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

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Descriptors : plastics, density measurement

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. Consequently **JIS K 7112 : 1980** is replaced with **JIS K 7112 : 1999**.

This revision has been prepared based on **ISO 1183 : 1987 *Plastics—Methods of determining the density and relative density of non-cellular plastics.***

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

Introduction This Japanese Industrial Standard has been prepared based on the first edition of **ISO 1183** *Plastics—Methods of determining the density and relative density of non-cellular plastics*, published in 1987, but a portion of the specifications (method 2 of 5.4.4.2.2) is added to meet the actual circumstances in Japan.

1 Scope

1.1 This 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, moulded articles reduced to small particles or liquid material.

Determination of density for liquid material is in accordance with annex 2.

— 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 Normative reference The following standards contains provisions which, through reference in this text, constitute provisions of this Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

ISO 31-3 *Quantities and units—Part 3 : Mechanics*

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

NOTE JIS K 7100 *Standard atmospheres for conditioning and testing of plastics*

3 Definitions For the purpose of this Standard, the following definitions apply.

- a) **density ρ_t** : The ratio of the mass of the sample to its volume V_t (at the temperature t), expressed in kg/m³, kg/dm³ (g/cm³) or kg/l (g/ml).
- b) **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 temperature specified in ISO 291 (23 °C 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”.

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

$$d_{t_2}^{t_1} = \frac{\rho_{s,t_1}}{\rho_{w,t_1}}$$

where,

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

ρ_{s,t_1} is the density of the specimen, at temperature t_1 [kg/dm³ (g/cm³)],

ρ_{w,t_1} is the density of the water, at temperature t_2 [kg/dm³ (g/cm³)], values at some laboratory temperatures are as follows:

Table 1 Example of water density

t °C	$\rho_{w,t}$ kg/dm ³ (g/cm ³)
20	0.998 20
23	0.997 54
25	0.997 04
27	0.996 51
30	0.995 65

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 in Table 2 for clarification.

Table 2 Terms and units

English term	Symbol	Formulation	Units
density (mass density)	ρ	$\frac{m}{V}$	kg/m ³ kg/dm ³ (g/cm ³) kg/l (g/ml)
relative density	d	$\frac{\rho_{s,t1}}{\rho_{w,t2}}$	dimensionless
specific volume	v	$\frac{V}{m} = \frac{1}{\rho}$	m ³ /kg dm ³ /kg (cm ³ /g) l/kg (ml/g)

4 Conditioning

4.1 Standard condition of test place The standard condition of test place shall, as a rule, be 23 °C ± 2 °C for the temperature of test room and relative humidity (50 ± 5) % in accordance with JIS K 7100, however, measuring temperature is allowed to be 25 °C when test room temperature is 23 °C by the agreement between the interested parties.

4.2 Conditioning of state of sample 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 (Immersion method)

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 pycnometer shall be equipped with a thermometer graduated in 0.1 °C from 0 °C 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 g 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 less.

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 23 °C ± 0.1 °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 pycnometer empty and then containing freshly distilled water at temperature t . Weigh the same pycnometer, 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 (g);

m_W is the mass of water (g);

$\rho_{W,t}$ is the density of water at temperature t (g/cm³).

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

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

where,

$m_{s,A}$ is the mass of the specimens in air (g);

$m_{s,IL}$ is the uncorrected mass of the specimens in the immersion liquids (g);