INTERNATIONAL STANDARD

ISO 2811-3

Second edition
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Paints and varnishes — Determination of density —

Part 3: Oscillation method

Peintures et vernis — Détermination de la masse volumique —

Partie 3: Méthode par oscillation

Reference number
ISO 2811-3:2011(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 2811-3 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

This second edition cancels and replaces the first edition (ISO 2811-3:1997), which has been technically revised.

The main changes are:

a) The unit for the density has been changed from grams per millilitre to grams per cubic centimetre, because this is the more common SI unit.

b) The determination in duplicate has been changed to a single determination.

c) The precision data has been corrected.

d) The normative references have been updated.

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*

Paints and varnishes — Determination of density —

Part 3: Oscillation method

1 Scope

This part of ISO 2811 specifies a method for determining the density of paints, varnishes and related products using an oscillator.

The method is suitable for all materials, including paste-like coatings. If a pressure-resistant type of apparatus is used, the method is also applicable to aerosols.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1513, *Paints and varnishes — Examination and preparation of test samples*

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

ISO 15528, *Paints, varnishes and raw materials for paints and varnishes — Sampling*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
density
ρ
mass divided by the volume of a portion of a material

NOTE This is expressed in grams per cubic centimetre.

4 Principle

A glass or stainless-steel U-tube is filled with the product under test. The tube is clamped at both ends and then subjected to oscillation. The resonance frequency of the filled tube varies with the mass contained in the tube, i.e. the density of the product under test.

5 Temperature

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

Carry out the test at (23,0 ± 0,5) °C.

NOTE For some purposes a different temperature, for example (20,0 ± 0,5) °C, might be needed.

The test sample, tube and oscillator 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 Oscillator, consisting of a glass or stainless-steel U-tube and apparatus to cause the U-tube to oscillate. One model displays the resonance frequency; another calculates and displays the density.

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

6.3 Temperature-controlled chamber, capable of maintaining the oscillator and test sample at the specified or agreed temperature (see Clause 5).

6.4 Disposable plastic syringe, of sufficient capacity to fill the U-tube.

7 Sampling

Take a representative sample of the product under test, as described in ISO 15528. Examine and prepare the sample as described in ISO 1513.

8 Procedure

8.1 General

Carry out a single determination on a fresh test sample.

8.2 Determination

Ensure that the apparatus is clean, both by inspection and by checking that the display indicates the density of air (or the corresponding period of oscillation at resonance).

Fill the U-tube with the product under test (about 2 cm^3) in accordance with the oscillator manufacturer's instructions (i.e. until the level is above the upper of the two clamps holding the U-tube). Avoid introducing air bubbles, which cause unsteady readings.

NOTE The presence of non-visible air bubbles becomes apparent due to the fact that the measured values vary considerably.

Close the upper filler-hole. Using the thermometer (6.2), check that the temperature of the temperature-controlled chamber is within the specified limits.

Start up and operate the oscillator in accordance with the manufacturer's instructions.

If using an apparatus which displays the period of oscillation at resonance, take at least three readings of the period of oscillation, T, and at least two of the temperature. The values of T shall not differ by more than 0,000 1 ms. If they do, make three more measurements.

If using an apparatus which displays the density directly, take at least three readings of the density and at least two of the temperature. The density values shall not differ by more than 0,000 2 g/cm^3. If they do, make three more measurements.

After the measurements, clean the apparatus in accordance with the manufacturer's instructions. It is essential to leave it clean and dry, and to check that the display indicates the density of air (or the corresponding period of oscillation).

9 Calculation

If the period of oscillation, T, has been read, calculate the density, ρ, using Equation (1):

$$\rho = \frac{1}{\mathrm{A}} \times \left(T^2 - \mathrm{B} \right) \tag{1}$$

where A and B are two apparatus constants (see Annex A).

If the temperature used is not the reference temperature, the density can be calculated using Equation (C.1).

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 values in 10.2 and 10.3 are valid.

10.2 Repeatability limit, r

The value below which the absolute difference between two single test results, obtained on identical material by one operator in one laboratory using the same equipment within a short interval of time using the standardized test method, may be expected to lie, with a 95 % probability, is 0,001 g/cm^3.

10.3 Reproducibility limit, R

The value below which the absolute difference between two test results, obtained on identical material by operators in different laboratories using the standardized test method, may be expected to lie, with a 95 % probability, is 0,002 g/cm^3.

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 2811-3:2011;

c) the type (model) of apparatus used;

d) the test temperature;

e) the density measurement determined in accordance with 8.2, or the density calculated in accordance with Clause 9, in grams per cubic centimetre, rounded to the nearest 0,001 g/cm^3;

f) any deviation from the test method specified;

g) any unusual features (anomalies) observed during the test;

h) the date of the test.

Annex A
(normative)

Calibration of the apparatus — Determination of the apparatus constants

A.1 General

If using an apparatus which displays the period of oscillation at resonance, the apparatus constants need to be determined for use in Equation (A.1). If using an apparatus which displays the density directly, the constants are entered into the memory of the data-processing unit of the apparatus.

The apparatus constants have to be determined and regularly checked by the user. They are usually obtained by measurements in air and in distilled or deionized water of at least grade 2 purity, as defined in ISO 3696.

A.2 Procedure

Make several measurements with air and water over a period of several minutes in each case, as described in 8.2. If the values obtained are not constant, repeat the measurements.

The apparatus constants are valid only at temperatures which do not differ from the temperature, t_T, at which they were determined by more than 0,5 °C. For other test temperatures, the constants shall be determined again.

The apparatus constants shall be determined at the beginning of each series of measurements and checked at the end.

NOTE Differences can occur in the period of oscillation due to the presence of impurities.

A.3 Calculation of apparatus constants

Calculate the mean values of the period of oscillation for water, T_W, and for air, T_A. Use these mean values to calculate the two apparatus constants, A and B, as given by Equation (A.1):

$$\rho = \frac{1}{A} \times \left(T^2 - B \right) \qquad \text{(A.1)}$$

Annex B
(informative)

Density values for damp air, air-free water and tetrachloroethylene

Table B.1 — Density of damp air

Temperature	Pressure mbar								Relative humidity
	900	920	940	960	980	1 000	1 013,25	1 050	
°C	Density ρ_A g/cm^3								%
15	0,001 08	0,001 11	0,001 13	0,001 15	0,001 18	0,001 20	0,001 22	0,001 26	89
20	0,001 06	0,001 09	0,001 11	0,001 13	0,001 16	0,001 18	0,001 20	0,001 24	65
25	0,001 05	0,001 07	0,001 09	0,001 12	0,001 14	0,001 16	0,001 18	0,001 22	48
30	0,001 03	0,001 05	0,001 07	0,001 10	0,001 12	0,001 14	0,001 16	0,001 20	35,8
35	0,001 01	0,001 03	0,001 06	0,001 08	0,001 10	0,001 12	0,001 14	0,001 18	27
40	0,001 00	0,001 02	0,001 04	0,001 06	0,001 08	0,001 11	0,001 12	0,001 16	20,6
45	0,000 98	0,001 00	0,001 02	0,001 05	0,001 07	0,001 09	0,001 10	0,001 14	15,9
50	0,000 96	0,000 99	0,001 01	0,001 03	0,001 05	0,001 07	0,001 09	0,001 13	12,3

Table B.2 — Density of pure, air-free water

Temperature t °C	Density ρ_W g/cm^3	Temperature t °C	Density ρ_W g/cm^3	Temperature t °C	Density ρ_W g/cm^3
10	0,999 7	22	0,997 77	25	0,997 04
11	0,999 6				
12	0,999 5	22,1	0,997 75	25,1	0,997 02
13	0,999 38	22,2	0,997 72	25,2	0,996 99
14	0,999 24	22,3	0,997 7	25,3	0,996 97
15	0,999 1	22,4	0,997 68	25,4	0,996 94
16	0,998 94	22,5	0,997 65	25,5	0,996 91
17	0,998 77	22,6	0,997 63	25,6	0,996 89
18	0,998 59	22,7	0,997 61	25,7	0,996 86
19	0,998 4	22,8	0,997 58	25,8	0,996 83
		22,9	0,997 56	25,9	0,996 81
20	0,998 2	23	0,997 54	26	0,996 78
				27	0,996 51
20,1	0,998 18	23,1	0,997 51	28	0,996 23
20,2	0,998 16	23,2	0,997 49	29	0,995 94
20,3	0,998 14	23,3	0,997 46	30	0,995 65
20,4	0,998 12	23,4	0,997 44	31	0,995 34
20,5	0,998 1	23,5	0,997 42	32	0,995 02
20,6	0,998 08	23,6	0,997 39	33	0,994 7
20,7	0,998 05	23,7	0,997 37	34	0,994 37
20,8	0,998 03	23,8	0,997 34	35	0,994 03
20,9	0,998 01	23,9	0,997 32		
21	0,997 99	24	0,997 29	36	0,993 68
				37	0,993 33
21,1	0,997 97	24,1	0,997 27	38	0,992 96
21,2	0,997 95	24,2	0,997 24	39	0,992 59
21,3	0,997 92	24,3	0,997 22	40	0,992 21
21,4	0,997 9	24,4	0,997 19		
21,5	0,997 88	24,5	0,997 17		
21,6	0,997 86	24,6	0,997 14		
21,7	0,997 84	24,7	0,997 12		
21,8	0,997 81	24,8	0,997 09		
21,9	0,997 79	24,9	0,997 07		

Table B.3 — Density of tetrachloroethylene

Temperature t °C	Density ρ g/cm^3
0	1,655 8
15	1,631 1
20	1,622 8
25	1,614 6
30	1,606 4
35	1,598 3

Annex C
(informative)

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 cubic centimetre, at the reference temperature can be calculated using Equation (C.1):

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

where

ρ_t is the density, in grams per cubic centimetre, of the product at the test temperature;

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;

t_C is the reference temperature, in degrees Celsius;

t_T is the test temperature, in degrees Celsius.

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