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Plastics — Acquisition and presentation of comparable single-point data —

Part 2: Long-fibre-reinforced plastics

Plastiques — Acquisition et présentation de caractéristiques intrinsèques comparables —

Partie 2: Plastiques renforcés par de longues fibres

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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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical behaviour*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 249, *Plastics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 10350-2:2011), which has been technically revised. The main change compared to the previous edition are as follows:

— normative reference IEC 60250 has been cancelled and replaced by IEC 62631-2-1;

— normative reference IEC 60093 has been cancelled and replaced by either IEC 62631-3-1 or ISO 3915.

These changes were made previously for plastics in ISO 10350-1.

A list of all parts in the ISO 10350 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.

Introduction

This document has been prepared because users of long-fibre-reinforced plastics find that available data cannot always be readily used to compare the properties of similar materials, especially when the data have been supplied by different sources. Even when the same standard tests have been used, they can allow the adoption of a wide range of alternative test conditions, and the data obtained are not necessarily comparable. The purpose of this document is to identify specific methods and conditions of test to be used for the acquisition and presentation of data in order that valid comparisons between materials can be made.

This document is concerned with tests employed to present "single-point" data on the limited range of properties commonly included in data sheets and used for the preliminary selection of materials. Such data represent the most basic approach to the specification of properties of materials and this document thus facilitates the first steps towards more efficient selection and use of plastics in the many applications to which they are suited.

Many properties of long-fibre-reinforced plastics are anisotropic. The test method standards for these properties have been produced with different procedures for specific types of reinforcement. In this document, use of the appropriate procedure is specified rather than the use of a specific specimen geometry as adopted in ISO 10350-1[1] for moulding materials. This is necessary for the recording of meaningful material property values.

Complementary International Standards (such as ISO 11403-1[2], ISO 11403-2[3] and ISO 11403-3[4]) are concerned with the standardized acquisition and presentation of multipoint data, to demonstrate how properties vary with important factors such as time, temperature and the presence of particular natural and chemical environments. In these International Standards, some additional properties are included. Their use provides a more substantial database than one containing only single-point data, and so enables improved assessment of the fitness of a material for any particular application. In addition, ISO 11403-1, which deals with mechanical properties, assists predictions of the performance of components and ISO 11403-2, covering thermal and processing properties, aids predictions of melt-flow behaviour during manufacturing. ISO 11403-3 is concerned with environmental influences on properties, and other parts may be prepared to cover additional properties. The various parts of ISO 11403 were written primarily for moulding materials. The test methods and test conditions referred to might not therefore be ideally suited to the acquisition of data for all long-fibre-reinforced plastics.

Plastics — Acquisition and presentation of comparable single-point data —

Part 2: Long-fibre-reinforced plastics

1 Scope

ISO 10350 identifies specific test procedures for the acquisition and presentation of comparable data for certain basic properties of plastics. In general, each property is specified by a single experimental value, although in certain cases properties are represented by two values obtained under different test conditions or along different directions in the material. The properties included are those presented conventionally in manufacturers' data sheets.

This document applies to reinforced thermoplastic and thermosetting materials where the reinforcement fibres are either discontinuous with a fibre length prior to processing greater than 7,5 mm or continuous (e.g. fabric, continuous-strand mat or unidirectional).

ISO 10350-1 deals specifically with unreinforced and filled plastics, including those using fibres less than 7,5 mm in length.

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 62, *Plastics — Determination of water absorption*

ISO 75-3, *Plastics — Determination of temperature of deflection under load — Part 3: High-strength thermosetting laminates and long-fibre-reinforced plastics*

ISO 179-1, *Plastics — Determination of Charpy impact properties — Part 1: Non-instrumented impact test*

ISO 179-2, *Plastics — Determination of Charpy impact properties — Part 2: Instrumented impact test*

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

ISO 527-4, *Plastics — Determination of tensile properties — Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites*

ISO 527-5, *Plastics — Determination of tensile properties — Part 5: Test conditions for unidirectional fibre-reinforced plastic composites*

ISO 1172, *Textile-glass-reinforced plastics — Prepregs, moulding compounds and laminates — Determination of the textile-glass and mineral-filler content — Calcination methods*

ISO 1183 (all parts), *Plastics — Methods for determining the density of non-cellular plastics*

ISO 1268 (all parts), *Fibre-reinforced plastics — Methods of producing test plates*

ISO 2577, *Plastics — Thermosetting moulding materials — Determination of shrinkage*

ISO 2818, *Plastics — Preparation of test specimens by machining*

ISO 3915, *Plastics — Measurement of resistivity of conductive plastics*

ISO 4589-2, *Plastics — Determination of burning behaviour by oxygen index — Part 2: Ambient-temperature test*

ISO 6603-2, *Plastics — Determination of puncture impact behaviour of rigid plastics — Part 2: Instrumented impact testing*

ISO 7822, *Textile glass reinforced plastics — Determination of void content — Loss on ignition, mechanical disintegration and statistical counting methods*

ISO 11357-2, *Plastics — Differential scanning calorimetry (DSC) — Part 2: Determination of glass transition temperature and step height*

ISO 11357-3, *Plastics — Differential scanning calorimetry (DSC) — Part 3: Determination of temperature and enthalpy of melting and crystallization*

ISO 11359-2, *Plastics — Thermomechanical analysis (TMA) — Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature*

ISO 14125:1998, *Fibre-reinforced plastic composites — Determination of flexural properties*

ISO 14127, *Carbon-fibre-reinforced composites — Determination of the resin, fibre and void contents*

ISO 14130, *Fibre-reinforced plastic composites — Determination of apparent interlaminar shear strength by short-beam method*

ISO 15310, *Fibre-reinforced plastic composites — Determination of the in-plane shear modulus by the plate twist method*

IEC 60112, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60243-1, *Electrical strength of insulating materials — Test methods — Part 1: Tests at power frequencies*

IEC 60296, *Fluids for electrotechnical applications — Unused mineral insulating oils for transformers and switchgear*

IEC 60695-11-10, *Fire hazard testing — Part 11-10: Test flames — 50 W horizontal and vertical flame test methods*

IEC 60695-11-20, *Fire hazard testing — Part 11-20: Test flames — 500 W flame test methods*

IEC 62631-2-1, *Dielectric and resistive properties of solid insulating materials — Part 2-1: Relative permittivity and dissipation factor — Technical Frequencies (0,1 Hz - 10 MHz) — AC Methods*

IEC 62631-3-1, *Dielectric and resistive properties of solid insulating materials — Part 3-1: Determination of resistive properties (DC methods) — Volume resistance and volume resistivity — General method*

IEC 62631-3-2, *Dielectric and resistive properties of solid insulating materials — Part 3-2: Determination of resistive properties (DC methods) — Surface resistance and surface resistivity*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
single-point data
data characterizing a plastics material by means of those property tests in which important aspects of performance can be described with single-value results

3.2
specimen coordinate axes
coordinate axes for a material in which the fibres are preferentially aligned in one direction

Note 1 to entry: Where the material contains a known axis of preferred fibre orientation, then this is defined as the "1"-axis (or "1"-direction). For materials prepared as a test plate, then the in-plane direction transverse to the "1"-axis is defined as the "2"-axis.

Note 2 to entry: Where the direction of preferred orientation is not known, the "1"-axis is taken as the production direction of the composite or the reinforcement (e.g. the warp direction for fabrics).

4 Specimen preparation and conditioning

Specimens shall be cut from test plates manufactured by the method given in the part of the ISO 1268 series appropriate to the material under test. Machining shall be performed in accordance with ISO 2818, as applicable, and the dimensions of the specimen shall comply with those for the appropriate specimen in Table 2.

The moulding conditions stipulated in the ISO 1268 series, or other appropriate International Standard, shall be recorded with the single-point data for that material. Typical parameters are shown in Table 1.

Table 1 — Moulding parameters

Moulding-material type	Manufacturing method and standard	Manufacturing parameters
Long-fibre-reinforced plastic	Test plate manufacture ISO 1268-1 to ISO 1268-11	Typical parameters given in the appropriate part of the ISO 1268 series covers: Temperatures (e.g. of mould, resin, preform, cure, post-cure) Pressures (e.g. of moulding, holding, resin transfer, vacuum level) Times, speeds and rates (e.g. curing times, speed of winding or pultrusion, quantity of glass and resin sprayed by unit of time)

For materials that have properties that are not significantly sensitive to any absorbed water, specimens shall be conditioned in accordance with the International Standard appropriate to the material concerned. If no materials standard is available, condition test specimens according to ISO 291. The preferred conditions are at (23 ± 2) °C and (50 ± 10) % RH for a minimum length of time of 88 h (see ISO 291).

For those materials having properties that are significantly dependent upon the concentration of any absorbed water, data shall be presented both for material that is dry and also for material that is in equilibrium with an atmosphere of 50 % RH at 23 °C but with the following exceptions (see Table 2).

— Rheological properties 1.1 to 1.6 — dry only

— Thermal properties 3.1 to 3.8 — dry only

— Surface resistivity and comparative tracking index 4.6 and 4.9 — 50 % RH only

For these materials, consult the relevant materials standard for procedures for conditioning specimens to achieve material that is dry or in equilibrium under 50 % RH. Following such conditioning, all test specimens shall be stored at (23 ± 2) °C for a minimum of 16 h before testing. The storage atmosphere shall then be either dry or at 50 % RH, depending upon the condition of the specimen.

5 Test requirements

The test methods, test conditions and units specified in Table 2 shall be used when determining data. Where the test method has different procedures for different types of reinforcement, then the appropriate procedure shall be used for the material under test.

6 Presentation of results

The presentation of data shall be as shown in Table 2, and the data shall be preceded by information that identifies the material together with the information required by Clause 4 where appropriate. This shall include the matrix resin used, the type of reinforcing fibre used, the mass fraction and form of the reinforcing fibres, and the processing method used to produce the test specimens.

Where this document requires measurements of a property to be made in different directions as defined by the coordinate specimen axes. Separate measurements shall be made along the "1" and "2"-axes. The measurements shall be recorded under the headings "Value 1" and "Value 2", respectively. Where only a single value is required, this shall be recorded under the "Value 1" heading.

Indicate whether the specimens tested were dry or were in equilibrium with an atmosphere of 50 % RH at 23 °C, or whether properties are insensitive to the presence of water.

The minimum number of specimens that shall be tested is specified for each property in the associated test method standard (in order that the value recorded for each property be as representative as possible of the material being tested, however, it is recommended that test specimens be prepared from at least three samples of the material taken from the production of the material over an extended timescale). Record the mean value for each property (or the central value if this is stipulated in the test method standard) in the "Value" column.

Table 2 — Long-fibre-reinforced plastic composites — Test conditions and format for the presentation of single-point data[a]

Property		Symbol	Standard	Specimen type (dimensions in mm)	Value 1	Value 2	Unit	Test conditions and supplementary instructions	
1	**Rheological properties** (for properties 1.1 to 1.6, see statement in Clause 4)								
1.1	Melt mass-flow rate								
1.2	Melt volume-flow rate								
1.3	Moulding shrinkage of thermosetting polymers	S_{M1}	ISO 2577				%		
1.4		S_{M2}							
1.5	Moulding shrinkage of thermoplastics								
1.6									
2	**Mechanical properties** (for properties 2.8 and 2.9, see statement in Clause 4)								
2.1	Tensile modulus[b]	E_t	ISO 527-4 or ISO 527-5	Use the specimen type specified in the part appropriate to the material			MPa	See Figure 1	For test speed, see relevant part
2.2	Yield stress	σ_Y							
2.3	Yield strain	ε_Y							
2.4	Nominal strain at break	ε_{tB}							
2.5	Stress at 50 % strain	σ_{50}							
2.6	Stress at break[b]	σ_B	ISO 527-4 or ISO 527-5	Use the specimen type specified in the part appropriate to the			MPa	See Figure 1	For test speed, see relevant part
2.7	Strain at break[b]	ε_B					%		
2.8	Tensile creep modulus	$E_{tc}1$							
2.9		$E_{tc}10^3$							
2.10	Flexural modulus	E_f	ISO 14125:1998 Method A	Use the specimen type specified for the material			MPa	Use three-point flexure	
2.11	Flexural strength	σ_{fM}						Use test speed specified for the appropriate specimen type	
2.12	Charpy impact strength[c]	a_{cU}	ISO 179-1 or ISO 179-2	80 × 10 × 4			kJ/m^2	Use flatwise impact	
2.13	Charpy notched impact strength	a_{cA}							
2.14	Tensile impact strength	a_{t1}							

Table 2 *(continued)*

Property		Symbol	Standard	Specimen type (dimensions in mm)	Value 1	Value 2	Unit	Test conditions and supplementary instructions	
2.15	Puncture impact behaviour[d]	F_M	ISO 6603-2	140 × 140 × 4			N	Maximum force	Striker diameter 20 mm Striker velocity 4,4 m/s Lubricate the striker Clamp the specimen sufficiently to prevent any out-of-plane movement of its outer regions
2.16		E_p					J	Puncture energy at 50 % decrease in force after the maximum	
2.17	In-plane shear modulus	G_{12}	ISO 15310	150 × 150 × 4			GPa	Test speed 1 mm/min	
2.18	Interlaminar shear strength	ILS	ISO 14130	20 × 20 × 2			MPa	For non-standard sizes, use scaling rules in standard Test speed 1 mm/min	
3	**Thermal properties** (for properties 3.1 to 3.8, see statement in Clause 4)								
3.1	Melting temperature[e]	T_m	ISO 11357-3	Moulding compound			°C	Record melting peak temperature Use 10 °K/min	
3.2	Glass transition temperature	T_g	ISO 11357-2					Record midpoint temperature Use 10 °K/min	
3.3	Temperature of deflection under load[f]	T_f	ISO 75-3				°C		
3.4									
3.5									
3.6	Vicat softening temperature	T_v50/50							
3.7	Coefficient of linear thermal expansion	α_1	ISO 11359-2	4-mm-thick plate specimen			$°C^{-1}$	Record the secant value over the temperature range 23 °C to 55 °C	
3.8		α_2							
3.9	Burning behaviour[g]	B50/3,0	IEC 60695-11–10	125 × 13 × 3				Record one of the classifications V-0, V-1, V-2, HB40 or HB75	
3.10		B50/*h*		Greater thickness *h*					
3.11		B500/3,0	IEC 60695-11–20	≥ 150 × ≥ 150 × 3				Record classification 5 VA, 5 VB or N	
3.12		B500/*h*		Greater thickness *h*					
3.13	Oxygen index	OI 23	ISO 4589-2	80 × 10 × 4			%	Use procedure A: top surface ignition	

Table 2 *(continued)*

Property		Symbol	Standard	Specimen type (dimensions in mm)	Value 1	Value 2	Unit	Test conditions and supplementary instructions	
4	**Electrical properties** (for properties 4.6 and 4.9, see statement regarding water content in Clause 4)								
4.1	Relative permittivity	ε_r 100	IEC 62631-2-1	≥ 60 × ≥ 60 × 2				100 Hz	Compensate for electrode edge effects
4.2		ε_r 1M						1 MHz	
4.3	Dissipation factor	tan δ 100						100 Hz	
4.4		tan δ 1M						1 MHz	
4.5	Volume resistivity	ρ_e	IEC 62631–3–1	≥ 60 × ≥ 60 × 2			Ω·m	Voltage 500 V	Value at 1 minute Used for materials having volume resistivity of 10^4 Ω·m or more.
			ISO 3915	Type A1 or ≥ 10 × 75 to 150 × 2				≤ 10 V	Used for materials having volume resistivity less than 10^4 Ω·m.
4.6	Surface resistivity	σ_e	IEC 62631–3–2	≥ 60 × ≥ 60 × 2			Ω	Voltage 500 V	Use contacting line electrodes 1 mm to 2 mm wide, 50 mm long and 5 mm apart or circular electrodes as shown in IEC 62631–3–2, Figure 3
4.7	Electric strength[h,i]	E_B 1	IEC 60243–1	≥ 60 × ≥ 60 × 2			kV/mm	Use 20 mm diameter spherical electrodes	
4.8		E_B 2		≥ 60 × ≥ 60 × 4				Immerse in transformer oil in accordance with IEC 60296 Use a voltage application rate of 2 kV/s	
4.9	Comparative tracking index[i]	CTI	IEC 60112	≥ 20 × ≥ 20 × 4				Use solution A	

Table 2 *(continued)*

Property		Symbol	Standard	Specimen type (dimensions in mm)	Value 1	Value 2	Unit	Test conditions and supplementary instructions
5	**Other properties**							
5.1	Water absorption	w_W	ISO 62	Thickness ≥ 1			%	Saturation value in water at 23 °C
5.2		w_H						Equilibrium value at 23 °C, 50 % RH
5.3	Density[j]	ρ	ISO 1183 (all parts)	4-mm-thick plate specimen of the material			kg/m^3	
5.4	Glass and mineral content (by calcination)	M_{glass} M_{filler}	ISO 1172	—			%	
5.5	Fibre content	W_f/V_f	ISO 14127	—			%	Use acid digestion method
5.6	Void content	φ_v	ISO 7822 or ISO 14127	—			%	

[a] To maintain consistency with the format for data presentation in ISO 10350-1, a common numbering system for property lines has been used. ISO 10350-1:2017, Table 2 is reproduced here with additional lines inserted for new properties. The properties shown shaded are not relevant to the majority of long-fibre-reinforced plastics because, in general, these materials show little plastic deformation as well as reduced time-dependent behaviour, and they cannot be injection moulded. For those materials that can be conveniently injection moulded, values for the properties shaded can be recorded as additional, optional, data using test methods and test conditions identified in ISO 10350-1.

[b] The data to be recorded for the properties in 2.1, 2.6 and 2.7 are intended to give a fair impression of the nature of the stress-strain curve to failure (see Figure 1).

[c] While edgewise impact is used in ISO 10350-1, flatwise impact is specified here for fibre-reinforced materials because this is a more appropriate loading direction for these materials.

[d] In order to achieve comparable data with this test, the application of a lubricant to the striking surface is specified to minimize the friction between the striker and the test specimen. See the test method standard for details of suitable lubricants and their application. Results from an unlubricated test may be higher, owing to friction, and the mode of failure may be different from that in the lubricated test.

[e] This property is only measured for thermoplastic composite materials.

[f] See the test method standard for suitable specimen dimensions. It is not considered necessary to use specific specimen dimensions in order to obtain comparable data.

[g] The symbol N denotes that the material does not satisfy any of the classifications of this method.

[h] The specimen shall be sufficiently wide to prevent discharge along the surface.

[i] Measurement at the greater thickness of 4 mm shall be carried out for those materials that do not give realistic results when moulded to a thickness of 2 mm. Since measurements of electric strength are dependent upon the thickness of the specimen, an additional value may be recorded here, for those materials that can be moulded with a thickness of 2 mm, to demonstrate the dependence on thickness.

[j] The four methods specified in the various parts of ISO 1183 are regarded as equivalent for the purposes of this document.