



IEC 60455-2

Edition 3.0 2015-06

# INTERNATIONAL STANDARD

---

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

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 17.220.99; 29.035.01

ISBN 978-2-8322-2748-0

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## 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 ( $\epsilon_r$ ).....	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

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

## FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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.

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.

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,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

## 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).

# 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 – Ringand-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*