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PUBLIC DECREE

As the authority with substantive and territorial jurisdiction in the matter of laying down metrological and technical requirements for specified measuring instruments and stipulating test methods for their type approval and verification pursuant to § 14(1) of Act No 505/1990, on metrology, as amended (hereinafter the 'Metrology Act'), 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 (hereinafter the 'CMI') commenced ex officio proceedings on 30 April 2024 pursuant to § 46 CAP, and, based on the supporting documents, issues the following:

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MEASURE OF A GENERAL NATURE

number: 0111-OOP-C104-26

laying down metrological and technical requirements for specified measuring instruments, including test methods for type approval, verification and checking of specified measuring instruments:

'laboratory oscillation-type density meters with sample temperature control or automatic temperature correction'.

1 Definitions

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

1.1
oscillation-type density meter for liquids

a measuring instrument designed to measure the density of liquids and to determine quantities functionally related to the density of liquids (the concentration of a particular component of the liquid – typically the volume percentage of alcohol in an aqueous solution, for example). It is based on the principle of an oscillating sensor whose oscillation frequency/period is a function of liquid density.

1.2
measuring cell

a measuring tube acting as an oscillating sensor, filled with the liquid to be measured

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

1.3
laboratory oscillation-type density meter with sample temperature control

a ‘benchtop’ laboratory oscillation-type density meter with a measuring tube housed in a thermostat, which allows the liquid being measured to be heated to the required temperature and its density to be subsequently determined at that temperature (typically at a reference temperature of 20 °C or 15 °C). Tempering is usually provided by a Peltier cell.

1.4
laboratory oscillation-type density meter with automatic temperature correction

A ‘hand-held’ or ‘portable’ laboratory oscillation-type density meter without a thermostat, with the measuring cell positioned freely within the instrument’s chamber. The instrument measures the density of the liquid at its current temperature, which is detected by a temperature sensor located on the outer wall of the measuring tube, and then corrects (converts) this value according to a predefined equation to give the density at the reference temperature (typically 20 °C or 15 °C).

1.5
adjustment

calibration of the measuring instrument using reference samples of known density (typically air and distilled water), determination of instrument constants

1.6
liquid density *(ρ)*

is a derived physical quantity defined as the mass of a liquid divided by its volume at the given temperature. Density is a temperature-dependent quantity, and its value always relates to the temperature of the liquid for which it is being determined. In practice, the most commonly used reference temperature is 20 °C (aqueous solutions, alcohol) or 15 °C (propellants, crude oil and petroleum products, organic substances). The unit in the SI system is $kg \cdot m^{-3}$, or $g \cdot cm^{-3}$.

1.7
percentage by volume of alcohol in an aqueous solution

determines the percentage by volume of pure (100 %) ethanol in the whole volume of an aqueous solution of ethanol (ethyl alcohol). The unit is ‘% v/v’ and is generally stated at a reference temperature of 20 °C. It can be determined from the density of a binary mixture of ethanol and water by conversion using approved and internationally recognised alcoholometric tables. The conversion may only be used for ethanol-water binary mixtures without dissolved sugars (i.e. pure distillates). It may not be used for beer, wine, liqueurs, etc.

1.8
software

1.8.1
legally relevant

required for compliance with the requirements of this Measure of a General Nature (hereinafter also 'OOP') and/or affecting compliance with the requirements of this OOP

1.8.2
legally relevant software (LRSW)

the part of the software, including the specific parameters of the type in question, that is essential for the metrological characteristics

NOTE: All other software is referred to as legally irrelevant. Unless otherwise specified below, ‘software’ means legally relevant software.

2 Metrological requirements

2.1 Rated operating conditions

Density meters must meet the metrological requirements within the range of operating conditions specified by the manufacturer.

Measurements are carried out at normal atmospheric pressure.

2.2 Measuring interval and units

The measurement range for density and temperature, the type of liquid being measured and, where applicable, the viscosity range of the liquids are specified by the manufacturer.

The density interval must be expressed in liquid density values or in values of quantities functionally related to liquid density.

It may therefore be expressed in terms of values and corresponding units of measurement:

a) liquid density;
b) percentage by volume of alcohol in a binary ethanol-water mixture;
c) quantities functionally related to the density of liquids (e.g. the concentration of a particular component of a liquid).

In cases (b) and (c), the technical documentation for the density meter must specify a conversion factor, table or other formula that converts the density of the liquid into the specified units.

2.3 Maximum permissible error

2.3.1 Temperature

For ‘portable hand-held’ laboratory density meters with automatic temperature correction, the maximum permissible error in the temperature reading of the liquid being measured is ±0.5 °C.

For ‘benchtop’ laboratory density meters capable of temperature control of the sample being measured, the maximum permissible error in the temperature reading of the liquid being measured is as set out in Table 1:

Table 1 – Maximum permissible errors corresponding to the respective resolution of the temperature indication

Resolution (°C)	**Resolution** ($kg \cdot m^{-3}$)	**Maximum permissible error** (°C)
0.01	0.1	±0.25
0.01	0.01	±0.05
0.01	0.001	±0.05
0.001	0.01	±0.05
0.001	0.001	±0.05

2.3.2 Density

The maximum permissible errors corresponding to the respective resolution of the density indication are set out in Table 2. The viscosity-corrected density values or the viscosity-uncorrected density values indicated by the measuring instrument being tested are used for the evaluation of the criterion. The selected type of indication must be specified in the measuring instrument's type approval certificate. For density meters with automatic temperature correction, the density values converted to the density at the reference temperature are used.

Table 2 – Maximum permissible errors corresponding to the respective resolution of the density indication

Resolution ($kg \cdot m^{-3}$)	**Maximum permissible error** ($kg \cdot m^{-3}$)
0.1	±1.0
0.1	±0.5
0.01	±1.0
0.01	±0.2
0.01	±0.1
0.01	±0.05
0.001	±0.1
0.001	±0.05

An oscillation-type density meter may be designed to have more than one maximum permissible error, depending on the operating mode, the measurement range, the ambient conditions and the properties of the sample being measured. The conditions and limitations to which the maximum permissible error applies are specified in the measuring instrument's type-approval certificate.

2.3.3 Percentage by volume of alcohol

For density meters that allow readings to be displayed both as a percentage by volume and in units of viscosity-corrected density, the measurement error in units of density is assessed in accordance with point 2.2.2

For portable density meters designed to measure alcohol content, the maximum permissible errors are specified in Table 3:

Table 3 – Maximum permissible errors corresponding to the respective resolution of the indication, as a percentage by volume

Resolution (% v/v)	**Resolution** (°C)	**Range** (% v/v)	**Maximum permissible error** (% v/v)
0.01	0.1	0 to 100	±0.2
0.01	0.01	0 to 100	±0.2

2.4 Automatic temperature correction

For instruments equipped with automatic temperature correction, when a density value or a value of a quantity functionally related to the density of a liquid is indicated on the instrument's display, it must be clear that it is a density value or a value of a quantity functionally related to the density of the liquid, corrected (converted) to the value at the relevant reference temperature.

The technical documentation for the density meter must specify the conversion factor, table or other formula used for the correction (conversion) in question.

3 Technical requirements

3.1 Measuring instrument design

A density meter must be equipped with:

a) a measuring cell;
b) an indicator;
c) a thermostat capable of controlling the temperature of the liquid being measured or a device for automatic temperature correction;
d) temperature sensor;
e) adjustment elements;
f) a system for detecting and displaying faults and operator errors.

3.1.1 Measuring cell

The measuring tube may take various forms; provided that its appearance does not affect the functionality of the measuring cell; its most common shape is a U-tube or ω-tube.

The measuring tube must be made of a chemically resistant material, typically borosilicate glass, so that it can withstand both the effects of the liquids for which the density meter is intended, and the cleaning agents used to remove residues of those liquids from the instrument.

In the case of 'benchtop' density meters, the measuring cell is filled with the liquid to be measured either manually using a syringe via a Luer connector, or by an automatic suction device. 'Hand-held' density meters are filled with a suction piston with a manual or electric drive.

In order to check that the measuring cell has been properly cleaned or filled, it must be visible through a glass viewing port or imaged with a CCD camera, and the image shown on the instrument's display.

3.1.2 Indicator

The indicator must indicate:

a) the name of the quantity currently displayed, i.e. density or quantity functionally related to density, or these quantities corrected for the reference temperature;
b) the value of the quantity together with the relevant unit, i.e. density in $kg \bullet m^{-3}$, or $g \bullet cm^{-3}$, or % v/v alcohol;
c) the temperature of the measured liquid in degrees Celsius, together with the unit;
d) any faults or measurement errors.

In the case of 'benchtop' density meters with sample temperature control, the indicator must be capable of showing the instrument constants (adjustment parameters) on request.

The resolution of the liquid density indication must be at least 0.1 $kg \bullet m^{-3}$. The indication of alcohol percentage by volume must be at least 0.01 % v/v.

When the measuring cell is empty, properly cleaned and dried, a correctly adjusted instrument must indicate the air density value.

For a temperature of t (°C) and a pressure of p (mbar or hPa), the density of air ρ ($g \bullet cm^3$) is determined using the following formula (for air humidity of 50 %):

$$\rho = \left[\frac{0.34844 \cdot p - \left(0.5 \cdot \left(0.252 \cdot t - 2.0582\right)\right)}{273.15 + t} \right] / 1000 \qquad (3.1)$$

3.1.3 Temperature sensor

The temperature sensor must be installed or fitted as a separate unit so as to ensure good thermal contact with the sample.

The temperature sensor must have a resolution of at least 0.1 °C. For density meters with a resolution of 0.01 $kg \bullet m^{-3}$ or better, the temperature sensor must have a resolution of at least 0.01 °C.

3.1.4 Device for sample tempering

Density meters with a resolution of 0.01 $kg \bullet m^{-3}$ and better must have a device enabling the sample to be tempered.

3.1.5 Automatic temperature correction device

'Hand-held' or 'portable' density meters must have a device for automatic temperature correction.

When a density value or a value of a quantity functionally related to the density of a liquid is being indicated, the instrument's display must make it clear that the value shown is either the density value or a value of a quantity functionally related to the density of the liquid, corrected (converted) to the value at the relevant reference temperature.

Information on the corrections performed, including substance type, transfer relationship or table, and operating temperature range, must be specified in the measuring instrument's technical documentation.

3.1.6 Material

The measuring instrument must be made of materials that ensure its reliability and durability during use.

Those parts of the density meter that come into contact with the liquids being measured must resist the effects of the liquids for the measurement of which the density meter is intended. It must also withstand the products intended for cleaning the measuring instrument from residues of measured liquids for the measurement of which the density meter is intended.

3.2 Tamper protection

3.2.1 Securing the measuring instrument

The design of the vibration-type density meter must allow it to be secured with an official mark to prevent tampering with the meter, including its adjustment mechanisms. The location of the official marks shall be stated in the type approval certificate.

3.2.2 External system interface

In the case of vibration-type density meters equipped with an external system interface that permits parallel or serial communication with an external data collection system, control system or manual terminal, it must be possible to protect transducer parameters from unauthorised access (both intentional and unintentional) using this communication. The method used to secure the external system's interface against unauthorised access shall be specified in the type-approval certificate.

3.3 Electromagnetic compatibility

Vibration-type density meters must not be affected by electrical or electromagnetic interference, or must react to it in a defined manner (for example by reporting an error, blocking measurements, etc.). They also must not radiate any unwanted electromagnetic fields. During electromagnetic compatibility tests, the measuring instrument must function normally within the limits of the maximum permitted error pursuant to Table 1 or must react in a defined manner.

3.4 Resistance of the measuring instrument to environmental influences

3.4.1 Mechanical resistance

The design of the density meter and materials used must guarantee sufficient rigidity, stability and resistance to mechanical vibrations and shocks.

3.5 Software

The measuring instrument software must be clearly identifiable. The identification must be associated with the software and must be possible to display in an easily executable manner.

Both the software and any legally relevant parameters must be protected from accidental, unintentional and deliberate interference, damage or modification. Evidence of any interference with the software must be available. Neither the measuring instrument nor the software may have any features that could facilitate fraudulent use, and they must be designed in such a way as to minimise the potential for misuse.

The measuring instrument must be secured to prevent new software from being loaded into it.

The measuring instrument must be equipped with mechanisms for checking correct operation and detecting significant errors. Errors must be detected and shown on the display, or transmitted via a communication interface where appropriate.

At the same time, neither the software nor the hardware components of the measuring instrument may be unduly influenced by any other device or by modules or parts of the measuring instrument or measuring system that are not legally relevant. Only interactions or data transfers that do not unduly influence the measurement process or result, legally relevant software, legally relevant parameters, metrological characteristics or measured data are allowed.

It must not be possible to delete or edit audit records (i.e. records of parameter changes, calibration, software updates, etc.).

Stored or transmitted measured data must be protected from modification and must contain sufficient information for further use for legally relevant purposes and for the reconstruction of their origin.

The legally relevant parts of the software – the functions and algorithms used, data flows, software interfaces, security measures and other characteristics that have, or may have, an impact on the measurement result – must be documented in sufficient detail to enable an assessment of conformity with the requirements. Documentation must be provided for the type approval process.

4 Labelling

The density meter must be labelled with the following information:

a) the manufacturer’s name or trade mark;
b) type or model designation;
c) serial number;
d) type approval certificate number;
e) supply voltage;

any other relevant characteristics specified for that particular type.

The label must be indelible, clearly visible and legible.

5 Measuring instrument type approval

The measuring instrument type approval process includes:

a) a documentation check;
b) basic functional tests;

c) software validation and testing;
d) an electromagnetic compatibility (EMC) test;
e) a test of the effect of supply voltage on battery-operated density meters;
f) supplementary tests for electrically powered measuring density meters.

5.1 Documentation check

During type approval, the following are assessed: the completeness of the technical documentation, including the operating instructions; the conformity of the metrological and technical characteristics specified by the manufacturer in the documentation with the technical and metrological requirements of this regulation, as set out in Chapters 2 and 3, including the identification of the software; and the appearance and completeness of the measuring instrument as per the technical documentation.

The manufacturer must specify the storage, installation and adjustment requirements, including environmental conditions, operation and maintenance requirements, safety rules necessary for the use of the oscillation-type density meter, the adjustment process (determining and setting instrument constants), the liquid density measurement procedure, liquid temperature measurement, setting the temperature, technical parameters – working ranges for density, temperature, viscosity, pressure and, where applicable, flow, maximum permissible errors (accuracy), resolution, repeatability, cleaning method, the use of suitable cleaning agents and information on error messages.

5.2 Basic functional tests

5.2.1 Oscillation system test

5.2.1.1 Drift

The test is carried out as follows:

a) Once switched on, the density meter – with an empty, cleaned and dried measuring cell – must be left to stabilise at the set reference temperature for 24 hours. The displacement of the displayed density $\Delta_{\rho 24}$ at a constant temperature of 20 °C must not exceed 1 % of the maximum permissible error of the density meter within the next 24 hours.
   If the density meter is not designed for a measuring temperature of 20 °C, the displacement at another nominal measuring temperature of the density meter must not exceed 5 % of the maximum permissible error set out in Table 2.
b) The density meter is calibrated in accordance with the manufacturer's instructions.
c) The density meter is filled with a sample of distilled water at 20.0 °C. The measurement is carried out three times. The mean density value ρ_1 is recorded. After a minimum of 10 days without any adjustments, the measurement is repeated three times and the mean density ρ_2 is calculated. The density meter must be in operation for the entire duration of the test.

The drift is calculated using the following formula:

$$\Delta_{\rho 24} = (\rho_2 - \rho_1)/\Delta t \qquad (5.1)$$

where Δt is the difference in days between two triplicate measurements.

If the density meter is not designed for a measuring temperature of 20 °C, the test is carried out at a different rated measuring temperature.

5.2.1.2 Effect of sample viscosity

The density meter must be designed so that the maximum permissible errors comply with the requirements of Article 2.3 when measuring samples with different viscosities. Tests are performed using Newton liquids of known density and viscosity that are representative of the intended use of the oscillation-type density meter. Liquids must not be corrosive to density sensor materials.

5.2.1.3 Difference between the temperature of the measured sample and the sensor tempering temperature

The test is performed only on laboratory oscillation-type density meters with sample temperature control. During the test, the manufacturer's recommendations for the maximum temperature difference between the temperature of the liquid to be filled into the measuring cell and the temperature of the measuring cell are followed, if such difference has been specified by the manufacturer.

The test is carried out as follows:

a) The instrument is switched on and allowed to stabilise at a set reference temperature of 20 °C for 24 hours.
b) If the manufacturer does not specify a maximum temperature difference, the selected reference liquid (e.g. n-nonane) is heated to 30 °C.
c) The measuring cell is filled with the specified reference liquid and the density value is read once the system has stabilised.
d) The second density value is read after 10 minutes.

The difference between these two values must not exceed 20 % of the maximum permissible error as set out in Table 2. If the oscillation-type density meter is not designed for a measuring temperature of 20 °C, the test is carried out in a similar manner at a different nominal measuring temperature of the oscillation-type density meter.

The test is carried out in a similar manner with the liquid cooled to 10 °C.

The temperatures to which the test fluids are cooled or heated must not exceed the limits specified by the manufacturer or dictated by the physical properties of the fluid.

5.2.2 Temperature measurement test

The test of temperature variation between the displayed temperature and the actual temperature of the sample is carried out either by direct comparison of the temperature sensor with a suitable temperature reference standard or by an indirect method using reference fluids of known density values and a coefficient of cubic thermal expansion within the tested range (e.g. distilled water).

For density meters with sample temperature control, the direct comparison method is carried out by placing a suitable temperature standard inside the measuring cell as close as possible to the point where the temperature sensor of the density meter connects to the measuring cell. For density meters without sample temperature control, the reference standard is placed in a climatic chamber together with the density meter being tested.

The test is carried out at a minimum of three temperature points, taking into account the width of the temperature range (if applicable). The test points are chosen as close as possible to the lower and upper limit and centre of the temperature range.

If the test temperature range for laboratory density meters with sample temperature control includes a temperature of 20 °C, this temperature is selected as one of the test points.

5.2.3 Density measurement test

Prior to the commencement of the density measurement test, the instrument's adjustment is checked and any necessary adjustments to the instrument are carried out. If, during the adjustment check, the density meter fails to meet the criteria because it cannot be adjusted to meet them, the actual density measurement test is not carried out.

For density meters with automatic temperature correction that use a piston to draw the liquid into the measuring cell, the repeatability of the measurement is also checked using distilled water or other suitable reference liquid. If the density meter fails the repeatability test, the actual density measurement test is not carried out.

5.2.3.1 Adjustment check and adjustment of the instrument

Prior to the commencement of the adjustment check and any adjustment, the measuring cell must be thoroughly cleaned and dried. This is carried out according to the manufacturer's recommendations and instructions. The cell is cleaned using a suitable cleaning agent, followed by water or, if necessary, pure ethanol, and finally the density meter is dried by blowing it with clean, dry air.

The adjustment of the density meter is checked at adjustment points (air, distilled water). Observed deviations from air density values (see Formula 3.1) and distilled water (see Table 4 and Formulas 5.2 and 5.3, as applicable) must not exceed half of the maximum permissible density indication error for the given density meter type.

Table 4 – Density values for distilled water (according to equation (5.2)) ($kg \bullet m^{-3}$)

t (°C)	**0.0**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
19	998.404	998.385	998.365	998.345	998.325	998.305	998.285	998.265	998.244	998.224
20	998.203	998.182	998.162	998.141	998.120	998.099	998.077	998.056	998.035	998.013

For a temperature different from the values given in Table 4, the density value is calculated using the formula:

- according to 'Spieweck/Bettin':

$$\rho(t) = \frac{\sum_{n=0}^{5} a_n \cdot t^n}{1 + b \cdot t} \qquad (5.2)$$

where a_0 ..... is $9.998\,395\,2 \bullet 10^{2}$ $kg \bullet m^{-3}$,
a_1 ..... $1.695\,257\,7 \bullet 10^{1}$ $°C^{-1} \bullet kg \bullet m^{-3}$,
a_2 ..... $-7.990\,512\,7 \bullet 10^{-3}$ $°C^{-2} \bullet kg \bullet m^{-3}$,
a_3 ..... $-4.624\,175\,7 \bullet 10^{-5}$ $°C^{-3} \bullet kg \bullet m^{-3}$,
a_4 ..... $1.058\,460\,1 \bullet 10^{-7}$ $°C^{-4} \bullet kg \bullet m^{-3}$,
a_5 ..... $-2.810\,300\,6 \bullet 10^{-10}$ $°C^{-5} \bullet kg \bullet m^{-3}$,
b ..... $1.688\,723\,6 \bullet 10^{-2}$ $°C^{-4} \bullet kg \bullet m^{-3}$,

or from the formula

- according to 'CIPM':

$$\rho(t) = a_5 \cdot \left[1 - \frac{(t + a_1)^2 \cdot (t + a_2)}{a_3 \cdot (t + a_4)} \right] \qquad (5.3)$$

where a_1 ..... is $-3.983\,035$ °C,
a_2 ..... 301.797 °C,
a_3 ..... 522 528.9 $°C^2$,
a_4 ..... 69.348 81 °C,
a_5 ..... 999.974 950 $kg \bullet m^{-3}$.

If the deviations found are greater, the adjustment is carried out in accordance with the manufacturer's instructions, thereby determining and adjusting the new constants of the instrument The adjustment check is then repeated.

Adjustment checks and adjustment are carried out at a reference temperature of 20 °C. Distilled or demineralised water is used.

5.2.3.2 Repeatability test

The test is carried out on density meters with automatic temperature correction that use a piston to suck the liquid into the measuring cell.

At least 10 measurements of distilled water (or other reference liquid, if applicable) are carried out. The deviations of the individual measurements are determined from the reference value. None of the deviations may differ from the other deviations by more than the maximum permissible error for the given type of density meter.

5.2.3.3 Liquid density measurement test

Each test is related to the currently set constants of the instrument and is bound to these constants.

The density measurement accuracy test is carried out either using reference liquids with known density values within the required temperature and density range or by direct comparison with a reference density meter using suitable test liquids.

As far as possible, test liquids are selected so that their properties are as close as possible to the intended use for which the density meter is approved.

The density meter is tested at a minimum of five points, evenly distributed across the entire approved density measurement range. Outermost points as close as possible to the lower and upper limits of the density measurement range are selected. The position of the points depends on the reference fluids chosen and on the temperature and pressure. For narrow ranges, this number of points may be reduced. At each point, tests are carried out at temperatures as close as possible to the lower and upper limits of the temperature range and at the mid-point of the temperature range, taking into account the width of the temperature range (where applicable).

If the test temperature range for laboratory density meters with sample temperature control includes a temperature of 20 °C, this temperature is selected as one of the test points.

The density is measured three times at each test point. The calculated mean value is the result of the measurement at the test point. The deviation of the mean value from the reference density of the test liquid at any test point must not exceed the respective maximum permissible error for the type of density meter.

5.2.4 Test of the correctness of density conversion into units functionally related to density

The density conversion accuracy test is performed separately for each authorised unit.

The test is performed for the entire range of density and temperature values for which the conversion to a given concentration unit is defined:

a) at a minimum of five points evenly distributed over the entire density measurement range (including the upper and lower limits) at the reference temperature;

b) if the conversion is defined (i) for a temperature other than the reference temperature, the test referred to in (a)(i) is carried out for this other temperature;

c) If a conversion factor is defined for a temperature range, the test specified in point (a) is carried out across the entire temperature range, at the upper and lower limits of the temperature range and at least at one point between each limit of the temperature range and the reference temperature or the temperature specified in point (b), unless a conversion factor for the reference temperature is defined.

The test is carried out either by directly measuring suitable reference liquids on the calibrated instrument being tested, or by simulating the input density value on the instrument being tested using software. The converted value in the concentration unit indicated by the instrument under test is

compared with the value in the concentration units under test corresponding to the input and/or measured density value according to the relevant conversion table. The values must show compliance at all points tested.

5.3 Software validation and testing

The software is validated and tested, and an assessment is made as to whether it meets the requirements set out in paragraph 3.3, 'Software'. Software testing consists of a review of documentation and functional tests.

5.3.1 Assessment of documentation

The documentation is assessed to check whether it corresponds to the software of the measuring instrument. An assessment is made as to whether the measures implemented to detect and protect the legally relevant software and legally relevant parameters from accidental, unintentional and deliberate alterations, interference or damage are appropriate and sufficient.

5.3.2 Functional testing

The instrument is checked to ensure it is functioning in accordance with the documentation. Potential error states are also tested. The ability to detect serious errors (if possible) is checked by causing, implementing or simulating these errors and checking the response of the measuring instrument. The identification of the measuring instrument software and its interconnection with the software is checked.

5.3.2.1 Security

A functional check is carried out to ensure that the software is protected from modification, interference or damage. The measuring instrument's response to such intervention is tested, and it is verified whether evidence is available after each software intervention.

A check is carried out to verify whether new software can be uploaded to the meter without breaching protection.

Random checks will be carried out to verify compliance with legally relevant parameters. The effect of incorrect parameter selection on the measured data and the detectability of such an error is tested.

A check is carried out to verify whether the measuring instrument is equipped with mechanisms for checking correct operation and detecting significant errors. A test is performed whether errors are detected and displayed on the screen or transmitted further through the communication interface.

An assessment is made as to whether replacement of memory containing legally relevant software or legally relevant parameters is prevented, and whether any other unauthorised interference affecting the measurement result or the metrological characteristics is also prevented.

A test is carried out to verify that the meter is not, and cannot be, unduly influenced via the communication interface or by modules that are not relevant for legal purposes, or by other parts of the meter or the metering system.

A check is carried out to verify that audit records relating to changes to parameters, calibration, etc. cannot be deleted or edited.

5.3.2.2 Measured data

Tests are carried out to verify that the measured data are protected against accidental, unintentional and deliberate alterations, both during display and whilst being stored or transmitted. At test is carried out to check whether the communication interruption has an impact on the measurement process and whether data is lost due to a communication failure.

An assessment is made as to whether stored or transferred data contain sufficient information needed for their further use for legally relevant purposes, to identify the measurements and to reconstruct their origin.

5.4 Electromagnetic compatibility (EMC) tests

The density meter readings are monitored during testing. The condition stipulated in Article 2.3. for reference ambient conditions must be met prior to each electromagnetic compatibility test. The difference between errors recorded before and during EM compatibility tests may not exceed the maximum permitted error under reference or operating conditions, or the density meter must react in a defined manner.

The lower values given in brackets may only be used if the equipment cannot be used in an industrial environment. This fact must be sufficiently brought to the attention of the user.

At all test points, the density meter must exhibit normal function during measurement within the limits of the maximum permissible error specified in Article 2.3.

5.4.1 Electrostatic discharge immunity test

Electrostatic discharge immunity is tested with the density meter switched on, preferably with a contact discharge of ±4 kV on the metallic part and an air discharge of ±8 kV on the non-metallic part. Discharges are applied to the density meter's housing and to coupling plates near the density meter.

During the test, 10 measurements are to be carried out with a reference liquid of a known density value for each polarity of the discharge voltage. One discharge is applied during each measurement. The interval between discharges should be at least 10 seconds.

5.4.2 Test of immunity to a radiated high-frequency electromagnetic field

Immunity to a radiated high-frequency electromagnetic field is tested with the density meter switched on, in the frequency range 80 MHz to 6 GHz, at a test field intensity of 10(3) V/m up to 1 GHz and 3 V/m up to 6 GHz.

The test field is amplitude-modulated to a depth of 80 %; the modulation signal has a sinusoidal waveform with a modulation frequency of 1 kHz.

The tested density meter is irradiated with vertically and horizontally polarized fields from four mutually perpendicular directions.

The test is carried out at the following frequencies: (26, 40, 60, 80, 100, 120, 144, 150, 160, 180, 200, 250, 350, 400, 435, 500, 600, 700, 800, 934, 1,000, 1 400, 2 000, 2 400, 2 500 and 3 000, 3 500, 4 000, 4 500, 5 000, 5 500, 6 000) MHz. One measurement is made at each frequency with a reference liquid of a known density value. If interference with the density meter is detected at any frequency, testing is carried out in the vicinity of that frequency so as to identify the maximum level of interference at a frequency resolution of approximately 1 %.

5.4.3 Test of the influence of supply voltage on battery-powered density meters

The test of the influence of supply voltage is performed on battery-powered measuring instruments at supply voltage adjusted successively to $U_{max} = U_{bat.max}$ and $U_{min} = U_{bat.min}$ for density meters, where $U_{bat.min}$ is the lowest operating voltage of the battery as specified by the density meter supplier for ambient temperature 20 °C, and $U_{bat.max}$ is the voltage of a new battery at zero load.

During this test, the density meter operate as designed within the maximum permissible error specified in Article 2.3.

5.6.4 Tests of immunity to AC supply voltage limit values

Immunity to AC supply voltage limit values is tested with the density meter switched on at the lowest specified voltage, at nominal voltage and at the highest specified voltage at nominal frequency.

5.6.7 Immunity to short supply voltage dips and interruptions

The density meter's immunity to supply voltage dips is tested at nominal supply voltage.

The supply voltage is reduced to 75 % of the nominal supply voltage for 5 seconds. In order to rule out transients, the ramp-up period should not be shorter than 100 ms.

For DC-powered devices, the interruption must last 5 ms, 20 ms, 100 ms, and 500 ms.

For AC-powered devices, dips always begin when the voltage passes through its zero point, sequentially before both the positive and negative cycle. The interruptions must last for 1, 5, 10, and 25 AC voltage cycles. The supply voltage is reduced to 0 %, 40 % and 75 %.

5.6.8 Immunity to electrical fast transients/bursts

The density meter's immunity to electrical fast transients/bursts is tested with the density meter switched on, using the following voltages:

±2(1) kV on the AC supply voltage terminals;

±2(1) kV on the DC supply voltage terminals, lines longer than 3 m;

±1(0.5) kV on terminals for signal, data, and control lines longer than 3 m;

±2(1) kV on terminals for signal, data, and control cables that can be connected directly to power grids, lines longer than 3 m.

The pulse repetition frequency is 5 kHz, the burst repetition interval is 300 ms and the total duration of the test for each of the inputs and one pulse polarity is at least one minute.

The density meter’s indication is monitored during testing.

5.6.9 Immunity to surges

The density meter’s immunity to surges is tested with the density meter switched on with a surge of t_r/t_h = 1.2/50 µs and a voltage of:

±2(1) kV line to earth and ±1(0.5) kV line-to-line on AC supply voltage lines longer than 3 m;

±2(1) kV line to earth and ±1(0.5) kV line-to-line on DC supply voltage lines;

±1 kV asymmetric on signal, data and control lines longer than 30 m not directly connected to the power grid,

±2(1) kV line to earth and ±1(0.5) kV line-to-line for signal, communication and control lines longer than 30 m that are directly connected to the power grid.

All lower levels of the tested voltage are always tested.

The density meter’s input level must be set so that its output level is at 50 % of the output signal’s range. The density meter’s output signal is monitored during testing.

5.6.10 Immunity to conducted disturbances induced by high-frequency fields

The density meter's resistance to conducted disturbances induced by high-frequency fields is tested when it is switched on, over a frequency range of 150 kHz to 80 MHz, with an open-circuit test voltage of 3 V. The disturbance is applied to:

- AC or DC power lines;
- signal, data, and control lines longer than 3 m not directly connected to the power grid;
- signal, data, and control lines longer than 3 m directly connected to the power grid;

The density meter’s input level must be set so that its output level is at 50 % of the output signal’s range. The density meter’s output signal is monitored during testing.

5.4.4 Immunity to power-frequency magnetic fields

Long-term immunity to power-frequency magnetic fields is tested with the density meter switched on in a 30 A/m magnetic field. The density meter must be exposed to the field consecutively along all three basic axes.

6 Initial verification

Taking the intended use of the density meter into account, for the tests specified in points 6.2 and 6.3, it is possible to carry out an initial verification within a narrower (limited) range than that specified by the manufacturer or than the type-approved measurement range.
During verification, the density meter is subject to the requirements applicable at the time it was put into circulation.

6.1 Visual inspection

The purpose of the visual inspection is to check that:

a) the density meter submitted for verification conforms to the approved type;
b) the density meter is complete and undamaged;
c) the markings and inscriptions are complete, correct and legible, and in accordance with the approved measuring instrument type;
d) the installed software version conforms to the version specified by the manufacturer and in conformity with the approved measuring instrument type.

If the density meter fails to meet visual inspection requirements, no further tests are performed.

6.2 Temperature measurement test

The test of temperature variation between the displayed temperature and the actual temperature of the sample is carried out either by direct comparison of the temperature sensor with a suitable temperature reference standard or by an indirect method using reference fluids of known density values and a coefficient of cubic thermal expansion within the tested range (e.g. distilled water).

For density meters with sample temperature control, the direct comparison method is carried out by placing a suitable temperature standard inside the measuring cell as close as possible to the point where the temperature sensor of the density meter connects to the measuring cell. For density meters without sample temperature control, the reference standard is placed in a climatic chamber together with the density meter being tested.

The test is carried out at a minimum of three temperature points, taking into account the width of the temperature range (if applicable). The test points are chosen as close as possible to the lower and upper limit and centre of the temperature range. However, if a laboratory density meter with sample temperature control is only used to measure density at reference temperatures (i.e. 15 °C and/or 20 °C), the test is limited to these temperature points only.

6.3 Density measurement test

The test is carried out in accordance with point 5.2.3 of this Measure, with the wording of point 5.2.3.3 amended as follows:

Liquid density measurement test

Each test is related to the currently set constants of the instrument and is bound to these constants.

The density measurement accuracy test is carried out either using reference liquids with known density values within the required temperature and density range or by direct comparison with a reference density meter using suitable test liquids.

As far as possible, test liquids are selected so that their properties are as close as possible to the intended use for which the density meter is approved.

The density meter is tested at a minimum of five points, evenly distributed across the entire approved density measurement range. Outermost points as close as possible to the lower and upper limits of the density measurement range are selected. The position of the points depends on the reference fluids

chosen and on the temperature and pressure. For narrow ranges, this number of points may be reduced. At each point, tests are carried out at temperatures as close as possible to the lower and upper limits of the temperature range and at the mid-point of the temperature range, taking into account the width of the temperature range (where applicable).

However, if a laboratory density meter with sample temperature control is only used to measure density at reference temperatures (i.e. 15 °C and/or 20 °C), the test is limited to these temperature points only.

The density is measured three times at each test point. The calculated mean value is the result of the measurement at the test point. The deviation of the mean value from the reference density of the test liquid at any test point must not exceed the respective maximum permissible error for the type of density meter.

7 Subsequent verification

During verification, the density meter is subject to the requirements applicable at the time it was put into circulation.

The verification of the measuring instrument is carried out in accordance with Chapter 6.

8 Measuring instrument testing

When checking measuring instruments pursuant to § 11a of the Metrology Act at the request of a person who may be affected by incorrect measurement, the procedure under Chapter 6 is followed, except for the last sentence of Article 6.1.

A check is always carried out if the integrity of the measuring instrument is ensured and its technical condition allows it.

Maximum permissible errors 1.5 times the maximum permissible error specified in Table 2 shall apply.

9 Notified standards

For the purposes of specifying the metrological and technical requirements for measuring instruments and specifying the testing methods for their type approval and verification arising from this Measure of a General Nature, the CMI shall notify Czech technical standards, other technical standards or technical documents of international or foreign organisations, or other technical documents containing more detailed technical requirements (hereinafter ‘notified standards’). The CMI will publish a list of these notified standards associated with the relevant measure, together with the measure of a general nature, in a manner accessible to the public (at www.cmi.cz).

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

Compliance with a notified standard is one of the ways to demonstrate compliance. These requirements may also be met by using another technical solution guaranteeing an equivalent or higher level of protection of legitimate interests.

II.

G R O U N D S

Pursuant to § 14(1)(j) of the Metrology Act, for the implementation of § 6(2), § 9(1) and (9) and § 11a(3) thereof, the CMI has issued this Measure of a General Nature laying down metrological and technical requirements for specified measuring instruments and tests for their type approval and verification – 'laboratory oscillation-type density meters with sample temperature control or automatic temperature correction'.

Decree No 345/2002 laying down measuring instruments for mandatory verification and measuring instruments subject to type approval, as amended, classifies the given measuring instruments under item 8.1.6 in the annex 'Second type list of specified measuring instruments' as measuring instruments subject to type approval and verification.

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

Director General