INTERNATIONAL STANDARD

ISO 2811-2

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Paints and varnishes — Determination of density —

Part 2:
Immersed body (plummet) method

Peintures et vernis — Détermination de la masse volumique —
Partie 2: Méthode par immersion d'un corps (plongeur)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 2811-2 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

Together with the other parts, this part of ISO 2811 cancels and replaces ISO 2811:1974, which has been technically revised.

ISO 2811 consists of the following parts, under the general title *Paints and varnishes — Determination of density*:

— *Part 1: Pyknometer method*

— *Part 2: Immersed body (plummet) method*

— *Part 3: Oscillation method*

— *Part 4: Pressure cup method*

Annex A forms an integral part of this part of ISO 2811. Annex B is for information only.

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Paints and varnishes — Determination of density —

Part 2:
Immersed body (plummet) method

1 Scope

This part of ISO 2811 is one of a series of standards dealing with the sampling and testing of paints, varnishes and related products.

It specifies a method for determining the density of paints, varnishes and related products using balls or other round bodies as immersion bodies (plummets).

The method is limited to materials of low or medium viscosity, and is particularly suitable for production control.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 2811. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 2811 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1512:1991, *Paints and varnishes — Sampling of products in liquid or paste form.*

ISO 1513:1992, *Paints and varnishes — Examination and preparation of samples for testing.*

3 Definition

For the purposes of this part of ISO 2811, the following definition applies.

3.1 density, ρ**:** The mass divided by the volume of a portion of a material, expressed in grams per millilitre (g/ml).

4 Principle

The method is based on Archimedes' principle. A container is filled with the product under test and placed on the analytical balance. The plummet is attached to a tripod and is immersed in the product under test. The density is calculated from the balance readings before the plummet is immersed in the material under test and after it is immersed.

5 Temperature

The effect of temperature on density is highly significant with respect to filling properties, and varies with the type of product.

For international reference purposes, it is essential to standardize one test temperature, and (23 ± 0,5) °C is specified in this part of ISO 2811. However, it may be more convenient to carry out comparative testing at some other agreed temperature, for example (20 ± 0,5) °C as specified by relevant weights and measures legislation (see also annex B, clause B.2).

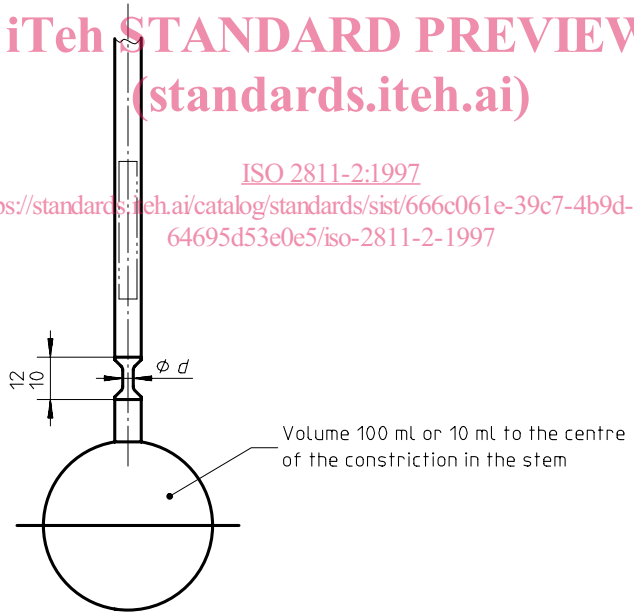
The test sample and plummet shall be conditioned to the specified or agreed temperature, and it shall be ensured that the temperature variation does not exceed 0,5 °C during testing.

6 Apparatus

Ordinary laboratory apparatus and glassware, together with the following:

6.1 Plummets, of non-corrodible metal, e.g. copper-zinc alloy (brass), stainless steel or aluminium, as illustrated in figure 1. The type illustrated is available with a volume of 10 ml or 100 ml.

Dimensions in millimetres



d = 3 mm for the 100 ml plummet
d = 1 mm for the 10 ml plummet

Figure 1 — Plummet

Each plummet shall be marked with its volume, the reference temperature and the surface tension and density of the reference liquid in the following form:

100 ml 23 °C 25 mN/m 1,2 g/ml

Analytical balance, accurate to 10 mg.

6.3 Thermometer, accurate to 0,2 °C and graduated at intervals of 0,2 °C or finer.

6.4 Temperature-controlled chamber, capable of accommodating the balance, plummet and sample and maintaining them at the specified or agreed temperature (see clause 5).

6.5 Tripod or other suitable device, for suspending the plummet and accurately adjusting its depth of immersion.

7 Sampling

Take a representative sample of the product to be tested, as described in ISO 1512. Examine and prepare the sample as described in ISO 1513.

8 Procedure

8.1 General

Carry out the determination in duplicate, each time on a fresh test sample.

The volume of the plummet shall be checked at regular intervals, e.g. after about 100 measurements or if any changes are noticed in the plummet (see annex A).

8.2 Determination

8.2.1 Selection of procedure

There are two procedures, one for all normal paints and one for those products containing fast-evaporating solvents.

8.2.2 Normal procedure

Ensure the plummet (6.1) is thoroughly clean before use. Place the plummet and the test sample next to the balance (6.2) in the temperature-controlled chamber (6.4) for approximately 30 min.

Place a sufficient volume of the test sample in a vessel of suitable size and capacity, e.g. 400 ml for a 100 ml plummet and 100 ml for a 10 ml plummet.

Using the thermometer (6.3), measure the temperature of the test sample. Check throughout the determination that the temperature of the chamber remains within the specified limits.

Place the vessel plus test sample on the balance and record the mass m_1 (uncorrected for buoyancy) to the nearest 10 mg. Clamp the plummet onto the tripod (6.5) in such a way that it can be immersed in the sample without touching the sides of the vessel (see figure 2).

Immerse the plummet in the sample until the surface of the liquid reaches the middle of the constriction in the plummet stem and record the mass m_2 to the nearest 10 mg.

NOTE — If the balance is tared between weighings, mass $m_1 = 0$.

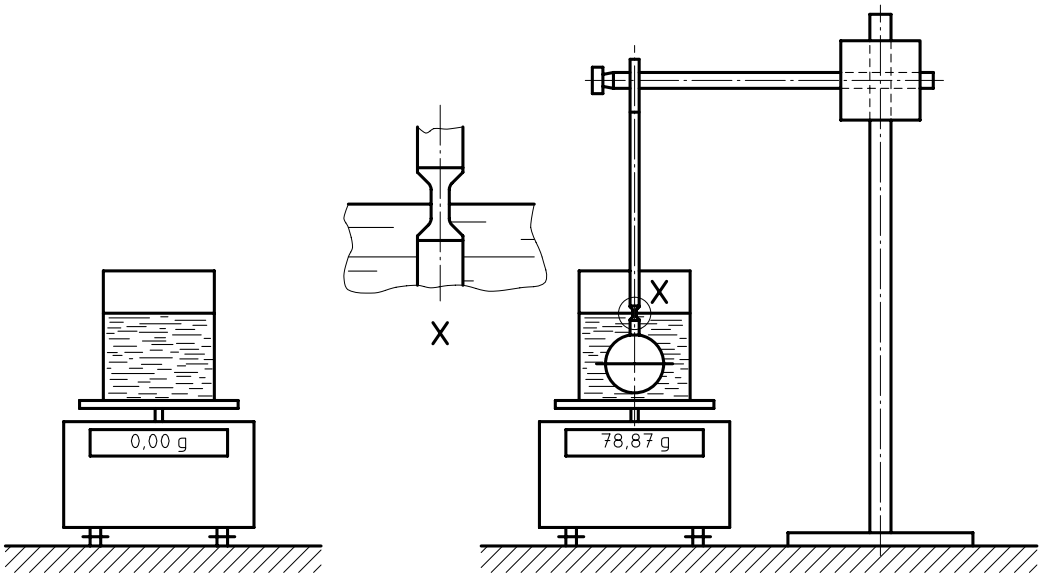


Figure 2 — Determination of density by the plummet method

8.2.3 Paints containing fast-evaporating solvents

Ensure that the plummet (6.1) is thoroughly clean before use. Place the plummet and the test sample next to the balance (6.2) in the temperature-controlled chamber (6.4) for approximately 30 min.

Using the thermometer (6.3), measure the temperature t_T of the test sample. Check throughout the determination that the temperature of the chamber remains within the specified limits.

Place a vessel of suitable size, containing a sufficient volume of test sample, on a laboratory jack.

Clamp the plummet onto a retort stand and place the stand on the balance in such a way that the plummet can be immersed in the sample by raising the laboratory jack without the plummet touching the sides of the vessel. Record the mass m_2

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The formula given in clause 9 can be used to calculate the density, except that m_1 and m_2 are as follows:

m_1 is the mass of the retort stand and plummet after immersion of the plummet in the sample;

m_2 is the mass of the retort stand and plummet before immersion of the plummet.

9 Calculation

Calculate the density ρ of the sample, in grams per millilitre, at the test temperature t_T using the following equation:

$$\rho = \frac{m_2 - m_1}{V_t}$$

where

m_1 is the mass, in grams, of the vessel containing the sample before immersion of the plummet;

m_2 is the mass, in grams, of the vessel after immersion of the plummet;

V_t is the volume, in millilitres, of the plummet up to the middle of the constriction in the stem at the test temperature t_T, determined in accordance with annex A.

NOTE — The result is not corrected for air buoyancy because the uncorrected value is required by most filling-machine control procedures and the correction (0,001 2 g/ml) is negligible in relation to the precision of the method.

If the test temperature used is not the reference temperature, then the density can be calculated using the equation in annex B, clause B.2.

10 Precision

10.1 General

The precision of the method depends on the characteristics of the product to be tested. For materials which contain no entrapped air, the following values are valid:

10.2 Repeatability (r)

The value below which the absolute difference between two single test results, each the mean of duplicates, obtained on identical material by one operator in one laboratory within a short interval of time using the standardized test method may be expected to lie with a 95 % probability is 0,002 g/ml.

10.3 Reproducibility (R)

The value below which the absolute difference between two test results, each the mean of duplicates, obtained on identical material by operators in different laboratories using the standardized test methods may be expected to lie with a 95 % probability is 0,004 g/ml.

NOTE — These figures are taken from DIN 53217-3:1991, *Determination of density of paints, varnishes and similar coating materials by the displacement float method*.

11 Test report

The test report shall include at least the following information:

a) all details necessary to identify the product tested;

b) a reference to this part of ISO 2811 (i.e. ISO 2811-2);

c) the type of plummet used and its volume (e.g. 100 ml ball);

d) the test temperature;

e) the result of each density measurement and the mean, rounded to the nearest 0,001 g/ml;

f) any deviation from the test method specified;

g) the date of the test.

Annex A
(normative)

Calibration of plummet

A.1 Procedure

Clean the plummet thoroughly with a suitable solvent which does not leave a residue on evaporation.

Place the plummet and the liquid to be used for the determination of its volume next to the balance in the temperature-controlled chamber for approximately 30 min. Use a liquid of density similar to that of the paint products to be examined using the plummet. Pour a sufficient amount of the liquid into a suitable vessel, e.g. a 400 ml beaker for 100 ml plummets or a 100 ml beaker for 10 ml plummets.

Using the thermometer, measure the temperature of the liquid. Check throughout the determination that the temperature of the chamber remains within the specified limits.

Place the vessel plus liquid on the balance and record the mass m_1 to the nearest 10 mg. Clamp the plummet onto the tripod in such a way that it can be immersed in the liquid without touching the sides of the vessel (see figure 2).

Immerse the plummet in the liquid until the surface of the liquid reaches the middle of the constriction in the plummet stem and record the mass m_2.

Immediately after the second weighing measure the temperature of the liquid. It is this temperature which is taken as the calibration temperature.

NOTE — Distilled water can be used as the calibration liquid, but it has the disadvantage that its surface tension (72 mN/m) is higher than that of paints, varnishes and similar coating materials and their diluents. If water is used, a few drops of wetting agent are usually added to reduce the surface tension to about 30 mN/m to 40 mN/m. Alternatively, an organic solvent with a surface tension in the above range and whose density has been determined precisely using a glass pyknometer can be used.

A.2 Determination of volume of plummet

Calculate the volume V_t, in millilitres, of the plummet using the following equation:

$$V_t = \frac{m_2 - m_1}{\rho_C}$$

where

m_1 is the mass, in grams, of the vessel containing the liquid before immersion of the plummet;

m_3 is the mass, in grams, of the vessel after immersion of the plummet;

ρ_C is the density, in grams per millilitre, of the calibration liquid.

Annex B
(informative)

Temperature variation

B.1 Correction for thermal expansion of the plummet

If the test temperature t_T differs by more than 5 °C from the temperature at which the volume of the plummet is known, then the density should preferably be corrected for the change in volume of the plummet.

Calculate, to five significant figures, the volume V_t, in millilitres, of the plummet at the test temperature using the following equation:

$$V_t = V_C \left[1 + \gamma_P \left(t_T - t_C\right)\right]$$

where

V_C is the volume, in millilitres, of the plummet at the calibration temperature t_C;

t_T is the test temperature, in degrees Celsius;

t_C is the calibration temperature, in degrees Celsius;

γ_P is the volume coefficient of thermal expansion, in reciprocal degrees Celsius ($°C^{-1}$), of the material from which the plummet is made (see table B.1).

Table B.1 — Coefficient of thermal expansion γ_P of materials used for plummets

Material	γ_P $°C^{-1}$
Copper-zinc alloy (brass)	54×10^{-6} [value for CuZn37 (Ms63)]
Austenitic stainless steel	48×10^{-6}
Aluminium	69×10^{-6}

B.2 Calculation of density at the reference temperature from measurements at other temperatures

If the density of the product under test is determined at a temperature different from the reference temperature the density ρ_C, in grams per millilitre, at the reference temperature can be calculated as follows:

$$\rho_C = \frac{\rho_t}{\left[1 + \gamma_m\left(t_C - t_T\right)\right]} = \rho_t\left[1 - \gamma_m\left(t_C - t_T\right)\right]$$

where

t_C is the reference temperature, in degrees Celsius;

t_T is the test temperature, in degrees Celsius;

γ_m is the volume coefficient of thermal expansion of the product under test, the approximate value of γ_m being 2×10^{-4} °C^{-1} for waterborne paints and 7×10^{-4} °C^{-1} for other paints;

ρ_t is the density, in grams per millilitre, of the product at the test temperature.