range 0,15 – 80 MHz</p>
Maximum allowable variations:	<p>a) for interruptible measuring systems</p> <p>either significant faults do not occur or checking facilities detect a malfunctioning and act upon it in accordance with 4.6.3 when significant faults occur</p> <p>b) for non-interruptible measuring systems, no significant faults occur.</p>

A.4.6 Electrostatic discharge

Test method:	Electrostatic discharge (ESD)
Object of the test:	To verify compliance with the provisions in 4.7.1.1 under conditions of direct and indirect electrostatic discharge.
References:	IEC 61000-4-1 (2000-04). Electromagnetic Compatibility (EMC). Part 4-1: Testing and measurement techniques - Overview of IEC 61000-4 series [25] IEC 61000-4-2 (1995-01) with amendment 1 (1998-01) Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques, Section 2: Electrostatic discharge immunity test. Consolidated Edition: IEC 61000-4-2 (2001-04) Ed. 1.2
Test procedure in brief:	An ESD generator shall be used with a performance as defined in the referred standard. The EUT shall be tested under reference conditions. At least 10 discharges shall be applied. The time interval between successive discharges shall be at least 10 seconds, during the same measurement or simulated measurement. Contact discharge is the preferred test method. Air discharges shall be used where contact discharge cannot be applied.
Test severities:	8 kV for air discharges 6 kV for contact discharges
Number of test cycles:	At each test point, at least ten direct discharges shall be applied at intervals of at least ten seconds between discharges, during the same measurement or simulated measurement. For indirect discharges, a total of ten discharges shall be applied on the horizontal coupling plane and a total of ten discharges for each of the various positions of the vertical coupling plane.
Maximum allowable variations:	a) for interruptible measuring systems either significant faults do not occur or checking facilities detect a malfunctioning and act upon it in accordance with 4.6.3 when significant faults occur b) for non-interruptible measuring systems, no significant faults occur.

A.4.7 Power frequency magnetic field

Test method:	Power frequency magnetic field (50 Hz or 60 Hz)
Object of the test:	To verify compliance with the provisions in 4.7.1.1 under conditions of power frequency magnetic field (50 Hz or 60 Hz).
References:	IEC 61000-4-8 (1993-06) with amendment 1 (2000-11) Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test Consolidated Edition: IEC 61000-4-8 (2001-03) Ed. 1.1
Test procedure in brief:	The test consists of exposure to power frequency magnetic field (50 Hz or 60 Hz)
Test severities:	Severity level 4: Magnetic field strength 30 A/m for continuous field Magnetic field strength 300 A/m for short duration (1 – 3 s) Severity level 5: Magnetic field strength 100 A/m for continuous field Magnetic field strength 1000 A/m for short duration (1 – 3 s)
Maximum allowable variations:	a) for interruptible measuring systems either significant faults do not occur or checking facilities detect a malfunctioning and act upon it in accordance with 4.6.3 when significant faults occur b) for non-interruptible measuring systems, no significant faults occur.

A.4.8 Burst (transients) on signal, data and control lines

Test method:	Electrical bursts
Object of the test:	To verify compliance with the provisions in 4.7.1.1 under conditions where electrical bursts are superimposed on input/output and communication ports.
References:	<p>IEC 61000-4-1 (2000-04) Basis EMC Publication; Electromagnetic compatibility (EMC); Part 4: Testing and measurement techniques; Section 1: Overview of IEC 61000-4 series.</p> <p>IEC 61000-4-4 (1995-01) with Amendment 1 (2000-11) and Amendment 2 (2001-07); Electromagnetic compatibility (EMC) – Part 4: Testing and Measurement techniques – Section 4: Electrical fast transient/burst immunity test. Basic EMC Publication.</p>
Test procedure in brief:	<p>A burst generator shall be used with the performance characteristics as specified in the referred standard.</p> <p>The test consist of exposure to bursts of voltage spikes for which the repetition frequency of the impulses and peak values of the output voltage on 50 Ω and 1000 Ω load are defined in the referred standard.</p> <p>The characteristics of the generator shall be verified before connecting the EUT.</p> <p>Both positive and negative polarity of the bursts shall be applied.</p> <p>The duration of the test shall not be less than 1 min for each amplitude and polarity.</p> <p>For the coupling of the bursts into the input/output and communication lines, a capacitive coupling clamp as defined in the standard shall be used.</p> <p>The bursts are applied during all the time necessary to perform the test; to that purpose more bursts than indicated above may be necessary.</p> <p>During tests, the EUT shall be in operation, simulated inputs are permitted.</p>
Test severities:	Severity level 3: 1 kV for the amplitude (peak value)
Maximum allowable variations:	<p>a) for interruptible measuring systems either significant faults do not occur or checking facilities detect a malfunctioning and act upon it in accordance with 4.6.3 when significant faults occur</p> <p>b) for non-interruptible measuring systems, no significant faults occur.</p>

A.4.9 Tests for power from road vehicle battery

A.4.9.1 Voltage variations

Test method: Variation in supply voltage

Object of the test: To verify compliance with the provisions in 4.7.1.1 under conditions of varying battery voltage.

References: The upper limits specified in this clause (16 V and 32 V) are in accordance with ISO/FDIS 16750-2:2003 Road vehicles – Environmental conditions and testing for electrical and electronic equipment; Part 2: Electrical loads.

The lower limits (9 V and 16 V) are in accordance with ISO/FDIS 16750-2:2003 code C, respectively code F.

For specifications of the power supply used during the test to simulate the battery, refer to ISO 7637-2 (1990), clause 4.4, Road vehicles - electrical disturbance by conducting and coupling, Part 2: Commercial vehicles with nominal 24 V supply voltage - Electrical transient conduction along supply lines only, or

ISO/DIS CD 7637-2.3, clause 5.4, Road vehicles – electrical disturbance by conducting and coupling – Part 2: Electrical transient conducting along supply lines only.

Test procedure in brief: The test consists of exposure to the specified power supply condition for a period sufficient for achieving temperature stability and for performing the required measurements.

If a standard power supply (with sufficient current capacity) is used in bench testing to simulate the battery, it is important that the low internal impedance of the battery also be simulated.

The continuous supply source shall have an internal resistance R_i less than 0,01 Ω dc and an internal impedance $Z_i = R_i$ for frequencies less than 400 Hz.

During tests, the EUT shall be in operation, simulated inputs are permitted.

Test severities: Severity level C and F:

Voltage	12 V battery	upper limit	18 V
	24 V battery	upper limit	32 V
			.
	12 V battery	lower limit	9 V
	24 V battery	lower limit	16 V

Maximum allowable variations: At supply voltage levels between upper and lower limit, all functions shall operate as designed and all errors shall be within the maximum permissible errors.

A.4.9.2 Electrical transient conduction along supply lines

Test method: Electrical transient conduction along supply lines

Object of the test: To verify compliance with the provisions in 4.7.1.1 or under the following conditions:

- transients on the supply lines due to supply disconnection from inductive loads (pulse 1);
- transients due to a sudden interruption of currents in a device connected in parallel with the device under test due to the inductance of the wiring harness (pulse 2a);
- transients from DC motors acting as generators after the ignition is switched off (pulse 2b);
- transients on the supply lines , which occur as a result of the switching processes (pulses 3a and 3b);
- voltage reductions caused by energizing the starter-motor circuits of internal combustion engines (pulse 4)

References:

ISO/DIS CD 7637-2.3 (2003)
Road vehicles - electrical disturbance by conducting and coupling. Part 2: Electrical transient conduction along supply lines only

§ 4.6.1: Test pulse **1** § 4.6.3: Test pulse **3a + 3b**
§ 4.6.2: Test pulse **2a + 2b** § 4.6.4: Test pulse **4**

Test procedure in brief: The test consists of exposure to disturbances on the power supply by direct coupling on supply lines.

During tests, the EUT shall be in operation, simulated inputs are permitted.

Test severities: Severity level 4:

Test pulse 1	12 V Battery		U_s	- 100	V
	24 V Battery	pulse 1a	U_s	- 200	V
		pulse 1 b	U_s	- 1100	V
Test pulse 2	12 and 24 V Battery		U_s	+ 100	V
Test pulse 3	12 V Battery	pulse 3a	U_s	- 150	V
		pulse 3b	U_s	+ 100	V
	24 V Battery	pulse 3a	U_s	- 200	V
		pulse 3b	U_s	+ 200	V
Test pulse 4	12 V Battery		U_s	- 7	V
	24 V Battery		U_s	- 16	V
Test pulse 6	12 V Battery		U_s	- 300	V

Maximum allowable variations: a) for interruptible measuring systems
either significant faults do not occur or checking facilities detect a malfunctioning and act upon it in accordance with 4.6.3 when significant faults occur
b) for non-interruptible measuring systems,
no significant faults occur.

A.4.9.3 Electrical transient conduction via lines other than supply lines

Test method: Electrical transient conduction along lines other than supply lines

Object of the test: To verify compliance with the provisions in 4.7.1.1 under conditions of transients which occur on other lines as a result of the switching processes (pulses a and b)

References: ISO 7637-3 (1995) with correction 1 (1995), § 4.5: Test pulses **a and b**. Road vehicles - Electrical disturbance by conducting and coupling -

Part 3: Passenger cars and light commercial vehicles with nominal 12 V supply voltage and commercial vehicles with 24 V supply voltage - Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines

Test procedure in brief: The test consists of exposure to bursts of voltage spikes by capacitive and inductive coupling via lines other than supply lines.

During tests, the EUT shall be in operation, simulated inputs are permitted.

Test severities: Severity level IV:

12 V Battery	U_s	- 60	V
	U_s	+ 40	V
24 V Battery	U_s	- 80	V
	U_s	+80	V

Maximum allowable variations: a) for interruptible measuring systems
either significant faults do not occur or checking facilities detect a malfunctioning and act upon it in accordance with 4.6.3 when significant faults occur
b) for non-interruptible measuring systems,
no significant faults occur.

ANNEX 1
EXAMPLES FOR TANKERS WITH MECHANICAL SENSORS
(Informative)

Homework: I. Chren: Modify this annex, check the actual situation and the actual use, add legends, help from Austria and France,

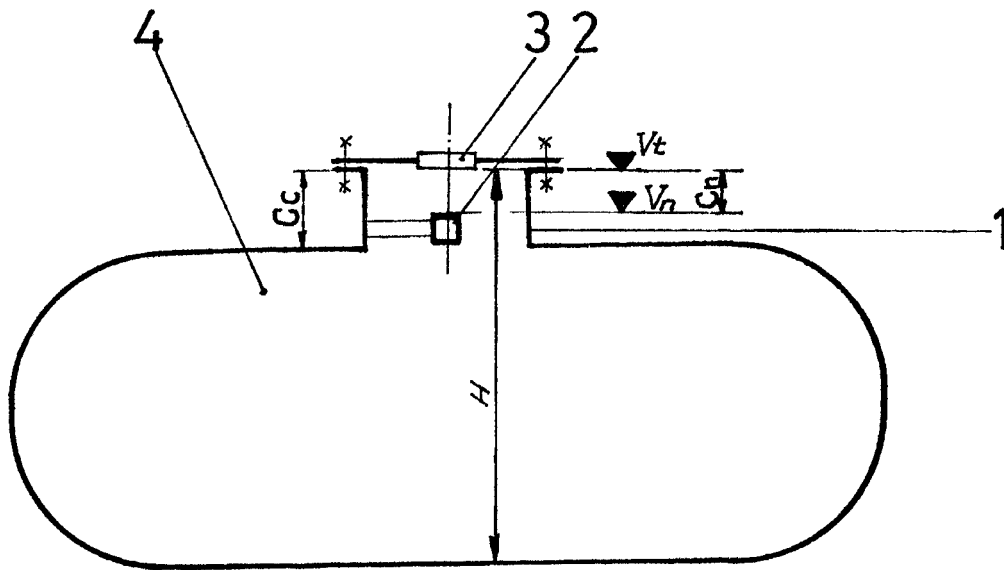


Fig. A.1-1: Single or two (opposite) volumetric marks or indexes in the dome

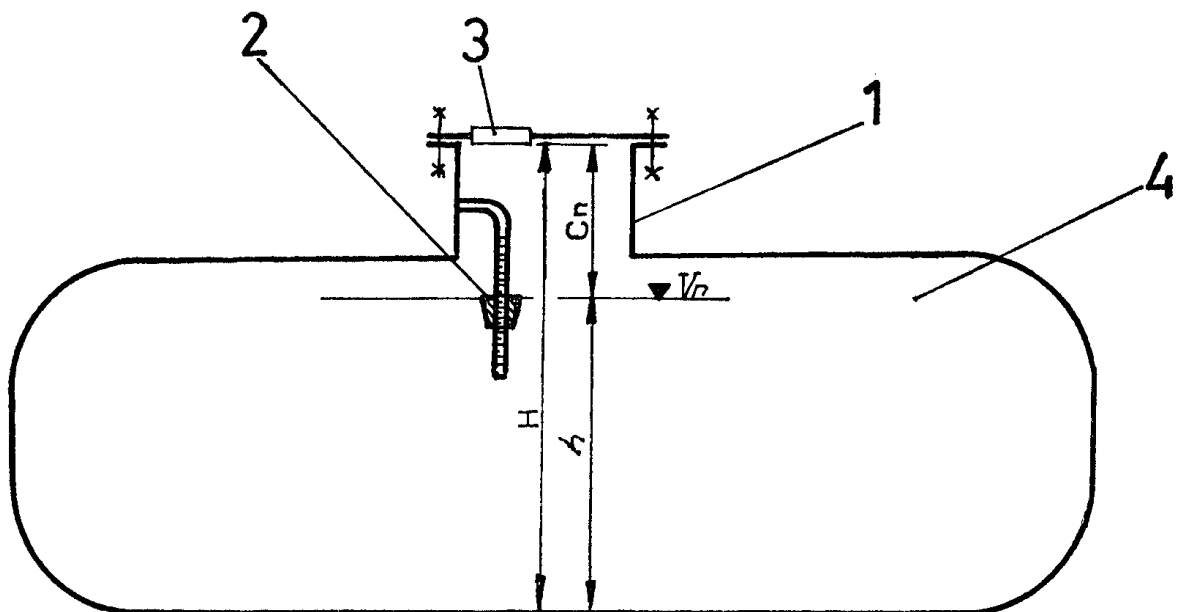
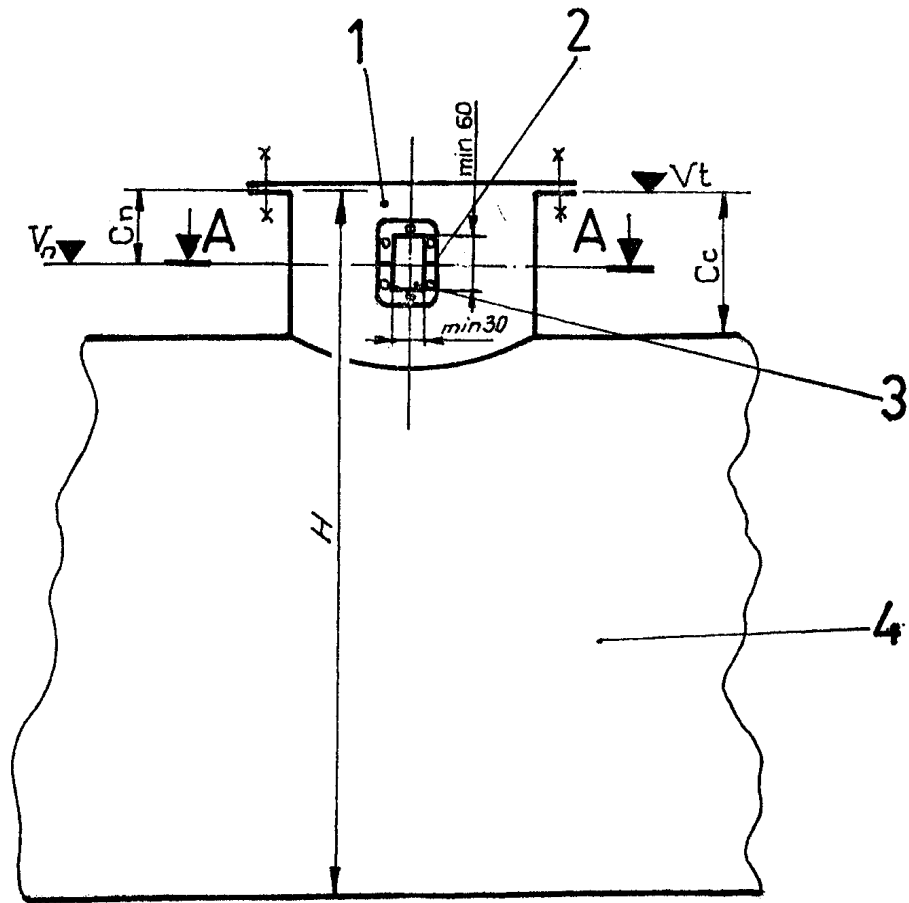


Fig. A.1-2: Top edge of the index fixed on holder (one-mark dipstick)



Section A-A

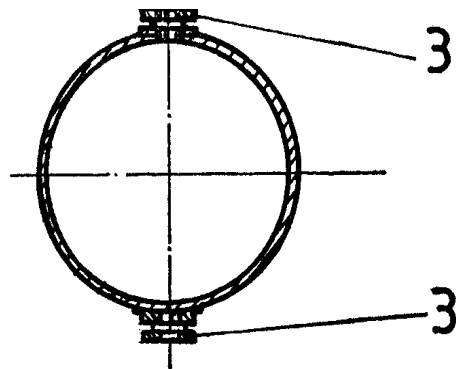


Fig. A.1-3: Single mark or graduated window in dome

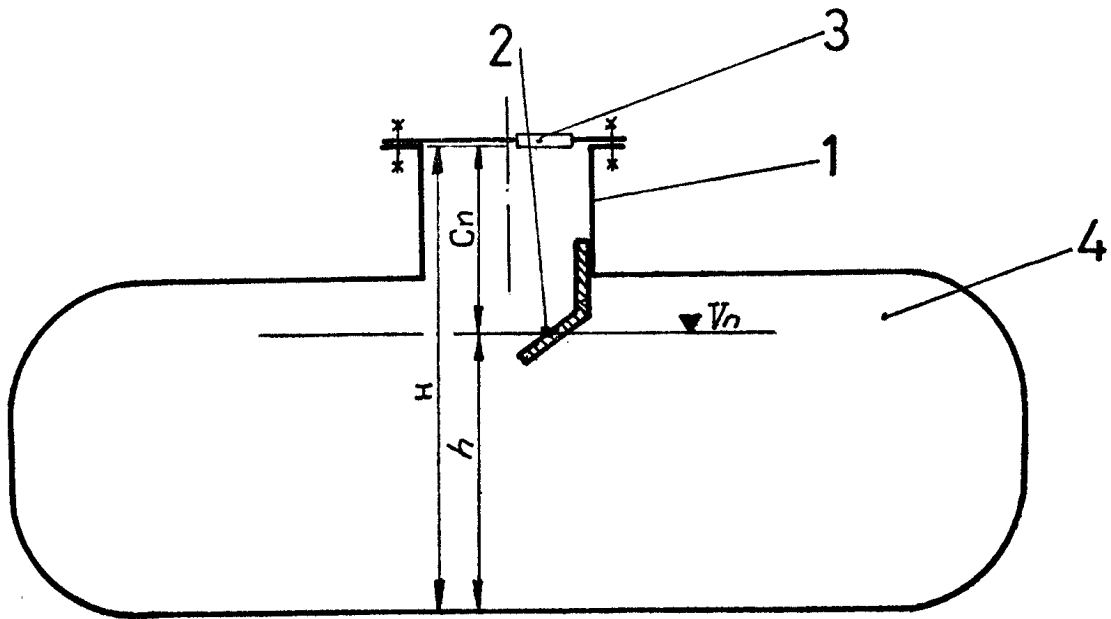


Fig. A.1-4: Single volumetric mark in tank (on console fixed to dome)

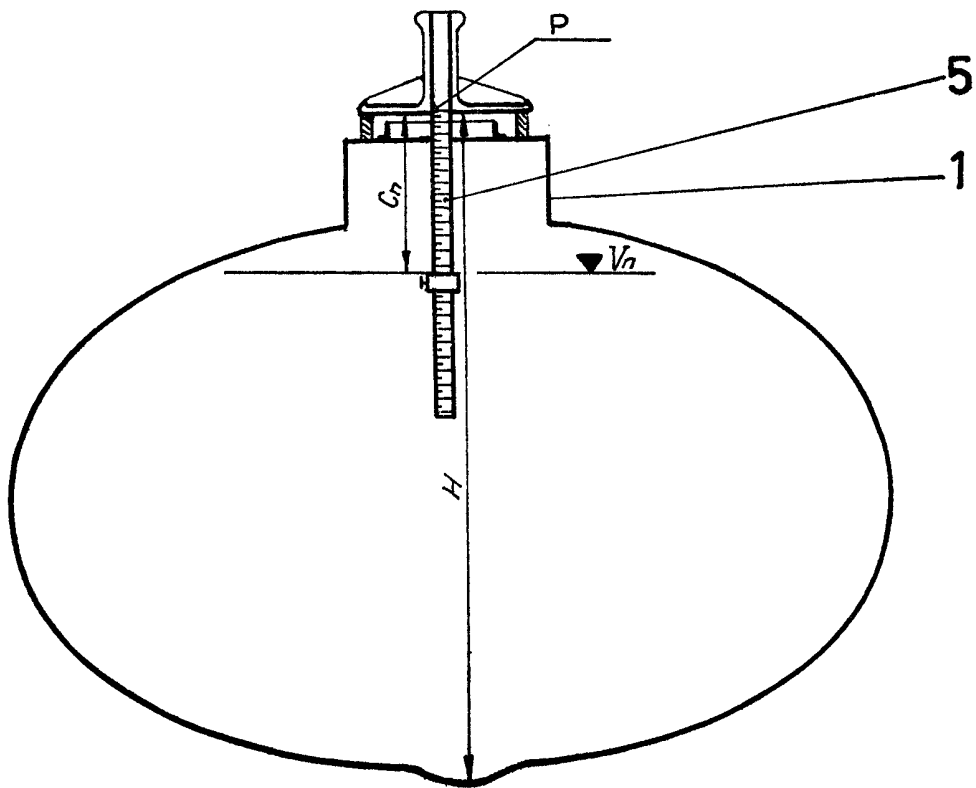


Fig. A.1-5: Mechanical dipstick with sliding index

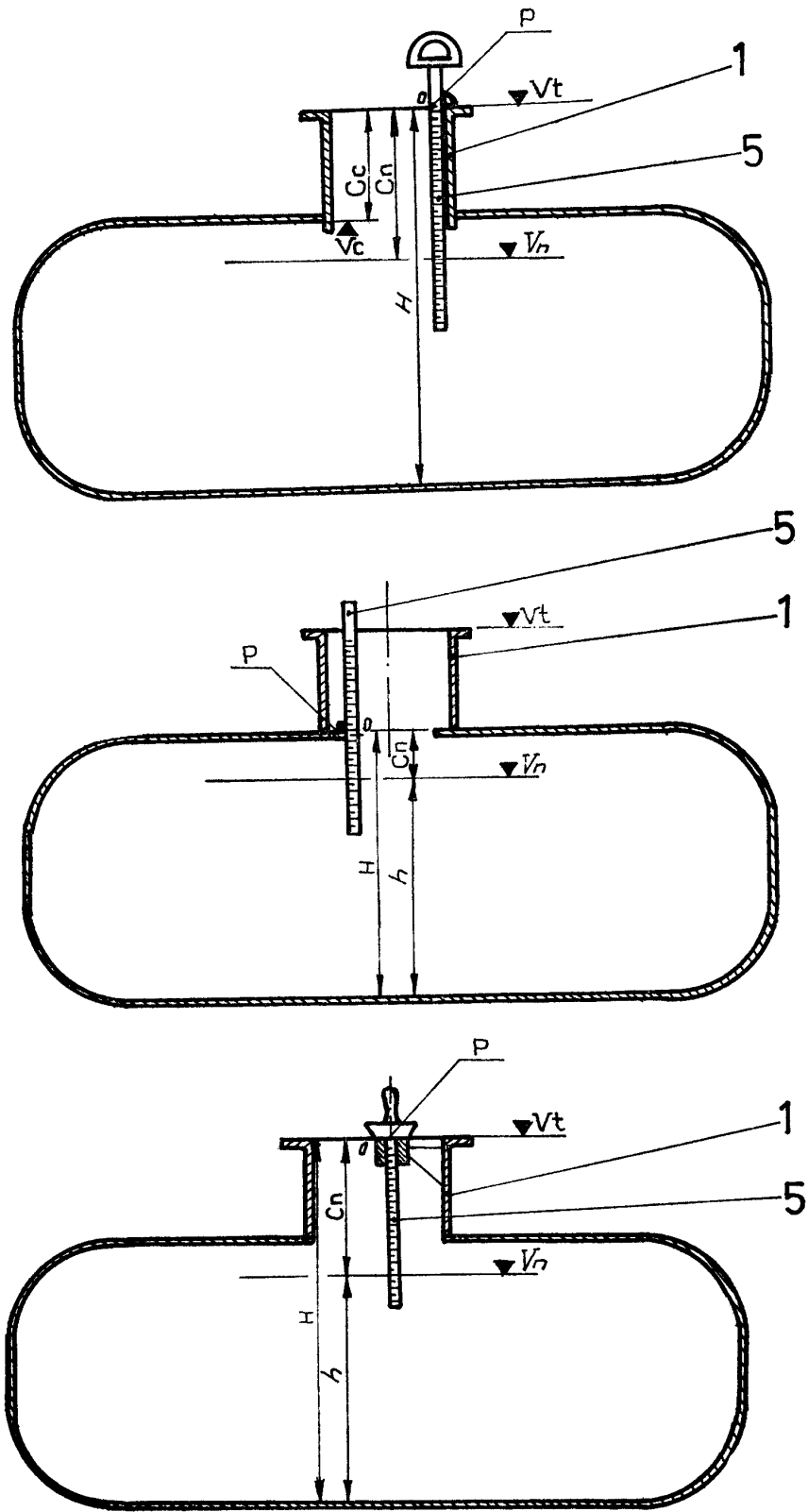


Fig. A.1-6: Examples of mechanical dipsticks and placement of RPT

ANNEX 2
EXAMPLES FOR AUTOMATIC MEASURING SYSTEMS
WITH ELECTRONIC LEVEL GAUGES
 (Informative)

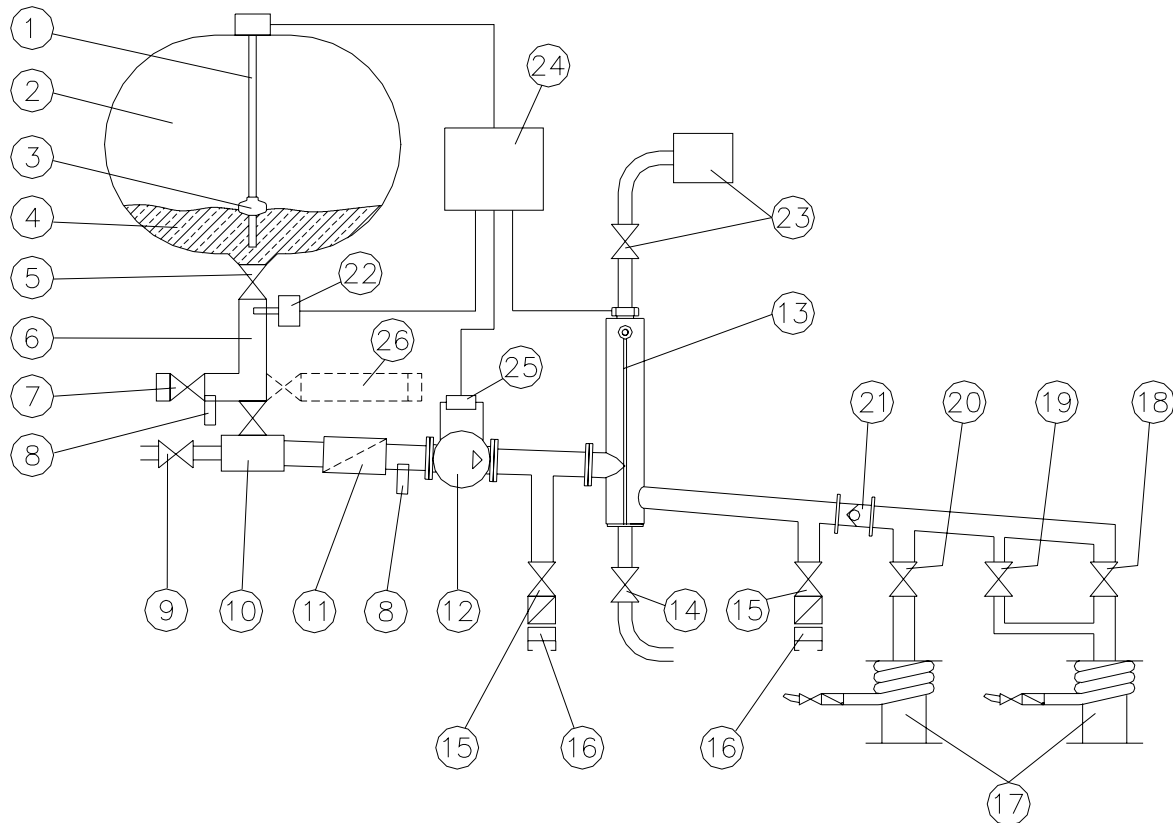


Fig. A.2-1: Schematic set-up of the measuring system of a tanker for oils in its maximum version (for explaining the basic components and functions)

- (1) level sensor
- (2) measuring tank/measuring compartment
- (3) float, if appropriate
- (4) product
- (5) bottom valve
- (6) discharge line
- (7) dry coupler (API)
- (8) liquid detector (if appropriate, in collector line and downstream of pump)
- (9) collector vent valve
- (10) collector line (shown with valve function)
- (11) filter system
- (12) pump
- (13) level sensor for pipe system, alternatively: gas separator
- (14) draining, if appropriate
- (15) valve of empty hose
- (16) coupler of empty hose with filter and inspection glass (alternative positions)
- (17) hose reel with full hose
- (18) valve of full hose 2

- (19) valve of full hose 2 (reduced delivery without shutdown valve)
- (20) valve of full hose 1
- (21) non-return valve
- (22) temperature sensor
- (23) ventilation, if appropriate
- (24) electronic measuring and control unit
- (25) control apparatus for pump motor, if necessary
- (26) delivery line to the right, if appropriate

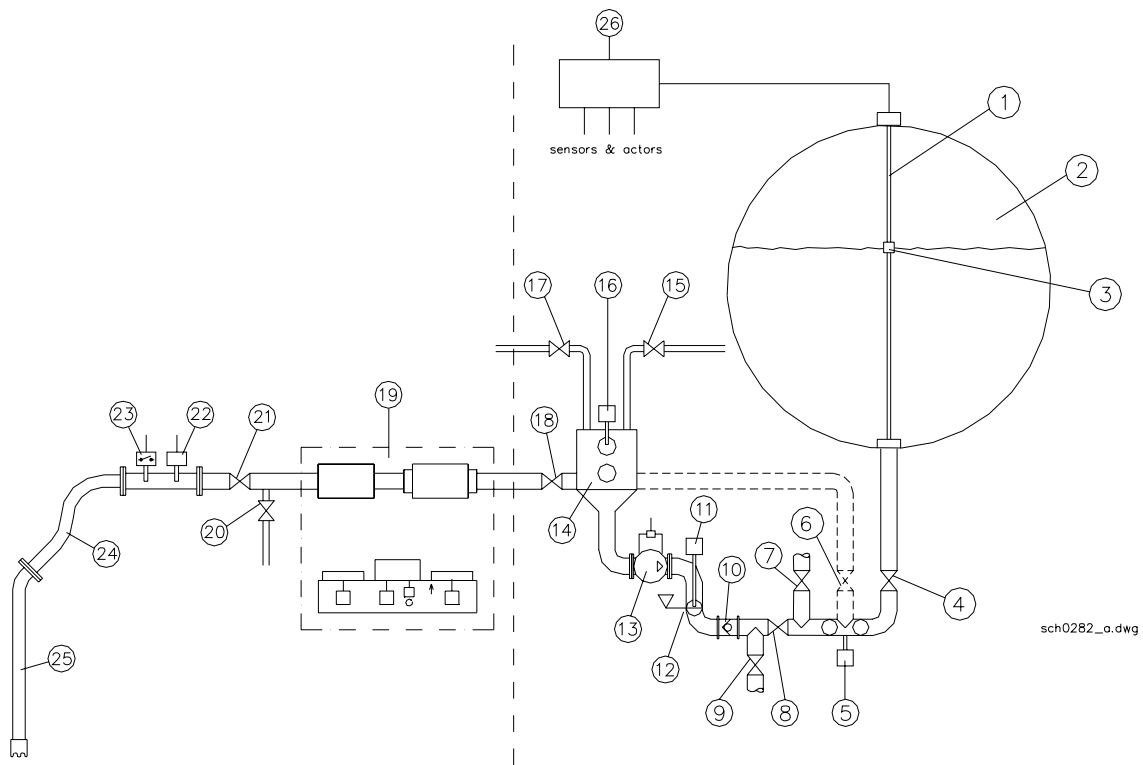


Fig. A.2-2: Schematic set-up of the measuring system of a road tanker for milk in its maximum version (for explaining the basic components and functions)

- (1) level sensor
- (2) measuring tank/measuring compartment
- (3) float, if appropriate
- (4) valve for compartment 1
- (5) pipe empty sensor
- (6) valve for pumping to the trailer
- (7) valve for compartment 2...n
- (8) valve for pumping to the trailer
- (9) valve for pumping to the trailer
- (10) non-return valve
- (11) transfer point sensor

- (12) transfer point with inspection glass
- (13) pump with control apparatus for pump motor, if necessary
- (14) suck bottle
- (15) pressure air valve
- (16) suck bottle level sensor
- (17) vacuum valve
- (18) suck bottle clearing valve
- (19) milk sampling system
- (20) pressure air valve
- (21) mainstream suck valve
- (22) temperature sensor
- (23) vacuum sensor
- (24) suction hose
- (25) suction lance
- (26) electronic measuring and control unit

ANNEX 3
EXAMPLES FOR VOLUME CONVERSION TO 15 °C
(FROM METERING TO BASE CONDITIONS) – MINERAL OILS
(Informative)

Homework S. Just: Check the following table, use as reference OIML R63 or ISO 91-1 if possible

The volume conversion of mineral oils is based on the following rules:

	Product group	Tables	Conversion Equation
Generalized products Correction of volume to 15°C against density at 15°C	B	Manual of Petroleum Measurement Standards Chapter 11.1.54.4 – Volume Correction Factors ASTM D 1250-80 Volume VIII, Table 54B	Chapter 11.1.54.4 – 6 ASTM D 1250-80 Volume X
Generalized Lubricating Oils Correction of volume to 15°C against density at 15°C	D	Manual of Petroleum Measurement Standards Chapter 11.1.54.10 – Volume Correction Factors ASTM D 1250-82 Volume XIV, Table 54D	Chapter 11.1.54.10 ASTM D 1250-82 Volume XIV

The conversion (volume correction factor) is based on the following constants:

	Product group	Oil group	Range of density [kg/m ³]	K ₀ [(kg/m ³) ² /°C]	K ₁ [(kg/m ³)/°C]	function
Generalized Products	B	Petrol	600,0 – 770,4	346,4228	0,4388	2.2
		Naphtha	770,5 – 787,5	-0,00336312	2680,3206	2.3
		Jet-A-1 Kerosene	787,6 – 838,5	594,5418	0,0	2.2
		Fuel oil	838,6 – 1200,0	186,9696	0,4862	2.2
Generalized Lubricating Oils	D	Lubricants	750,0 – 1164,0	0,0	0,6278	2.2

The volume correction factor (VCF) for product group B and D:

$$VCF_t = \frac{\rho_t}{\rho_{15}} = EXP [-\alpha_{15} \times \Delta t \times (1 + 0,8 \times \alpha_{15} \times \Delta t)] \quad (2.1)$$

where

$$\alpha_{15} = \frac{K_o}{\rho_{15}^2} + \frac{K_1}{\rho_{15}} \quad (2.2)$$

or

$$\alpha_{15} = K_o + \frac{K_1}{\rho_{15}^2} \quad (2.3)$$

ANNEX 4
EXAMPLES FOR VOLUME CONVERSION TO 15 °C
(FROM METERING TO BASE CONDITIONS) – LIQUIFIED PETROLEUM GAS (LPG)
 (Informative)

Homework S. Just: see Annex 3

The volume conversion of liquefied petroleum gas is based on the following rules:

	Product group	Tables	Conversion Function
Generalized light products (LPG) Correction of volume to 15°C against density at 15°C	X	Density determination (54 X)	DIN 51 757 Annex B and Annex G

The constants P1, P2 and P3 used to calculate the volume correction factor (VCF) are:

Range of density kg/m ³	P ₁	P ₂	P ₃	P ₄
500 to 600	4075,0 × 10 ⁻³	5050,0 × 10 ⁻⁶	27,5 × 10 ⁻³	45,0 × 10 ⁻⁶
> 600 to 620	2448,9 × 10 ⁻³	2340,9 × 10 ⁻⁶	1,589 × 10 ⁻³	1,947 × 10 ⁻⁶
> 620 to 640	2225,1 × 10 ⁻³	1980,0 × 10 ⁻⁶	1,588 × 10 ⁻³	1,946 × 10 ⁻⁶
> 640 to 650	1936,6 × 10 ⁻³	1529,1 × 10 ⁻⁶	1,588 × 10 ⁻³	1,946 × 10 ⁻⁶

The volume correction factor (VCF) for product group X:

$$VCF_t = \frac{\rho_t}{\rho_{15}} = 1 + (P_2 - \frac{P_1}{\rho_{15}}) \times \Delta t + (P_4 - \frac{P_3}{\rho_{15}}) \times \Delta t^2$$

where

$$\Delta t = t - 15$$

ANNEX 5
DENSITY AND VOLUME (OF 1 KG) OF DESTILLED WATEREXAMPLES FOR
 (Informative)

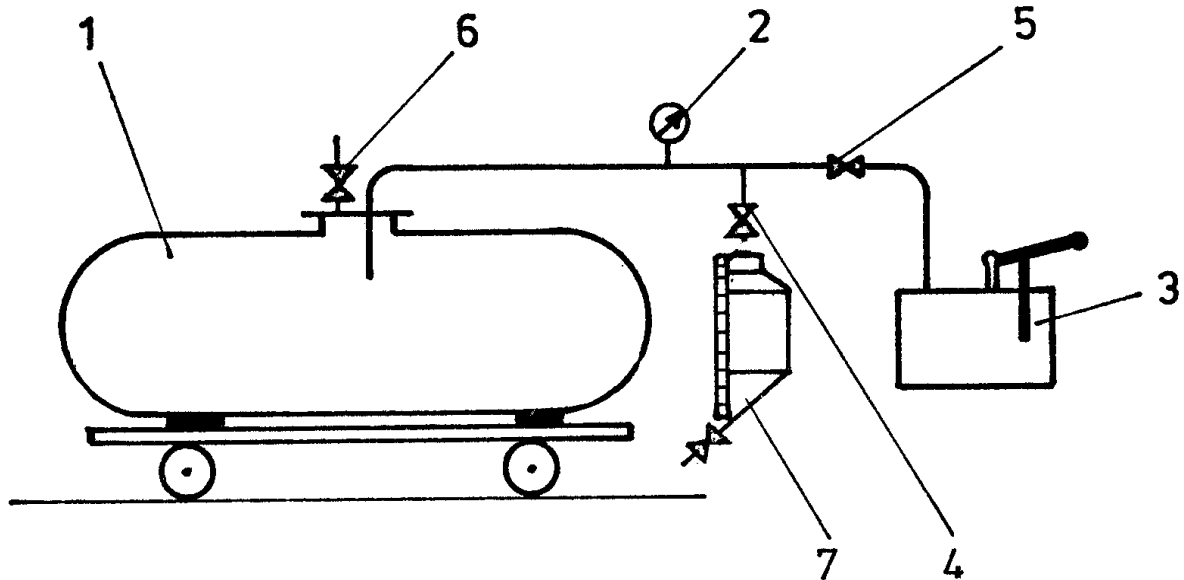
**Homework Mr. Kolaczia: Review the reference,
 check the accordance of the values used,
 check if there exist already OIML or ISO documents**

Temperature * °C	Density kg/m ³	Volume of 1 kg L
1	999,899	1,00010
2	999,940	1,00006
3	999,964	1,00004
4	999,972	1,00003
5	999,964	1,00004
6	999,940	1,00006
7	999,901	1,00010
8	999,848	1,00015
9	999,780	1,00022
10	999,699	1,00030
11	999,604	1,00040
12	999,496	1,00050
13	999,375	1,00063
14	999,242	1,00076
15	999,097	1,00090
16	998,940	1,00106
17	998,772	1,00123
18	998,593	1,00141
19	998,402	1,00160
20	998,201	1,00180
21	997,989	1,00201
22	997,767	1,00224
23	997,535	1,00247
24	997,293	1,00271
25	997,041	1,00297
26	996,780	1,00323
27	996,509	1,00350
28	996,230	1,00378
29	995,941	1,00408
30	995,643	1,00438
31	995,337	1,00469
32	995,022	1,00500
33	994,698	1,00533
34	994,367	1,00567
35	994,027	1,00601

* IPTS 90

Reference: Bettin, F. - Spieweck H., PTB Mitteilungen 100, 3/90.

ANNEX 6
DETERMINATION OF THE VOLUME EXTENSION OF A TANKER UNDER THE
INFLUENCE OF INTERNAL PRESSURE
 (Informative)



- (1) tank under test
- (2) pressure gauge
- (3) hydraulic pump
- (4) ball valve
- (5) separation valve
- (6) vent
- (7) standard capacity 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 stepwise withdrawn and its volume is measured using the volumetric measure 7; the volume is indicated on the graduated rule of the measure 7, and the corresponding pressure is read from the pressure gauge 2.

The calculated volume changes ΔV_i are recorded in tabular form:

Pressure in tank P (bar)	Increase of tank volume ΔV (litres)
P_1	ΔV_1
P_2	ΔV_2
....
P_{max}	ΔV_{max}

or presented in the form of a graph dependency $\Delta V = \Delta V(P)$.

**Annex 7: Example of certificate on calibration
(Adapted Annex 5 of original R 80 – will be added later)**

**Annex 8: Example of calibration of a rail tanker
(Adapted Annex 6 of original R 80 - will be added later)**