ČESKÝ METROLOGICKÝ INSTITUT

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PUBLIC DECREE

As the authority with substantive and territorial jurisdiction in the matter of defining metrological and technical requirements for specified measuring instruments and stipulating test methods for type approval and verification of specified measuring instruments pursuant to § 14(1) of Act No 505/1990 on metrology, as amended, and in accordance with the provisions of § 172 et seq. of Act No 500/2004, the Code of Administrative Procedure, as amended (hereinafter the 'CAP'), the Czech Metrology Institute (CMI) commenced ex officio proceedings on 26 February 2016 pursuant to § 46 of the CAP and, based on supporting documents, issues the following:

I.

GENERAL MEASURE

number: 0111-OOP-C067-16

laying down the metrological and technical requirements for legally controlled measuring instruments, including testing methods for type approval and verification of the following legally controlled measuring instruments:

'liquid transport tanks'

1 Basic definitions

For the purposes of this General Measure, the terms and definitions according to VIM and VIML[1] and the following definitions apply:

1.1
liquid transport tank (cistern)

a tank which serves to transport liquids and simultaneously as a volume measurement device for liquids with maximum viscosity of 20 mPa·s at measurement temperature, permanently installed on a road or railway vehicle or removable, which may be divided into several measuring chambers

[1] TNI 01 0115 International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM) and International Vocabulary of Legal Metrology (VIML) are part of the technical harmonisation compendium 'Terminology in the field of metrology', which is publicly available at www.unmz.cz.

1.2
static measuring system

a system comprising the measuring tank itself and attached and auxiliary devices. A static measuring system can also be used to determine calculated values for liquids

1.3
connected device

a device intended for the performance of individual functions directly related to processing, transmitting, or displaying measurement results

Examples of connected devices:

- a zeroing device,
- a repeating indicator,
- a printer,
- a recording device,
- a price indicator,
- a conversion apparatus.

1.4
auxiliary device

a part or device other than a connected device required to achieve correct measurement, or intended for facilitating measurement operations, or that can influence measurement in any way

Examples of auxiliary devices:

- a sampling apparatus,
- a gas indicator,
- a sight-glass,
- a filter or pump,
- a gas separator,
- a device used for a transmission point,
- an anti-swirl device,
- branches or by-passes,
- valves, hoses.

1.5
nominal volume

the volume marked on the tank or on its chamber that usually corresponds to the volume of liquid in the tank or chamber at reference temperature if the tank is filled to its maximum permissible level or volume mark

NOTE The nominal volume value may be restricted by safety regulations.

1.6
total tank volume

the maximum amount of liquid the tank or chamber can contain before it overflows, under reference temperature

1.7
expansion volume of a tank

the difference between total and nominal volume

1.8
true tank volume

the conventional value of the volume of liquid in the tank or chamber at operating temperature

1.9
indicated volume

the volume value provided by a volumetric measurement system

1.10
indicated volume error

the difference between the indicated volume of the tank or chamber and the true volume

1.11
tank calibration

a set of operations performed to determine the volume of the tank or chamber, using methods that meet technical and metrological requirements, such as measurement at one or more filling levels using measurement of geometric dimensions, gravimetric, or volumetric methods

1.12
liquid level

the open surface of the liquid whose volume is being measured

1.13
reference point

an easily identifiable point on a vertical measurement axis to which the measured liquid level relates

1.14
top reference point (RPT)

a reference point in the upper part of the tank, under normal operating conditions above the surface of the liquid

1.15
bottom reference point (RPB)

a reference point in the lower part of the tank, under normal operating conditions below the surface of the liquid

1.16
reference height (*H*)

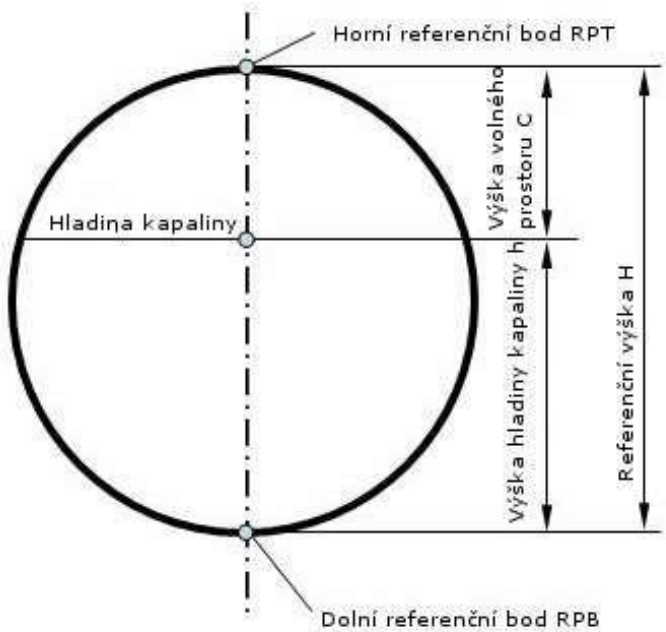
the distance between the top and bottom reference point, measured along the vertical measurement axis

1.17
open space height (*C*)

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

1.18
liquid height (*h*)

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



Výška hladiny kapaliny h	Liquid level height h
Výška volného prostoru C	Open space height C
Referenční výška H	Reference height H
Horní referenční bod RPT	Top reference point RPT
Dolní referenční bod RPB	Bottom reference point RPB
Hladina kapaliny	Liquid level

Figure 1 – Tank schematic for specification of points according to definitions 1.12 to 1.18

1.19
tank sensitivity

the change in liquid level Δh divided by the corresponding relative change in volume $\Delta V/V$ of volume V contained in height h

1.20
calibration table

a table that shows the relationship between the liquid level and the volume of liquid contained in the tank (chamber) at this height under reference conditions (including tank position)

1.21
baffle

an internal device in a tank or chamber, for example a partition inside the tank, that is used to reduce the movement of liquid during transport and to increase the mechanical stability of the tank

1.22
level sensor

a device that measures the level of liquid in a tank or chamber.

1.23
level sensor measurement range

the range between the minimum and maximum indication of the level sensor. The lower limit depends on the type and system and must be significantly higher than the liquid level corresponding to the smallest measured amount in the tank or chamber. The upper limit depends on tank height and must be greater than the maximum permissible filling height of the tank or chamber.

1.24
tilting sensor

a device to measure longitudinal and transverse angles

1.25
longitudinal axis and longitudinal angle

the tank's axis of symmetry parallel to the tank's main direction of movement in its normal position. The vertical angle of rotation of the axis is called the longitudinal angle. It is positive when the front part of the tank rises.

1.26
transverse axis and transverse angle

the tank's horizontal axis, perpendicular to its longitudinal axis in normal position. The vertical angle of rotation of the axis is called the transverse angle. It is positive when the right part of the tank rises (relative to the direction of movement).

1.27
baffle pipe

a mechanical device (usually shaped like a pipe with openings) used to reduce or eliminate the effect of surface waves on level measurement and to protect the level sensor from physical damage

1.28
transfer point

the point from which the liquid is defined as delivered or received

1.29
empty hose

a hose connection that only contains liquid product during a transaction, and is usually completely emptied prior to completion of the transaction. It is attached past the transfer point in dispensing systems (before the transfer point in receiving systems)

1.30
full hose

a hose connection filled with liquid product prior to and after a transaction. In this case the transfer point is situated near the outlet from the full hose.

1.31
distributor (collector)

an apparatus interconnected with valves with outlets from measuring chambers that allows delivery from one or more chambers through one common pipe

1.32
direct output

a cistern vehicle with gravity unloading, every separate measurement chamber has its own outlet. A filling connector is often used as an outlet

1.33
top filling

filling the measuring chamber from above through a filling opening that is opened for this use

1.34
bottom filling

filling the measuring chamber from the bottom via a standardised dry connector (for example an API adapter) and via a foot valve that is built into the bottom of the measuring chamber and opened for this use

1.35
transaction

delivery of a liquid product from one or more measuring chambers to the recipient. A transaction can also involve receiving (for example a milk collection vehicle). A transaction is complete if the parties to the transaction have approved it regarding the amount of the transaction. This can be payment, signature of a cheque, signature of a bill of delivery, etc. The parties to the transaction can be the parties themselves or their representatives.

1.36
reference position

the position for delivery from (or filling) the measuring tank in accordance with the design drawing. This is the basis for the corrective function of tilting. The zero tilt point is the zero point for both (longitudinal and transverse) tilts.

1.37
measurement conditions

the conditions under which liquid volume is measured (e.g. temperature, viscosity, tank position)

1.38
basic conditions

specific conditions for which the measured volume is recalculated (e.g. temperature, density)

1.39
liquid detector

a device used to detect the presence of liquid in a pipe or tank and for testing prior to start and after completion whether all parts of the measurement system are either entirely filled with liquid (a full-hose system) or entirely empty (an empty-hose system)

1.40
liquid indicator

a device used to indicate the presence of liquid in a pipe (for example a sight-glass)

1.41
minimum measured quantity (MMQ)

the smallest volume of liquid for which measurement is metrologically permissible for the tank, or separately for each chamber. It must be stipulated only for a measurement system suitable for measuring individual volumes. Alternatively, the expressions ‘minimum delivery’ or ‘minimum offtake’ may be used.

1.42
minimum nominal volume deviation (E_{min})

double the absolute value of the maximum permissible error for the minimum measured quantity of the tank or chamber

2 Metrological requirements

Metrological requirements are based on the requirements of OIML R 80-1 ‘Road and rail tankers with level gauging. Part 1: Metrological and technical requirements[2]’.

2.1 Rated operating conditions

Rated operating conditions are presented in Table 1.

[2] OIML R 80-1 ‘Road and rail tankers with level gauging. Part 1: Metrological and technical requirements’ – publicly available at www.oiml.org

Table 1 – Rated operating conditions

Ambient temperature	minimum	−25 °C (1)
	maximum	+55 °C (1)
Humidity	up to condensation	
(1) This value is stipulated by a national authority according to the country's climate.		

The reference temperature of the liquid in the tank is +15 °C or +20 °C and the reference pressure is normal atmospheric pressure. For justified reasons other values may also be used (for example a reference temperature of +12 °C and a higher pressure for liquefied petroleum gas).

2.2 Measuring interval

The measuring interval is stipulated by the measuring instrument's manufacturer.

2.3 Maximum permissible error

2.3.1 Classification of accuracy classes and maximum permissible error

Depending on the area of use of a static measuring system situated on an undercarriage, the accuracy class is determined according to Table 2.

Table 2 – Accuracy class for measuring systems on road cisterns:

Class	Area of use
0.5	Measuring systems for the transport and supply of low-viscosity liquids (≤20 mPa·s) stored at atmospheric pressure, with the exception of potable liquids. Measuring systems for milk, beer, and other foamy liquids. Measuring systems for dispensing fuel into aircraft.
1.0	Measuring systems for liquefied pressurised gases measured at −10 °C or higher.
1.5	Measuring systems for liquid carbon dioxide. Measuring systems for liquefied pressurised gases measured at less that −10 °C
2.5	Measuring systems for liquids at temperatures below −153 °C.

Table 3 - Maximum permissible errors

Measuring instrument (part thereof)		Maximum permissible error for accuracy class			
		0.5	**1.0**	**1.5**	**2.5**
A	Static measuring system	0.5 %	1.0 %	1.5 %	2.5 %
B	Measuring transport tank	0.3 %	0.5 %	1.0 %	1.5 %

The maximum permissible error from row A of Table 3 is used for the entire measuring system, under measuring conditions, without any adjustment between various tests, for:

- type tests,
- initial verification,
- subsequent verification.

The maximum permissible error from row B of Table 3 is used for:

- measuring tank type tests under measurement conditions, and
- tank verification prior to initial verification of the measuring system.

For measured volumes between the minimum measured quantity and double the minimum measured quantity, the absolute value of the maximum permissible error does not have to be smaller than the minimum nominal volume deviation.

The minimum measured quantity is defined only for tanks intended for sub-measurements.

The minimum measured quantity must be determined for each chamber and may not be greater than one fourth (1/4) of this nominal volume.

The minimum measured quantity must be equal to or greater than the greater of the following values:

- the volume corresponding to the difference in levels in Table 4 in the area of minimum sensitivity,
- the volume calculated as the change caused by manufacturing volume tolerances (between true and design geometry) may not exceed three-fifths (3/5) of the maximum permissible error specified in row A of Table 3 for every permissible tilt angle.

Table 4

---	**Accuracy classes**			
	0.5	**1.0**	**1.5**	**2.5**
Difference in levels (mm)	200	171	190	200

NOTE Differences in levels are derived from the expanded uncertainty for corresponding accuracy classes given in Table 7.

The minimum measured quantity of a measuring system must be expressed in one of the following ways:

a) 1× 10*n*, 2× 10*n* or 5× 10*n* litres, where n is a whole number,

b) a whole multiple of 100 litres.

The reference height of the tank or chamber may not change during filling by more than the greater of the values given in Table 5.

Table 5

---	**Accuracy classes**			
	0.5	**1.0**	**1.5**	**2.5**
Maximum permissible change in reference height *H* (mm)	2 mm or *H*/1000	4 mm or *H*/500		

The volume of the chamber may not change by more than one-third (1/3) of the maximum permissible error in row B of Table 3 due to the filling or emptying of an adjacent chamber.

Tank material must be such that a change in the tank’s volume due to a change in temperature of ±10 °C from the reference temperature is not greater than 1/3 of the maximum permissible error in row B of Table 3.

Tanks for liquids not measured under atmospheric pressure must be designed so that a change in pressure over the entire permissible range does not cause a change in volume greater than 1/5 of the maximum permissible error in row B of Table 3.

The volume of liquid remaining in the tank or chamber after it has been completely emptied may not be greater than one-tenth of the absolute value of the maximum permissible error in row B of Table 3 applied to the volume of the tank or chamber.

The hysteresis of the level sensor may not exceed one-third of the sensitivity given in Table 6 for tanks for delivering an entire chamber or one-third of the expanded uncertainty given in Table 7 for partial delivery, or its influence can be included in evaluation of the uncertainty.

The shape of the tank for delivering an entire chamber must be such that in the area of level measurement sensitivity is equal to or greater than specified in Table 6.

Table 6

Tanks for delivering an entire chamber	**Accuracy classes**			
	0.5	**1.0**	**1.5**	**2.5**
Minimum tank sensitivity Δh for $\Delta V/V$ in mm (1/1 000 of measured volume)	1.5	1.0	0.5	0.3

The top and bottom reference point must be clearly defined and implemented.

It must be possible to measure the level of the contained liquid manually. The measuring rod must be vertical.

The expanded uncertainty of level measurement for partial delivery may not exceed the values specified in Table 7.

Table 7

Tanks for partial delivery	**Accuracy classes**			
	0.5	**1.0**	**1.5**	**2.5**
Level measurement uncertainty U_x in mm	0.7	1.2	2.0	3.5

The expanded uncertainty of measurement U_x is stipulated in accordance with special legislation[3] as the standard uncertainty of measurement multiplied by an extension coefficient k = 2, which for a normal distribution corresponds to a probability of 95 %.

The indication resolution for level measurement must be in accordance with Table 8.

Table 8

---	**Accuracy classes**			
	0.5	**1.0**	**1.5**	**2.5**
Maximum resolution value for level indication in mm	0.1	0.2	0.5	1.0

The submersion of the float within the permissible density range of the measured liquid (specified in the type approval certificate) may not change by more than is specified in Table 9. Measuring systems without appropriate correction of submersion due to changes in liquid density have this influence included in the level measurement uncertainty.

[3] ‘Guide to the expression of uncertainty in measurement’ (GUM).

Table 9

Maximum change in float submersion in mm for	Accuracy classes			
	0.5	**1.0**	**1.5**	**2.5**
- partial deliveries	0.5	0.8	1.6	2.5
- delivery of the entire chamber	1.5	2.4	4.8	7.5

For ultrasound level sensors, within the permissible range of properties of the measured liquid (specified in the type approval certificate), the measured height may not change by more than that specified in Table 7. To convert the level measurement result to volume, an electronic data processing system must have a calibration table stored, containing level/volume pairs for every measuring chamber. The number and spacing of these values depends on tank geometry. Intermediate values are calculated using appropriate interpolation. Extrapolation is not permitted.

The range of levels in the calibration table must cover all routine operating situations. Filling the measuring chamber above the highest permissible point must be prevented, or must be considered a fault.

The calibration table is determined by gradually filling or emptying every chamber in the normal position. If a tank is equipped with a device to correct the influence of tilt on volume, it may not exceed the minimum nominal volume deviation over a range of ±4° (longitudinally and laterally).

The calibration table, as well as tilt correction data, must be stored in the system and protected from tampering.

The total volume under basic conditions can be determined using one of these two methods pursuant to the appropriate technical standard (OIML)[4]:

Method A: Conversion is performed during measurement. Every partial volume $\Delta V_{t,i}$ is converted to $\Delta V_{0,i}$:

$$\Delta V_{0,i} = \varphi(\Delta V_{t,i}, t) \tag{1}$$

The total volume under basic conditions is given by the equation:

$$V_0 = \sum_i \Delta V_{0,i} \tag{2}$$

Method B: Conversion is performed at the end of measurement using the weighted average temperature, calculated from temperatures ti of partial volumes $\Delta V_{t,i}$:

$$t = \frac{\sum_i t_i \times \Delta V_{t,i}}{V_t} \tag{3}$$

The total volume under basic conditions is given by the equation:

$$V_0 = \varphi(V_t, t) \tag{4}$$

During a transaction the temperature of the flowing liquid is measured:

a) proportionally to volume – partial volumes may not be greater than one-fifth of the minimum measured quantity,

b) proportionally to time – the time interval may not be greater than the time needed to measure one-fifth of the minimum measured quantity at maximum flow rate.

[4] OIML R 63 Petroleum measurement tables.

The total volume under measurement conditions is given by the equation:

$$V_t = \sum_i \Delta V_{t,i} \tag{5}$$

2.3.2 Maximum permissible errors of measuring system elements

The maximum permissible errors for determining the weighted average temperature are specified in Table 10.

Table 10

---	Accuracy classes			
	0.5	**1.0**	**1.5**	**2.5**
Maximum permissible error in determining temperature	±0.5 °C			±1.0 °C

3 Technical requirements

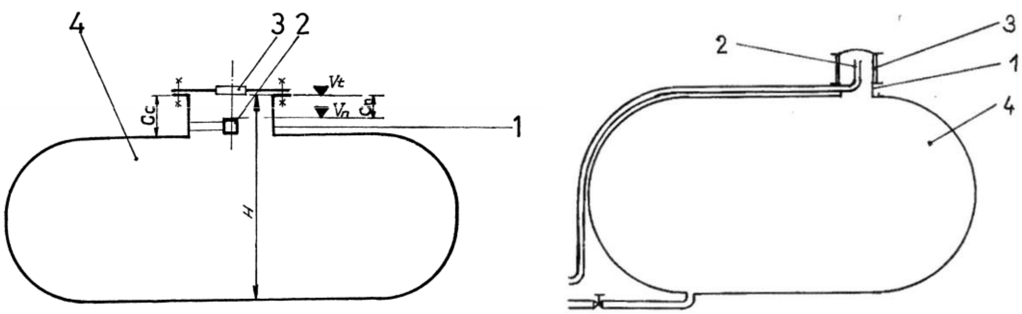
Technical requirements are based on the requirements of OIML R 80-1[2].

3.1 Kinds of measuring instruments

Tanks are categorised according to the following criteria:

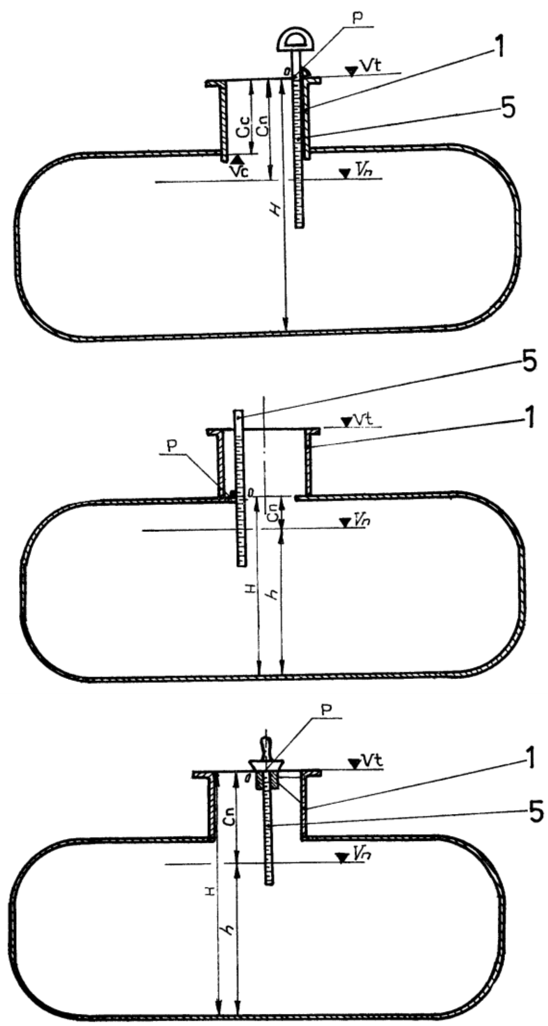
a) volume measurement principle:

- mechanical level measurement (one or more volume marks, gauge, measuring rod, or measuring strip), see Figures 2 and 3:



Legend: 1 - tank dome, 2 - volume mark, 3 - sight-glass, 4 - tank

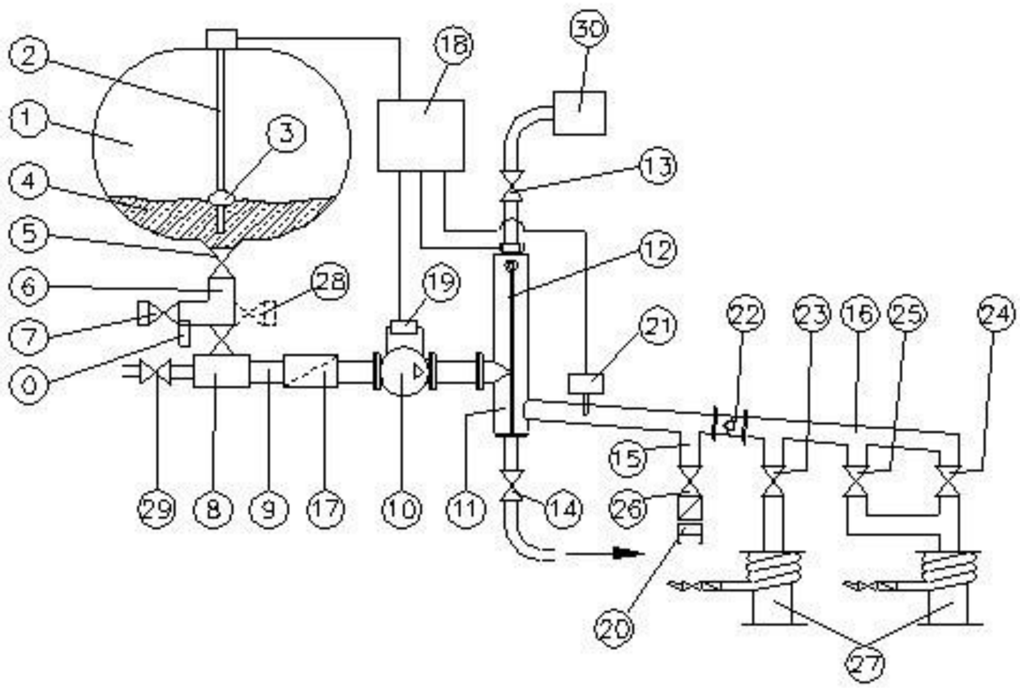
Figure 2 - Tank with one (two opposed) mark(s) in the dome, or with an overflow (beer tank)



Legend: 1 - tank dome, 5 - measuring rod

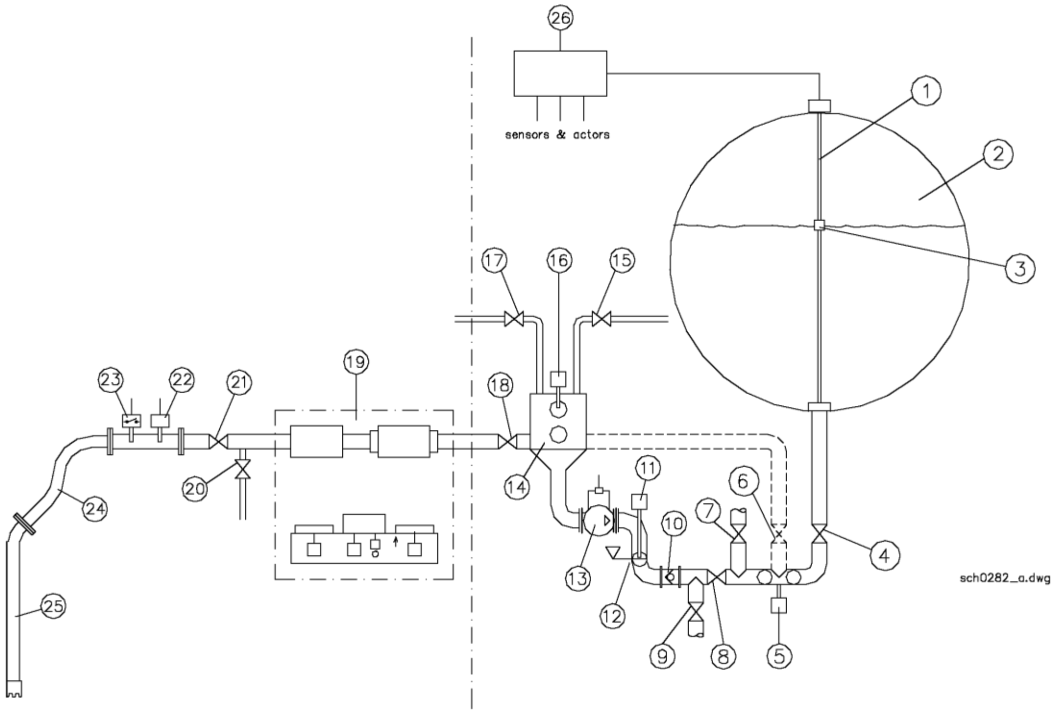
Figure 3 - Examples of tanks with a mechanical measuring rod in the dome

- electronic level measurement (an electronic level indicator with a float/slider, ultrasound level indicator, radar/laser level indicator, other contactless measurement principle),
- automatic volume measurement (can include complete automatic control and monitoring of delivery/receipt, inclusion of tilt influences, remaining amount, surface waves, etc.), see Figures 4 and 5



Legend: 0 - liquid remnant sensor, 1 - tank, 2 - electronic level indicator, 3 - float, 4 - liquid, 5 - foot valve, 6 - full/empty pipes, 7 - filling (dry) connector, 8 - collector, 9, 15, 16 - pipes, 10 - pump, 11 vapour separator, 12 - level indicator, 13 - vent valve, 14 - separator discharge valve, 17 - filter, 18 - measuring and control unit, 19 - pump bypass, 20 - empty hose, 21 - temperature sensor, 22 - non-return valve, 23, 24, 25 - full hose valve, 26 - empty hose valve, 27 - full hose, 28 - alternative dry connector on right side, 29 - collector air purge valve, 30 - separator vent lock

Figure 4 – Example of an automatic measuring system with electronic level indicators for dispensing fuel



Legend: 1 - electronic level indicator, 2 - tank, 3 - float, 4, 7 - chamber vent, 5 - remaining liquid sensor, 6, 8, 9 - valve for pumping into trailer, 10 - non-return valve, 11 - transfer point sensor, 12 - transfer point with sight-glass, 13 - pump, 14 - suction container, 15 - pressurised air valve, 16 - level sensor, 17 - vacuum valve, 18 - shut-off valve, 19 - milk sampling system, 20 - pressure valve, 21 - main shut-off valve, 22 - temperature sensor, 23 - vacuum sensor, 24 - suction hose, 25 - suction adapter, 26 - measuring and control unit

Figure 5 – Example of an automatic measuring system with electronic level indicators for receiving milk

b) connected equipment – the tank is/is not equipped with:

- an installation for measuring partially delivered or received quantities,
- an internal pump,
- a distributor (collector),
- an installation with a full hose.

c) conditions of use (influencing factors):

- according to pressure, atmospheric or pressurised (e.g. liquefied gases or beer),
- according to temperature, without heating, with/without insulation, with heating with/without insulation.

d) nominal volume:

- road tankers usually have a tank volume from 0.5 m^3 to 50 m^3,
- rail tankers usually have a tank volume from 10 m^3 to 120 m^3.

e) tank mounting method:

- directly and permanently on the frame of the vehicle, trailer, or semi-trailer, self-propelled, removable,

- temporarily on a vehicle with the use of equipment to ensure that the tank remains fixed with respect to the vehicle.

3.2 Tank design requirements

If the tank is split into chambers, each chamber is considered to be a separate tank.

The nominal volume of a tank or its chamber must be at least 500 litres.

The shape and location of the tank or chamber, including filling and discharge equipment, must facilitate complete and quick emptying of the tank in all of its permitted positions.

Complete emptying must be ensured:

a) by appropriate tank shape;

b) by the bottom generatrix of the tank having a gradient of at least 2 % (1.2°) if the vehicle is in a horizontal position;

c) in another manner.

If it cannot be emptied completely in all positions expected during operation, a device must be used to facilitate complete emptying (e.g. an additional liquid sensor in the chamber and/or tilt monitoring).

The measuring tank must have pads at least 500 mm long affixed to it to check normal position using an electronic level gauge.

The emptying apparatus includes one or two outlet pipes (making it possible to empty the tanker on either side), each with a shut-off valve. The flow of liquid between the tank and the outlet pipe can be stopped with a foot valve. If the tank has two outlet pipes, an appropriate interlocking arrangement must prevent the simultaneous use of both outlet pipes. The outlet pipe must be as short as possible and must have an appropriate gradient (at least 2 ° is recommended). There must be a liquid sensor or sight-glass at the lowest point of the outlet pipe (except for automatic measuring systems).

For full-hose delivery, gas separators must be used or existing equipment must operate so that the full hose is entirely filled when the level is being measured.

A change from full to empty hose or substitution of full-hose systems during a transaction is only permissible if the filling levels in all chambers are monitored simultaneously.

It must be possible to empty each chamber separately. The tank may be equipped with a discharge distributor. A distributor without automatic control must have an appropriate device that will prevent discharge from one chamber to another. The presence of the distributor must be specified in the certificate.

Tanks intended for filling aircraft may have a device connected at their lowest point for decanting water and impurities. This device has a separate small-diameter decanting pipe.

Tanks must be tight and impermeable, resistant against deformations during transport, filling, and discharge. The shell and bottom of the tank may be reinforced. Internal reinforcements may not prevent the escape of gases during filling or complete emptying of the chamber.

Nominal tank volume may not differ from the volume recorded in manufacturing documentation by more than 10 %. It is forbidden to place any dead space into the tank in order to change its volume, or any other items that when removed or changed will change the tank volume.

Beer tanks are pressure vessels. Each chamber is equipped with a relief valve, a pressure sensor, a filling and discharge valve, an oval access port, and a graduated bell. The air relief tube that leads into the graduated bell becomes the overflow edge, thus defining the measuring space.

Fixed internal components (e.g. heating coils) inside the measuring chamber are allowed if they are present during measurement and they cannot be modified or removed.

The shape of the tank or chamber should be such that it quickly calms waves on the surface of the liquid.

In order to minimise the effects of tilting, tanks or chambers should be longitudinally and transversely symmetrical, and level sensors should be centrally located. If correct measurement is not possible in all positions expected during operation, the tank must be equipped with an apparatus to measure position relative to the reference position.

Tilt	- according to the manufacturer's specifications, a maximum of ±5° in the longitudinal and transverse direction, - during delivery, the bottom of each chamber should have a gradient towards the discharge opening (to the foot valve)

Tanks with mechanical or electronic level measurement must include:

a) a dome with reinforcing elements serving as an inspection opening and as an expansion space and, in some applications (not for fuels), to increase tank sensitivity. It is located on top of the tank, if possible along its axis.

   The dome can include:

   - a filling opening connected with a tight closure;
   - a flange for monitoring filling;
   - a ventilation apparatus or a bi-directional safety valve.

The level mark can be in the dome or in the upper part of the tank body in a manner that complies with sensitivity requirements. The dome can be cylindrical or oval with vertical walls; a minimum diameter of 500 mm is recommended to facilitate tank or chamber inspection.

b) tanks with mechanical level measurement must have a ladder to access the dome and a platform for the individual performing tank measurement and inspection.

c) tanks with electronic level measurement must:

   - prevent access to the tank interior with a seal or other means, or
   - must facilitate easy visual inspection pursuant to point (b).

Tanks for the transport of hazardous liquids must also comply with other relevant regulations (such as protection against overfilling or protection against explosion; tanks for liquefied gases may not have domes, and are subject to regulations for the design of pressure vessels).

Tanks for the transport of liquid foodstuffs may not affect the quality of the transported liquids (due to shape, material, etc.) and must also comply with other relevant regulations.

Both of the above requirements may not influence the tank’s measuring function.

The measuring system may contain a sampling apparatus to determine the properties of the measured liquid.

If the sampled amount is less than one-third of the absolute value of the maximum permissible error in row B of Table 3 applied to the nominal volume of the tank or chamber, this quantity need not be included in measurement results.

Exceeding the measurement range of the level sensor must be considered a defect.

The level sensor may be equipped with a baffle tube in order to calm waves on the surface. In the area of the bottom, top, and in between, the tube must have openings for liquid exchange. The tube may not influence measurement, for example due to the deposition of contaminants during normal operation.

In the case of a level sensor with a float, the float may not change its mass or volume due to the measured liquid. Pressure also may not affect its volume. The cross-section of the float must be known within the scope of its submersion range. The float shape may not lead to liquid retention, except for capillary action, nor to retention of gas or water underneath the float.

In the case of ultrasound level sensors, the effects of the properties of the measured liquid (density, modulus of elasticity) on signal passage time may be compensated using an appropriate method, such as reference marks.

The measuring system may be equipped with additional sensors (temperature, density, pH, etc.) whose measured values are used to calculate volume or provide information about the condition of the liquid.

3.3 Conversion apparatus

Supporting data for conversion (e.g. density under basic conditions, or thermal expansion coefficient) may either be set permanently or may be adjustable depending on the product. This data must be protected from tampering.

If data is adjustable, the indicator and if appropriate also the printout must clearly state which value was used, or which product was measured.

The measurement method – with or without conversion due to the effect of temperature on volume – for the given product must be selected during verification. Similarly, only one set of data may be entered for conversion for the given product.

The reading of the indication must be reliable, easy, and unambiguous. The customer must be able to check it without taking special measures. Display of the quantity during the course of measurement is only mandatory in the case of direct public sale.

The type of quantity displayed (under measurement conditions or under basic conditions) must be clear.

Indication resolution must be in the form (1, 2 or 5) × 10^n where n is a whole number that may not exceed one-tenth of the minimum nominal volume deviation.

In measurement mode, it must be possible to output all measured and calculated values, including supporting data. However, not all values need to be permanently displayed. The measuring system can have various units to display the same measured amount.

In the case of quantity conversion, the unconverted quantity may not be displayed during normal operation. However, the unconverted quantity must be available for test purposes.

The unit price can be entered prior to or after delivery. It is used to calculate the total price, which may be printed on the bill of delivery or on the invoice.

A printer is only required for measuring systems for mineral oils and liquefied gas.

If a bill of delivery is generated, it must contain at least the following information:

- identification of the measuring system (e.g. serial number, vehicle number),
- the name of the product or group of products,
- the transaction number,
- the volume under measurement conditions with the comment ‘at delivery temperature’ or the volume under basic conditions.

If more than one chamber is used during the transaction for delivery/receipt, all results may be printed on the same bill of delivery. If there is more than one data item for the same product, these items may be totalled.

If the same printout contains information from a verified part of the system along with information from an unverified part of the system, the verified information must be preceded and followed by a special symbol (a star ‘*’). This fact must be stated in the measuring instrument’s documentation or in another suitable location so that the user of the measuring instrument is informed in a sufficient manner.

Measuring systems may have a recording device to store measured values prior to their use or to keep a record of the business transaction as proof in case of dispute. A device for reading stored information is part of the recording device.

The recording medium must have sufficient permanency to protect data from damage under normal operating conditions. It must not be possible to change stored data (intentionally or unintentionally). There must be sufficient memory for any planned use.

Measuring systems that are not used for direct public sale may have data memory instead of a printer. In this case, all data required for a printout must be stored.

Unless stipulated otherwise, measurement data must be stored at least until an invoice is issued and the deadline for any claims pursuant to applicable legislation has passed before it is deleted. If the recording device is full and the stored data cannot be deleted because these periods have not yet expired, it must be impossible to commence additional measurement.

If the measured data has been printed out or transmitted in a manner permitted for verification, it can be deleted.

3.4 Fault prevention and measuring instrument security

The critical change value for the measured volume of liquid is equal to the greater of the following values:

a) one-fifth of the maximum permissible error corresponding to the measured quantity, or

b) the minimum nominal volume deviation.

If the transaction is not interrupted due to a power failure, all measuring and control functions in the measuring system must function using a backup source during said power failure.

If the transaction is interrupted due to a power failure, data from the moment of interruption must be stored and displayed for a sufficient period so that this transaction can be completed. In this case, the absolute value of the maximum permissible error increases to 5 % of the minimum delivery.

A monitoring apparatus is used to detect faults that have an influence on the measured volume that exceeds the critical change value and must have the following effect:

a) it automatically corrects volume changes, or

b) it takes out of service only the faulty equipment, while the measuring system continues in accordance with regulations without this equipment, or

c) it stops the transaction.

The monitoring apparatus is checked for proper operation, for example by:

a) disconnecting the sensor, or

b) interrupting the signal circuit, or

c) disconnecting power supply.

For measuring systems with level indicators, only a type I or P monitoring apparatus is permitted. Type I is a discontinuous monitoring apparatus that is only active at the start and end of each transaction, while type P is a continuous monitoring apparatus that operates during the entire duration of the transaction.

Monitoring apparatus for level sensors (type P), temperature sensors (type P), liquid sensors (type I), and tilt sensors (type I) must ensure the sensors are usable, operating correctly, transmitting data correctly and, if appropriate, also comply with the stipulated measurement range.

A monitoring apparatus for values of permanently stored instructions and data and all procedures for internal transmission and storage of data concerning measured results must be of type I or P.

A monitoring apparatus for correct calculations must be of type P.

A monitoring apparatus for the display will make it possible to monitor the improper functioning of individual elements, or automatic monitoring, or will prevent erroneous interpretation. Automatic detection can for example monitor the current between segments of LED displays, or measure the grid voltage of fluorescent displays. A visual check is performed for example using the black-white test.

A monitoring apparatus for connected equipment must check that it is usable, if needed, and validity of data transmission. A printer monitoring apparatus must also check for the presence of paper.

3.5 Power supply

Measuring instruments that use an electronic conversion apparatus must have a power supply that is suited for the environment in which they are operated (for example in an explosive environment) pursuant to applicable legislation.

Table 11

<table>
<tr><td>Supply voltage (1) (2)</td><td colspan="2">(U_{nom} −15 %) to (U_{nom} +10 %)</td></tr>
<tr><td>Supply frequency (1)</td><td colspan="2">(f_{nom} −2 %) to (f_{nom} +2 %)</td></tr>
<tr><td>Internal battery voltage (1)</td><td colspan="2">the minimum voltage under which the device works properly according to specifications for voltage supplied by a new battery</td></tr>
<tr><td rowspan="2">Road vehicle battery voltage (2)</td><td>12 V battery</td><td>9-16 V</td></tr>
<tr><td>24 V battery</td><td>16-32 V</td></tr>
<tr><td>Tilt</td><td colspan="2">according to manufacturer specifications</td></tr>
<tr><td colspan="3">(1) As applicable.
(2) Values of U_{nom} are provided on the measuring device. If the range is specified, ‘–15 %’ corresponds to the lower value and ‘+10 %’ corresponds to the upper value of the range.</td></tr>
</table>

3.6 Resistance of the measuring instrument to external influences

Measuring instruments are intended for measurement outdoors, i.e. climactic environment class H3 (see also OIML R 80-1[2].

Measuring instruments are transported on vehicles — mechanical environment M3 (see also OIML R 80-1[2].

3.7 Electromagnetic environment

For measuring instruments connected with electronic transducers and a conversion apparatus, electromagnetic environment class E3 is defined (see also OIML R 80-1[2].

3.8 Measuring instrument security and fraud protection

Measuring instruments must contain protective devices that may be sealed in such a way that after being sealed, before and after the measuring instrument has been correctly installed, there is no way it can be disassembled or modified without damaging the seal or protective devices.

4 Measuring instrument labelling

4.1 Markings on the measuring instrument

Every tank must have a clearly visible and easily readable data plate. The plate material must be resistant to the tank's operating conditions and must facilitate easy recording. The plate must be affixed to the tank in a way that makes it impossible to remove without damaging the metrological seal.

The data plate must bear the following information:

a) the manufacturer's name or mark;

b) the tank's type and year of manufacture (the year may be part of the serial number);

c) the tank's serial number;

d) the type and year of manufacture of the level indication system, if used;

e) the serial number of the level indication system, if used;

f) the type-approval mark;

g) the nominal volume of the tank or of each chamber;

h) the accuracy class, if other than 0.5;

i) the minimum delivery of the tank or of each chamber;

j) the reference temperature, if other than +15 °C;

k) the type of liquid;

l) the test and operating overpressure or underpressure;

m) the calibration method: SVL = with baffle or BVL = without baffle (if it can be dismounted);

n) the tank material type or the thermal expansion coefficient of the tank material;

o) the type of protective interior coating, if used.

If appropriate, empty space is left for the verification mark.

4.2 Documentation

Prior to initial verification, it is necessary to draw up measuring system documentation that must contain:

a) all information on the data plate;

b) a sealing plan;

c) a schematic of the pipe system;

d) a pneumatic schematic with metrologically important lines indicated;

e) a printout of calibration parameters and calibration tables, if used;

f) the maximum diameter and maximum length of the full hose, if used;

g) a special table with a description of changes to the measuring system, repairs, and any damage to official marks including their confirmation;

h) the checksum of a program permissible for verification and its parameters, if used.

Measuring system documentation is part of the measuring system and must be kept in the cistern vehicle (tanker).

4.3 Calibration plate

Tanks with measuring rods with a scale in non-volume units can replace documentation with a calibration plate attached to the tank, with the following information:

a) the name of the entity that calibrated the tank and created the calibration table;
b) the certificate number;
c) the reference temperature;
d) the number of heating elements, if used;
e) a calibration table (as a function of volume/height).

4.4 Certificate

A certificate for road tankers must contain the following information:

a) the issuing authority and certificate number;
b) the holder’s name, and, if applicable, also their address;
c) the name or mark of the manufacturer, the type, year of manufacture, and serial number;
d) the vehicle's plate number, if applicable;
e) the number of chambers and heating elements, if used;
f) identification of the reference point and vertical axis of measurement, if these are used;
g) the method used;
h) rules for filling outlet pipes, indication if a distributor is present;
i) the uncertainty in determining volume values specified in the certificate;
j) the date of issue and expiry date;
k) the name and signature of a responsible individual;
l) a diagram explaining the symbols used;
m) the height of the pivot during measurement (for trailers only);
n) the number and location of verification marks.

The certificate must contain the following information for each chamber:

a) nominal volume;
b) total volume;
c) height of ullage from nominal volume;
d) reference height.

A certificate for rail tankers must contain the following information:

a) the issuing authority and certificate number;
b) the registration number of the rail tanker;
c) the holder's name, and if applicable also their address;
d) the test method, place, and date;
e) identification of the reference point and vertical axis of measurement;

f) rules for filling the tank and outlet pipes;

g) reference height;

h) total volume and corresponding height of ullage;

i) the reference temperature;

j) the uncertainty in determining volume values specified in the certificate;

k) the date of issue and expiry date of the certificate;

l) the name and signature of a responsible individual;

m) a diagram explaining the symbols used;

n) a calibration table in statutory units, the volume of liquid in the tank as a function of the height of ullage expressed in centimetres, within the range of level measurement;

o) the number and location of verification marks.

4.5 Placement of the official mark

The tank must have prepared locations for attaching official marks. Official mark placement is stipulated in the measuring instrument's type approval certificate.

The location of the main official mark is on the measuring instrument's data plate.

All measuring systems must have official marks affixed in a way that prevents or indicates unauthorised tampering. The following places are sealed (if used):

a) the indication apparatus of the level gauge system;

b) the control unit and interface;

c) transducer boxes, including cables to measurement sensors (for example for temperature and the presence of liquid);

d) tilt sensors;

e) temperature sensors;

f) liquid sensors (except for those that removed during cleaning);

g) measuring rods at their upper and lower attachment points;

h) a measuring system data plate, operating instructions, and a pneumatic and pipe diagram;

i) lids on domes and chamber access ports for measuring systems that are filled only from the bottom;

j) heating elements connected to the tank. No seals are applied to the pipe system.

Official mark placement must be designed so that sealing and an external inspection can take place without any obstructions. Official mark placement is stipulated individually for each type in the type-approval certificate.

5 Type approval of the measuring instrument

5.1 In general

Transport tank measuring systems subject to metrological control are subject to all of the following operations:

a) type approval;

b) a preliminary test (if it contains electronic components);

c) initial verification;

d) subsequent verification.

An application for type approval of a road or rail tanker must contain the following documents:

a) a description of its technical characteristics and operating principle (including the level measurement system and connecting devices, if used);

b) drawings depicting:

- the entire road or rail tanker system;
- the entire tank systems, including its chambers;
- the entire system and function of the level gauge system;
- auxiliary and additional devices, according to use;
- details of the dome, reinforcements, and outlet devices;
- a data plate;
- the location of seals and official marks.

The number of samples needed for type tests is determined by the entity performing the test.

Type tests for road and rail tankers include the following operations in accordance with the relevant technical standard document (OIML)[5], in particular:

a) an external inspection,

b) a leakage test,

c) a pressure test (the responsibility of the manufacturer, who submits test results), if needed. Figure 6 shows an example of a measuring system to determine the increase in tank volume due to internal pressure,

d) a test of the tank' thermal expansion,

e) a dimensional stability test (change of reference height for an empty/full chamber),

f) test of volumetric stability during operation (the influence of adjacent chambers due to alternating filling and emptying),

g) correct filling test,

h) complete emptying test,

i) calibration of the dependence of volume/level for individual chambers,

j) test of sensitivity and expansion volume,

[5] OIML R 80-2 'Road and rail tankers with level gauging. Part 1: Metrological controls and tests' – CD1

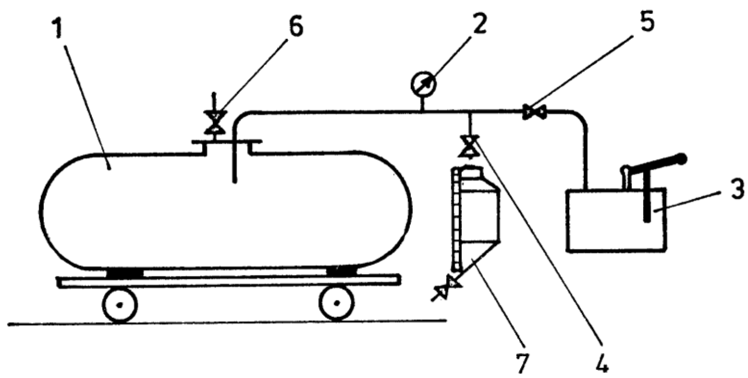
k) test of connecting devices and tilt correction, if used,

l) ullage test,

m) evaluative tests of electronic parts (climactic – dry heat, cold, wet heat cyclically; vibration – cyclically; electrical – changes in supply voltage, supply voltage dip, discharge, electrostatic discharge, electromagnetic sensitivity, defects in DC-powered devices).

   For tankers with electronic level measurement, safety class I is used in accordance with the applicable technical standard (OIML)[6],

n) software is validated pursuant to the applicable technical standard: Welmec guide 7.2[7].



Legend: 1 – tank, 2 – pressure sensor, 3 – hydraulic pump, 4, 5, 6 – valves, 7 – measuring container

Figure 6 – Determining the increase in tank volume due to internal pressure

The applicant must inform the approving authority of all changes and additions related to type approval. These changes and additions are subject to additional type approval if they influence or could influence measurement results or the regulatory conditions of the measuring system's use. The authority that approved the original type will decide what tests will be performed to increase the scope of approval, depending on the type of changes.

A preliminary test of the tank is performed using geometric, volumetric or weight methods. The expanded uncertainty ($k = 2$) of the volume of liquid in the tank may not exceed one-third of the maximum permissible error pursuant to Table 3, row B.

The preferred test liquid for calibration is water or the liquid for which the measuring system is intended, or another suitable liquid with low thermal expansion, if possible. For the weight method, a liquid with a sufficiently accurately measured or having a well-known density must be used.

The test liquid for calibrating tanks intended for transport of beverages or food industry products must be hygienically clean and non-toxic.

A preliminary test of temperature sensors is performed at a minimum of three points in the temperature range. Preferred test temperatures are the minimum (or near 0 °C), reference and maximum temperature.

A preliminary test of tilt sensors is performed for tilts of approximately ±5 ° in both directions (longitudinal and transverse), as well as for simultaneous tilts in both directions. Installation direction must be specified on the sensor cabinet.

[6] OIML D 11 General requirements for electronic measuring instruments.

[7] WELMEC 7.2 Software Guide (Measuring Instruments Directive 2014/32/EU). The document is publicly available at www.welmec.org

A preliminary test of the volume conversion apparatus must be performed for at least two points for each product or group of products used. Values may come from actual measurement or may be simulated. Hardware and software protection must be checked.

A preliminary test of floats consists of individual compensation of the submersion of each float with its own correction coefficient. This coefficient is determined according to reference submersion of a reference float of the same type. The diameter and weight of the float must be within tolerances specified in the type-approval certificate. No official mark is placed on floats.

A preliminary test of ultrasound level sensors is performed using a reference tube and a precisely defined reflective mark. The permitted deviation is specified in the type-approval certificate.

A preliminary test of electronic measuring rods for a float system is conducted using filling of various lengths. Permitted deviations are specified in the type-approval certificate. Every float measuring rod must have a document with its serial number, the speed of sound and linearisation coefficients.

A preliminary test of a measuring tube for ultrasound systems consists of a check of the physical dimensions of reference marks. Permitted deviations are specified in the type-approval certificate.

A preliminary test of the computer or control unit consists of a check whether the software (its modules) and its signatures are the same as the version specified in the type-approval certificate or its amendments. A check is performed to determine whether metrological data is protected (e.g. via an electronic seal).

Unless specified otherwise, all parts subject to a preliminary test must have an official mark and be sealed if necessary.

If all tests are passed and the requirements of this measure are complied with, a type-approval certificate is issued and the measuring instrument is issued a type-approval mark pursuant to special legislation[8].

5.2 Visual inspection

The following is assessed during a visual inspection of a transport tank:

- the external and internal appearance of the tank or chambers,
- compliance with specifications in the type approval certificate, including the version of software (modules) and its signatures, if used,
- identification of parts used and their preliminary test certificates, if they exist,
- the validity and identification of calibration tables and tilt corrections, if they exist,
- stored values of metrological parameters (e.g. float correction, product data, volume conversion mode, etc.),
- the functionality of the measuring system,
- measuring system documentation is valid and complete,

5.3 Functional tests

a) leakage test – the tank or chamber, when filled up to the nominal volume mark, may not allow the test liquid to pass or to show any other signs of leakage,

b) an expansion volume test,

c) determination of ullage (in pipes for tanks),

[8] Implementing Decree of the Ministry of Industry and Trade No 262/2000, which provides for uniformity and accuracy of measuring instruments and measurements, as amended.

d) a check of the level sensor (interruption point – for level gauge systems),

e) an accuracy test (except for tanks with one volume mark):

- a test of volume measurement using a reference standard measuring container of volume between 0.8 to 2 times the value of the minimum delivery. If such a reference standard is not available, this quantity can be accumulated using n measurements. Prior to commencing the test, the entire system must be at least 90 % full. During the last measurement until the chamber is emptied, the volume of pipes must be taken into account. For each chamber, as many measurements are performed as the volume of the chamber allows. The difference between the counter and the reference standard may not be greater than ±0.3 %. During measurement of residual emptying without a level gauge, the entire system must be entirely emptied.
- a test of volume measurement using water by weight allows the optimum size of the test measurement for each chamber size to be determined. Prior to commencing the test, the entire system must be at least 90 % full. The difference between the counter and the reference standard may not be greater than ±0.3 %.
- a test of volume measurement using a flow reference standard, which may not have a deviation greater than 0.1 %. During measurement of one chamber, the temperature of the liquid may not change by more than ±3 °C. In order to minimise systematic error, the reference standard must operate between 35 % and 70 % of maximum flow rate during all measurements.
- calibration of pipe volume. The discharge valve and foot valve are closed on a chamber filled with a measurable quantity of liquid. The foot valve remains closed and the discharge valve is opened. Once the contents of the pipes have poured out and dripped out, the volume of liquid captured is measured either volumetrically or by weight (the current density needs to be measured).
- a test of a level gauge system with a full hose (if built in). Prior to the test, the chamber is filled with 200 L of test liquid plus the volume of pipes and full hose. Batches of 200 L are dispensed. The permissible error is ±0.3 % of the minimum delivery, but not less than ±3 L. The test has ended when discharged below the lowest point of the pipe.
- the expanded uncertainty (k = 2) of the volume of liquid in the tank for initial verification may not exceed one-third of the maximum permissible error pursuant to Table 3.
- determination of the minimum measured quantity for each chamber within the scope of calibration; the value of MMQ may be changed no later than during initial verification (e.g. if measurement results exceed permissible error).

f) a test of connected devices,

g) a tilt correction test:

- the tilt correction test is performed at two levels, at about 25 % and at about 80 % of chamber volume. The vehicle is first allowed to come to rest in a horizontal position and then in four axial tilts. The volume of the chambers is printed out in all positions. In the horizontal position, the position indicator must be within ±0.05°. Tilts must be greater than ±3° and the other axis may be within ±0.5°. The corrected volume during tilt may not differ from the volume in the horizontal position by more than 0.3 % of the chamber's minimum delivery.

All parts of the level gauge system that influence metrological parameters are subject to preliminary testing. The use of simulators must be authorised by the entity that performed the type tests.

All test equipment used must have the required accuracy and must be traceable to national reference standards. Tests and test equipment must be documented.

5.4 Tests of resistance of the conversion apparatus to environmental interference

Of the tests specified below, those that are relevant to the design and conditions of intended use of the conversion apparatus are performed.

5.4.1 Tests of resistance to climatic influences

5.4.1.1 Test of resistance to limits of temperatures

Resistance to limits of ambient temperatures are tested with the conversion apparatus switched on:

a) using dry heat at a temperature of +55 °C for 2 h;

b) using cold at a temperature of -25 °C for 2 h.

After the stipulated amount of time has passed, an accuracy test is performed under the given temperature limit at three points of the measurement interval. Measurement errors may not exceed the maximum permissible errors specified in Table 3.

5.4.1.2 Test of resistance to humidity

Resistance to humidity is tested with the conversion apparatus switched off using cyclical wet heat over two 24-hour cycles at a maximum temperature of +55 °C and relative humidity greater than 95 %.

Once both cycles have been completed and operating conditions have been restored, measurement error may not exceed the maximum permissible error specified in Table 3.

5.4.2. Vibration test (random)

The apparatus is tested in three mutually perpendicular axes, attached in the normal manner and in a normal operating position, in each case for two minutes. Power is switched off during the vibration.

- overall frequency range = (10–150) Hz
- overall RMS = 7 $m \cdot s^{-2}$
- ASD level (10–20) Hz = 1 $m2 \cdot s^{-3}$
- ASD level (20–150) Hz = −3 dB/octave

Once vibrations have ended, measurement errors may not exceed the maximum permissible errors specified in Table 3.

5.4.3 Test of immunity to a radio-frequency radiated electromagnetic field

Immunity to a radio-frequency radiated electromagnetic field is tested with the conversion apparatus switched on; inputs may be simulated.

The electromagnetic field has the following properties:

- 10 V/m for the frequency range (26–2 000) MHz
- amplitude modulation 80 % with a 1 kHz frequency sine wave.

Either no critical change will occur during interference, or the monitoring device must detect incorrect operation and, in the case of a critical change, intervene in accordance with Article 3.4.

5.4.4 Test of immunity to a radio-frequency conducted electromagnetic field

Immunity to a radio-frequency conducted electromagnetic field is tested with the conversion apparatus switched on; inputs may be simulated. The electromagnetic field has the following properties:

- 10 V for an amplitude of 50 Ω
- frequency range (0.15–80) MHz

Either no critical change will occur during interference, or the monitoring device must detect incorrect operation and, in the case of a critical change, intervene in accordance with Article 3.4.

5.4.5 Test of immunity to electrostatic discharge

Electrostatic discharge immunity shall be tested with the conversion apparatus switched on, preferably using a 6 kV contact discharge applied to the conductive surface of the measuring instrument or an 8 kV air discharge applied to coupling planes mounted in the vicinity of the measuring instrument.

The test must be performed for at least one flow rate and simulated input signals are permitted. Either no critical change will occur during interference, or the monitoring device must detect incorrect operation and, in the case of a critical change, intervene in accordance with Article 3.4.

5.4.6 Test of immunity to a 50 Hz power frequency magnetic field

Magnetic field immunity is tested with the conversion apparatus switched on with a 50 Hz frequency, magnetic field measuring 30 A/m for a permanent field and 300 A/m for a transient magnetic field (1 to 3 seconds).

Either no critical change will occur during interference, or the monitoring device must detect incorrect operation and, in the case of a critical change, intervene in accordance with Article 3.4.

5.4.7 Test of immunity to transients/surges on signal, data and control lines

Immunity to transients/surges is tested with the conversion apparatus switched on, with a test voltage of ±1 kV on signal terminals with a repetition frequency of 5 kHz. The interference is applied to all of the measuring instrument's inputs and outputs, each time for at least 1 minute.

The test must be performed for at least one flow rate and simulated input signals are permitted. Either no critical change will occur during interference, or the monitoring device must detect incorrect operation and, in the case of a critical change, intervene in accordance with Article 3.4.

5.4.8 Test of immunity to supply voltage limit values

Immunity to supply voltage limit values shall be tested with the conversion apparatus switched on. For AC power its limits are given as (U_{nom} − 15 %) and (U_{nom} + 10), where U_{nom} is the nominal supply voltage.

Measurement errors at limit values may not exceed the maximum permissible errors specified in Table 3.

5.4.9 Test of immunity to surges on mains power lines

Interference consists of three positive and three negative pulses. For AC, the pulses must be applied synchronously with AC supply voltage at phase angles of 0°, 90°, 180°, and 270°. Voltage amplitude is 1.0 kV for line-to-line and 2.0 kV for line-to-ground.

The test must be performed for at least one flow rate and simulated input signals are permitted. Either no critical change will occur after interference has ended, or the monitoring device must detect incorrect operation and, in the case of a critical change, intervene in accordance with Article 3.4.

5.4.10 Test of immunity to AC mains voltage dips, short interruptions and slow voltage fluctuations

Immunity to AC mains voltage dips, short interruptions and slow voltage fluctuations is tested with the conversion apparatus switched on, by applying the following voltage reductions to all power inputs:

- 100 % of U_{nom} for 0.5 AC power period;
- 100 % of U_{nom} for 1 AC power period;
- 60 % of U_{nom} for 10 AC power periods;
- 30 % of U_{nom} for 25 AC power periods;
- 20 % of U_{nom} for 250 AC power periods;

- 100 % of U_{nom} for 250 AC power periods.

The test must be performed for at least one flow rate and simulated input signals are permitted. Either no critical change will occur during interference, or the monitoring device must detect incorrect operation and, in the case of a critical change, intervene in accordance with Article 3.4.

5.4.11 Immunity to electrical fast transients/pulse clusters on mains power lines

Immunity to transients/pulse clusters is tested with the conversion apparatus switched on, with a test voltage of ±2 kV on signal terminals with a repetition frequency of 5 kHz. Interference is applied for each amplitude and polarity for at least 1 minute.

The test must be performed for at least one flow rate and simulated input signals are permitted. Either no critical change will occur during interference, or the monitoring device must detect incorrect operation and, in the case of a critical change, intervene in accordance with Article 3.4.

5.4.12 Test of immunity to low internal battery voltage

Immunity to low internal battery voltage is tested with the conversion apparatus switched on and in measurement mode. The supply voltage is gradually reduced until the tested device stops operating correctly. This is tested for all functions.

Measurement errors at limit values may not exceed the maximum permissible errors specified in Table 3.

5.4.13 Test of immunity to changes in vehicle battery voltage

Immunity to supply voltage changes is tested with the conversion apparatus switched on. For 12 V supply voltage this is 9 V and 16 V, for 24 V supply voltage this is 16 V and 32 V.

Measurement errors at limit values may not exceed the maximum permissible errors specified in Table 3.

5.4.14 Test of immunity to transient electrical connections along power cables from the vehicle battery

Immunity to transient connections is tested with the conversion apparatus switched on, with a test voltage pursuant to Table 12:

Table 12

Test pulses	**Pulse voltage U_s**	
	U_{nom} = 12 V	U_{nom} = 24 V
2a (sudden power interruption in a parallel device)	+50 V	+50 V
2b (switching off of a DC motor)	+10 V	+20 V
3a (result of switching processes)	−150 V	−200 V
3b (result of switching processes)	+100 V	+200 V

Simulated input signals are permitted. Either no critical change will occur during interference (in case 2b after interference has ended), or the monitoring device must detect incorrect operation and, in the case of a critical change, intervene in accordance with Article 3.4.

5.4.15 Test of immunity to transient electrical connections through other than power cables from the vehicle battery

Immunity to transient connections is tested with the conversion apparatus switched on, with a test voltage of:

12 V battery	Pulse a	U_s	−60	V
	Pulse b	U_s	+40	V
24 V battery	Pulse a	U_s	−80	V
	Pulse b	U_s	+80	V

Simulated input signals are permitted. Either no critical change will occur during interference, or the monitoring device must detect incorrect operation and, in the case of a critical change, intervene in accordance with Article 3.4.

6 Initial verification

6.1 In general

Initial verification of tanks consists of the following operations (the application of individual items depends on the design of the specific tank type):

a) visual inspection

- the external and internal appearance of the tank or chambers;
- compliance with specifications in the type approval certificate, including the version of software (modules) and its signatures, if used;
- identification of parts used and their preliminary test certificates, if they exist,
- the validity and identification of calibration tables and tilt corrections, if they exist,
- stored values of metrological parameters (e.g. float correction, product data, volume conversion mode, etc.);
- the functionality of the measuring system;
- that measuring system documentation is valid and complete;

b) leakage test – the tank or chamber, when filled up to the nominal volume mark, may not allow the test liquid to pass or to show any other signs of leakage;

c) an expansion volume test;

d) determination of ullage (in pipes for tanks);

e) a check of the level sensor (interruption point – for level gauge systems);

f) an accuracy test (except for tanks with one volume mark):

- a test of volume measurement using a reference standard measuring container of volume between 0.8 to 2 times the value of the minimum delivery. If such a reference standard is not available, this quantity can be accumulated using n measurements. Prior to commencing the test, the entire system must be at least 90 % full. During the last measurement until the chamber is emptied, the volume of pipes must be taken into account. For each chamber, as many measurements are performed as the volume of the chamber allows. The difference between the counter and the reference standard may not be greater than ±0.3 %. During measurement of residual emptying without a level gauge, the entire system must be entirely emptied.

- a test of volume measurement using water by weight allows the optimum size of the test measurement for each chamber size to be determined. Prior to commencing the test, the entire system must be at least 90 % full. The difference between the counter and the reference standard may not be greater than ±0.3 %.
- a test of volume measurement using a flow reference standard, which may not have a deviation greater than 0.1 %. During measurement of one chamber, the temperature of the liquid may not change by more than ±3 °C. In order to minimise systematic error, the reference standard must operate between 35 % and 70 % of maximum flow rate during all measurements.
- calibration of pipe volume. The discharge valve and foot valve are closed on a chamber filled with a measurable quantity of liquid. The foot valve remains closed and the discharge valve is opened. Once the contents of the pipes have poured out and dripped out, the volume of liquid captured is measured either volumetrically or by weight (the current density needs to be measured).
- a test of a level gauge system with a full hose (if built in). Prior to the test, the chamber is filled with 200 L of test liquid + the volume of pipes and full hose. Batches of 200 L are dispensed. The permissible error is ±0.3 % of the minimum delivery, but not less than ±3 L. The test has ended when discharged below the lowest point of the pipe.
- the expanded uncertainty (k = 2) of the volume of liquid in the tank for initial verification may not exceed one-third of the maximum permissible error pursuant to Table 3.
- determination of the minimum measured quantity for each chamber within the scope of calibration; the value of MMQ may be changed no later than during initial verification (e.g. if measurement results exceed permissible error).

g) a test of connected devices;

h) a tilt correction test:

- the tilt correction test is performed at two levels, at about 25 % and at about 80 % of chamber volume. The vehicle is first allowed to come to rest in a horizontal position and then in four axial tilts. The volume of the chambers is printed out in all positions. In the horizontal position, the position indicator must be within ±0.05°. Tilts must be greater than ±3° and the other axis may be within ±0.5°. The corrected volume during tilt may not differ from the volume in the horizontal position by more than 0.3 % of the chamber's minimum delivery.

All parts of the level gauge system that influence metrological parameters are subject to preliminary testing. The use of simulators must be authorised by the entity that performed the type tests.

All test equipment used must have the required accuracy and must be traceable to national reference standards. Tests and test equipment must be documented.

6.2 Evaluation of tests

The measuring instrument has passed if during testing it has complied with all requirements of Chapter 6 of this Measure of a General Nature.

7 Follow-up verification

Subsequent verification of tanks consists of the following operations (the application of individual items depends on the design of the specific tank type):

a) visual inspection:

- the external and internal appearance of the tank or chambers, extent/locations/degree of damage,
- compliance with specifications in the type approval certificate, including the version of software (modules) and its signatures, if used,
- identification of parts used and their preliminary test certificates, if they have been repaired or replaced,
- the validity and identification of calibration tables and tilt corrections, if they exist,
- stored values of metrological parameters (e.g. float correction, product data, volume conversion mode, etc.),
- the functionality of the measuring system,
- measuring system documentation is valid and complete,

b) accuracy test:

- a test of volume measurement using a reference standard measuring container of volume between 0.8 to 2 times the value of the minimum delivery. If such a reference standard is not available, this quantity can be accumulated using n measurements. At least three measurements are performed: an offtake in the upper range, an offtake in the middle range, and an offtake until completely empty. The difference between the counter and the reference standard may not be greater than ±0.5 % of the minimum measured quantity.
- a test of volume measurement using a flow reference standard, which may not have a deviation greater than 0.1 %. During measurement of one chamber, the temperature of the liquid may not change by more than ±3 °C. In order to minimise systematic error, the reference standard must operate between 35 % and 70 % of maximum flow rate during all measurements.
- a test of a level gauge system with a full hose (if built in). Prior to the test, the chamber is filled with 200 L of test liquid + the volume of pipes and full hose. Batches of 200 L are dispensed. The permissible error is ±0.3 % of the minimum delivery, but not less than ±3 L. The test has ended when discharged below the lowest point of the pipe.
- the expanded uncertainty ($k = 2$) of the volume of liquid in the tank for subsequent verification may not exceed one-third of the maximum permissible error pursuant to Table 3.

c) a test of connected devices, d) a tilt correction test:

- the tilt correction test is performed at two levels, at about 25 % and at about 80 % of chamber volume. The vehicle is first allowed to come to rest in a horizontal position and then in four axial tilts. The volume of the chambers is printed out in all positions. In the horizontal position, the position indicator must be within ±0.05°. Tilts must be greater than ±3° and the other axis may be within ±0.5°. The corrected volume during tilt may not differ from the volume in the horizontal position by more than 0.3 % of the chamber's minimum delivery.

All test equipment used must have the required accuracy and must be traceable to national reference standards. Tests and test equipment must be documented.

A tank or chamber with one volume mark is marked with the volume obtained through calibration, rounded down according to Table 13.

Table 13

Accuracy class	**0.2**	**0.3**	**0.5**	**1.0**
Calibrated chamber volume *V* in litres	Round down to litres			
$V \leq 1500$	0.5	1.0	2.0	5.0
$1\,500 < V \leq 5000$	1.0	2.0	5.0	10.0
$V > 5000$	2.0	5.0	10.0	20.0

A measuring instrument accuracy test is performed to determine whether the reading provided by the measuring instrument matches the volume within the maximum permissible error. The measuring instrument's relative deviation is calculated according to the following relationship:

$$e = \frac{V_n - V}{V} \times 100 \qquad (6)$$

where V_n .... is the reading of the tested measuring instrument,

V .... is the true volume of liquid in the measuring instrument.

7.1 Evaluation of tests

The measuring instrument is suitable for verification purposes if it passed all tests pursuant to this chapter.

8 Measuring instrument check

When checking measuring instruments pursuant to § 11a of the Metrology Act at the request of an entity that could be affected by its incorrect measurement, Chapter 7 of this General Measure is followed, except that the maximum permissible errors are doubled.

9 Notified standards

To specify metrological and technical requirements for measuring devices and to specify verification and type-approval test methods stemming from this General Measure, the CMI notifies Czech technical standards, other technical standards or technical documents of international or foreign organisations or other technical documents containing detailed technical requirements (hereinafter 'notified standards'). The CMI shall publish a list of these notified standards attached to the relevant measures, together with the General Measure, in a manner accessible to the public (on www.cmi.cz).

Compliance with notified standards or parts thereof is considered, to the extent and under the conditions stipulated by this general measure, to be compliance with the requirements stipulated by this measure to which these standards or parts thereof apply.

Compliance with notified standards is one way of demonstrating compliance with the requirements. These requirements may also be met by using another technical solution guaranteeing an equivalent or higher level of protection of legitimate interests.

II.

GROUNDS

Pursuant to § 14(1)(j) of the Metrology Act, the CMI has issued this General Measure to implement § 6(2), § 9(1) and (9), and § 11a(3) of the Metrology Act, defining metrological and technical requirements for specified measuring instruments and tests for type approval and verification of specified measuring instruments – 'liquid transport tanks'.

Implementing Decree No 345/2002 stipulating measuring instruments for mandatory verification and measuring instruments subject to type approval, as amended, classifies this type of measuring instrument as a measuring instrument subject to type approval and verification under item 1.3.5(c) in the Annex's 'List of Specified Measuring Device Types'.

This legislation (General Measure) was notified in accordance with Directive (EU) 2015/1535 of the European Parliament and of the Council of 9 September 2015 defining a procedure for the provision of information in the field of technical regulations and of rules on Information Society services.

III.

INSTRUCTIONS

In accordance with § 173(2) CAP, no appeals may be made against general measures.

In accordance with the provisions of § 172(5) CAP, decisions on objections are final and cannot be appealed against. Compliance of general measures with legislation may be subject to a review process in accordance with § 94 to § 96 CAP. A party to the proceedings may initiate review proceedings to be conducted by the administrative authority which issued this general measure. If the administrative authority finds no reason to commence the review proceedings, it shall communicate and provide grounds for this fact within 30 days. Pursuant to § 174(2) CAP, a ruling on the commencement of review proceedings may be issued within three years of the entry into force of the general measure.

IV.

ENTRY INTO FORCE

This General Measure shall enter into force on the fifteenth day following the date of posting it on the official notice board (§ 24d of the Metrology Act).

RNDr. Pavel Klenovský m.p.

Director General

Person responsible for accuracy: Mgr. Tomáš Hendrych

Posted on: 21 November 2018

Signature of the authorised person confirming posting:Tomáš Hendrych m.p.

Removed on: 24 January 2019

Signature of the authorised person confirming removal: Tomáš Hendrych m.p.

Entry into force: 6 December 2018

Signature of the authorised person indicating entry into force: Tomáš Hendrych m.p.