BS EN 61858-1:2014

BSI Standards Publication

Electrical insulation systems — Thermal evaluation of modifications to an established electrical insulation system (EIS)

Part 1: Wire-wound winding EIS

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National foreword

This British Standard is the UK implementation of EN 61858-1:2014. It is identical to IEC 61858-1:2014. It supersedes BS EN 61858:2008 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/112, Evaluation and qualification of electrical insulating materials and systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2014

ISBN 978 0 580 81149 4
ICS 29.080.30

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2014.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61858-1

May 2014

ICS 29.080.30

Supersedes EN 61858:2008

English Version

Electrical insulation systems - Thermal evaluation of modifications to an established electrical insulation system (EIS) - Part 1: Wire-wound winding EIS (IEC 61858-1:2014)

Systèmes d'isolation électrique - Évaluation thermique des modifications apportées à un système d'isolation électrique (SIE) éprouvé - Partie 1: Système d'isolation électrique à enroulements à fils (CEI 61858-1:2014)

Elektrische Isoliersysteme - Thermische Bewertung von Veränderungen an einem erprobten elektrischen Isoliersystem (EIS) - Teil 1: EIS mit Runddraht-Wicklungen (IEC 61858-1:2014)

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Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Foreword

The text of document 112/252/CDV, future edition 1 of IEC 61858-1, prepared by IEC/TC 112 "Evaluation and qualification of electrical insulating materials and systems" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61858-1:2014.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-12-19
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2017-03-19

This document supersedes EN 61858:2008.

EN 61858-1:2014 includes the following significant technical changes with respect to EN 61858:2008:

a) this part is specifically for wire-wound winding EIS;

b) new figures and charts support the contents.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 61858-1:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60034-18-21	NOTE	Harmonized as EN 60034-18-21.
IEC 60317-15	NOTE	Harmonized as EN 60317-15.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

Publication	Year	Title	EN/HD	Year
IEC 60085	2007	Electrical insulation - Thermal evaluation and designation	EN 60085	-
IEC 60172	-	Test procedure for the determination of the temperature index of enamelled winding wires	EN 60172	-
IEC 60216-5	-	Electrical insulating materials - Thermal endurance properties - Part 5: Determination of relative thermal endurance index (RTE) of an insulating material	EN 60216-5	-
IEC 60317-1	-	Specifications for particular types of winding wires - Part 1: Polyvinyl acetal enamelled round copper wire, class 105	-	-
IEC 60317-2	-	Specifications for particular types of winding wires - Part 2: Solderable polyurethane enamelled round copper wire, class 130, with a bonding layer	EN 60317-2	-
IEC 60317-3	-	Specifications for particular types of winding wires - Part 3: Polyester enamelled round copper wire, class 155	-	-
IEC 60317-4	-	Specifications for particular types of winding wires - Part 4: Solderable polyurethane enamelled round copper wire, class 130	EN 60317-4	-
IEC 60317-8	-	Specifications for particular types of winding wires - Part 8: Polyesterimide enamelled round copper wire, class 180	EN 60317-8	-
IEC 60317-12	-	Specifications for particular types of winding wires - Part 12: Polyvinyl acetal enamelled round copper wire, class 120	EN 60317-12	-

Publication	Year	Title	EN/HD	Year
IEC 60317-13	-	Specifications for particular types of winding wires - Part 13: Polyester or polyesterimide overcoated with polyamide-imide enamelled round copper wire, class 200	EN 60317-13	-
IEC 60317-19 [1)]	-	Specifications for particular types of winding wires - Part 19: Solderable polyurethane enamelled round copper wire overcoated with polyamide, class 130	EN 60317-19	-
IEC 60317-20	-	Specifications for particular types of winding wires - Part 20: Solderable polyurethane enamelled round copper wire, class 155	EN 60317-20	-
IEC 60317-21	-	Specifications for particular types of winding wires - Part 21: Solderable polyurethane enamelled round copper wire overcoated with polyamide, class 155	EN 60317-21	-
IEC 60317-22	-	Specifications for particular types of winding wires - Part 22 : Polyester or polyesterimide enamelled round copper wire overcoated with polyamide, class 180	EN 60317-22	-
IEC 60317-23	-	Specifications for particular types of winding wires - Part 23: Solderable polyesterimide enamelled round copper wire, class 180	EN 60317-23	-
IEC 60317-25	-	Specifications for particular types of winding wires - Part 25: Polyester or polyesterimide overcoated with polyamide-imide enamelled round aluminium wire, class 200	EN 60317-25	-
IEC 60317-26	-	Specifications for particular types of winding wires - Part 26: Polyamide-imide enamelled round copper wire, class 200	EN 60317-26	-
IEC 60317-34 [1)]	-	Specifications for particular types of winding wires - Part 34: Polyester enamelled round copper wire, class 130 L	EN 60317-34 [1)]	-
IEC 60317-35	-	Specifications for particular types of winding wires - Part 35: Solderable polyurethane enamelled round copper wire, class 155, with a bonding layer	EN 60317-35	-
IEC 60317-36	-	Specifications for particular types of winding wires - Part 36: Solderable polyesterimide enamelled round copper wire, class 180, with a bonding layer	EN 60317-36	-

[1)] Withdrawn publication.

Publication	Year	Title	EN/HD	Year
IEC 60317-37	-	Specifications for particular types of winding wires - Part 37: Polyesterimide enamelled round copper wire, class 180, with a bonding layer	EN 60317-37	-
IEC 60317-38	-	Specifications for particular types of winding wires - Part 38: Polyester or polyesterimide overcoated with polyamide-imide enamelled round copper wire, class 200, with a bonding layer	EN 60317-38	-
IEC 60317-42	-	Specifications for particular types of winding wires - Part 42: Polyester-amide-imide enamelled round copper wire, class 200	EN 60317-42	-
IEC 60317-43	-	Specifications for particular types of winding wires - Part 43: Aromatic polyimide tape wrapped round copper wire, class 240	EN 60317-43	-
IEC 60317-46	-	Specifications for particular types of winding wires - Part 46: Aromatic polyimide enamelled round copper wire, class 240	EN 60317-46	-
IEC 60317-48	-	Specifications for particular types of winding wires - Part 48: Glass-fibre wound resin or varnish impregnated, bare or enamelled round copper wire, temperature index 155	EN 60317-48	-
IEC 60317-50	-	Specifications for particular types of winding wires - Part 50: Glass-fibre wound silicone resin or varnish impregnated, bare or enamelled round copper wire, temperature index 200	EN 60317-50	-
IEC 60317-51	-	Specifications for particular types of winding wires - Part 51: Solderable polyurethane enamelled round copper wire, class 180	EN 60317-51	-
IEC 60317-53	-	Specifications for particular types of winding wires - Part 53: Aromatic polyamide (aramid) tape wrapped rectangular copper wire, temperature index 220	EN 60317-53	-
IEC 60317-54 [1)]	-	Specifications for particular types of winding wires - Part 54: Polyester enamelled round copper wire, class 155L	-	-
IEC 60317-55	-	Specifications for particular types of winding wires - Part 55: Solderable polyurethane enamelled round copper wire overcoated with polyamide, Class 180	EN 60317-55	-

[1)] Withdrawn publication.

Publication	Year	Title	EN/HD	Year
IEC 60317-57	-	Specifications for particular types of winding wires - Part 57: Polyamide-imide enamelled round copper wire, class 220	EN 60317-57	-
IEC 60505	-	Evaluation and qualification of electrical insulation systems	EN 60505	-
IEC 61033	-	Test methods for the determination of bond strength of impregnating agents to an enamelled wire substrate	EN 61033	-
IEC 61857	Series	Electrical insulation systems - Procedures for thermal evaluation	EN 61857	Series
IEC 61857-1	2008	Electrical insulation systems - Procedures for thermal evaluation - Part 1: General requirements - Low-voltage	EN 61857-1	2009
IEC 61857-21	-	Electrical insulation systems - Procedures for thermal evaluation - Part 21: Specific requirements for general-purpose models - Wire-wound applications	EN 61857-21	-
IEC 62317-2	-	Ferrite cores - Dimensions - Part 2: Pot-cores for use in telecommunications, power supply, and filter applications	EN 62317-2	-

CONTENTS

INTRODUCTION

This International Standard describes procedures for the evaluation of changes to an established electrical insulation system (EIS) for wire-wound electro technical devices and the effect of these changes on the thermal classification of the established EIS.

This Part 1 of IEC 61858 is for wire-wound winding EIS. Part 2 of IEC 61858 addresses modifications of form-wound winding EIS.

General principles for evaluation and qualification of EIS can be found in IEC 60505. Unless the procedures of this standard indicate otherwise, the principles of IEC 60505 should be followed.

The thermal classification of an EIS is established either by known service life, in accordance with IEC 60505, or evaluated in accordance with the IEC 61857 series.

ELECTRICAL INSULATION SYSTEMS – THERMAL EVALUATION OF MODIFICATIONS TO AN ESTABLISHED ELECTRICAL INSULATION SYSTEM (EIS) –

Part 1: Wire-wound winding EIS

1 Scope

This part of IEC 61858 lists the required test procedures for qualification of modifications of an established electrical insulation system (EIS) with respect to its thermal classification. This standard is applicable to EIS used in wire-wound winding electrotechnical devices. The test procedures are comparative in that the performance of a candidate EIS is compared to that of a reference EIS, which has proven service experience in accordance with IEC 60505 or has been evaluated by one of the procedures given in the IEC 61857 series.

2 Normative references

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60085:2007, *Electrical insulation – Thermal evaluation and designation*

IEC 60172, *Test procedure for the determination of the temperature index of enamelled winding wires*

IEC 60216-5, *Electrical insulating materials – Thermal endurance properties – Part 5: Determination of relative thermal endurance index (RTE) of an insulating material*

IEC 60317-1, *Specifications for particular types of winding wires – Part 1: Polyvinyl acetal enamelled round copper wire, class 105*

IEC 60317-2, *Specifications for particular types of winding wires – Part 2: Solderable polyurethane enamelled round copper wire, class 130, with a bonding layer*

IEC 60317-3, *Specifications for particular types of winding wires – Part 3: Polyester enamelled round copper wire, class 155*

IEC 60317-4, *Specifications for particular types of winding wires – Part 4: Solderable polyurethane enamelled round copper wire, class 130*

IEC 60317-8 *Specifications for particular types of winding wires – Part 8: Polyesterimide enamelled round copper wire, class 180*

IEC 60317-12, *Specifications for particular types of winding wires – Part 12: Polyvinyl acetal enamelled round copper wire, class 120*

IEC 60317-13, *Specifications for particular types of winding wires – Part 13: Polyester or polyesterimide overcoated with polyamide-imide enamelled round copper wire, class 200*

IEC 60317-19, *Specifications for particular types of winding wires – Part 19: Solderable polyurethane enamelled round copper wire overcoated with polyamide, class 130* (withdrawn)[1]

IEC 60317-20, *Specifications for particular types of winding wires – Part 20: Solderable polyurethane enamelled round copper wire, class 155*

IEC 60317-21, *Specifications for particular types of winding wires – Part 21: Solderable polyurethane enamelled round copper wire overcoated with polyamide, class 155*

IEC 60317-22, *Specifications for particular types of winding wires – Part 22: Polyester or polyesterimide enamelled round copper wire overcoated with polyamide, class 180*

IEC 60317-23, *Specifications for particular types of winding wires – Part 23: Solderable polyesterimide enamelled round copper wire, class 180*

IEC 60317-25, *Specifications for particular types of winding wires – Part 25: Polyester or polyesterimide overcoated with polyamide-imide enamelled round aluminium wire, class 200*

IEC 60317-26, *Specifications for particular types of winding wires – Part 26: Polyamide-imide enamelled round copper wire, class 200*

IEC 60317-34, *Specifications for particular types of winding wires – Part 34: Polyester enamelled round copper wire, class 130 L* (withdrawn)[1]

IEC 60317-35, *Specifications for particular types of winding wires – Part 35: Solderable polyurethane enamelled round copper wire, class 155, with a bonding layer*

IEC 60317-36, *Specifications for particular types of winding wires – Part 36: Solderable polyesterimide enamelled round copper wire, class 180, with a bonding layer*

IEC 60317-37, *Specifications for particular types of winding wires – Part 37: Polyesterimide enamelled round copper wire, class 180, with a bonding layer*

IEC 60317-38, *Specifications for particular types of winding wires – Part 38: Polyester or polyesterimide overcoated with polyamide-imide enamelled round copper wire, class 200, with a bonding layer*

IEC 60317-42, *Specifications for particular types of winding wires – Part 42: Polyester-amide-imide enamelled round copper wire, class 200*

IEC 60317-43, *Specifications for particular types of winding wires – Part 43: Aromatic polyimide tape wrapped round copper wire, class 240*

IEC 60317-46, *Specifications for particular types of winding wires – Part 46: Aromatic polyimide enamelled round copper wires, class 240*

IEC 60317-48, *Specifications for particular types of winding wires – Part 48: Glass-fibre wound resin or varnish impregnated, bare or enamelled round copper wire, temperature index 155*

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[1] Withdrawn.

IEC 60317-50, *Specifications for particular types of winding wires – Part 50: Glass-fibre wound silicone resin or varnish impregnated, bare or enamelled round copper wire, temperature index 200*

IEC 60317-51, *Specifications for particular types of winding wires – Part 51: Solderable polyurethane enamelled round copper wire, class 180*

IEC 60317-53, *Specifications for particular types of winding wires – Part 53: Aromatic polyamide (aramid) tape wrapped rectangular copper wire, temperature index 220*

IEC 60317-54, *Specifications for particular types of winding wires – Part 54: Polyester enamelled round copper wire, class 155 L*
(withdrawn)[2]

IEC 60317-55, *Specifications for particular types of winding wires – Part 55: Solderable polyurethane enamelled round copper wire overcoated with polyamide, class 180*

IEC 60317-57, *Specifications for particular types of winding wires – Part 57: Polyamide-imide enamelled round copper wire, class 220*

IEC 60505, *Evaluation and qualification of electrical insulation systems*

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

IEC 61857 (all parts), *Electrical insulation systems – Procedures for thermal evaluation*

IEC 61857-1:2008, *Electrical insulation systems – Procedures for thermal evaluation – Part 1: General requirements – Low voltage*

IEC 61857-21, *Electrical insulation systems – Procedures for thermal evaluation – Part 21: Specific requirements for general purpose models – Wire-wound applications*

IEC 62317-2, *Ferrite cores – Dimensions – Part 2: Pot-cores for use in telecommunications, power supply, and filter applications.*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
enamelled winding wire
insulated conductors made in accordance with the IEC 60317 series

3.2
wrapped insulated winding wire
insulated conductor, round or shaped, where the insulation is applied as a tape, with or without an adhesive, made from a film or a paper and applied to the conductor, made in accordance with the IEC 60317 series

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2 Withdrawn.

3.3
random wound coils
coils for use in an electrotechnical device made with enamelled winding wire without concern for the location of the turns

3.4
precision wound coils
coils for use in an electrotechnical device made with enamelled winding wire with each turn positioned in a specific and successive way

3.5
form wound winding coil
rectangular wire formed to a coil for use in an electrotechnical device

Note 1 to entry: Usually made with an insulated conductor this may be enamelled, fibrous wrapped or enamelled with fibrous wrapping. Afterwards the coil is wound it receives multiple layers of tape wrapped insulation and is vacuum- or vacuum-pressure impregnated with a resin, or wrapped with sufficient layers of a pre-impregnated B-stage tape and processed using resin-rich method.

3.6
wire-wound winding electrical insulation system
EIS evaluated with the wire wound coils that are either random or precision wound; not form wound coils

3.7
wire-wound winding electrotechnical device
electrotechnical device designed utilizing a wire-wound EIS

3.8
electrical insulation system
EIS
insulating structure containing one or more electrical insulating materials (EIM) together with associated conducting parts employed in an electrotechnical device

3.9
electrical insulating material
EIM
material with negligibly low electric conductivity, used to separate conducting parts at different electrical potentials

3.10
candidate EIS
EIS under evaluation concerning its thermal endurance for service capability

3.11
reference EIS
established EIS evaluated on the basis of either a known service experience record or a known comparative functional evaluation

3.12
EIS assessed thermal endurance index
EIS ATE
numerical value of temperature in degrees Celsius for the reference EIS as derived from known service experience or a known comparative functional evaluation

3.13
EIS relative thermal endurance index
EIS RTE
numerical value of the temperature in degrees Celsius of the candidate EIS which is relative to the known EIS ATE of a reference EIS, when both EIS are subjected to the same ageing and diagnostic procedures in a comparative test

4 General considerations

This standard provides relatively low-cost and short-time methods by which the user can make modifications to an established EIS by selecting the following evaluating procedures:

- Procedure A Without test
- Procedure B Compatibility test in accordance with Clause 10
- Procedure C Single-point thermal aging test Clause 11
- Procedure D Full thermal aging test in accordance with Clause 12

The main evaluation points are as following:

a) the impact on the thermal life of the EIS if the thickness of an EIM is changed;
b) the compatibility, under thermal stress, of a substituted EIM;
c) the compatibility, under thermal stress, of other components used in intimate contact with an established EIS.

EIM having different temperature indices (ATE/RTE) according to IEC 60216-5, may be combined to form an EIS having a thermal class that may be higher or lower than that of any of the individual components according to IEC 60505.

There may be more than one EIS in a particular apparatus. These EIS may have different thermal classes.

The following Figure 1 is an overview of this standard for guidance in selecting the proper clauses for evaluation.

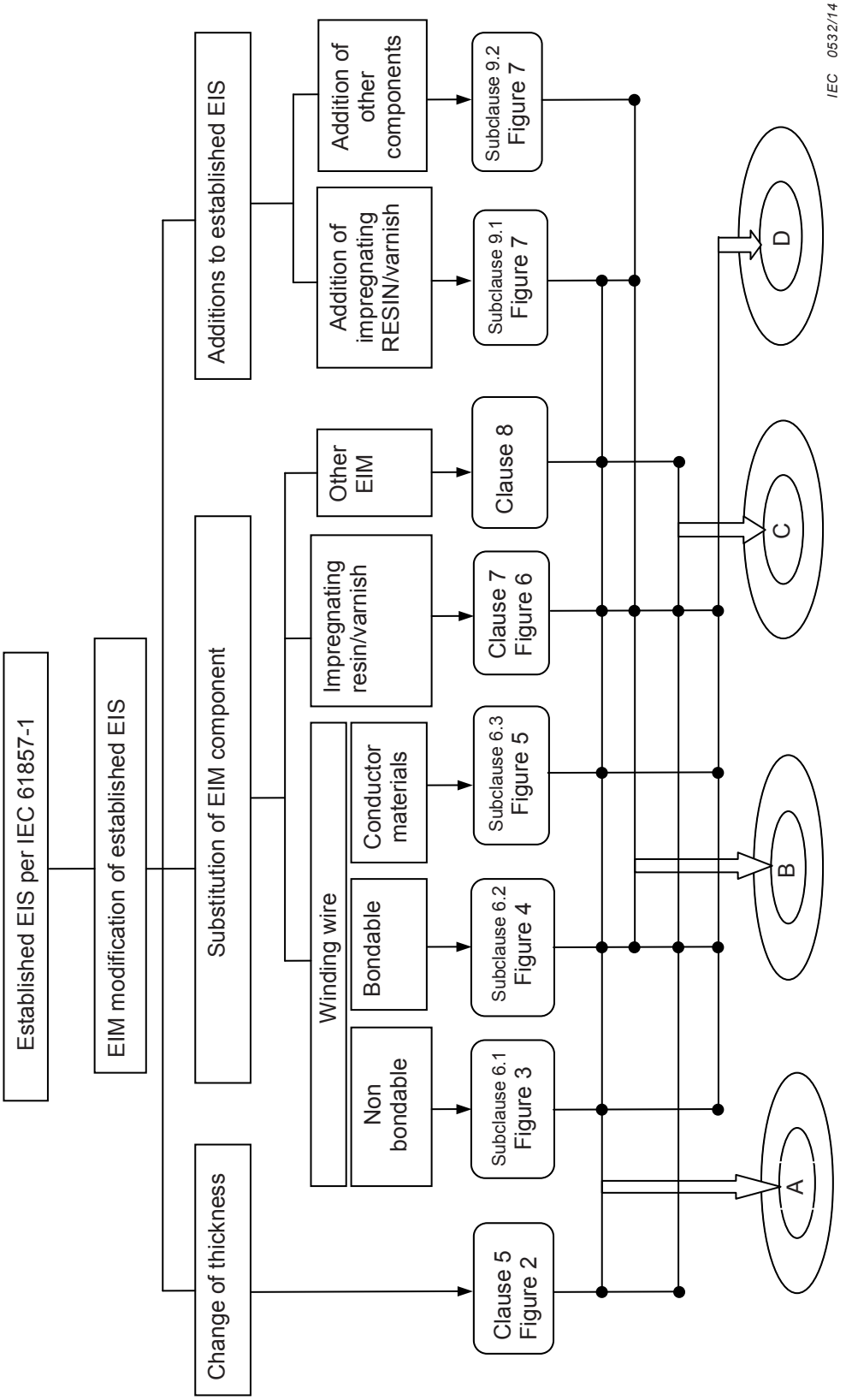


Figure 1 – Overview of evaluation methods

5 Substitution of phase or ground insulation

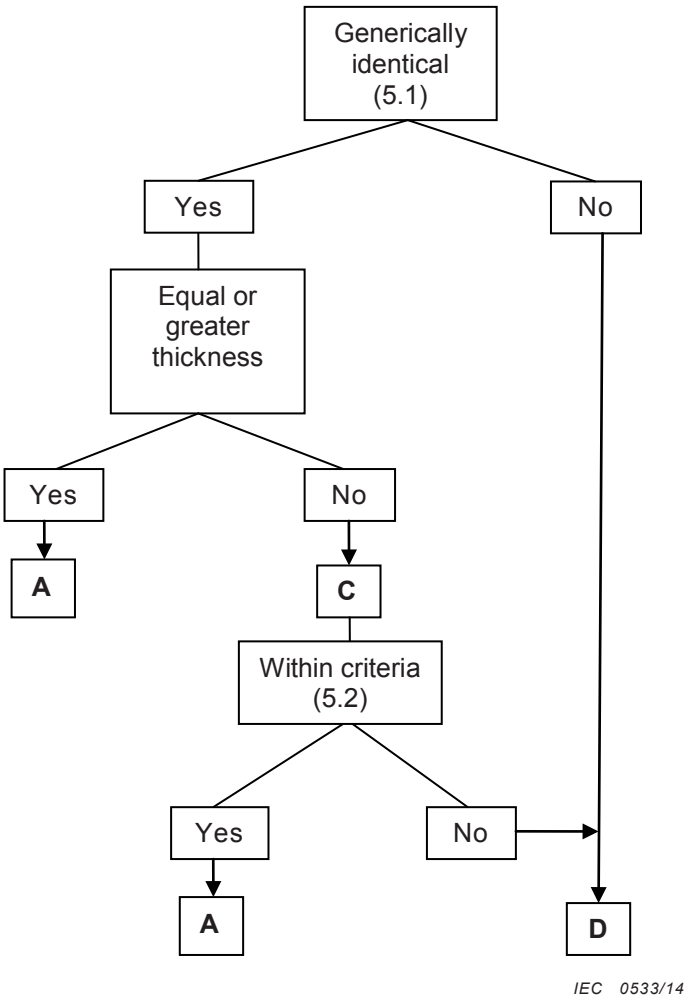


Figure 2 – Substitution of phase and ground insulation

5.1 Generically identical

"Generically identical" refers to both chemical and physical properties of the original and alternate materials having equal mechanical and electrical performances, in regards to the thermal endurance.

Basic chemical composition and physical identity can be established by analytical data based on appropriate analysis such as IR spectroscopic, thermogravimetric, differential thermal analysis (DTA) and/or atomic absorption analyses. The specific tests are typically agreed upon by the interested parties.

Generically identical and the same or increased thickness of an EIM can be substituted without additional test.

Substitution of generically identical EIM at a reduced thickness is allowed if it meets the criteria of Clause 10.

5.2 Substitution or addition of selected components and additives

Substitution or addition of select additives in an EIM may be allowed with reduced or no additional testing (if agreed upon by all interested parties).

An EIM evaluated as part of the established EIS, used in combination with another EIM or other component, may be used based upon acceptable results when tested for compatibility according to Clause 9. The thickness of the EIM shall not be less than that which was evaluated in the established EIS.

If none of the above conditions are met, full thermal aging in accordance with Clause 12 shall be conducted.

Generically identical properties and the same or increased thickness of an EIM can be substituted without additional test.

Representative samples of the established EIS (the reference EIS) and of the EIS with reduced EIM thicknesses (the candidate EIS) shall be evaluated in accordance with Clause 11.

6 Substitution of winding wire

6.1 Non bondable winding wire

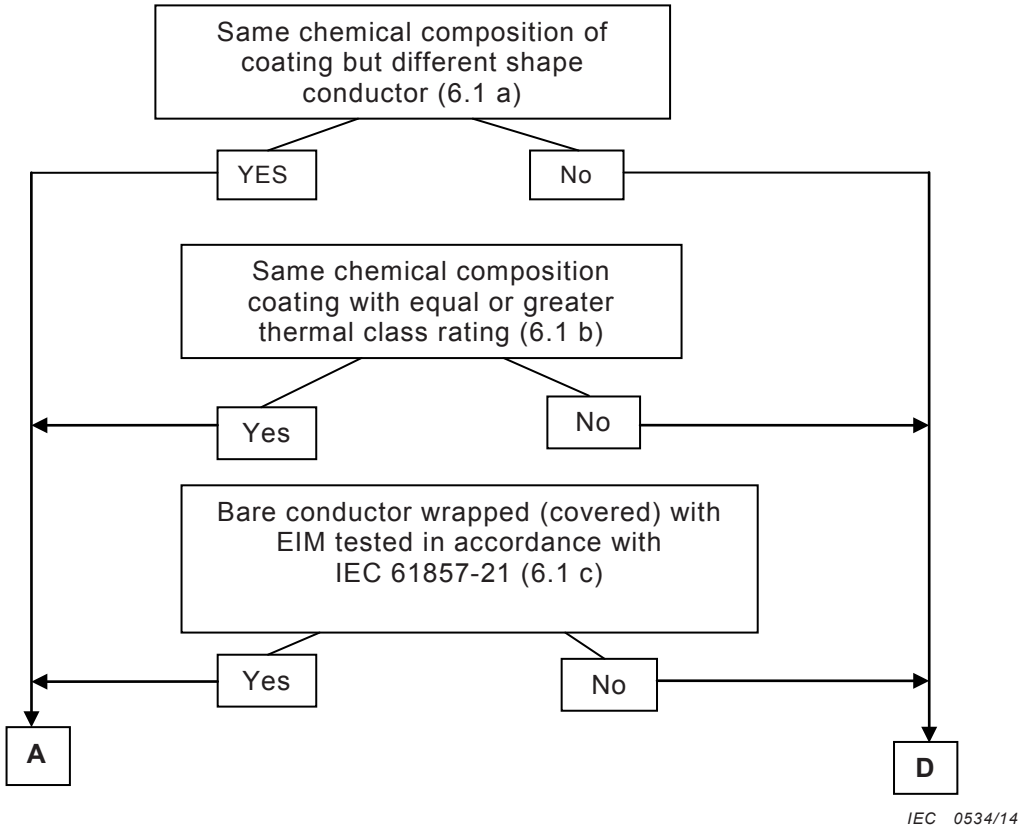


Figure 3 – Substitution of non-bondable winding wire

Substitution of a winding wire evaluated in the established EIS can be made without additional testing when one or more of the following conditions have been met:

a) the winding wire conforms to an IEC 60317 specification having the same chemical composition, according to the Annex A groupings, as the winding wire evaluated in the established EIS but is of a different size or shape;

b) the winding wire conforms to an IEC 60317 specification having the same chemical composition, according to the Annex A groupings, as the winding wire evaluated in the established EIS and has an equal or higher thermal class;

c) the winding wire is a bare conductor insulated with one of the EIM evaluated as part of the established EIS in accordance with IEC 61857-21.

The thickness to be used shall be such that the electrical stress per unit thickness is not greater than the stress to which the EIM was subjected during the ageing test.

NOTE For substitution of an alternate EIM, refer to Clause 8.

6.2 Bondable winding wire

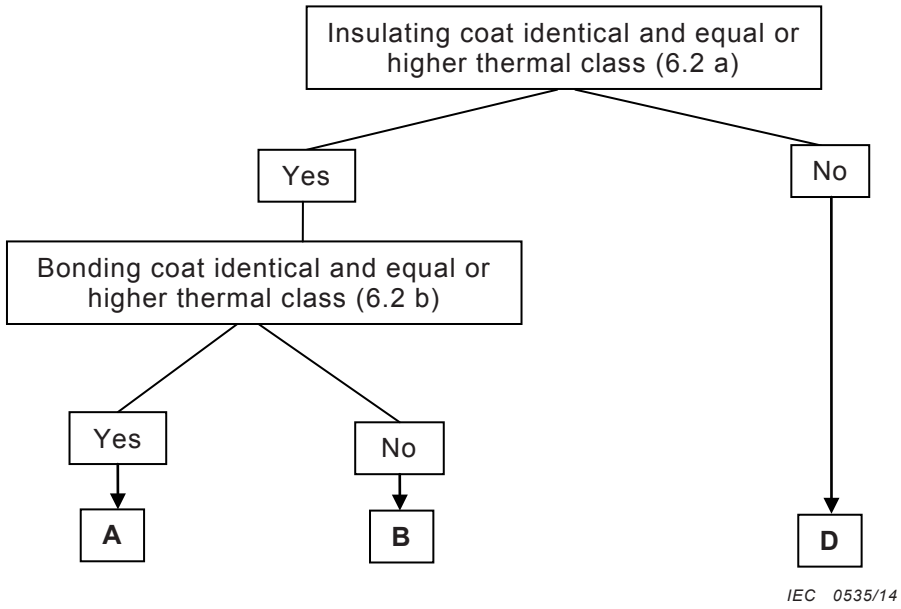


Figure 4 – Substitution of bondable winding wire

One bondable magnet wire is able to be substituted for another bondable magnet wire when the following a) or b) conditions are satisfied:

a) the magnet wire insulating coating is identical and of equal or higher class as evaluated by the IEC 60317 series. The bondable coating is also chemically identical; procedure A applies;

b) the magnet wire insulating coating is identical and of equal or higher class as evaluated by the IEC 60317 series. The bondable coat is chemically different, procedure B applies.

6.3 Substitution of conductor material

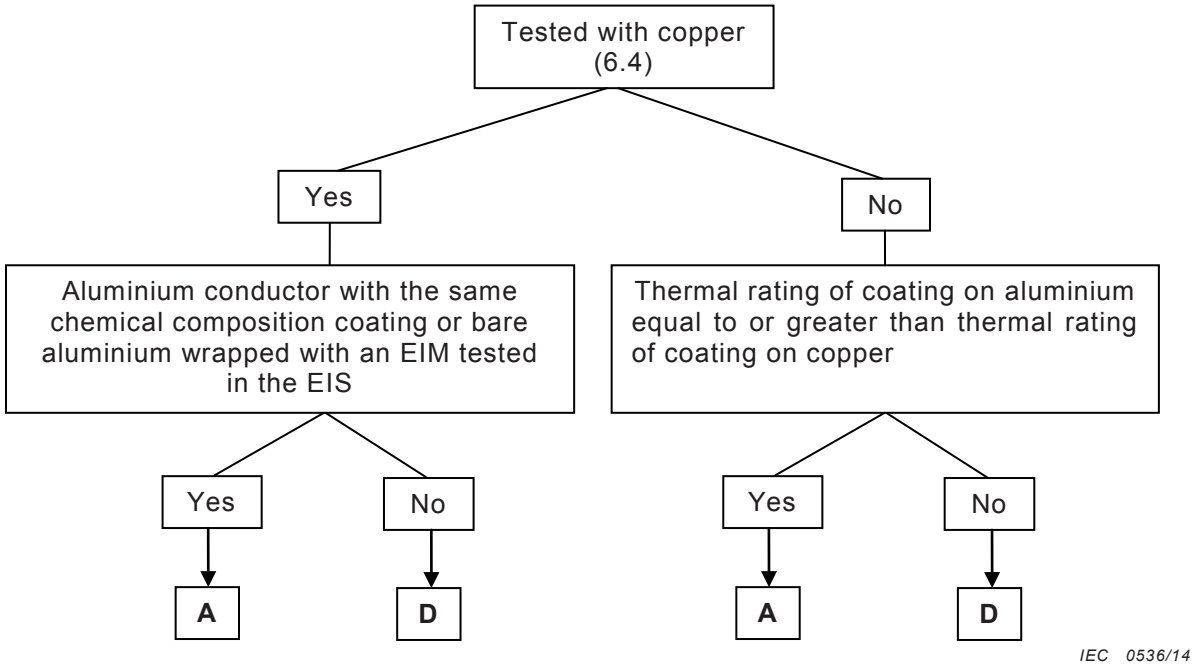


Figure 5 – Substitution of conductor material

An established EIS, which has been evaluated with copper as the conductor, may use either copper or aluminum conductor.

An established EIS, which has been evaluated with aluminum as the conductor, may use either aluminum or copper conductor, provided the thermal performance of the substitute winding wire has been established to be equal to or better than the winding wire evaluated.

7 Substitution of impregnating resin/varnish

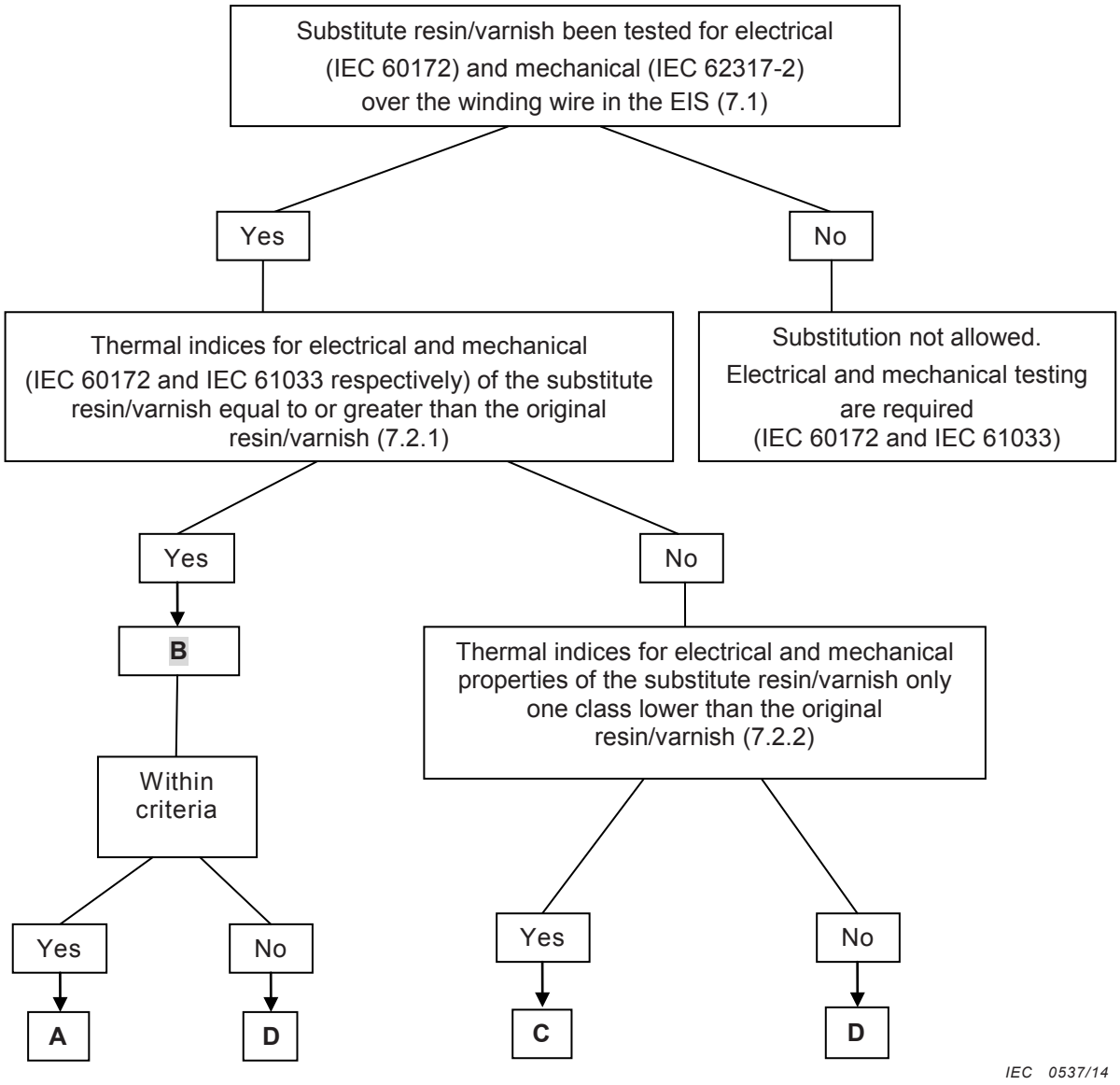


Figure 6 – Substitution of impregnating resin/varnish

7.1 Thermal class determination

The thermal classes of both the candidate resin/varnish and the reference resin/varnish used in the established EIS shall be determined by comparison of the manufacturer's thermal ageing data using the test methods in Table 1. Both tests shall be conducted.

Table 1 – Thermal ageing test methods for resin/varnishes

Test method	IEC designation
Twisted pair	IEC 60172, specifying the specific resin/varnish winding wire combination
Helical coil	IEC 61033 specifying the specific resin/varnish winding wire combination. Use 22 N as the value which specifies the end of life at each ageing temperature. A minimum of three ageing temperatures; the average life at the highest ageing temperature being a minimum of 100 h and the average life at the lowest ageing temperature being a minimum of 5 000 h. The temperature index value is defined as the temperature intercept for the time of 20 000 h. The helical-coil thermal class assigned to the resin/varnish winding wire combination shall be equal to or less than the temperature index (see Table 1 of IEC 60085:2007, Thermal class assignment).

7.2 Evaluation

7.2.1 Thermal classes equal or better

When both thermal classes of the candidate impregnating resin/varnish (twisted pair and helical coil) are equal to or higher than the thermal classes of the impregnating resin/varnish in the established EIS, then substitution is allowed:

a) based on acceptable results when tested for compatibility using the procedure from Clause 10; or

b) based on acceptable results when tested according to Clause 11.

7.2.2 One thermal class lower

If one or both of the thermal classes of the candidate impregnating resin/varnish (twisted pair and/or helical coil) are no more than one thermal class lower than the thermal classes of the impregnating resin/varnish of the established EIS, then substitution is allowed based on acceptable results when tested in accordance with Clause 11.

NOTE If the established EIS has received its thermal class rating without the inclusion of an impregnating resin/varnish, refer to 9.1 for addition of an impregnating resin/varnish.

7.2.3 Other criteria

A resin/varnish not meeting the above criteria shall be evaluated according to IEC 61857-1 for wire wound winding equipment.

8 Substitution with other EIM

8.1 Technically equivalent materials

Substitution with EIM, which have an identical chemical composition, is acceptable with no additional testing.

8.2 Previous evaluation

An EIM evaluated as part of the established EIS, used in combination with another EIM or other component, may be used, based upon acceptable results when tested for compatibility according to Clause 10. The thickness of the EIM shall not be less than that which was evaluated in the established EIS.

8.3 Other

Substitution with or addition of any other EIM shall require full thermal evaluation per IEC 61857-1. Substitution or addition of select additives which is agreed upon by all interested parties as no effect to thermal degradation in an EIM may be allowed with no additional testing.

9 Evaluation of additions

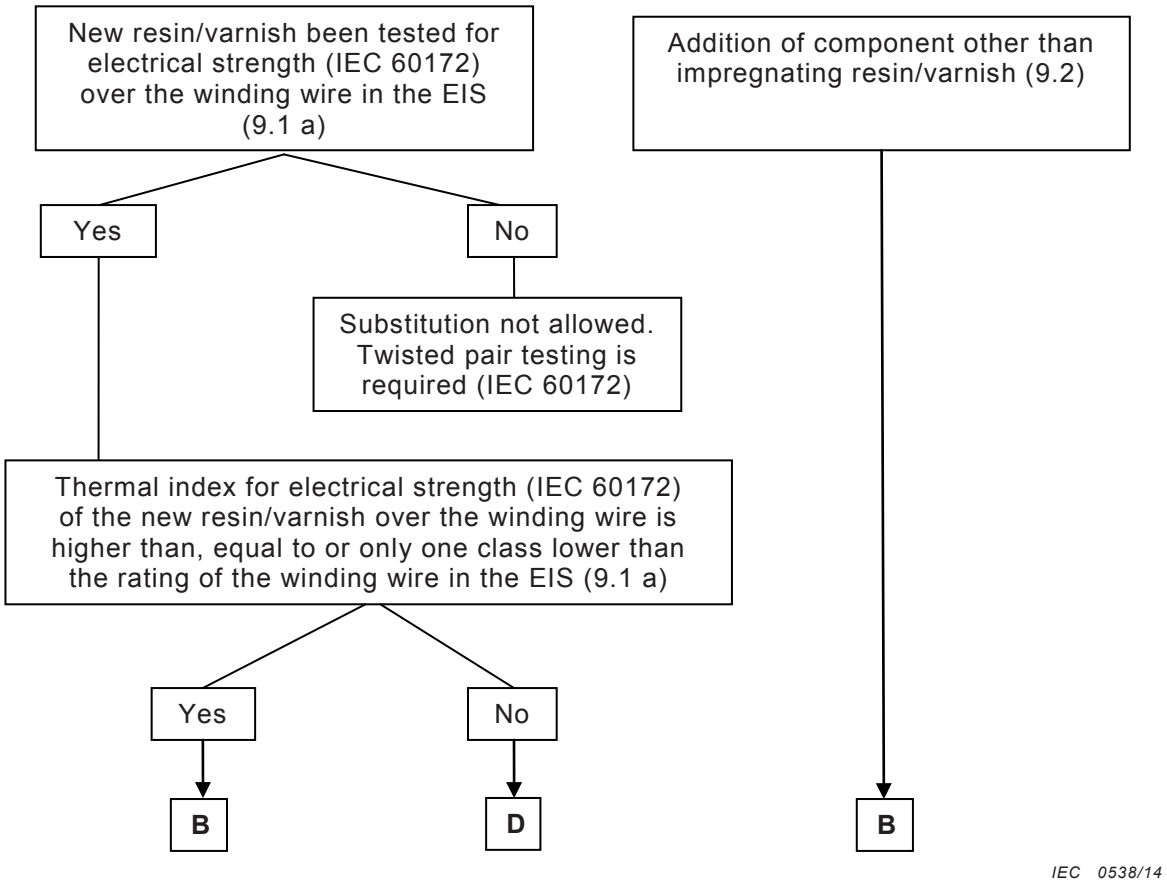


Figure 7 – Additions of resins/varnishes and other components used in combination with the EIMs evaluated in the EIS

9.1 Addition of an impregnating resin/varnish

An impregnating resin/varnish may be added to an established unvarnished EIS if the following conditions are met:

a) the impregnating resin/varnish shall be evaluated with the specific winding wire according to IEC 60172 and the resultant thermal class shall be not more than one thermal class below that of the unvarnished winding wire;

b) the candidate impregnating resin/varnish shall meet the criteria of 9.2.

9.2 Addition of other components

Other components that have to be used in conjunction with an established EIS shall be allowed based on acceptable results when tested for compatibility using the procedure Clause 10.

NOTE Such materials are typically used for mechanical, heat transfer, decoration, or other non-electrically stressed functions.

10 Chemical compatibility of a combination of materials

10.1 General

This test procedure is useful for evaluating the chemical compatibility of a combination of materials for use in conjunction with an EIS. A specific combination of materials is sealed in a glass tube, subjected to a specified thermal ageing cycle and then subjected to a dielectric test. Candidate tube test results are then compared to the reference tube test results for qualification of the acceptability of the candidate EIS.

10.2 Construction

10.2.1 Test apparatus

The test apparatus shall consist of the following:

a) glass tubes with inside volume not exceeding 900 ml and a minimum length of 300 mm:
   1) flanged high-temperature glass tubes which are designed to be sealed with metal rings and gaskets are preferred;
   2) glass tubes which can be fusion sealed after the addition of all materials are an acceptable alternative;

b) gasket material for use with flanged high-temperature glass tubes:
   1) type TFE or FEP fluorocarbon;
   2) TFE elastomer for exposure temperatures not exceeding 155 °C.

10.2.2 Material specimens

The samples of material specimens that are to be placed in each tube shall include the following:

a) winding wire specimens; samples of twisted pair winding wire formed and tested in accordance with IEC 60172; a minimum of five winding wire samples shall be evaluated for each tube;

   Winding wire covered with fibrous material shall be tested in 230 mm straight lengths.

b) representative samples of the EIM qualified for use in the established EIS, such as impregnating varnish and ground insulation; sheet material shall have a surface area not less than 645 mm^2; moulding compounds shall have a minimum volume of 800 mm^3; impregnating varnish, if included in the EIS, shall be applied to the winding wire samples and cured in accordance with the manufacturer's specifications;

c) other non-metallic component samples intended for use in conjunction with the EIS such as lead cable, sheet insulation, tie cord, tape, sleevings and tubing, potting compounds and encapsulants; sheet material shall have a surface area not less than 645 mm^2; potting compounds and encapsulants shall have a minimum volume of 800 mm^3; lead cable, sleevings, tubing and tie cord shall have a minimum length of 25,4 mm.

10.2.3 Contents of tube

The contents of the tubes shall be as follows:

a) reference tube – shall contain only materials which were qualified in the original aging to establish EIS;

b) candidate tubes – each candidate tube shall contain the alternate materials in addition to all the materials qualified in the established EIS. Alternate materials which are not usually or cannot be used in conjunction with each other, such as alternate varnishes, shall each be tested in a separate candidate tube.

10.3 Test procedure

10.3.1 Preparation of tubes

The preparation of the tube assemblies shall be as follows:

a) Cleaning of the tubes

The tubes shall be filled with an effective solvent, such as acetone, for 24 h or longer, scrubbed well with detergent and a test tube brush, rinsed thoroughly twice with tap water and then with distilled water, and finally dried.

b) Drying of the tube

The tubes, gaskets, taps, nuts and bolts shall be conditioned for at least 1 h in an oven maintained at 105 °C ± 2 K, and shall then be removed from the oven and the samples immediately inserted.

c) Setting of the specimen

The twisted pairs of wire shall be prepared in accordance with 10.2.2 a) and proof-tested electrically according to IEC 60172 before insertion in tubes. The other materials shall then be positioned inside the tubes, avoiding contact with the twisted pairs if possible, so that there is no sticking during the ageing period. Open glass tubes shall be sealed at one end before being filled.

d) Drying of the specimen

After the tubes are filled, the tube, gaskets, taps, nuts and bolts shall be dried for at least 1 h in an oven maintained at 105 °C ±2 K. If open glass tubes are used, the oven temperature shall be 135 °C ±2 K. Certain materials may require additional conditioning to remove all moisture; if agreed upon by interested parties, higher temperatures and times may be used to condition these materials prior to insertion in the tubes. The bolts, threads and the underside of the top shall be lightly coated with silicone grease before being placed in the oven, and these parts shall be kept away from the gasket material and tubes.

e) Assembly of the tubes

Immediately upon removal from the oven, the gasket and clamp shall be assembled to the tube using protective gloves. Each bolt shall be torqued in a clockwise direction in increments of 0,5 Nm until a torque of 3,5 Nm is attained. If open glass tubes are used, the open end shall be fused.

Inspection of the tube sealing. Unless open glass tubes are used, the still warm assembly should be inverted in room temperature water to reduce the likelihood of shock and breakage. The assembly should remain in the water and cool for a minimum of 5 min. The cooling creates a vacuum in the tube that will draw in water if a leak is present. If open glass tubes are used, each tube should be returned to the oven which should then be turned off and allowed to cool to room temperature. The tubes should be removed and allowed to cool to room temperature and examined for possible leakage, as evidenced by condensation on the inner walls of the tubes.

f) Aging

Tubes should be placed in the pre-heated thermal conditioning oven. The thermal conditioning oven should not be opened during the conditioning cycle as this can effect the thermal ageing of the EIS under evaluation.

10.3.2 Thermal conditioning

The samples shall be conditioned for 336 h ±2 h (14 days) at a temperature equal to the thermal class of the established EIS plus 25 K; for example, the conditioning temperature of a Class 130(B) EIS would be 155 °C.

10.3.3 Opening procedure

After thermal conditioning of the tubes as described in 10.3.2, the oven should be turned off and allowed to cool to room temperature before the tubes are removed. Tubes should remain sealed prior to evaluation, which shall not to be delayed for more than three days. The tubes

should then be opened and the winding wire samples carefully removed and separated so as to reduce mechanical damage.

10.3.4 Evaluation of samples

The winding wire samples shall be evaluated as follows:

a) Twisted pairs shall be dielectrically stressed until breakdown by increasing the test voltage at a rate of 500 V/s, 48 Hz to 62 Hz, a.c. Winding wire covered with fibrous material shall be tested by applying the test voltage between the conductor and metallic foil, over a length of 100 mm, wrapped around the straight central portion of the specimen.

b) The average breakdown voltage for the winding wire samples from the candidate tube shall be compared to the average breakdown voltage for the winding wire samples from the reference tube. At least five test values are required for each set of winding wire samples; the criteria to be used for eliminating any one test value from the calculation of the average shall be determined by agreement between interested parties prior to testing.

c) The combination of materials in the candidate tube shall be considered compatible and qualified for use in the specific EIS tested if the average electric strength of the winding wire samples from the candidate tube is not less than 50 % of that of the winding wire samples from the reference tube.

NOTE The 50 % criterion has been found to be adequate, since the breakdown voltage drops drastically if incompatibility occurs between materials in the individual tubes.

11 Single-point thermal ageing test (procedure C)

11.1 Test objects

Representative test objects of the established EIS (reference EIS) and the candidate EIS shall be constructed and tested in accordance with IEC 61857-21 with the following exceptions:

a) the reference and candidate EIS shall be concurrently tested at the same temperature;

b) the ageing temperature should be selected from the full thermal ageing programme of the established EIS to give an expected test life of between 1 000 h to 2 000 h;

c) when an EIM, evaluated in the established EIS with multiple EIM, is no longer available, the reference test objects shall be constructed with all remaining materials.

11.2 Establishing the EIS relative thermal endurance index (EIS RTE)

The EIS RTE of the candidate EIS shall be established by comparing the original regression slope of the reference EIS with the time-temperature data point for the candidate EIS (refer to Figure 1 of IEC 61857-1:2008). The comparison shall be made using the correlation time established according to:

Correlation time

$$t_x = t_R \times e^{\left(\frac{M}{T_R + 273,15} - \frac{M}{T_A + 273,15} \right)}$$

EIS RTE of the candidate EIS

$$T_c = \left(\frac{M}{\ln\left(\frac{t_x}{t_c} \right) + \frac{M}{T_A + 273,15}} \right) - 273,15$$

where

M is the slope of the reference EIS regression equation;

T_R is the EIS ATE of the reference EIS, in degrees Celsius (°C);

T_A is the ageing temperature in degrees Celsius (°C);

T_c is the EIS RTE of the candidate system in degrees Celsius (°C);

t_R is the life of the reference EIS in hours (h);

t_c is the life of the candidate EIS in hours (h);

t_x is the correlation time in hours (h).

NOTE The procedure is largely approximated, assuming that reference and candidate EIS have the same slope of the thermal endurance line.

11.3 Interpretation of results

The candidate EIS shall be assigned the same thermal class rating as the reference EIS if the EIS RTE value, derived in 10.2, is within ±5 K of the EIS ATE value of the reference EIS. If the EIS RTE value of the candidate EIS is not within ±5 K of the EIS ATE value of the reference EIS, no thermal class rating shall be assigned to the candidate EIS. The candidate EIS can be aged at additional temperatures in accordance with IEC 61857-1 in order to establish the thermal class.

12 Full thermal aging test (procedure D)

Full thermal aging test shall be evaluated in accordance with the IEC 61857 series.

Annex A
(normative)

Classes of winding wire

Various types of commonly used enamelled winding wire, constructed in accordance with the IEC 60317 series, are presented in Table A.1. The accepted practice for substitution of winding wire is as follows:

a) winding wires of the same chemical composition with a thermal class equal to or higher than the type of wire evaluated in the established EIS may be substituted into the established EIS without additional testing;

b) winding wire of the same chemical composition having a thermal classification lower than the thermal class of the wire type(s) evaluated in the established EIS shall not be substituted;

c) winding wire substitutions not permitted under either b) or c) shall be tested according to IEC 61857-1.

Table A.1 – Winding wire types – Round copper or aluminum conductor

	Chemical composition of enamel	Thermal class	Conductor	IEC designation
Solderable	Poly urethane with bonding layer	130	Copper	60317-2
	Poly urethane	130	Copper	60317-4
	Poly urethane/polyamide overcoated	130	Copper	60317-19
	Poly urethane	155	Copper	60317-20
	Poly urethane with bonding layer	155	Copper	60317-35
	Poly urethane/polyamide overcoated	155	Copper	60317-21
	Polyesterimide	180	Copper	60317-23
	Polyesterimide with bonding layer	180	Copper	60317-36
	Poly urethane	180	Copper	60317-51
	Poly urethane/polyamide overcoated	180	Copper	60317-55
Non-solderable	Polyvinyl acetal	105	Copper	60317-1
	Polyvinyl acetal	120	Copper	60317-12
	Polyester	130L	Copper	60317-34
	Polyester	155	Copper	60317-3
	Polyester	155L	Copper	60317-54
	Polyesterimide	180	Copper	60317-8
	Polyesterimide	180	Aluminium	60317-4
	Polyesterimide with bonding layer	180	Copper	60317-37
	Polyester or polyesterimide/polyamide overcoated	180	Copper	60317-22
	Glass fibre wound resin or varnish impregunated	180	Copper	60317-48
	Glass fibre wound resin or varnish impregunated	200	Copper	60317-50
	Polyester or polyesterimide/polyamide overcoated	200	Aluminium	60317-25
	Polyester or polyesterimide/polyamide—imide overcoated	200	Copper	60317-13
	Polyester or polyesterimide/polyamide—imide overcoated with bonding layer	200	Copper	60317-38
	Polyamide—imide	200	Copper	60317-26
	Polyester-amide-imide	200	Copper	60317-42

	Chemical composition of enamel	Thermal class	Conductor	IEC designation
	Aromatic polyamide tape wrapped	220	Copper	60317-53
	Poly amide-imide	220	Copper	60317-57
	Polyimide tape wrapped	240	Copper	60317-43
	Aromatic polyimide	240	Copper	60317-46

Annex B
(informative)

Visual representations of coils

B.1 Form wound coils

Figures B.1 to B.4 show various visual representations of form wound coils.

IEC 0539/14

Figure B.1 – Form-wound coil comparison

IEC 0540/14

Figure B.2 – Form-wound coil comparison – Close-up

IEC 0541/14

Figure B.3 – Form-wound coil comparison – Different angle

IEC 0542/14

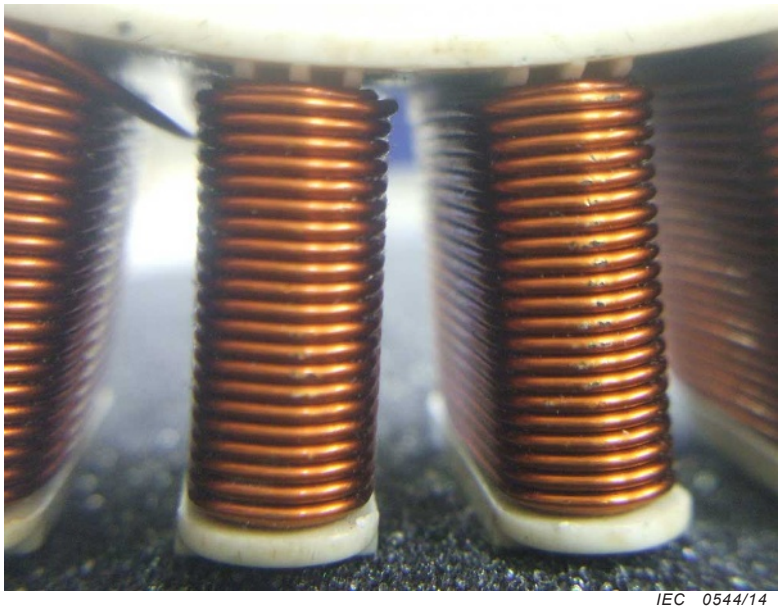
Figure B.4 – Form-wound coil detail

B.2 Precision-wound coil

Figures B.5 and B.6 show visual representations of precision-wound coils.

IEC 0543/14

Figure B.5 – Examples of precision-wound coils



IEC 0544/14

Figure B.6 – Example of precision-wound coil – Close-up

B.3 Random-wound coil

Figures B.7 and B.8 show visual representations of random-wound coils

IEC 0545/14

Figure B.7 – Example of random-wound coil

IEC 0546/14

Figure B.8 – Example of random-wound coil – Close-up

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IEC 60034-18-21, *Rotating electrical machines – Part 18-21: Functional evaluation of insulation systems – Test procedures for wire-wound windings – Thermal evaluation and classification*

IEC 60317-15, *Specifications for particular types of winding wires – Part 15: Polyesterimide enamelled round aluminium wire, class 180*

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