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Structural adhesives — Standard database of properties

Adhésifs structuraux — Base de données des caractéristiques

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Contents

Page

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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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 11, *Products*.

This second edition cancels and replaces the first edition (ISO 17194:2007), of which it constitutes a minor revision.

The main changes compared to the previous edition are as follows:

— the normative references updated;

— Table 2 has been updated;

— description of the simple stress analysis and Table 3 have been updated.

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

Over recent years, there has been an increase in the use of computer methods for the selection and evaluation of structural adhesives and for assistance with the manufacture and design of joints with these materials. The data sheets from materials suppliers generally do not supply all the property data that are needed to support the application of these methods.

This document specifies a set of basic properties for adhesives commonly required for the use of these materials in a wide range of applications. Test methods and test conditions are recommended for the measurement of the data to enable traceability of presented values. For each property, a single (preferred) test method and specific test conditions are identified in order to improve the comparability of data on different materials generated by different data suppliers.

In selecting the contents for this database, attempts have been made to find a balance in the quantity of data specified. Too much and data suppliers will be reluctant to produce the data, too little and the database has limited value. The aim is, therefore, not to present a comprehensive list of properties for adhesives but to be selective in identifying the most important properties that are needed for the use of adhesives for different applications. It should be noted that many adhesives have been developed with special properties for a particular application. It is possible that these properties will not be specified in the list associated with this document. However, scope has been included within this document for the presentation of additional data under test conditions identified by the data supplier. In this way, the special properties of the adhesive can be presented with the basic data.

Structural adhesives — Standard database of properties

1 Scope

This document specifies a set of basic properties commonly required for the selection and use of structural adhesives in different applications. ISO standard test methods and test conditions are also reviewed for the measurement of these data to facilitate traceability of recorded values (see Introduction).

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 527-1, *Plastics — Determination of tensile properties — Part 1: General principles*

ISO 527-2, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 868, *Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness)*

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

ISO 1817, *Rubber, vulcanized or thermoplastic — Determination of the effect of liquids*

ISO 2555, *Plastics — Resins in the liquid state or as emulsions or dispersions — Determination of apparent viscosity using a single cylinder type rotational viscometer method*

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

ISO 3219 (all parts), *Plastics — Polymers/resins in the liquid state or as emulsions or dispersions — Determination of viscosity using a rotational viscometer with defined shear rate*

ISO 11339, *Adhesives - T-peel test for flexible-to-flexible bonded assemblies*

ISO 4587, *Adhesives — Determination of tensile lap-shear strength of rigid-to-rigid bonded assemblies*

ISO 6721-4, *Plastics — Determination of dynamic mechanical properties — Part 4: Tensile vibration — Non-resonance method*

ISO 6721-5, *Plastics — Determination of dynamic mechanical properties — Part 5: Flexural vibration — Non-resonance method*

ISO 9142, *Adhesives — Guide to the selection of standard laboratory ageing conditions for testing bonded joints*

ISO 10364, *Adhesives — Determination of pot life (working life) of multi-component adhesives*

ISO 11343, *Adhesives — Determination of dynamic resistance to cleavage of high-strength adhesive bonds under impact wedge conditions — Wedge impact method*

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

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

ISO 15166-1, *Adhesives — Methods of preparing bulk specimens — Part 1: Two-part systems*

ISO 15166-2, *Adhesives — Methods of preparing bulk specimens — Part 2: Elevated-temperature-curing one-part systems*

ISO 17212, *Structural adhesives — Guidelines for the surface preparation of metals and plastics prior to adhesive bonding*

ISO 25217, *Adhesives — Determination of the mode 1 adhesive fracture energy of structural adhesive joints using double cantilever beam and tapered double cantilever beam specimens*

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

3 Terms and definitions

No terms and definitions are listed in this document.

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 https://www.electropedia.org/

4 Principle

A list is presented of properties that are generally useful for the selection and application of structural adhesives. Recommended test methods and test conditions are given for each property to help in the determination of values and to promote the presentation of traceable and comparable data.

5 Test specimens

Where possible, use the test specimens recommended in the test method standards employed to measure the properties given in Tables 1, 2 and 3. If alternative test methods are used, the test method reference shall be recorded with the results. The preparation of test specimens shall be as specified in ISO 17212 for joint specimens and ISO 15166-1 or ISO 15166-2 for bulk specimens. Since the properties of adhesives generally depend on the concentration of absorbed water, specimens shall be stored dry or in an atmosphere of (50 ± 10) % RH at (23 ± 2) °C prior to testing, for a sufficient time to reach zero or equilibrium water content as indicated by no significant further changes in the mass of the specimen with storage time.

6 Test conditions

Where possible, use the test conditions specified for each property in Tables 1, 2 and 3. If alternative test conditions are used, these shall be recorded with the results.

7 Test procedures

7.1 Basic properties

Test methods and test conditions recommended for the acquisition of data for basic properties are given in Table 1. The measurement temperature is (23 ± 2) °C. For measurements obtained at other temperatures, record the temperature with the result.

Record cure temperature, cure time, post-cure temperature and post-cure time used for specimen preparation. Record also whether specimens have been stored dry or at 50 % RH prior to testing.

Table 1 — Basic properties at 23 °C

Property	Units	Test method	Additional conditions
Tensile modulus	MPa	ISO 527-1, ISO 527-2	
Poisson's ratio	1		
Stress at failure	MPa		See NOTE 1.
Strain at failure	%		
Yield stress	MPa		See NOTE 2.
Yield strain	%		
Shear modulus	Pa	ISO 11003-1 ISO 11003-2	Record thickness of adhesive layer. Report whether ISO 11003-1 or -2 has been applied
Shear strength (highest shear stress)	Pa		
Shear strain at highest shear stress	1		
Shear stress at failure	Pa		When applicable
Shear strain at failure	1		When applicable
Lap shear strength	MPa	ISO 4587	Record thickness of adhesive layer. Record adherend material and surface treatment (see ISO 17212).
Peel resistance	MPa	ISO 11339	Record thickness of adhesive layer. Record adherend material and surface treatment (see ISO 17212).
Dynamic resistance to cleavage Dynamic cleavage energy	kN/m J	ISO 11343 See Note 3	Use symmetrical wedge. Record thickness of adhesive layer. Record adherend material and surface treatment (see ISO 17212)

NOTE 1 Strain at failure for ductile materials is measured after yield and therefore requires the measurement of a nominal strain. The nominal strain is derived from measurements of grip separation instead of extensometer values. See ISO 527-1:2019, 3.8 and 9.5, for the definition and measurement of nominal strain.

NOTE 2 See ISO 527-1:2019, 3.6.1 and 3.7.1, for definitions of stress and strain at yield, respectively.

NOTE 3 A wider interest in the toughness of an adhesive relates to a knowledge of the temperature of the transition from ductile to brittle behaviour. This temperature can be derived from measurements of toughness, using the cleavage test ISO 11343, as a function of temperature. Related information can be obtained from measurements of ductility at different temperatures using tests for fracture energy under impact (ISO 179-1 and ISO 179-2) or strain at failure in tensile tests on bulk specimens (see ISO 527).

NOTE 4 The service temperature range will be determined by the criteria used to decide maximum and minimum operating temperatures. Generally, the upper temperature is decided by the glass transition temperature T_g and the lower temperature by the transition from ductile to brittle behaviour. This lower temperature limit can be determined from measurements of toughness or ductility with temperature (see Note 3).

NOTE 5 The measured value of electric strength is very dependent on the thickness of the adhesive layer.

Table 1 *(continued)*

Mode 1 adhesive fracture energy Critical strain energy release rate, or adhesive fracture energy, for the applied mode I opening load	J/m^2	ISO 25217	Record thickness of adhesive layer.
Hardness	Shore A or D	ISO 868	3 s duration.
Glass transition temperature	°C	ISO 11357-2	
Dynamic mechanical modulus vs temperature (DMTA) curve	GPa	ISO 6721-4 or ISO 6721-5	From – 40 °C to above T_g.
Thermal expansion coefficient	K^{-1}	ISO 11359-2	Record values at 23 °C and at a temperature above T_g.
Service temperature range	°C	See Note 4	
Viscosity	Pa·s	ISO 2555 or ISO 3219 (all parts)	Record shear strain rate and time under load if the adhesive is thixotropic.
Working life	min	ISO 10364	
Volume change during cure	%	ISO 2577	
Density	kg/m^3	ISO 1183	
Water absorption	%	ISO 62	Saturation value at (23 ± 2) °C.
Volume resistivity	ohm·m	IEC62631-3-1	
Electric strength	kV/mm	IEC 60243-1	Use a specimen with a thickness of the adhesive layer of 0,5 mm. See Note 5.

NOTE 1 Strain at failure for ductile materials is measured after yield and therefore requires the measurement of a nominal strain. The nominal strain is derived from measurements of grip separation instead of extensometer values. See ISO 527-1:2019, 3.8 and 9.5, for the definition and measurement of nominal strain.

NOTE 2 See ISO 527-1:2019, 3.6.1 and 3.7.1, for definitions of stress and strain at yield, respectively.

NOTE 3 A wider interest in the toughness of an adhesive relates to a knowledge of the temperature of the transition from ductile to brittle behaviour. This temperature can be derived from measurements of toughness, using the cleavage test ISO 11343, as a function of temperature. Related information can be obtained from measurements of ductility at different temperatures using tests for fracture energy under impact (ISO 179-1 and ISO 179-2) or strain at failure in tensile tests on bulk specimens (see ISO 527).

NOTE 4 The service temperature range will be determined by the criteria used to decide maximum and minimum operating temperatures. Generally, the upper temperature is decided by the glass transition temperature T_g and the lower temperature by the transition from ductile to brittle behaviour. This lower temperature limit can be determined from measurements of toughness or ductility with temperature (see Note 3).

NOTE 5 The measured value of electric strength is very dependent on the thickness of the adhesive layer.

7.2 Durability in different environments

Data measured using the test method and conditions given in Table 2 reveal the influence on the lap shear strength of the adhesive of exposure to different environments. The tolerance on the test and exposure temperatures specified in Table 2 shall be ±3 °C, except at 23 °C where the tolerance shall be ±2 °C. Results obtained using the conditions specified in the first row of the table show the dependence of shear strength on temperature separately from the effects of any ageing. In subsequent rows, specimens are subjected to exposure for 30 days in the environments shown and then tested at (23 ± 2) °C. The procedure for conditioning specimens shall be in accordance with ISO 9142 for the procedure for conditioning specimens. Where it is known that a particular adhesive is not recommended for use with the chemicals shown in Table 2, then the letters NR shall be given in place of experimental values.

Record cure temperature, cure time, post-cure temperature and post-cure time used for specimen preparation. Also record adherend material and surface treatment (see ISO 17212).

Table 2 — Data on durability in different environments

Property (test method)	Test temperature	Ageing prior to test
Lap-shear strength (ISO 4587)	– 40 °C, 23 °C and 70 °C	No ageing (optionally include additional test temperatures to demonstrate the working range of the adhesive)
	23 °C	Expose for 30 days to: ambient humidity at 70 °C 90 % RH at 70 °C water at 23 °C water at 90 °C isopropyl alcohol at 23 °C 10 % acetic acid at 23 °C 35 % sodium hydroxide at 23 °C standard fuel (ISO 1817 liquid 2) at 23 °C motor oil (ISO 1817 oil No. 3) at 23 °C ethylene glycol (50 % by volume in water) at 23 °C optionally, other chemicals and temperatures. Record details.

7.3 Simple stress analysis

Data obtained by the tests recorded in Table 3 are required for carrying out calculations of stress and strain distributions in the adhesive in a bonded joint under load, for example using finite-element analysis. If an elastic analysis is carried out, only the first three rows of data are needed. Data specified by the fourth and fifth row or a complete stress vs strain curve are required for a stress analysis that takes account of plastic deformation using an elastic-plastic model appropriate for adhesive and in general polymer materials with the ability to properly consider hydrostatic stress effects.

Property values shall be recorded at 23 °C and, optionally, at additional temperatures to allow stress analysis calculations of behaviour at other temperatures.

Table 3 — Properties required for a simple stress analysis

Property	Units	Test method	Temperature, °C	Additional information
Tensile modulus	MPa	ISO 527-1, ISO 527-2	23	See NOTE 1
			Optional	
Poisson's ratio	1	ISO 527-1, ISO 527-2	23	See NOTE 1
			Optional	
Stress vs strain curve	MPa	ISO 527-1, ISO 527-2	23	See NOTE 2
			Optional	

NOTE 1 In order to characterize elastic behaviour for a stress analysis, values are needed for tensile modulus and Poisson's ratio. These are most conveniently obtained from tests on bulk specimens. If bulk specimens are not available, a value for the shear modulus can be obtained from a thick-adherend shear test (ISO 11003-2) and used with an estimate of Poisson's ratio to calculate a value for the tensile modulus.

NOTE 2 A stress/strain curve is required to characterize the non-linear behaviour of the adhesive in a stress analysis that takes account of plastic deformation and flow. As with modulus measurements, this is most easily measured using bulk specimen tests for the determination of tensile properties. If bulk specimens are not available, a shear stress/shear strain curve can be determined on joint specimens using the thick-adherend shear test (ISO 11003-2). In the case of adhesives and in general polymer materials however an appropriate plasticity model with the ability to properly consider hydrostatic stress effects is required, which requests material parameters arising from both, tensile bulk specimen and thick adherend shear testing. The use of one type of stress strain curves may lead to results not valid for arbitrary type of loading.

8 Precision

For information on the typical precision of the test methods used to generate the data specified in Tables 1 to 3 in Clause 7, the associated test standard should be consulted.

Bibliography

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

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

[3] ISO 11003-2, *Adhesives — Determination of shear behaviour of structural adhesives — Part 2: Tensile test method using thick adherends*

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