BS EN 61858-2:2014

BSI Standards Publication

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

Part 2: Form-wound EIS

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National foreword

This British Standard is the UK implementation of EN 61858-2:2014. It is identical to IEC 61858-2:2014. It supersedes BS IEC 61858-2:2014, which is withdrawn.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.

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

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Amendments/corrigenda issued since publication

Date	Text affected
30 June 2014	This corrigendum renumbers BS IEC 61858-2:2014 as BS EN 61858-2:2014. Annex ZA inserted

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EN 61858-2

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English Version

Electrical insulation systems - Thermal evaluation of modifications to an established electrical insulation system (EIS) - Part 2: Form-wound EIS (IEC 61858-2:2014)

Systèmes d'isolation électrique - Évaluation thermique des modifications apportées à un système d'isolation électrique (SIE) éprouvé - Partie 2: Système d'isolation électrique à enroulements préformés (CEI 61858-2:2014)

Elektrische Isoliersysteme - Thermische Bewertung von Veränderungen an einem erprobten elektrischen Isoliersystem (EIS) - Teil 2: EIS mit Flachdraht-Wicklungen (IEC 61858-2:2014)

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Foreword

The text of document 112/253/CDV, future edition 1 of IEC 61858-2, 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 61858-2:2014.

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• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2017-03-19

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 61858-2:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated:

IEC 60172	NOTE	Harmonized as EN 60172.

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 When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60034-18-31	2012	Rotating electrical machines - Part 18-31: Functional evaluation of insulation systems - Test procedures for form-wound windings - Thermal evaluation and classification of insulation systems used in rotating machines	EN 60034-18-31	2012
IEC 60085	2007	Electrical insulation - Thermal evaluation and designation	EN 60085	2008
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 60216-6	-	Electrical insulating materials - Thermal endurance properties - Part 6: Determination of thermal endurance indices (TI and RTE) of an insulating material using the fixed time frame method	EN 60216-6	-
IEC 60317	Series	Specifications for particular types of winding wires	EN 60317	Series
IEC 60317-16 [1)]	-	Specifications for particular types of winding wires - Part 16: Polyester enamelled rectangular copper wire, class 155	EN 60317-16 [1)]	-
IEC 60317-17	-	Specifications for particular types of winding wires - Part 17: Polyvinyl acetal enamelled rectangular copper wire, class 105	EN 60317-17	-
IEC 60317-18	-	Specifications for particular types of winding wires - Part 18 : Polyvinyl acetal enamelled rectangular copper wire, class 120	EN 60317-18	-
IEC 60317-27	-	Specifications for particular types of winding wires - Part 27: Paper tape covered rectangular copper wire	EN 60317-27	-

[1)] Withdrawn publication.

Publication	Year	Title	EN/HD	Year
IEC 60317-28	-	Specifications for particular types of winding wires - Part 28: Polyesterimide enamelled rectangular copper wire, class 180	EN 60317-28	-
IEC 60317-29	-	Specifications for particular types of winding wires - Part 29: Polyester or polyesterimide overcoated with polyamide-imide enamelled rectangular copper wire, class 200	EN 60317-29	-
IEC 60317-30 [1)]	-	Specifications for particular types of winding wires - Part 30: Polyimide enamelled rectangular copper wire, class 220	EN 60317-30	-
IEC 60317-31	-	Specifications for particular types of winding wires - Part 31: Glass-fibre wound resin or varnish impregnated, bare or enamelled rectangular copper wire, temperature index 180	EN 60317-31	-
IEC 60317-32	-	Specifications for particular types of winding wires - Part 32: Glass-fibre wound, resin or varnish impregnated, bare or enamelled rectangular copper wire, temperature index 155	EN 60317-32	-
IEC 60317-33	-	Specifications for particular types of winding wires - Part 33: Glass-fibre wound, resin or varnish impregnated, bare or enamelled rectangular copper wire, temperature index 200	EN 60317-33	-
IEC 60317-39	-	Specifications for particular types of winding wires - Part 39: Glass-fibre braided resin or varnish impregnated, bare or enamelled rectangular copper wire, temperature index 180	EN 60317-39	-
IEC 60317-40	-	Specifications for particular types of winding wires - Part 40: Glass-fibre braided resin or varnish impregnated, bare or enamelled rectangular copper wire, temperature index 200	EN 60317-40	-
IEC 60317-44	-	Specifications for particular types of winding wires - Part 44: Aromatic polyimide tape wrapped rectangular copper wire, class 240	EN 60317-44	-
IEC 60317-47	-	Specifications for particular types of winding wires - Part 47: Aromatic polyimide enamelled rectangular copper wire, class 240	EN 60317-47	-
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	-

[1)] Withdrawn publication.

Publication	Year	Title	EN/HD	Year
IEC 60317-58	-	Specifications for particular types of winding wires - Part 58: Polyamide-imide enamelled rectangular copper wire, class 220	EN 60317-58	-
IEC 60505	-	Evaluation and qualification of electrical insulation systems	EN 60505	-

CONTENTS

INTRODUCTION

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

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

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

Part-2: Form-wound 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 form-wound 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 IEC 60085 and IEC 60034-18-31.

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 60085:2007, *Electrical insulation – Thermal evaluation and designatio*n

IEC 60034-18-31:2012, *Rotating electrical machines – Part 18-31: Functional evaluation of insulation systems – Test procedures for form-wound windings – Thermal evaluation and classification of insulation systems used in rotating machines*

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

IEC 60216-6, *Electrical insulating materials – Thermal endurance properties – Part 6: Determination of thermal endurance indices (TI and RTI) of an insulating material using the fixed time frame method*

IEC 60317 (all parts), *Specifications for particular types of winding wires*

IEC 60317-16, *Specifications for particular types of winding wires – Part 16: Polyester enamelled rectangular copper wire, class 155*
(withdrawn)[1]

IEC 60317-17, *Specifications for particular types of winding wires – Part 17: Polyvinyl acetal enamelled rectangular copper wire, class 105*

IEC 60317-18, *Specifications for particular types of winding wires – Part 18: Polyvinyl acetal enamelled rectangular copper wire, class 120*

IEC 60317-27, *Specifications for particular types of winding wires – Part 27: Paper tape covered rectangular copper wire*

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1 Withdrawn in 2012.

IEC 60317-28, *Specifications for particular types of winding wires – Part 28: Polyesterimide enamelled rectangular copper wire, class 180*

IEC 60317-29, *Specifications for particular types of winding wires – Part 29: Polyester or polyesterimide overcoated with polyamide-imide enamelled rectangular copper wire, class 200*

IEC 60317-30, *Specifications for particular types of winding wires – Part 30: Polyimide enamelled rectangular copper wire, class 220*
(withdrawn)[2]

IEC 60317-31, *Specifications for particular types of winding wires – Part 31: Glass-fibre wound, polyester or polyesterimide varnish-trated, bare or enamelled rectangular copper wire, temperature index 180*

IEC 60317-32, *Specifications for particular types of winding wires – Part 32: Glass-fibre wound resin or varnish impregnated, bare or enamelled rectangular copper wire, temperature index 155*

IEC 60317-33, *Specifications for particular types of winding wires – Part 33: Glass-fibre wound resin or varnish impregnated, bare or enamelled rectangular copper wire, temperature index 200*

IEC 60317-39, *Specifications for particular types of winding wires – Part 39: Glass-fibre braided, polyester or polyesterimide varnish-treated, bare or enamelled rectangular copper wire, temperature index 180*

IEC 60317-40, *Specifications for particular types of winding wires – Part 40: Glass-fibre braided, silicone varnish-tratead, bare or enamelled rectangular copper wire, temperature index 200*

IEC 60317-44, *Specifications for particular types of winding wires – Part 44: Aromatic polyimide tape wrapped rectangular copper wire, class 240*

IEC 60317-47, *Specifications for particular types of winding wires – Part 47: Aromatic polyimide enamelled rectangular copper wire, class 240*

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

IEC 60317-58, *Specifications for particular types of winding wires – Part 58: Polyamide-imide enamelled rectangular copper wire, class 220*

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

3 Terms and definitions

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

3.1
enamelled winding wire
insulated conductors, round or shaped, where the insulation is applied in a liquid form and applied to the conductor, made in accordance with the IEC 60317 series

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2 Withdrawn in 2009.

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

3.3
random wire-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 wire-wound coils
coils for use in an electrotechnical device made with enamelled winding wire or sheet conductor and insulation with each turn positioned in a specific and successive way

3.5
form-wound coils
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 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 evaluating

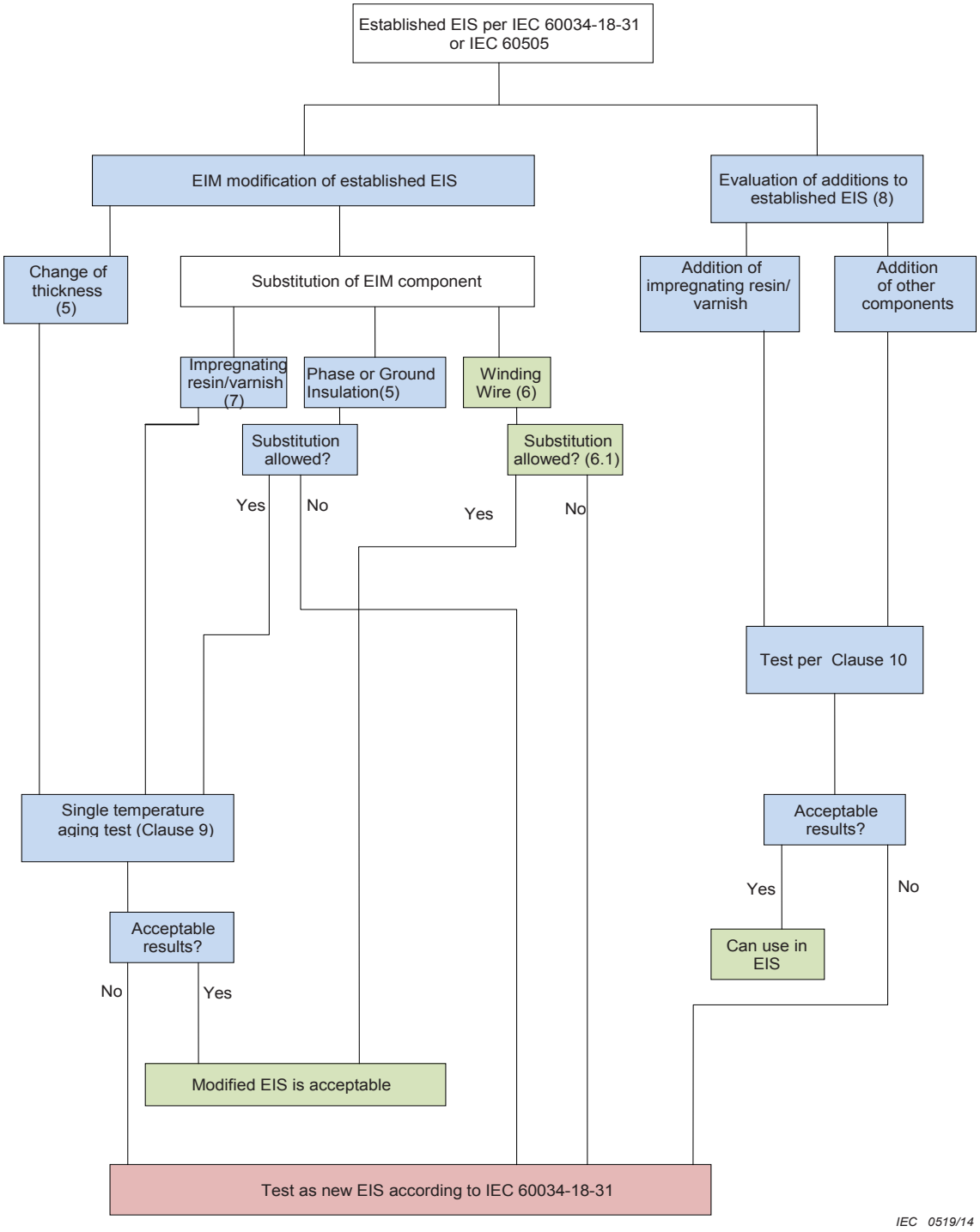
a) the impact on the thermal life of the EIS if the thickness of an EIM is changed,

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 thermal indices (ATE/RTE) can be established by testing in accordance with IEC 60216-5 or IEC 60216-6. According to IEC 60505, an EIS may be constructed with EIMs having different thermal indices. The thermal class of the EIS is established through testing and may be higher or lower than any of the individual components.

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



Key

Single temperature EIS evaluation

No testing required

Full thermal aging EIS evaluation

Figure 1 – Overview of evaluation methods

NOTE Figure 1 provides guidance in selecting the proper clauses for evaluation of modifications to an established form-wound EIS. Figure 1 serves as an overview for Clauses 5 to 8; Clauses 5 to 8 present details one category at a time.

In Figures 2, 3, and 4, the following letters represent a test procedure as indicated below:

- A = Procedure A: no testing required;
- B = Procedure B: sealed tube compatibility test (only utilized in IEC 61858-1);
- C = Procedure C: single-point thermal aging test (Clause 9);
- D = Procedure D: full thermal aging test (Clause 10).

5 Substitution of phase insulation and/or ground insulation

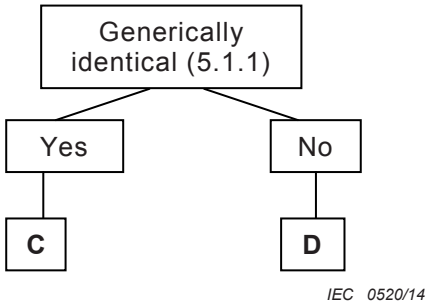


Figure 2 – Substitution of phase and ground insulation

5.1 Generically identical

"Generically identical" refers to both chemical and physical properties of the original and alternate materials. The alternate material shall have equal or better mechanical and electrical performance in regards to the thermal endurance.

Based on application of other properties, e.g. water permeability or process ability, these are critical to the performance of the system and should be considered prior to substitution.

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

Substitution of generically identical EIMs is allowed if it meets the criteria of Clause 9.

5.2 Substitution or addition of selected components and additives

Substitution or addition of select additives (e.g. colorants, fillers, etc.) 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 in accordance with Clause 9. The thickness of the established EIM shall not be less than that which was evaluated in the established EIS.

5.3 Reduction of thickness

An EIM in the established EIS can be used at a reduced thickness if it is successfully evaluated in accordance with Clause 9.

If none of the above conditions are met, full thermal aging in accordance with Clause 10 shall be conducted.

6 Substitution of winding wire

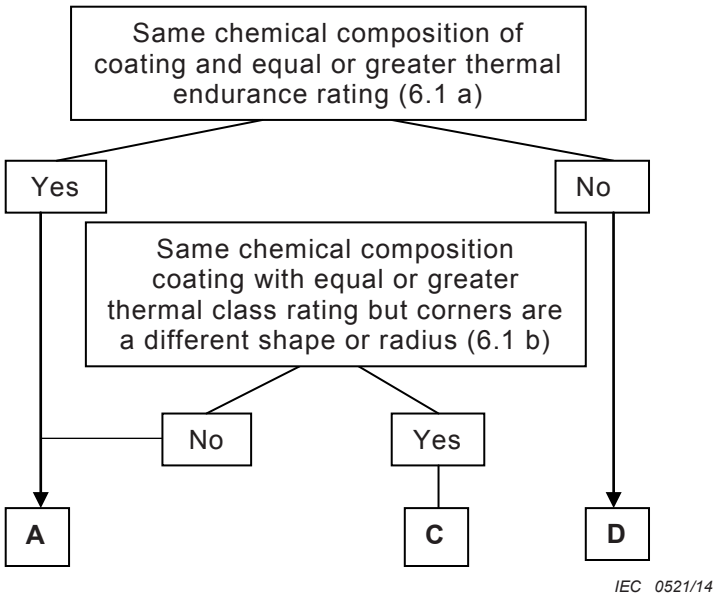


Figure 3 – Substitution of winding wire

6.1 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 and has an equal or higher thermal class with an equal build;

and

b) the conductor is of a different size or shape, but the radius of the corners are the equal.

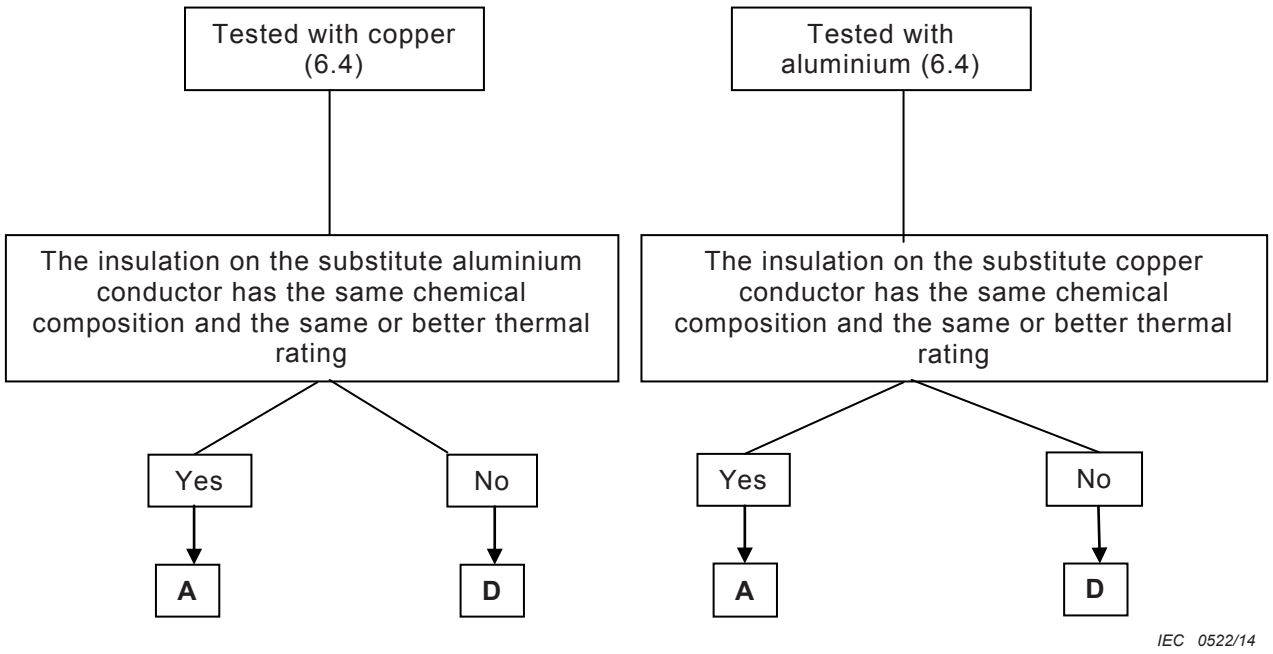


Figure 4 – Substitution of conductor material

6.2 Substitution of conductor material

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

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

6.3 Alternate winding wire

Winding wires that do not meet the criteria in 6.1 or 6.2 shall be evaluated in accordance with case D of IEC 60034-18-31:2012.

7 Substitution of impregnating resin/varnish

Substitution of impregnating resin/varnish is allowed if it meets the criteria of Clause 9.

8 Evaluation of additions

Any potential additions to the EIS tested in accordance with IEC 60034-18-31, shall meet the criteria of Clause 9.

9 Procedure C – Single-point thermal ageing test

9.1 Test objects

Representative test objects of the established EIS (reference EIS) and the candidate EIS shall be constructed and tested in accordance with IEC 60034-18-31 with the following exceptions:

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

b) the ageing temperature shall be selected from the full thermal ageing program 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.

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

The 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. 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.

9.3 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 9.2, is within ±5 K of the EIS ATE value of the reference EIS. If the RTE value of the candidate EIS is not within ±5 K of the 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 60034-18-31 in order to establish the thermal class.

10 Full thermal aging test (procedure D)

Full thermal aging test shall be evaluated in accordance with the IEC 60034-18-31.

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 that is not of the same chemical composition evaluated in the established EIS shall not be substituted

d) winding wire substitutions not permitted under either b) or c) shall be tested according to IEC 61858-1.

Table A.1 – Winding wire type – Rectangular conductor

Chemical composition of enamel (non solderable)	Thermal class	Conductor	IEC Designation
Polyvinyl acetal	105	Copper	60317-17
Polyvinyl acetal	120	Copper	60317-18
Paper tape covered		Copper	60317-27
Polyester	155	Copper	60317-16
Micapaper-PET film	155	Copper	
Glass fibre wound resin or varnish impregnated	155	Copper	60317-32
Polyesterimide	180	Copper	60317-28
Glass fibre wound resin or varnish impregnated	180	Copper	60317-31
Glass fibre braided resin or varnish impregnated	180	Copper	60317-39
Glass fibre wound resin or varnish impregnated	200	Copper	60317-33
Polyester or polyesterimide/polyamide-imide overcoated	200	Copper	60317-29
Glass fibre braided resin or varnish impregnated	200	Copper	60317-40
Polyimide enamelled	220	Copper	60317-30
Aromatic polyamide (aramid), tape wrapped	220	Copper	60317-53
Aromatic polyamide-imide	220	Copper	60317-58
Aromatic polyimide	240	Copper	60317-47
Aromatic polyimide, tape wrapped	240	Copper	60317-44

Annex B
(informative)

Visual representation of form-wound coil manufacturing process

Figures B.1 to B.9 illustrate the process involved in manufacturing form-wound coils.

NOTE Photos provided by courtesy of WuJiang Taihu Insulating Material Co., Ltd.

IEC 0523/14

Figure B.1 – Rectangular winding wire shaped into un-formed coil on coil forming machine

Figure B.2 – Un-formed coil being wrapped with a protective fabric

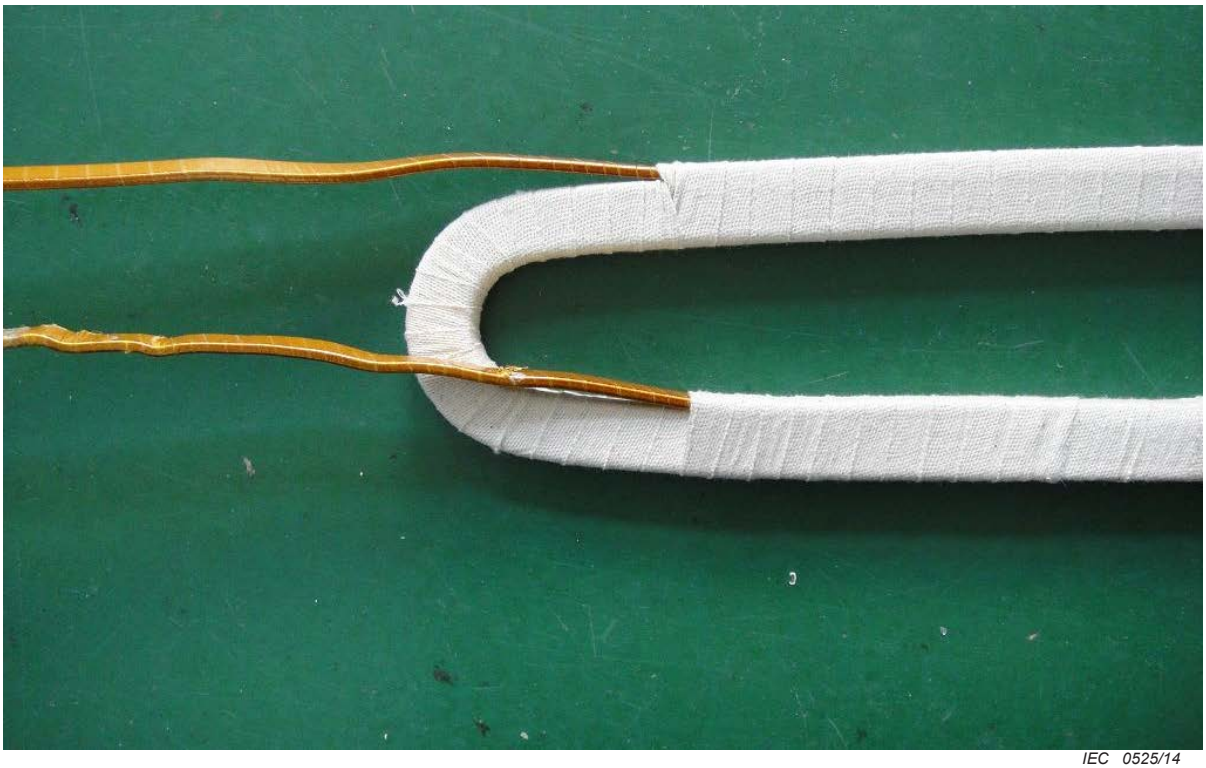


Figure B.3 – Un-formed coil completely wrapped with protective fabric

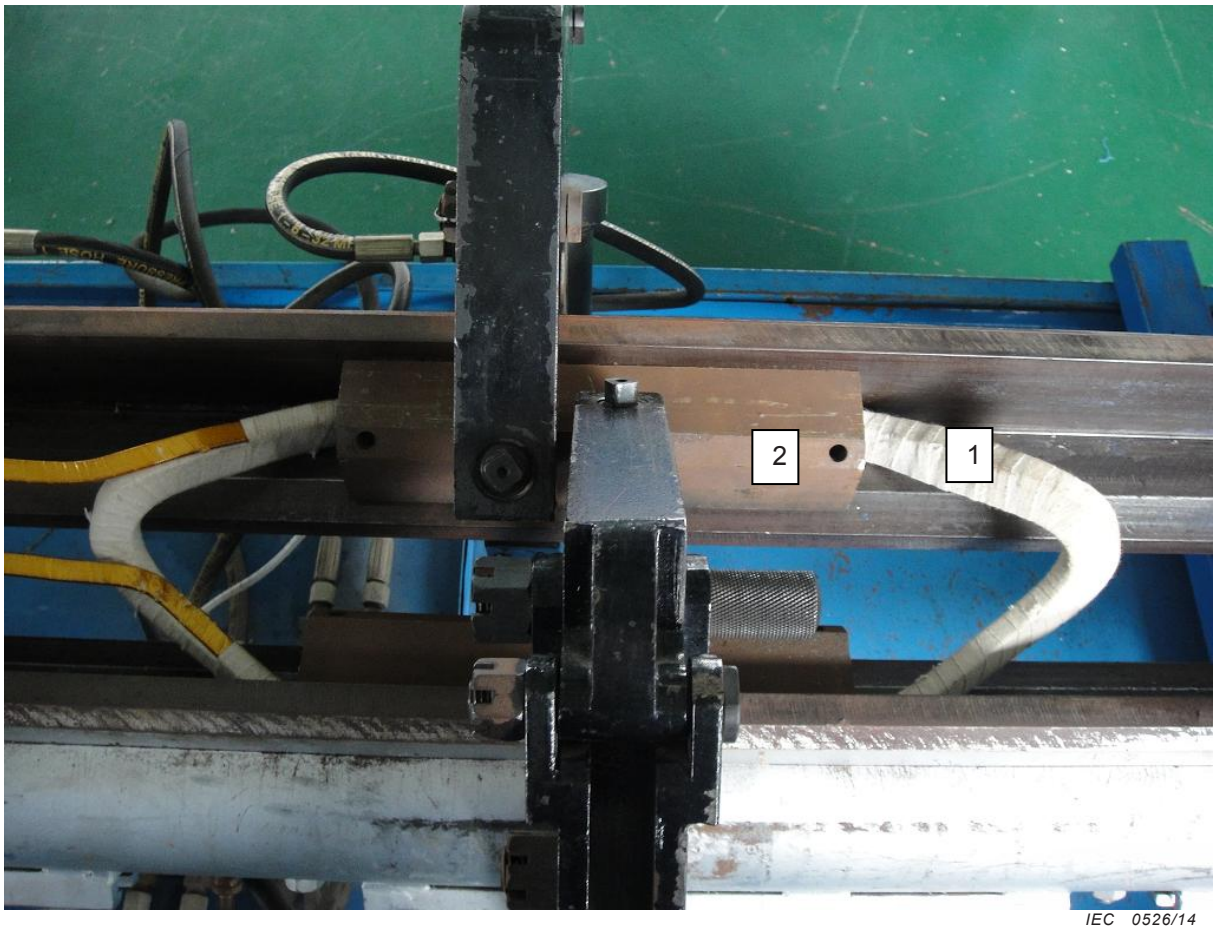


Figure B.4 – Coil forming machine stretches and bends oval coil to formed shape coil in the shaping apparatus

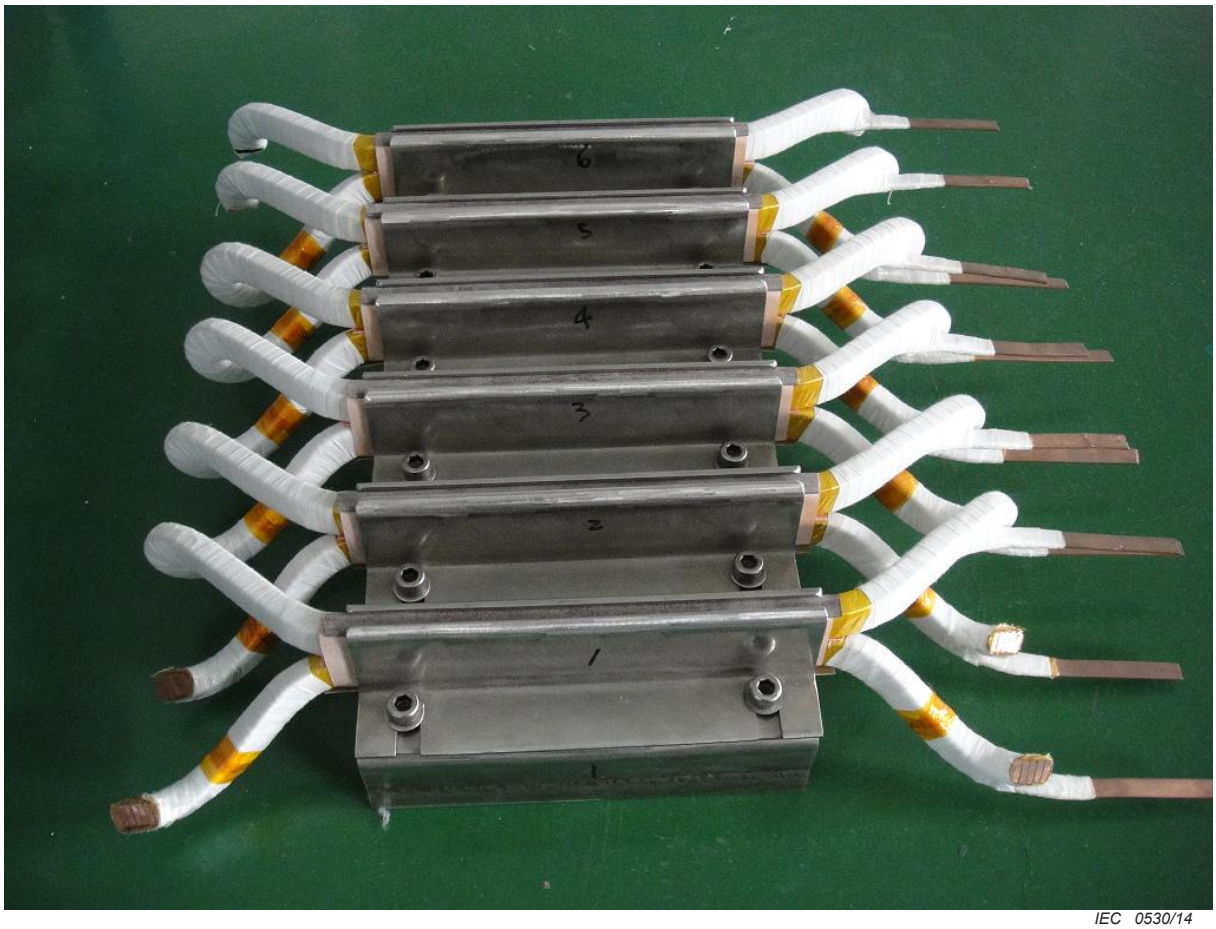
Figure B.5 – Formed coil with protective layer removed

IEC 0528/14

Figure B.6 – Close-up of formed coil's knuckle insulation

IEC 0529/14

Figure B.7 – Formed coil with multiple layers of insulation



IEC 0530/14

Figure B.8 – Formed coils placed into the form-wound test specimen or Formette

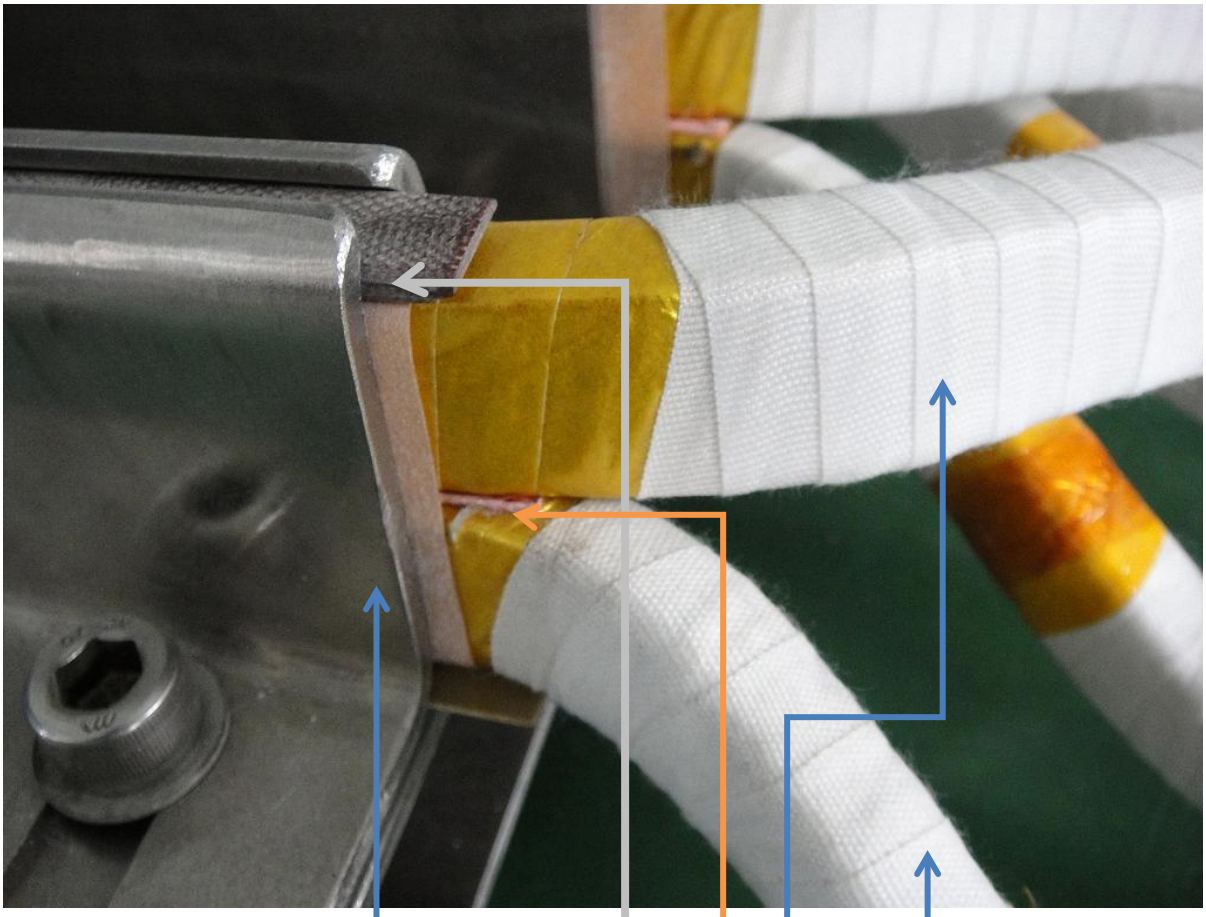


Figure B.9 – Insulation details

Bibliography

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

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