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Plastics — Methods for determining the density of non-cellular plastics —

Part 1: Immersion method, liquid pycnometer method and titration method

Plastiques — Méthodes de détermination de la masse volumique des plastiques non alvéolaires —
Partie 1: Méthode par immersion, méthode du pycnomètre en milieu liquide et méthode par titrage

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 5, *Physical-chemical properties*.

This third edition cancels and replaces the second edition (ISO 1183-1:2012), which has been technically revised. The main changes compared to the previous edition are as follows:

— the buoyancy correction has been revised.

A list of all parts in the ISO 1183 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This corrected version of ISO 1183-1:2019 incorporates the following corrections:

— correction of the definition of Formula (2).

Plastics — Methods for determining the density of non-cellular plastics —

Part 1: Immersion method, liquid pycnometer method and titration method

WARNING — The use of this document might involve hazardous materials, operations or equipment. This document does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this document to establish appropriate health and safety practices.

1 Scope

This document specifies three methods for the determination of the density of non-cellular plastics in the form of void-free moulded or extruded objects, as well as powders, flakes and granules.

— Method A: Immersion method, for solid plastics (except for powders) in void-free form.

— Method B: Liquid pycnometer method, for particles, powders, flakes, granules or small pieces of finished parts.

— Method C: Titration method, for plastics in any void-free form.

NOTE Density is frequently used to follow variations in physical structure or composition of plastic materials. Density can also be useful in assessing the uniformity of samples or specimens. Often, the density of plastic materials depend upon the choice of specimen preparation method. When this is the case, precise details of the specimen preparation method are intended to be included in the appropriate material specification. This note is applicable to all three methods.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 472, *Plastics — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 472 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
mass
m
quantity of matter contained in a body

Note 1 to entry: It is expressed in kilograms (kg) or grams (g).

3.2
apparent mass
m_{APP}
mass of a body obtained by measuring its weight using an appropriately calibrated balance

Note 1 to entry: It is expressed in kilograms (kg) or grams (g).

3.3
density
ρ
ratio of the mass *m* of a sample to its volume *V* (at the temperature *T*), expressed in kg/m^3, kg/dm^3 (g/cm^3) or kg/l (g/ml)

Note 1 to entry: The following terms, based upon ISO 80000-4[1], are given in Table 1 for clarification.

Table 1 — Density terms

Term	Symbol	Formulation	Units
Density	ρ	m/V	kg/m^3 kg/dm^3 (g/cm^3) kg/l (g/ml)
Specific volume	v	V/m (= $1/\rho$)	m^3/kg dm^3/kg (cm^3/g) l/kg (ml/g)

4 Conditioning

The test atmosphere shall be in accordance with ISO 291. In general, conditioning specimens to constant temperature is not required, because the determination itself brings the specimen to the constant temperature of the test.

Specimens which change in density during the test to such an extent that the change is greater than the required accuracy shall be conditioned prior to measurement in accordance with the applicable material specification. When changes in density with time or atmospheric conditions are the primary purpose of the measurements, the specimens shall be conditioned as described in the material specification and, if no material specification exists, then as agreed upon by the interested parties.

5 Methods

5.1 Method A — Immersion method

5.1.1 Apparatus

5.1.1.1 Analytical balance or **instrument specifically designed for measurement of density**, accurate to ±0,1 mg.

An automatically operating instrument may be used. The calculation of density may be done automatically using a computer or software integrated into the analytical balance.

5.1.1.2 Immersion vessel: a beaker or other wide-mouthed container of suitable size for holding the immersion liquid.

5.1.1.3 Stationary support, e.g. a pan straddle, to hold the immersion vessel above the balance pan.

5.1.1.4 Thermometer, graduated at 0,1 °C intervals, covering the range 0 °C to 30 °C.

5.1.1.5 Wire (if required), corrosion-resistant, of diameter not greater than 0,5 mm, for suspending specimens in the immersion liquid.

5.1.1.6 Sinker, of suitable mass to ensure complete immersion of the specimen, for use when the density of the specimen is less than that of the immersion liquid.

5.1.1.7 Pycnometer, with a side-arm overflow capillary, for determining the density of the immersion liquid when this liquid is not water. The pycnometer shall be equipped with a thermometer graduated at 0,1 °C intervals from 0 °C to 30 °C.

5.1.1.8 Liquid bath, capable of being thermostatically controlled to within ±0,5 °C, for use in determining the density of the immersion liquid.

5.1.2 Immersion liquid

Use freshly distilled or deionized water, or another suitable liquid, containing not more than 0,1 % of a wetting agent to help in removing air bubbles. The liquid or solution with which the specimen comes into contact during the measurement shall have no effect on the specimen.

The density of immersion liquids other than distilled water need not be measured provided they are obtained from an accredited source and are accompanied by a certificate.

5.1.3 Specimens

Specimens may be in any void-free form except for powder. They shall be of a convenient size to give adequate clearance between the specimen and the immersion vessel and should preferably have a mass of at least 1 g.

When cutting specimens from larger samples, proper equipment shall be used to ensure that the characteristics of the material do not change. The surface of the specimen shall be smooth and free from cavities to minimize the entrapment of air bubbles upon immersion in the liquid, otherwise errors will be introduced.

5.1.4 Procedure

5.1.4.1 Weigh the specimen, to the nearest 0,1 mg, in air while suspended with a wire of maximum diameter 0,5 mm. Record the mass of the specimen.

5.1.4.2 Immerse the specimen, still suspended by the wire, in the immersion liquid (5.1.2), contained in the immersion vessel (5.1.1.2) on the support (5.1.1.3). The temperature of the immersion liquid shall be 23 °C ± 2 °C (or 27 °C ± 2 °C). Remove any adhering air bubbles with a fine wire. Weigh the immersed specimen to the nearest 0,1 mg.

If the measurement is carried out in a temperature-controlled room, the temperature of the whole apparatus, including the immersion liquid, shall be within the range 23 °C ± 2 °C (or 27 °C ± 2 °C).

5.1.4.3 If necessary, determine the density of immersion liquids other than water as follows. Weigh the pycnometer (5.1.1.7) empty and then containing freshly distilled or deionized water at a temperature of 23 °C ± 0,5 °C (or 27 °C ± 0,5 °C). Weigh the same pycnometer, after cleaning and drying, filled with the

immersion liquid [also at a temperature of 23 °C ± 0,5 °C (or 27 °C ± 0,5 °C)]. Use the liquid bath (5.1.1.8) to bring the water and immersion liquid to the correct temperature. Calculate the density, ρ_{IL}, in grams per cubic centimetre, of the immersion liquid at 23 °C (or 27 °C), using Formula (1):

$$\rho_{IL} = \frac{m_{IL}}{m_W} \times \rho_W \quad (1)$$

where

m_{IL} is the mass of the immersion liquid, in g;

m_W is the mass of the water, in g;

ρ_W is the density of water at 23 °C (or 27 °C), in g/cm^3.

5.1.4.4 Calculate the density, ρ_S, in grams per cubic centimetre, of the specimen at 23 °C (or 27 °C), using Formula (2):

$$\rho_S = \frac{m_{S,A} \times \rho_{IL}}{m_{S,A} - m_{S,IL}} \quad (2)$$

where

$m_{S,A}$ is the apparent mass of the specimen in air, in g;

$m_{S,IL}$ is the apparent mass of the specimen in the immersion liquid, in g;

ρ_{IL} is the density of the immersion liquid at 23 °C (or 27 °C) as stated by the supplier or determined as specified in 5.1.4.3, in g/cm^3.

For specimens having a density below that of the immersion liquid, the test may be performed in exactly the same way as described above, with the following exception: a sinker of lead or other dense material is attached to the wire, such that the sinker rests below the liquid level, as does the specimen, during immersion. The sinker may be considered a part of the suspension wire. In this case, the uplift exerted by the immersion liquid on the sinker shall be allowed for by using Formula (3), rather than Formula (2), to calculate the density of the specimen:

$$\rho_S = \frac{m_{S,A} \times \rho_{IL}}{m_{S,A} + m_{K,IL} - m_{S+K,IL}} \quad (3)$$

where

$m_{K,IL}$ is the apparent mass of the sinker in the immersion liquid, in g;

$m_{S+K,IL}$ is the apparent mass of the specimen and sinker in the immersion liquid, in g.

The buoyancy of the suspension wire in air is normally considered to be negligible, but, for correction for air buoyancy, see Clause 6.

5.1.4.5 Perform the test on a minimum of three specimens and calculate the mean result to three decimal places.

5.2 Method B — Liquid pycnometer method

5.2.1 Apparatus

5.2.1.1 **Balance**, accurate to ±0,1 mg.

5.2.1.2 Stationary support (5.1.1.3).

5.2.1.3 Pycnometer (5.1.1.7).

5.2.1.4 Liquid bath (5.1.1.8).

5.2.1.5 Dessicator, connected to a vacuum system.

5.2.2 Immersion liquid

As specified in 5.1.2.

5.2.3 Specimens

Specimens of powders, granules or flakes shall be measured in the form in which they are received. The specimen mass shall be in the range of 1 g to 5 g.

5.2.4 Procedure

5.2.4.1 Weigh the pycnometer (5.2.1.3) empty and dry. Weigh a suitable quantity of the plastic material in the pycnometer. Cover the test specimen with immersion liquid (5.2.2) and remove all the air by placing the pycnometer in the desiccator (5.2.1.5) and applying a vacuum. Break the vacuum and almost completely fill the pycnometer with immersion liquid. Bring it to constant temperature [23 °C ± 0,5 °C (or 27 °C ± 0,5 °C)] in the liquid bath (5.2.1.4) and then complete filling exactly to the limit of the capacity of the pycnometer.

Wipe dry and weigh the pycnometer with the specimen and immersion liquid.

5.2.4.2 Empty and clean the pycnometer. Fill it with deaerated distilled or deionized water, remove any remaining air as above, and determine the mass of the pycnometer and its contents at the temperature of test.

5.2.4.3 Repeat the process with the immersion liquid if an immersion liquid other than water was used, and determine its density as specified in 5.1.4.3.

5.2.4.4 Calculate the density ρ_S, in grams per cubic centimetre, of the specimen at 23 °C (or 27 °C), using Formula (4):

$$\rho_S = \frac{m_S \times \rho_{IL}}{m_1 - m_2} \tag{4}$$

where

m_S is the apparent mass of the specimen, in g;

m_1 is the apparent mass of the liquid required to fill the empty pycnometer, in g;

m_2 is the apparent mass of the liquid required to fill the pycnometer containing the specimen, in g;

ρ_{IL} is the density of the immersion liquid at 23 °C (or 27 °C) as stated by the supplier or determined as specified in 5.1.4.3, in g/cm^3.

5.2.4.5 Perform the test on a minimum of three specimens and calculate the mean result to three decimal places.