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

*Plastiques — Méthodes pour déterminer la masse volumique et la densité relative des
plastiques non alvéolaires*

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 1183 was prepared by Technical Committee ISO/TC 61, *Plastics*.

It cancels and replaces ISO Recommendation R 1183 : 1970, of which it constitutes a technical revision.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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

1 Scope and field of application

1.1 This International Standard specifies four methods for the determination of the density and relative density of non-cellular plastics in the form of sheet, film, tube, moulded objects, and moulding powders, granules and pellets.

— Method A

Immersion method for plastics in a finished condition, whether machined or otherwise formed (see 5.1.3), but not powders.

— Method B

Pyknometer method for plastics in the form of powder, granules, pellets, flake or moulded articles reduced to small particles.

— Method C

Titration method for plastics in forms similar to those required for method A, including pellets.

— Method D

Density gradient column method for plastics in forms similar to those required for method A, and including pellets. Density gradient columns are columns of liquid, the densities of which increase uniformly from top to bottom. They are particularly suited to measurement of small samples of products and to comparison of densities.

1.2 Density and relative density are used frequently, both to follow the variations in the physical structures of specimens and in calculation of the amount of material necessary to fill a given volume. Density is the preferred property relating the mass and volume of an object, specimen or material. These properties may also be useful in assessing uniformity among samples or specimens. These methods are designed to yield results accurate to at least 0,2 % without applying corrections for weighings in air, and to 0,05 % with such corrections.

1.3 Often the density of plastics will depend upon the methods employed in the preparation of test specimens. When this is the case, precise details of the methods of preparation shall be given; these are ordinarily included in the specifications for the material.

2 References

ISO 31-3, *Quantities and units of mechanics*.

ISO 291, *Plastics — Standard atmospheres for conditioning and testing*.

3 Definitions

3.1 density, ρ_t : The ratio of the mass of the sample to its volume V_t (at the temperature t), expressed in kilograms per cubic metre, grams per cubic centimetre or grams per millilitre.

Ordinarily, t will be one of the standard laboratory temperatures specified in ISO 291 (23 or 27 °C).

3.2 relative density: The ratio of the mass of a given volume of material at the temperature t_1 to that of an equal volume of a reference material at the temperature t_2 ; it is expressed as relative density, at t_1 and t_2 (symbol: $d_{t_2}^{t_1}$) where t is the temperature, in degrees Celsius.

Ordinarily, t will be one of the standard laboratory temperatures specified in ISO 291 (23 or 27 °C).

Relative density may also be defined as the ratio of the density of a substance to the density of a reference substance under conditions that are specified for both substances.

NOTES

1 When the reference substance is water, the English term "specific gravity" is often used instead of "relative density", and the French term "densité" instead of "densité relative".

Density at t_1 °C may be converted to specific gravity, using the equation

$$d_{t_2}^{t_1} = \frac{\rho_{S,t_1}}{\rho_{W,t_2}}$$

where

$d_{t_2}^{t_1}$ is the specific gravity of the sample;

ρ_{S,t_1} is the density, in grams per cubic centimetre, of the specimen, at temperature t_1 ;

ρ_{W,t_2} is the density, in grams per cubic centimetre, of water, at temperature t_2 ; values at some laboratory temperatures are as follows:

t	$\rho_{W,t}$
°C	g/cm ³
20	0,998 2
23 ¹⁾	0,997 6
27	0,996 5

The International Bureau of Weights and Measures should be consulted for exact relationships between density and specific gravity at other temperatures.

2 The following equivalent terms, based upon ISO 31-3, are given here for clarification.

English term	French term	Symbol	Formulation	Units
density (mass density)	masse volumique	ρ	$\frac{m}{V}$	kg/m ³ g/cm ³ g/ml
relative density	densité relative	d	$\frac{\rho_1}{\rho_2}$	dimensionless
specific volume	volume massique	v	$\frac{V}{m} = \frac{1}{\rho}$	m ³ /kg cm ³ /g ml/g

4 Conditioning

In general, conditioning specimens to constant temperature will not be required because the determination itself brings the specimen to the constant temperature of the test. Conditioning specimens to constant moisture content, on the other hand, may be required.

Specimens which change in density during the test to such an extent that it may exceed the accuracy required of the density determination shall be conditioned before measurement in accordance with the applicable material specifications. When changes in density with time or atmospheric conditions are the primary purpose of the measurements, the specimens shall be conditioned as agreed upon by the interested parties.

5 Methods

5.1 Method A

5.1.1 Apparatus

5.1.1.1 Balance, accurate to 0,1 mg.

5.1.1.2 Pan straddle or other stationary support.

5.1.1.3 Pyknometer, of, for example, 50 ml capacity, with side-arm overflow capillary, for determining the density of the immersion liquid when this liquid is not water. The pyknometer shall be equipped with a thermometer graduated in 0,1 °C from 0 to 30 °C.

5.1.1.4 Liquid bath, capable of being thermostatically controlled to within 0,1 °C.

5.1.2 Immersion liquids: Freshly distilled water or other 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 and shall not be absorbed by the specimen in any significant quantity.

5.1.3 Specimens

Specimens may consist of films, sheets, tubes, moulded objects, granules other than powder, or specimens taken from such forms with surfaces made smooth in an appropriate way to minimize the entrapment of air bubbles upon immersion in the liquid. The specimen shall be of any convenient size to give adequate clearance between the specimen and beaker (a mass of approximately 1 to 5 g is often convenient).

5.1.4 Procedure

5.1.4.1 Weigh the specimen suspended with a wire of diameter 0,125 mm or less²⁾.

5.1.4.2 Immerse the specimen, still suspended by the wire, in the immersion liquid (5.1.2), contained in a beaker on the pan straddle or other stationary support (5.1.1.2). The temperature of the immersion liquid shall be $t \pm 0,1$ °C, where t is 23 or 27 °C. Remove adhering air bubbles with a fine wire. It is convenient to mark the level of immersion, for example, by a shallow notch in the wire. Weigh the immersed specimen.

5.1.4.3 Determine the density of immersion liquids other than water. Weigh the pyknometer (5.1.1.3) empty and then containing freshly distilled water at temperature t . Weigh the same pyknometer, after cleaning and drying, filled with the immersion liquid (also at temperature t). Calculate the density ρ_{IL} of the immersion liquid, using the equation

$$\rho_{IL} = \frac{m_{IL}}{m_W} \times \rho_{W,t}$$

where

m_{IL} is the mass of the immersion liquid;

m_W is the mass of water;

$\rho_{W,t}$ is the density of water at temperature t .

5.1.4.4 Calculate the density $\rho_{S,t}$ of the specimen, using the equation

$$\rho_{S,t} = \frac{m_{S,A} \rho_{IL}}{m_{S,A} - m_{S,IL}}$$

where

$m_{S,A}$ is the mass, in grams, of the specimens in air;

1) Reference temperature: see ISO 291.

2) Such a fine wire renders corrections for the apparent loss in mass of the wire unnecessary.