

INTERNATIONAL STANDARD

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**Resin based reactive compounds used for electrical insulation –
Part 2: Methods of test**

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**Composés réactifs à base de résines utilisés comme isolants électriques –
Partie 2: Méthodes d'essai**

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Resin based reactive compounds used for electrical insulation –
Part 2: Methods of test** (standards.iteh.ai)

**Composés réactifs à base de résines utilisés comme isolants électriques –
Partie 2: Méthodes d'essai**

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CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references.....	8
3 Terms and definitions	11
4 General notes on methods of test.....	11
4.1 Preparation and conditioning	11
4.2 Sequence of tests	12
4.3 Test report	12
5 Methods of test for reactive compounds and their components	12
5.1 Flash point.....	12
5.2 Density	12
5.3 Viscosity	12
5.4 Viscosity after storing at elevated temperature.....	12
5.5 Content of volatile organic components	13
5.6 Isothermal increase of viscosity (processing time).....	13
5.7 Shelf life	13
5.8 Colour.....	13
5.9 Softening temperature.....	14
5.10 Ash content.....	14
5.11 Filler content.....	14
5.12 Chlorine content.....	14
5.12.1 Total chlorine content of unsaturated polyesters and epoxide resins.....	14
5.12.2 Inorganic chlorine content of epoxide resins and glycidyl esters	14
5.12.3 Easily saponifiable chlorine content of epoxide resins and related materials.....	14
5.13 Tendency of cristallisation	14
5.14 Epoxide equivalent of epoxide resins	14
5.15 Content of isocyanate.....	14
5.16 Water content (Karl Fischer method).....	14
5.17 Hydroxyl value	15
5.17.1 Polyester resins	15
5.17.2 Resins other than polyester.....	15
5.18 Acid value of polyester resins	15
5.19 Amount of double bonds of unsaturated polyester and acrylate resins	15
5.20 Acid and acid-anhydride content of acid-anhydride hardeners	15
5.21 Amine value	15
5.22 Pot life	15
5.22.1 General	15
5.22.2 Resinous compounds for cable accessories.....	15
5.23 Gel time	16
5.23.1 Unsaturated polyester based compounds	16
5.23.2 Phenolic resin based compounds	16
5.23.3 Other compounds.....	16
5.24 Exothermic temperature rise.....	16
5.24.1 Unsaturated polyester based compounds	16

5.24.2	Resinous compounds for cable accessories	16
5.24.3	Other compounds	17
5.25	Total volume shrinkage of epoxide and unsaturated polyester based compounds	17
5.26	Curing in presence of water	17
5.26.1	General	17
5.26.2	Apparatus and materials	17
5.26.3	Pouring device	18
5.26.4	Procedure	18
5.26.5	Test report	18
5.27	Determination of the degree of curing	18
5.28	Curing in thick layer and emissions during curing	18
5.28.1	General	18
5.28.2	Equipment	19
5.28.3	Test specimen	19
5.28.4	Procedure	19
6	Methods of test for cured reactive compounds	20
6.1	General	20
6.2	Test specimens	20
6.2.1	General	20
6.2.2	Preparation of the reactive compound	20
6.2.3	Preparation of test specimens	21
6.2.4	Type and number of test specimens	21
6.3	Density	21
6.4	Mechanical properties	21
6.4.1	Tensile properties	21
6.4.2	Compressive properties	21
6.4.3	Flexural properties	22
6.4.4	Impact strength	22
6.4.5	Hardness	22
6.5	Thermal properties	22
6.5.1	Bond strength at elevated temperature	22
6.5.2	Linear thermal expansion	22
6.5.3	Thermal conductivity	22
6.5.4	Glass transition	23
6.5.5	Flammability	23
6.5.6	Thermal shock	23
6.5.7	Dry heat resistance of resins for cable accessories – Method of test	23
6.5.8	Wet heat resistance of resins for cable accessories	24
6.5.9	Loss of mass	26
6.5.10	Temperature index	27
6.6	Chemical properties	27
6.6.1	Water absorption	27
6.6.2	Effect of liquid chemicals	28
6.6.3	Resistance to mould growth	28
6.6.4	Water vapour permeability	28
6.7	Electrical properties	28
6.7.1	Effect of water immersion on volume resistivity	28
6.7.2	Dielectric dissipation factor ($\tan \delta$) and relative permittivity (ϵ_r)	29

6.7.3	Breakdown voltage and electric strength.....	30
6.7.4	Proof tracking index (PTI).....	31
6.7.5	Electrolytic corrosion.....	31
Annex A (informative) Health and safety.....		36
Bibliography		37
Figure 1 – Test apparatus for curing in presence of water test		32
Figure 2 – Test set-up for volume resistivity		33
Figure 3 – Example of electrode arrangement for flexible cured compound		34
Figure 4 – Example of electrode arrangement for rigid cured compound.....		35
Table 1 – Condition of the top side		19
Table 2 – Condition of the bottom side		19
Table 3 – Condition of the interior		20

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**RESIN BASED REACTIVE COMPOUNDS
USED FOR ELECTRICAL INSULATION –****Part 2: Methods of test**

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International Standard IEC 60455-2 has been prepared by IEC technical committee 15: Solid electrical insulating materials.

This third edition cancels and replaces the second edition published in 1998. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) Introduction of test methods related to IEC 60455-3-8;
- b) Additional and updated test methods for resins.

This bilingual version (2016-01) corresponds to the monolingual English version, published in 2015-06.

The text of this standard is based on the following documents:

FDIS	Report on voting
15/751/FDIS	15/757/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The French version of this standard has not been voted upon.

A list of all parts in the IEC 60455 series, published under the general title *Resin based reactive compounds used for electrical insulation*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
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INTRODUCTION

This part of IEC 60455 is one of a series which deals with solvent-free resin based reactive compounds and their components used for electrical insulation.

The series consists of three parts:

- Part 1: Definitions and general requirements (IEC 60455-1);
- Part 2: Methods of test (IEC 60455-2);
- Part 3: Specifications for individual materials (IEC 60455-3).

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RESIN BASED REACTIVE COMPOUNDS USED FOR ELECTRICAL INSULATION –

Part 2: Methods of test

1 Scope

This part of IEC 60455 specifies methods of test to be used for testing resin based reactive compounds, their components and cured compounds used for electrical insulation.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>)

IEC 60068-2-10:2005, *Environmental testing – Part 2-10: Tests – Test J and guidance: Mould growth*

IEC 60093:1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*

IEC 60112:2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60216 (all parts), *Electrical insulating materials – Thermal endurance properties*

IEC 60243-1:1998, *Electrical strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

IEC 60250:1969, *Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including metre wavelengths*

IEC 60296:2012, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60426:2007, *Electrical insulating materials – Determination of electrolytic corrosion caused by insulating materials – Test methods*

IEC 60455-1:1998, *Resin based reactive compounds used for electrical insulation – Part 1: Definitions and general requirements*

IEC 60455-3 (all parts), *Resin based reactive compounds used for electrical insulation – Part 3: Specifications for individual materials*

IEC 60455-3-8:2013, *Resin based reactive compounds used for electrical insulation – Part 3: Specifications for individual materials – Sheet 8: Resins for cable accessories*

IEC 60695-11-10:1999, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60814:1997, *Insulating liquids – Oil-impregnated paper and pressboard – Determination of water by automatic coulometric Karl Fischer titration*

IEC 61033:1991, *Test methods for the determination of bond strength of impregnating agents to an enamelled wire substrate*

IEC 61099:2010, *Insulating liquids – Specifications for unused synthetic organic esters for electrical purposes*

ISO 37:2011, *Rubber, vulcanized or thermoplastic – Determination of tensile stress-strain properties*

ISO 62:2008, *Plastics – Determination of water absorption*

ISO 75 (all parts), *Plastics and ebonite – Determination of temperature of deflection under load*

ISO 175:2010, *Plastics – Determination of the effects of liquid chemicals, including water*

ISO 178:2010, *Plastics – Determination of flexural properties*

ISO 179-1:2010, *Plastics – Determination of Charpy impact properties – Part 1: Non-instrumented impact test*

ISO 179-2:1997, *Plastics – Determination of Charpy impact properties – Part 2: Instrumented impact test*

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

ISO 306:2004, *Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST)*

ISO 527 (all parts), *Plastics – Determination of tensile properties*

ISO 584:1982, *Plastics – Unsaturated polyester resins – Determination of reactivity at 80 degrees C (conventional method)*

ISO 604:2002, *Plastics – Determination of compressive properties*

ISO 868:2003, *Plastics and ebonite – Determination of indentation hardness by means of a durometer (Shore hardness)*

ISO 1183-1:2012, *Plastics – Methods for determining the density of non-cellular plastics – Part 1: Immersion method, liquid pycnometer method and titration method*

ISO 1513:2010, *Paints and varnishes – Examination and preparation of samples for testing*

ISO 1523:2002, *Paints, varnishes, petroleum and related products – Determination of flashpoint – Closed cup equilibrium method*

ISO 1675:1985, *Plastics – Liquid resins – Determination of density by the pycnometer method*

- ISO 2039-1:1993, *Plastics – Determination of hardness – Part 1: Ball indentation method*
- ISO 2114:1996, *Plastics – Unsaturated polyester resins – Determination of partial acid value and total acid value*
- ISO 2431:1993, *Paints and varnishes – Determination of flow time by use of flow cups*
- ISO 2535:1997, *Plastics – Unsaturated polyester resins – Measurement of gel time at 25 degrees C*
- ISO 2554:1997, *Plastics – Unsaturated polyester resins – Determination of hydroxyl value*
- ISO 2555:1989, *Plastics – Resins in the liquid state or as emulsions or dispersions – Determination of apparent viscosity by the Brookfield test method*
- ISO 2592:1973, *Petroleum products – Determination of flash and fire points – Cleveland open cup method*
- ISO 3001:1997, *Plastics – Epoxide compounds – Determination of epoxide equivalent*
- ISO 3219:1993, *Plastics – Polymers/resins in the liquid state or as emulsions or dispersions – Determination of viscosity using a rotational viscometer with defined shear rate*
- ISO 3451-1:1997, *Plastics – Determination of ash – Part 1: General methods*
- ISO 3521:1997, *Plastics – Unsaturated polyester and epoxy resins – Determination of overall volume shrinkage*
- ISO 3679:1983, *Paints, varnishes, petroleum and related products – Determination of flashpoint – Rapid equilibrium method*
- ISO 4573:1978, *Plastics – Epoxide resins and glycidyl esters – Determination of inorganic chlorine*
- ISO 4583:1998, *Plastics – Epoxide resins and related materials – Determination of easily saponifiable chlorine*
- ISO 4615:1979, *Plastics – Unsaturated polyesters and epoxide resins – Determination of total chlorine content*
- ISO 4625:1980, *Binders for paints and varnishes – Determination of softening point – Ring-and-ball method*
- ISO 4895, *Plastics – Liquid epoxy resins – Determination of tendency to crystallize*
- ISO 7056, *Plastics laboratory ware – Beakers*
- ISO 9396:1997, *Plastics – Phenolic resins – Determination of the gel time at a given temperature using automatic apparatus*
- ISO 11357-2:1999, *Plastics – Differential scanning calorimetry (DSC) – Part 2: Determination of glass transition temperature*
- ISO 11359-2:1999, *Plastics – Thermomechanical analysis (TMA) – Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature*

ISO 11359-3:2002, *Plastics – Thermomechanical analysis (TMA) – Part 3: Determination of penetration temperature*

ISO 14896:2009, *Plastics – Polyurethane raw materials – Determination of isocyanate content*

ISO 15528:2000, *Paints, varnishes and raw materials for paints and varnishes – Sampling*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60455-1, IEC 60050, as well as the following apply.

3.1

volume resistance

that part of the insulation resistance which is due to conduction through the volume and excluding surface current

3.2

volume resistivity

volume resistance reduced to a cubical unit volume

3.3

dielectric dissipation factor $\tan \delta$

numerical value of the ratio of the imaginary to the real part of the complex permittivity

3.4

relative permittivity

ϵ_r

ratio of the absolute permittivity to the electric constant

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Note 1 to entry: In practical engineering, it is usual to employ the term 'permittivity' when referring to relative permittivity.

4 General notes on methods of test

4.1 Preparation and conditioning

Unless otherwise specified in the relevant specification standard or in the method of test, all tests shall be carried out at atmospheric conditions in a temperature range of between 21 °C and 29 °C and a relative humidity range of between 45 % and 70 %. Before measurements are made, the sample or test specimen shall be pre-conditioned under these atmospheric conditions for a time sufficient to allow the sample or the test specimen to reach stability. For taking samples in liquid or paste form, ISO 15528 shall be applied. For preparation of such samples for testing, ISO 1513 shall be applied.

NOTE For definitions of terms for standard atmospheres, see ISO 558. The test atmosphere as specified above does not comply with any of the two standard atmospheres as specified in ISO 291 but covers both ranges inclusive of their tolerances.

Normally, all requirements for a method of test are given in the description, and diagrams are intended only to illustrate one possible arrangement for conducting the test. In case of inconsistencies between this standard and the specification sheets of the IEC 60455-3 series, the latter shall prevail. When another standard is invoked for a test method, reference to that standard shall be included in the report.

4.2 Sequence of tests

To avoid unnecessary efforts, tests shall be carried out on the samples in the following sequence:

- 1) tests on individual components prior to mixing;
- 2) tests on reactive compound just after mixing (ready to use);
- 3) tests on cured compound;
- 4) tests on cured compound after pre treatment (thermal, humidity, water etc.).

If the sample under test fails a test the following tests may become obsolete.

4.3 Test report

If not otherwise specified, the test report shall include the following data:

- 1) resin designation and identification;
- 2) lot number or other identification;
- 3) confirmation of marking and labelling according to the material safety data sheet (MSDS);
- 4) test results;
- 5) major test parameters, including conditioning and calibration, if any;
- 6) processing conditions used to reactive compound;
- 7) copy of the technical data sheet (TDS) and MSDS.

5 Methods of test for reactive compounds and their components

5.1 Flash point

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For flash point temperatures of 79 °C and above, the method given in ISO 2592 shall be used. For flash point temperatures below 79 °C, the method given in ISO 1523 shall be used with any of the closed-cup apparatus as described in Annex A of ISO 1523:2002. ISO 1523 shall be read in conjunction with ISO 3679. Two measurements shall be made on two separate samples, and the two results of the flash point shall be reported along with reference to the standards applied.

5.2 Density

The method given in ISO 1675 shall be used. Two measurements shall be made, and the two results of the density shall be reported.

5.3 Viscosity

The viscosity shall be determined with a suitable device at $(23 \pm 0,5)$ °C if not otherwise specified. If a rotating type of device is used, it shall be in accordance with ISO 2555 (Brookfield type) or with ISO 3219 (a type working at a defined shear rate). If an efflux type of equipment is used, the method of test and the flow cup shall be in accordance with ISO 2431. Two measurements shall be made, and the two results of the viscosity shall be reported, along with reference to the standards applied.

5.4 Viscosity after storing at elevated temperature

This method is not applicable to one-component systems or components containing hardener.

If not otherwise specified, a sample of sufficient amount is stored for $(20 \pm 0,5)$ h at a temperature of (100 ± 3) °C in a sealed container. After cooling down to room temperature the

viscosity is measured according to 5.3. The increase of viscosity is calculated using the following equation:

$$\text{Increase of viscosity in \%} = (\eta_2 - \eta_1) \times 100 / \eta_1$$

where

η_1 = dynamic viscosity before storing

η_2 = dynamic viscosity after storing

5.5 Content of volatile organic components

This method is not applicable to one-component systems or components containing hardener. If not otherwise specified, the test shall be carried out in the following way:

The mass of an empty weighing bottle (about 80 mm × 30 mm), is taken to 0,001 g (m_1). A mass of 0,4 g to 0,5 g resin (m_2) is weighed to 0,001 g into the weighing bottle (well closed during weighing). Some drops of toluene are added to dilute the resin. The liquid is spread on the floor of the weighing bottle with a slight twist.

The open weighing bottle is placed into an oven with forced air circulation for at least 2 h at (110 ± 2) °C. After cooling down to room temperature in a desiccator the weighing bottle is weighed again to 0,001 g (m_3).

$$\text{Volatile organic components} = 100 \times (m_2 - (m_3 - m_1)) / m_2$$

5.6 Isothermal increase of viscosity (processing time)

This method is designed for PUR and EP resins. For UP resins gel time shall be used. If not otherwise specified, the test shall be carried out in the following way:

All components and equipment shall be at room temperature. The components of the resin are mixed according to the manufacturer's instructions. The mixing procedure shall not take more than 3 min. The time measurement starts after adding and mixing of the last component. After 10 min the first viscosity measurement is taken as the initial value. The measurement is repeated until the specified maximum viscosity is reached. The time between the initial value and the maximum value is reported as processing time.

5.7 Shelf life

The shelf life shall be determined by measurement of the change in a specified characteristic property after a certain storage time and temperature. Experience has shown that viscosity according to 5.3 and gel time according to 5.23 are appropriate characteristics. To assess shelf life, viscosity and/or gel time shall be determined according to 5.3 and/or 5.23 respectively, at a temperature and with an end-point as agreed upon between supplier and purchaser. Two measurements shall be made on both fresh material and on material stored for a time and at a temperature as agreed between supplier and purchaser. The two results of shelf life shall be reported, along with reference to the standards applied. The results shall contain the viscosity and/or the gel time before and after storing, the storing time and temperature and the test temperature.

5.8 Colour

The method given in ISO 6271 shall be used. Two measurements shall be made, and the two results of colour shall be reported along with reference to the standard applied.