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TECHNICAL SPECIFICATION

colour inside

Fire hazard testing –
Part 2-21: Glowing/hot-wire based test methods – Fire containment test on finished units

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CONTENTS

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FIRE HAZARD TESTING –

Part 2-21: Glowing/hot-wire based test methods – Fire containment test on finished units

FOREWORD

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IEC TS 60695-2-21 has been prepared by IEC technical committee 89: Fire hazard testing. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
89/1554/DTS	89/1561A/RVDTS

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

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

This publication has the status of a Technical Specification in accordance with IEC Guide 104 and ISO/IEC Guide 51.

NOTE The following print types are used:

- terms defined in Clause 3: in **bold** type.

A list of all parts in the IEC 60695 series, published under the general title *Fire hazard testing*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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INTRODUCTION

Fires might create hazards to life and property as a result of the generation of heat (emission of heat on fire hazard), and also as a result of the production of toxic effluent, corrosive effluent and smoke (fire effluents on the fire hazard). Fires start with ignition and then can grow, leading in some cases to flash-over and a fully developed fire. Resistance to ignition is therefore one of the most important parameters of a material to be considered in the assessment of a fire hazard.

Most current fire hazard assessment techniques evaluate the resistance to ignition characteristics of a single material or component. These assessment techniques are able to drive the preselection and validation of materials and components but are not able to evaluate the possible interaction of materials or components in a complex environment such as in a finished unit, once a fire event is initiated.

In a fault condition, a finished unit might be subject to the overheating of electrical connections and contacts. Such overheating can be caused by corrosion, poor crimp connections, incorrect assembly, erosion of contact surfaces, or mechanical fatigue. Insulating materials that are overheated can ignite and cause fire.

It is difficult to simulate the actual conditions of potential faults in finished units; therefore all possible fire hazards should be taken into account at the design stage and subsequently during the preselection of materials and components.

This fire containment test has been developed to verify if a finished unit is able to contain an internal fire event, generated by combustible parts ignited by a simulated overheated electrical connection.

FIRE HAZARD TESTING –

Part 2-21: Glowing/hot-wire based test methods – Fire containment test on finished units

1 Scope

This part of IEC 60695, which is a Technical Specification, specifies a **fire** containment test method for **finished units**. It is intended to verify the capability of containing of a fire event generated by an **effective ignition source** inside a **finished unit**.

Unless otherwise specified by the relevant product standard, determination of the **fire** containment described in this document does not apply to any of the following:

- A single electrical component;
- A single electrical component when incorporated into a **finished unit**;
- Electrical installation products such as distribution boards, circuit protection devices, switchgear, controlgear, cable management system and electrical accessories (wiring devices).

The test method described in this document does not apply to the following electrical connections:

- Low-power electrical connections contained in **finished units**, where the maximum power through the connection does not exceed 15 W.
- Soldered and welded electrical connections are exempted from the evaluations of this document.

This document is intended to be used for evaluating the capability of **fire** containment of **finished units**, during the selection of **finished units** and in the design of **finished units**.

The requirements, test method or test conditions of this document will not apply unless specifically referred to or included in the relevant publications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62368-1:2018, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

ISO 13943:2017, *Fire safety – Vocabulary*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
cheesecloth
bleached cotton cloth of approximately 40 g/m^2

[SOURCE: IEC 62368-1:2018, 3.3.6.2, modified – Deleted the Note to entry]

3.2
draught-free environment
space in which the results of experiments are not significantly affected by the local air speed

Note 1 to entry: A qualitative example is a space in which a wax candle **flame** remains essentially undisturbed. Quantitative examples are small-scale **fire** tests in which a maximum air speed of 0,1 m-s^{-1} or 0,2 m-s^{-1} is sometimes specified.

[SOURCE: ISO 13943:2017, 3.83]

3.3
effective ignition source
potential ignition source that has been proved to be able to initiate combustion of surrounding insulating material or combustible parts

Note 1 to entry: The proving methodology is defined by the test specified in 8.6.

3.4
enclosure
<electrotechnical> external casing protecting the electrical and mechanical parts of apparatus

Note 1 to entry: The term excludes cables.

[SOURCE: ISO 13943:2017, 3.93]

3.5
finished unit
complete unit which is designed to stand alone, usable by an end-user and having a direct function for the end-user

Note 1 to entry: It is intended to be placed on the market and/or taken into service as single unit.

Note 2 to entry: Electrical installation products such as distribution boards, circuit protection devices, switchgear, controlgear, cable management system and electrical accessories (wiring devices) are not considered to be finished units.

3.6
fire
process of combustion characterized by the emission of heat and fire effluent and usually accompanied by smoke, **flame** or glowing or a combination thereof

Note 1 to entry: In English language the term "**fire**" is used to designate three concepts, two of which relate to specific types of self-supporting combustion with different meanings. Of these three, two of them are designated using two different terms in both French and German.

[SOURCE: ISO 13943:2017, 3.114, modified – The domain <general> has been deleted.]

3.7
flame, noun
rapid, self-sustaining, sub-sonic propagation of combustion in a gaseous medium, usually with emission of light

[SOURCE: ISO 13943:2017, 3.159]

3.8
ignition
DEPRECATED: sustained **ignition**
initiation of sustained **flame**

[SOURCE: ISO 13943:2017, 3.218]

3.9
low-power point
electrical connection where the power dissipated at the connection does not exceed 15 W

Note 1 to entry: To dissipate more than 15 W at an electrical connection, the power delivered to a resistive load via the electrical connection must exceed 60 W. This is based on the maximum power transfer theorem that shows that an electrical connection can only dissipate one-fourth of the power delivered to a resistive load when the resistance of the connection is equal to the resistance of the load.

3.10
non-combustible material
not capable of undergoing combustion (see ISO 13943:2017, 3.55) under specified test conditions

EXAMPLE According to the test method described in this document, steel, glass, ceramic and concrete are considered examples of non-combustible materials.

[SOURCE: ISO 13943:2017, 3.282, modified – Added “test]

3.11
potential ignition source
electrical connection where electrical energy can cause **ignition**

[SOURCE: IEC 62368-1:2018, 3.3.9.1, modified – Deleted “PIS” and “location”]

4 Test specimen

4.1 General

The test specimen is a **finished unit**.

4.2 Verification of potential ignition sources

Before carrying out any tests on the test specimen, it is necessary to identify electrical connections and verify if these are **potential ignition sources** as described in 8.2 to 8.6.

4.3 Test conditions

The test conditions shall not be significantly different from those occurring when the **finished unit** is operated according to the intended use as specified by the manufacturer, taking into account 8.3. However, the test specimen shall be de-energized during the test with the factors identified in 8.3 supplied by an external power source. It is acceptable to have limited modifications to the test specimen and to the **potential ignition source** in order to allow access of the heating wire and the related supply wires. Such modifications should not be expected to have any significant effect on the test results.

5 Test apparatus

5.1 Nickel-Chromium wire (NiCr wire)

The heating wire shall be a Nickel/Chromium wire (NiCr wire), having a nominal composition of > 77 % Ni and 20 ± 1 % Cr, having a nominal diameter of 0,81 mm ± 0,05 mm (20 AWG), a minimum length of 100 mm and a resistance at ambient temperature between 15 °C and 35 °C of (0,22 ± 0,05) Ω per 100 mm length.

NOTE Nickel/Chromium wire is also known as NiCr8020.

5.2 Test circuit

The NiCr wire is heated by a constant current power supply having minimum output characteristic of 0 A to 15 A. The circuit shall contain a current measuring device which indicates a true RMS value having an accuracy of ± 2,5 % or more accurate.

5.3 Connections

Due to the high currents involved, it is essential that all electrical connections for the NiCr wire are capable of carrying the current without affecting the performance or long-term stability of the circuit. Connections between the NiCr wire and the supply wires shall be made using non-insulated straight butt splices, ceramic screw terminals or similar means provided that they are made of **non-combustible material**.

5.4 Cheesecloth

Cheesecloth is used to evaluate the possible spread of **fire** outside of the test specimen during the test in 8.7.

If not otherwise specified in the relevant product standard, **cheesecloth** shall be as specified in 3.1.

NOTE The Project Team is aware of the existence of several different types of ignition indicators on the market. Product committees are welcome to replace the currently described **cheesecloth** by other types. Product committees using different ignition indicators than the described are kindly invited to provide their feedback on the type of ignition indicator and its general behavior, when used according to this test method, to the Project Team, in order to be taken into account for the future revisions of this document.

5.5 Test chamber

The test chamber shall provide a **draught-free environment** and shall be provided with suitable means allowing the observation of specimen during the test of 8.6 and 8.7 and ensuring to meet the testing conditions defined in 7.3 at the start of the test. The volume of the test chamber shall be adequate to contain the test specimen and to ensure that oxygen depletion does not significantly affect the results.

It is recommended that the test chamber is fitted with an extraction device, such as an exhaust fan, to remove products of combustion which might be toxic. If fitted, the extraction device shall be switched off during the test and switched on after the test to remove fire effluents.

NOTE Examples of suitable means allowing the observation of specimen are windows and video-cameras.

5.6 Timing device

The timing device shall have a resolution of 0,1 s or less.

6 Verification of the NiCr wire

For each new spool of NiCr wire, the electrical resistance of 100 mm ± 1 mm NiCr wire cut, shall be measured at an ambient temperature between 15 °C and 35 °C before connecting it to the supply wires.

The resistance shall comply with the requirements of 5.1.

7 Conditioning

7.1 Conditioning of the test specimen

Unless otherwise specified in the relevant product standard, the test specimen shall be conditioned for 24 h in an atmosphere having a temperature between 15 °C and 35 °C and a relative humidity less than or equal to 75 %.

7.2 Conditioning of the cheesecloth

The **cheesecloth** shall be conditioned for 24 h in an atmosphere having a temperature between 15 °C and 35 °C and a relative humidity less than or equal to 75 %.

7.3 Testing condition

Tests shall be executed in a test chamber as described in 5.5, having a temperature between 15 °C and 35 °C and a relative humidity less than or equal to 75 % at the start of each test. Before each test, the test chamber shall be ventilated in order to ensure complete extraction of any fire effluent produced from previous tests.

NOTE In order to ensure complete extraction, it has been found useful to establish a minimum time of ventilation for each test chamber based on the chamber volume and the volumetric flow rate of the exhaust system.

8 Test procedure

8.1 Flow chart

A flow chart of the test procedure is shown in Figure 1.

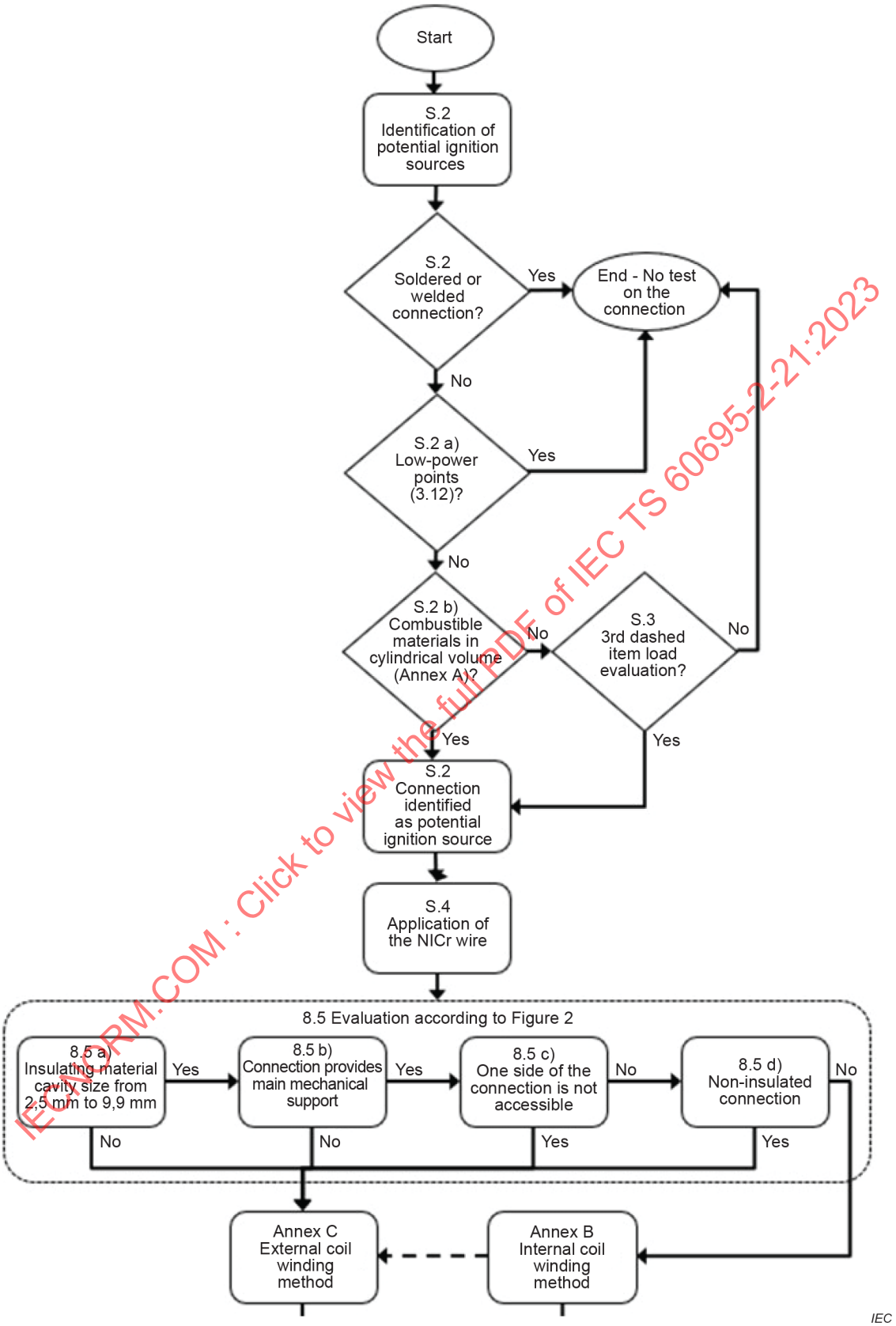


Figure 1 – Test procedure flow-chart *(1 of 2)*

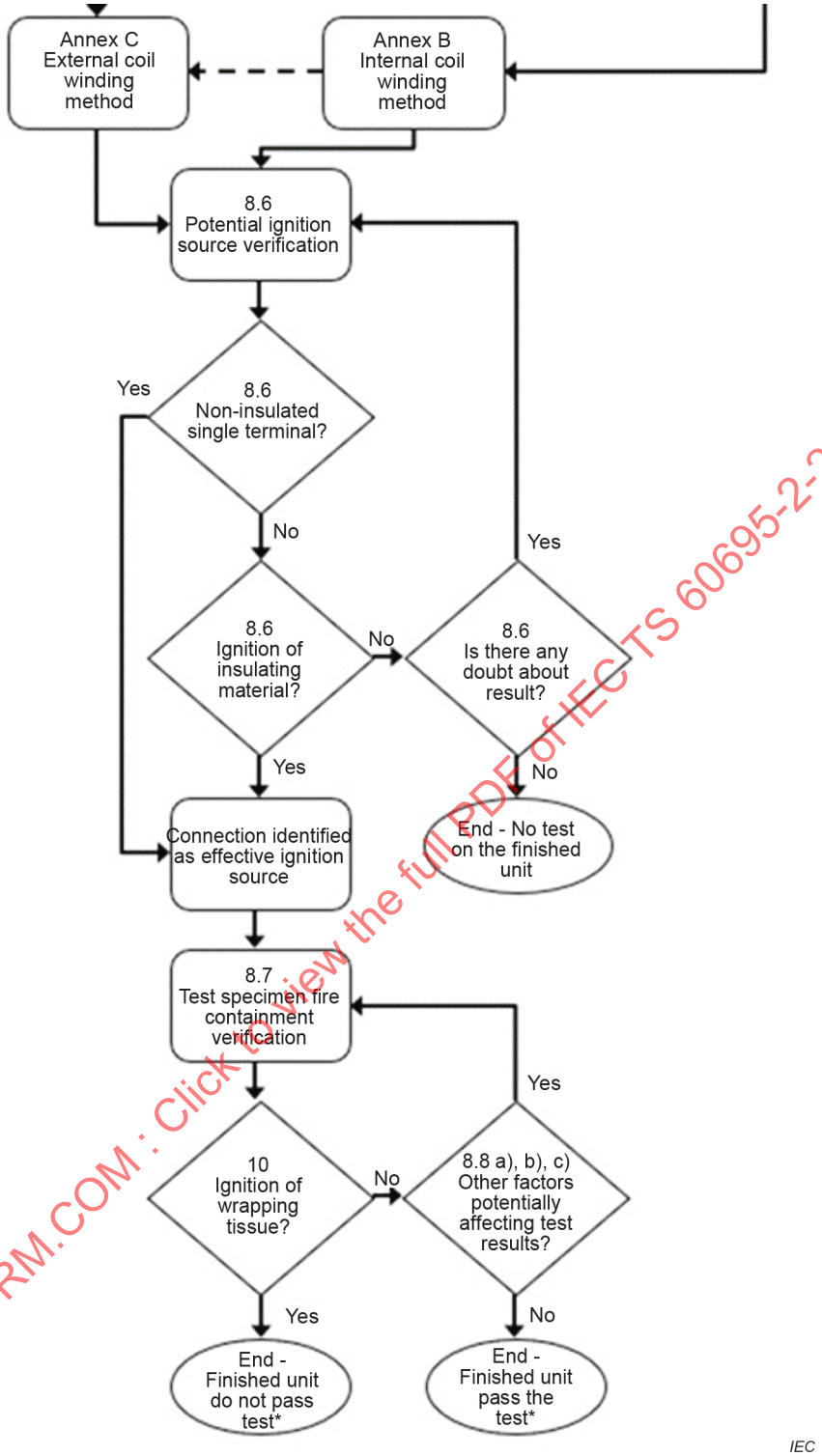


Figure 1 *(2 of 2)*

8.2 Identification of potential ignition sources

All electrical connections within the test specimen shall be evaluated to identify the **potential ignition sources**.

Soldered and welded connections are exempted from this evaluation.

An electrical connection is identified as **potential ignition source** if all the following conditions are met:

a) The connection is not a **low-power point**;

b) Combustible material is located within a cylindrical volume of 50 mm height and 20 mm in diameter placed above the electrical connection, according to the evaluation of Annex A and taking also into account the third dashed item of 8.3.

   Are exempted from this evaluation: the connections on small components on printed circuit boards, such as diodes, transistors, resistors, inductors, integrated circuits and capacitors not directly connected to the supply mains.

A list of all identified **potential ignition sources** shall be reported (see Clause 9).

The electrical connections identified as **potential ignition sources** shall be verified as described in 8.5.

All electrical connections that are not identified as **potential ignition sources** are exempted from testing.

8.3 Factors affecting test

The specimen operating conditions shall be considered regarding their likelihood to influence the test results.

The following are considered as factors potentially affecting test results:

– the test specimen is equipped with a forced ventilation system.

– the test specimen is equipped with a rotating device or a motor.

– a load might be placed into or on the test specimen when it is operated according to the intended use as specified by the manufacturer that could result in combustible parts moving inside the cylindrical volume described in Annex A, where these materials are not in the cylindrical volume without the load application.

If the test specimen is affected by any of the above factors the test shall be performed as described in 8.7 and then repeated according to the following:

– if the test specimen is equipped with a forced ventilation system that has an influence on the airflow surrounding the identified **potential ignition source** or **effective ignition source**, it shall be operated under its normal operating conditions but using a power supply independent of the test specimen.

– If the test specimen is equipped with a rotating device or a motor that has an influence on the airflow surrounding the identified **potential ignition source** or **effective ignition source**, it shall be operated under its normal operating conditions but using a power supply independent of the test specimen.

– If the test specimen can incorporate a load when it is operated according to the intended use as specified by the manufacturer, the maximum load declared by the test specimen manufacturer or an applicable load described by the relevant product standard shall be incorporated.

8.4 Application of NiCr wire

In a test, a **potential ignition source** identified in accordance with 8.2 is subject to the application of NiCr wire as described in 8.5.

If more than one **potential ignition source** has been identified, multiple connections may be independently evaluated within the same **finished unit**, provided that they are located such that they do not influence the outcome of the test. Each connection shall be evaluated using one independent NiCr wire, since reuse of the NiCr wire could lead to different results due to the possible oxidation of the wire surface and there will be a test for each connection.

Supply wires to the NiCr wire shall be supported and strain-relieved to prevent movement of the NiCr wire during test.

Once applied, the NiCr wire shall not touch materials other than the **potential ignition source** subject to the application.

Examples of supply wires fixation methodologies are provided in Annex D.

If, after testing, the NiCr wire is found completely moved or displaced from the original location, the test shall be repeated on a new electrical connection.

8.5 Selection of NiCr wire application methodology

NiCr wire is applied to the identified **potential ignition sources** according to the following:

The NiCr wire is applied as specified in Annex C if the **potential ignition source** meets any of the following.

a) Electrical connections having the maximum cross-sectional dimension of the insulating material cavity less than 2,5 mm or more than 9,9 mm in width and height as shown in Figure 2;

NOTE 1 By “maximum cross-sectional dimension” is meant the larger dimension of the insulating material cavity along its axes in width and height.

b) Insulated single terminal electrical connections, where the electrical metal part provides main mechanical support function for the connection;

Examples of this case are provided in Figure C.4.

NOTE 2 By “main mechanical support function” is meant that the removal of the metal part will result in displacement of the electrical connection insulating material from its original position.

c) Insulated single terminal or multi terminal electrical connections, where one of the two sides of the electrical connection is not accessible;

An example of this case is provided in Figure C.5.

NOTE 3 Examples for these connection types are, terminals where one side is molded or embedded into other materials, and cases were to apply the NiCr wire as internal coil major modification of the test specimen are needed, potentially affecting the test result.

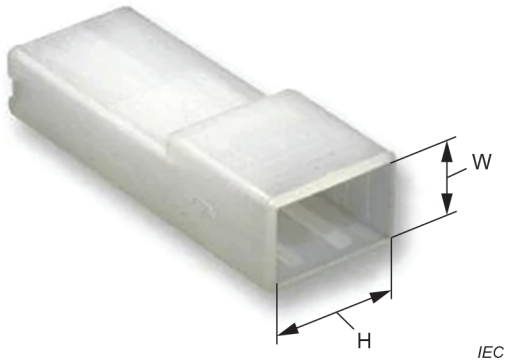
d) Non-insulated single terminal electrical connections.

An example of this case is provided in Figure C.3.

The NiCr wire shall be applied as specified in Annex B to insulated electrical connections having the maximum cross sectional dimension of the insulating material cavity between 2,5 mm and 9,9 mm in width and height as shown in Figure 1.

If not otherwise specified by the relevant product standard, for multiple electrical connections grouped and insulated within the same insulating material, only one electrical connection is subject to the application of the NiCr wire. The subject connection should be the one which is more likely to propagate the **flame**.

In case it is not possible to apply the NiCr wire as specified in Annex B due to mechanical or dimensional limitations, then the NiCr wire shall be applied to the **potential ignition source** as specified in C.2.



Keys

W) Maximum width in mm, of the insulating material cavity

H) Maximum height in mm, of the insulating material cavity

Figure 2 – Insulating material cavity cross sectional dimensions

The flow-chart of Figure 3 summarizes the NiCr wire application methodology selection process.

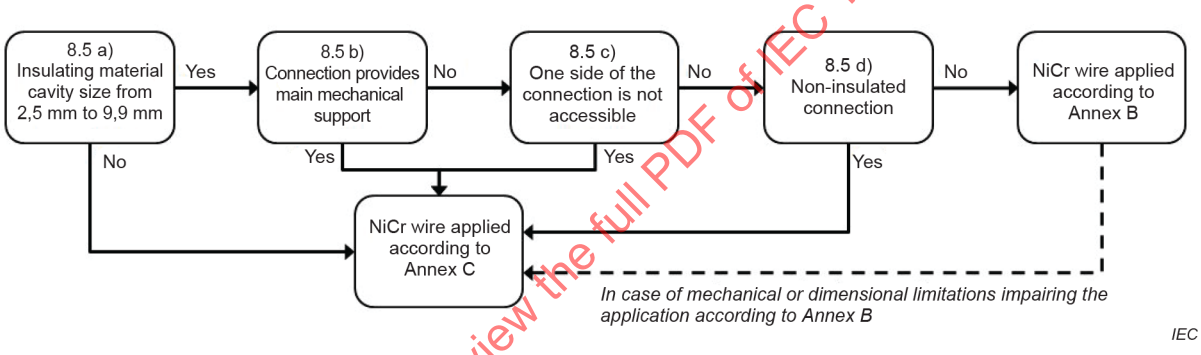


Figure 3 – NiCr wire application methodology selection flow-chart

8.6 Potential ignition source verification

Prior to carrying out the test as specified in 8.7, it shall be verified if the insulating material surrounding the identified **potential ignition source** can be ignited by the applied NiCr wire, as follow.

Potential ignition sources that are non-insulated single terminal electrical connections as described in 8.5 d) are considered as **effective ignition sources**, therefore are exempted from this verification and shall be tested directly on the test specimen as described in 8.7.

If there is any doubt concerning the test results, repetition of the test is required. The amount of retests shall be decided by the product committee. The test shall be repeated with replacement of the insulating material of the connection.

The **potential ignition source** shall be tested separately from the test specimen, applying the NiCr wire as described in 8.4 and 8.5. Care should be taken to keep the orientation of the **ignition source** the same as in the test specimen.

CAUTION:

Precautions shall be taken to safeguard the health of personnel conducting tests against

1) The risk of explosion, burning or fire;

2) The risk of burns and electric shock;

3) The inhalation of smoke and/or toxic products; and

4) The risk of toxic residues

A current of (14,0 ± 0,5) A is supplied to the NiCr wire within 2 s from the application of supply, after which it is maintained at this value until completion of the test. If during the test **ignition** is observed, the duration of flaming in seconds shall be recorded (see Clause 9).

If not otherwise specified by the relevant product standard, the test is terminated after 20 min or once all insulating material has been consumed, whichever is first.

If **ignition** is observed, then test is carried out on the test specimen as described in 8.7, using the same NiCr wire application method identified in 8.5 and considering the identified **potential ignition source** as **effective ignition source**.

If no **ignition** of the insulating material is observed, and there is any doubt about the result, the **potential ignition source** is not considered to be an **effective ignition source** and there is no need to test.

NOTE The **potential ignition source** test can be used to determine if a component is not an **effective ignition source**. If such determination is made, the component can be appropriately classified in the component end product standard.

8.7 Test specimen fire containment verification

Tests shall be performed on each identified **effective ignition source**, one at a time.

Testing should be conducted on a complete test specimen. However, if it is necessary to remove parts of an **enclosure** or to modify the test specimen in order to perform the test, care should be taken to ensure that the fire scenario is not significantly changed.

Examples of factors that can significantly change the fire scenario are:

– Air flow around the test area;
– Stress concentrations such as edges, bosses, ribs;
– Additional material that can support combustion.

Unless otherwise specified in the relevant product standard, the top, bottom and all sides of the test specimen shall be completely covered by a single layer of **cheesecloth**. A mechanical means, such as small pieces of metal foil adhesive tape, shall be used to secure the **cheesecloth** to the test specimen **enclosure**.

If for the application of NiCr wire, some components / parts of the test specimen **enclosure** are removed, these shall be repositioned according to the initial test specimen design, prior to the application of the **cheesecloth**.

After application of the NiCr wire to the identified **effective ignition source**, as identified in 8.5, the current to the NiCr wire is increased from 0 A to 14,0 A ± 0,5 A in a period of less than 2 s after which it is maintained at this value until completion of the test.

If not otherwise specified by the relevant product standard, the test is terminated after 20 min or if **ignition** of the **cheesecloth** is observed.

If no **ignition** is detected within 20 min, the current shall be removed from the NiCr wire. If **ignition** of the **effective ignition source** is detected, the test current shall be held constant until burning of the non-metallic combustible materials cease naturally or there is **ignition** of the **cheesecloth**. If **ignition** of the **cheesecloth** occurs, the **fire** shall be extinguished as soon as possible. If the NiCr wire fractures prematurely, the test shall be repeated on a new sample.

9 Observations and measurements

9.1 Initial observations

The following items shall be recorded:

a) A description of the tested test specimen;

b) A list of all the electrical connections of the test specimen;

c) For each electrical connection if it is or is not a **low-power point**;

d) For all electrical connections that are not **low-power points**, if combustible parts are observed in the area above the connection, as described in Annex A and 8.3, third dashed item;

e) A list of all identified **effective ignition sources**;

f) The electrical resistance of NiCr wire at ambient temperature for each series of performed tests;

g) The length of the NiCr wire used for each test performed and the application methodology according to Annex B or Annex C;

h) Pictures or technical design/production drawings showing the locations of the identified **potential ignition sources** and **effective ignition sources** within the test specimen; and

i) Pictures showing application of the NiCr wire to the identified **potential ignition sources** and **effective ignition sources**.

9.2 Test observations

9.2.1 During the time of the tests described in 8.6, the following observations shall be recorded:

a) Whether or not **ignition** occurred and, if so, the duration of flaming in seconds; and

b) The total test duration.

9.2.2 During the time of tests described in 8.7, the following observations shall be recorded:

a) Whether or not burning of the **cheesecloth** occurred;

b) The total test duration; and

c) Pictures showing the test specimen and **cheesecloth** after test.

10 Evaluation of test results

The test specimen is considered to have passed the test if no burn of the **cheesecloth** occurred, as indicated by the broken threads of the **cheesecloth**.

Browning of the **cheesecloth** is acceptable provided that all individual threads are unbroken. **Cheesecloth** fibres might become brittle after exposure to heat. Care shall be taken to prevent breakage of fibres during inspection.

11 Test report

The test report shall include the following information:

a) A reference to this Technical Specification;

b) A description of the test specimen including type and manufacturer;

c) The conditioning of the test specimen and the test conditions (see Clause 7);

d) Electrical characteristics of the identified **potential ignition sources** and **effective ignition sources**;

e) For each identified **effective ignition source**, type and characteristics of combustible parts located within a cylindrical volume 50 mm high and 20 mm in diameter above the connection, according to the evaluation of Annex A and 8.3, third dashed item.

f) For each identified **potential ignition source**, if **ignition** occurred at the time of the tests described in 8.6 and if so, the related duration of flaming in seconds; and

g) All test observations and the test results.

12 Information to be given in the relevant product standard

When referencing this test method, technical committees should indicate the following details:

a) The type and description of the test specimen;

b) Any deviation from the specified NiCr wire application methods;

c) Any different conditioning ranges or conditions of the test specimen, from those specified in this standard;

d) Any different or additional factor that could affect test results and related verification methodology, from those specified in 8.3.

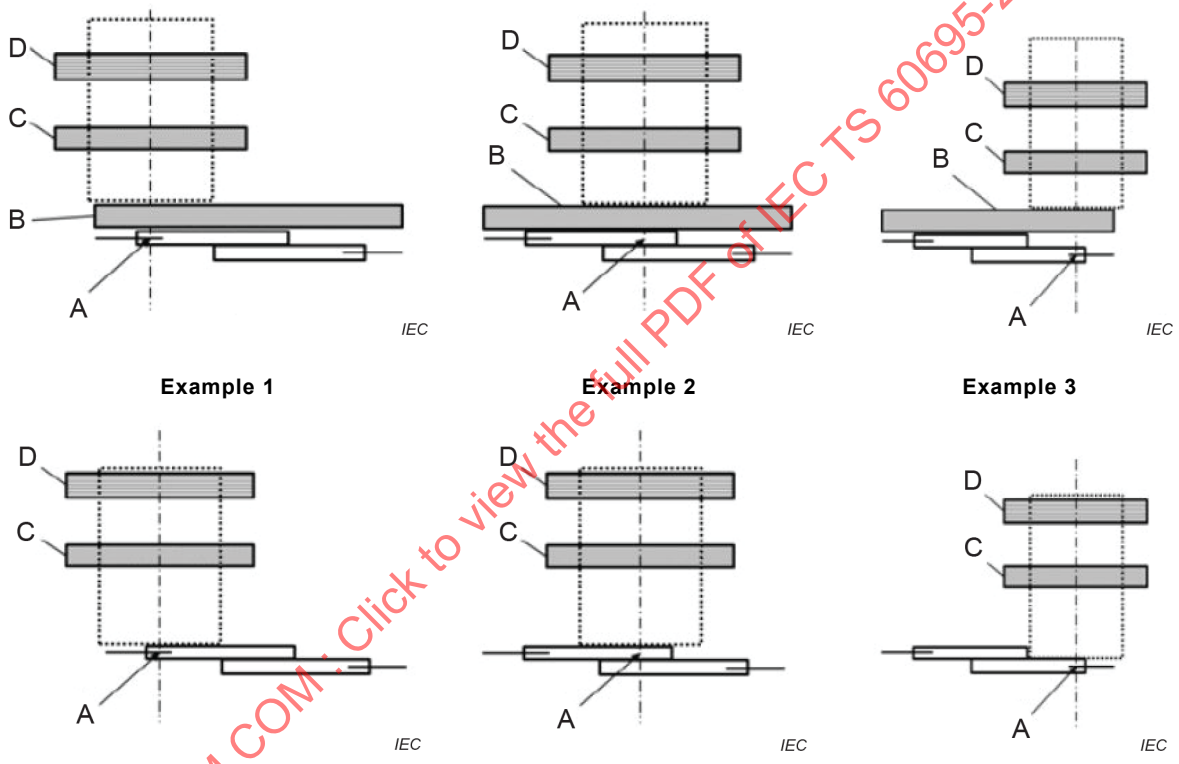
e) Any specific exemption for the application of this test method.

Annex A
(normative)

Interpretations of the location of the cylindrical volume

The cylindrical volume referred to in 8.2 is 50 mm height and 20 mm in diameter.

The cylinder shall be placed above the center of each connection and on top of any combustible parts that are supporting current carrying connections as shown in Figure 3, Examples 1 to 3. In case of non-insulated connections, the cylinder shall be placed above the center of each connection zone and directly on top of current carrying conductors as shown in Figure A.1, Examples 4 to 6. The cylinder shall project through all metallic and combustible materials. If "C" is metallic and is intended to act as barrier to "D", then the adequacy of the barrier shall be verified by application of the test described in 8.7.



Keys

A = Center of the connection zone

B = Combustible material supporting current carrying connection

C = Metallic or combustible material

D = Metallic or combustible material

Figure A.1 – Examples of the location of the cylindrical volume

Annex B
(normative)

NiCr wire application methods – Internal coil winding method

B.1 General

To apply the NiCr wire as internal coil the following procedure is used:

a) the metal electrical connection shall be removed from the insulating materials;

b) the insulating material internal cavity shall be prepared for NiCr insertion as described in B.2;

c) A NiCr wire coil having the same length of the removed metal electrical connection shall be formed as described in B.3;

d) The formed NiCr wire coil shall be inserted into the insulating material internal cavity and then connected to the supply wires before testing.

B.2 Insulating material cavity preparation

In order to permit the application of the NiCr wire coil, after removal of the metal electrical connection from the insulating material, due to possible insulating material cavity dimensions variation, modify the cavity by a drill bit to prepare it for the NiCr coil insertion.

NOTE Cavity modification by use of a drill bit is intended to create homogeneous dimensions of insulating material cavity, removing material portions that might interfere with NiCr coil insertion and ensuring that the gap between the prepared NiCr coil and the insulating material is not excessive, avoiding movement of the coil once heated.

When modifying the insulating material cavity, care shall be taken to not break the insulating material. If due to modification procedure, the insulating material breaks, it shall not be used for testing and a new insulating material sample shall be used.

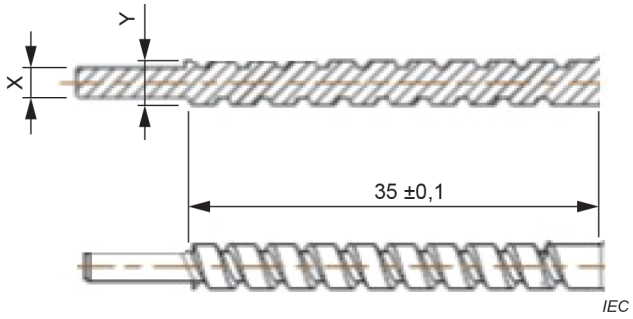
Based on the removed metal electrical connection maximum cross-sectional dimension, the appropriate drill bit shall be used, as specified in Table B.1.

B.3 NiCr wire coil preparation

Based on the removed metal electrical connection maximum cross-sectional dimension, wind the NiCr wire around the threads of a winding tool having the characteristics as specified in Figures B.1 to B.4 and Table B.1.

The resulting NiCr wire coil shall have same length as the removed electrical connection.

Dimensions in millimetres



Thread information
Major diameter: X ±0,1
Minor diameter: Y ±0,1
Distance between threads: 3,175 ±0,05

Figure B.1 – Winding tool

Table B.1 – Drill bit and winding tool dimensions

Electrical connection maximum cross-sectional dimension (mm)	**Drill bit diameter** (mm)	**Winding tool dimensions** (mm)	
		Shaft diameter (X)	**Threads diameter** (Y)
2,5 to 2,9	3,5	1,2	3,2
3,0 to 3,4	4,0	1,7	3,7
3,5 to 3,9	4,5	2,2	4,2
4,0 to 4,4	5,0	2,7	4,7
4,5 to 4,9	5,5	3,2	5,2
5,0 to 5,4	6,0	3,7	5,7
5,5 to 5,9	6,5	4,2	6,2
6,0 to 6,4	7,0	4,7	6,7
6,5 to 6,9	7,5	5,2	7,2
7,0 to 7,4	8,0	5,7	7,7
7,5 to 7,9	8,5	6,2	8,2
8,0 to 8,4	9,0	6,7	8,7
8,5 to 8,9	9,5	7,2	9,2
9,0 to 9,4	10,0	7,7	9,7
9,5 to 9,9	10,5	8,2	10,2

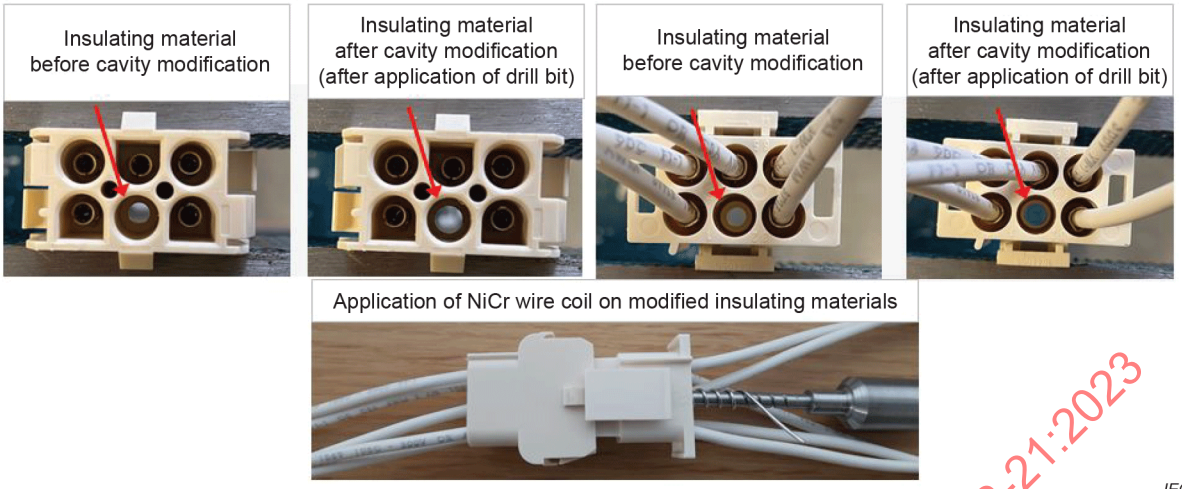


Figure B.2 – Example 1 of NiCr wire coil application

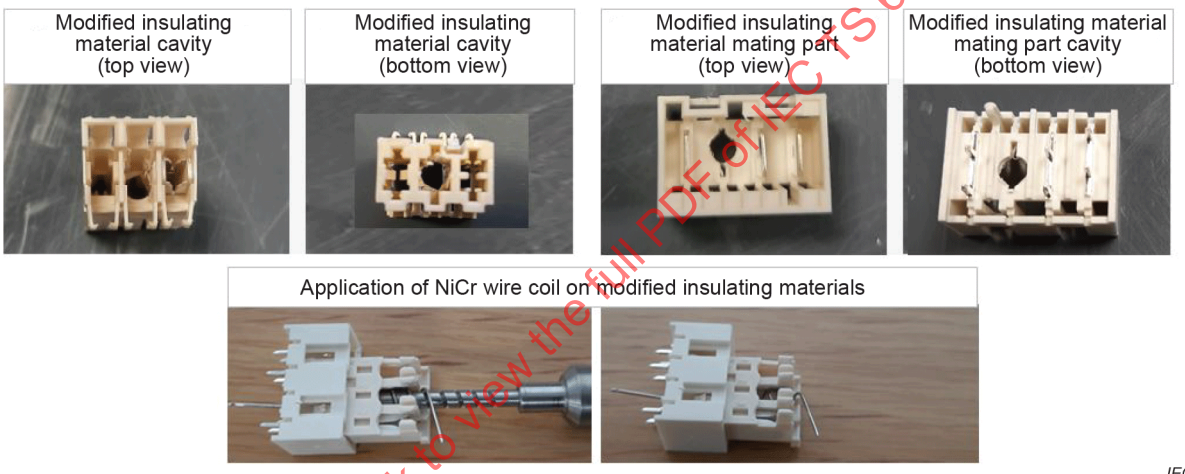


Figure B.3 – Example 2 of NiCr wire coil application

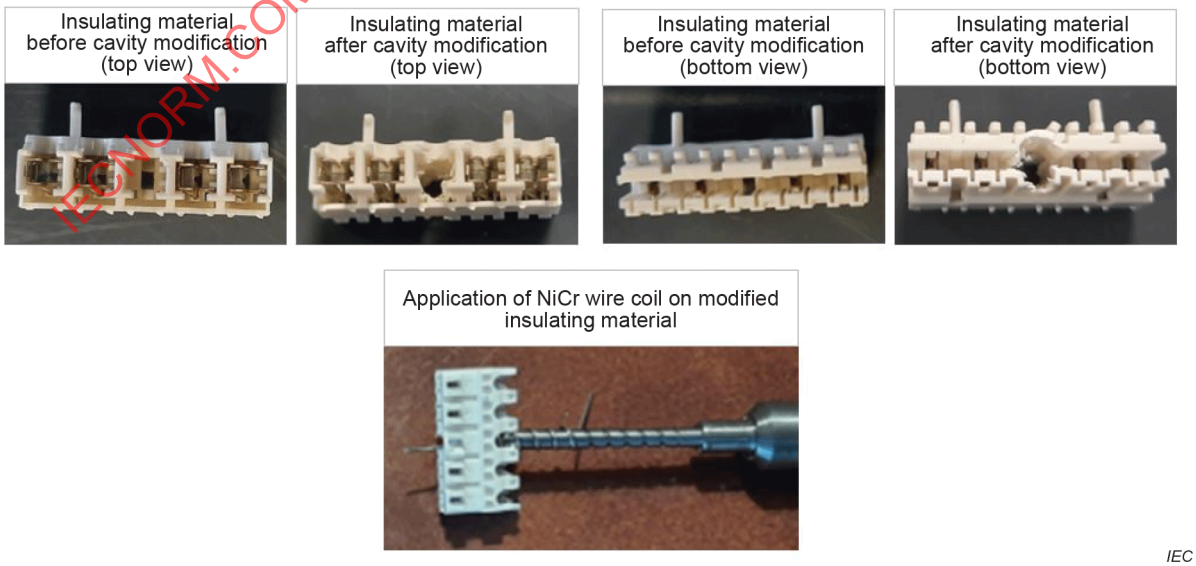


Figure B.4 – Example 3 of NiCr wire coil application

Annex C
(normative)

NiCr wire application methods – External winding method

C.1 General

Electrical connections identified according to 8.5, points a), b) and c), shall apply the NiCr wire as described in C.2.

Non-insulated single terminal electrical connections identified according to 8.5 d) shall apply the NiCr wire as described in C.3.

C.2 Insulated connections winding method

Wind the NiCr wire externally over the entire length of the insulating material surface. The distance between windings shall be 4,0 mm ± 1 mm. Intimate contact between the NiCr wire and the insulating material surface shall be maintained, as far as practical. See Examples 1 and 3 of Figure C.1 and Figure C.2.

Length of the used NiCr wire shall be reported, as specified in 9.1.

Examples 1 and 3 show an acceptable external winding of the insulating material.

Examples 2 and 4 show an unacceptable external winding of the insulating material.

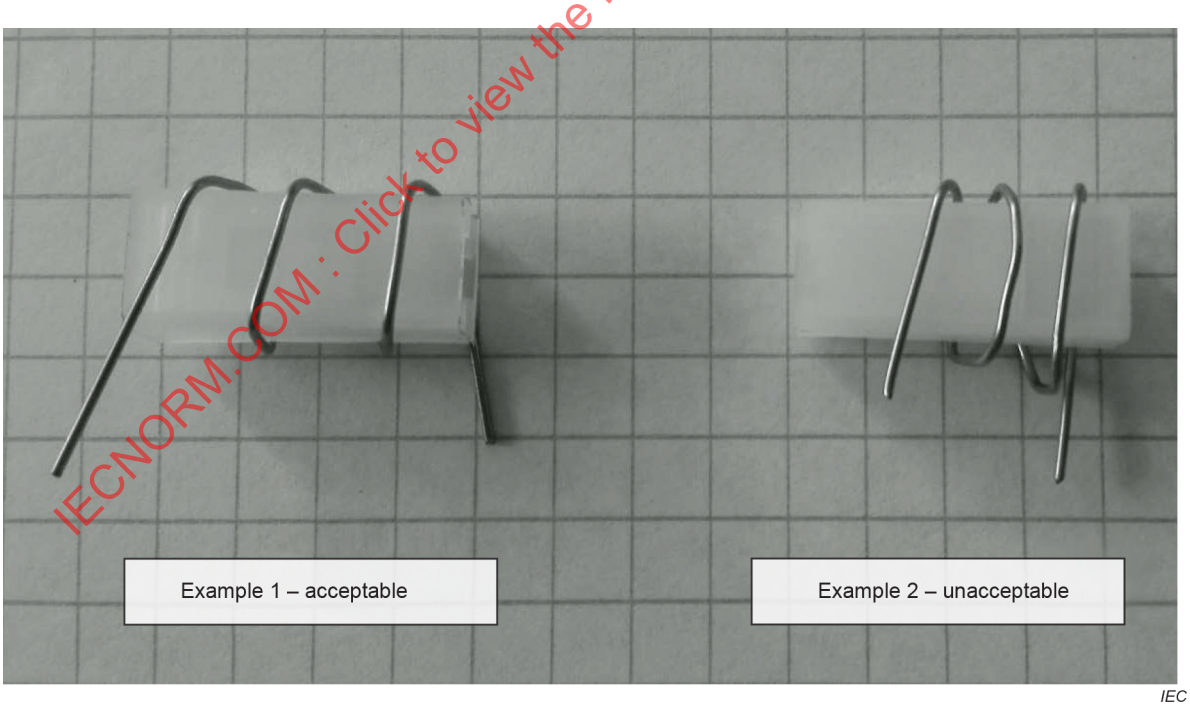


Figure C.1 – Single connection insulating material external winding – Side View

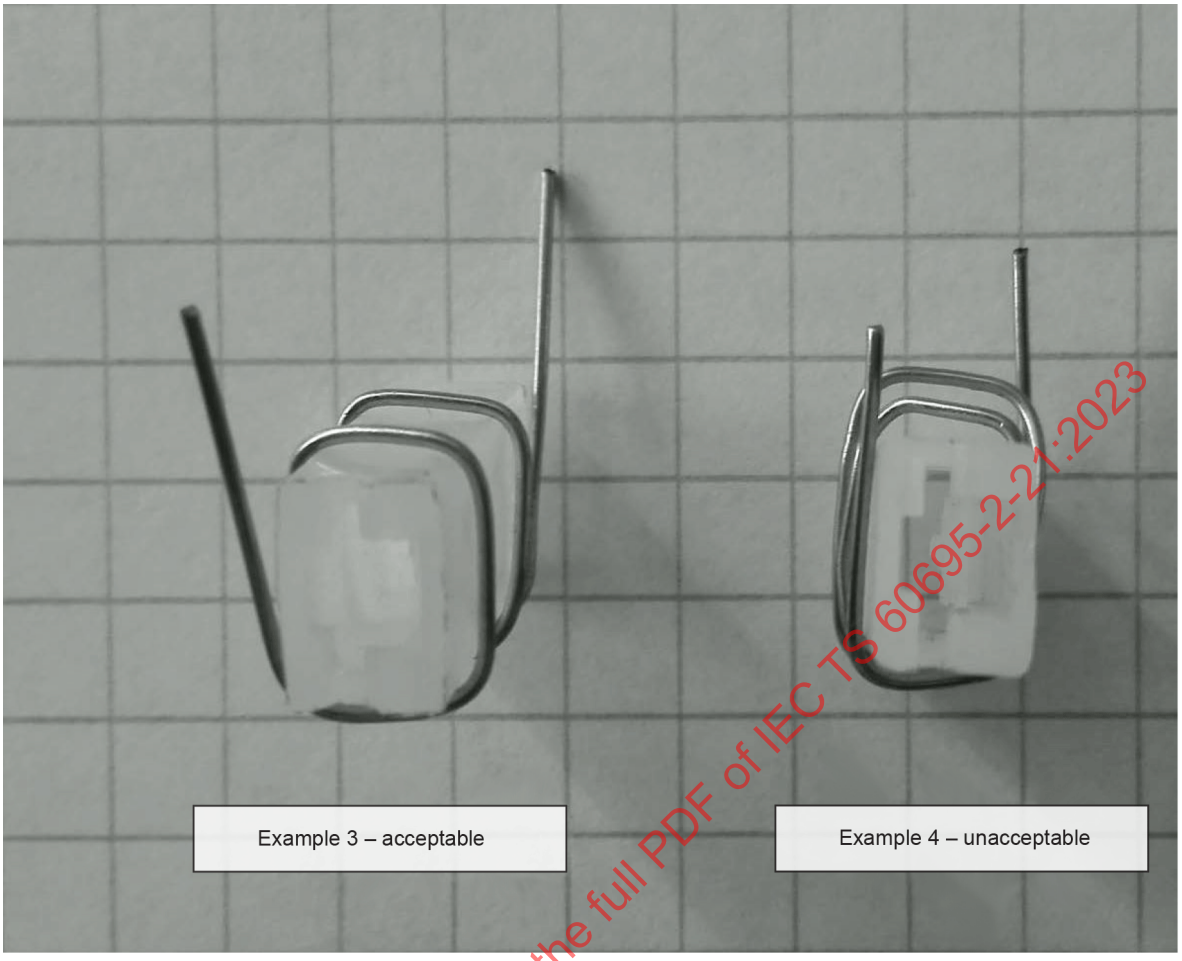


Figure C.2 – Single connection insulating material external winding – Front view

C.3 Non-insulated connections winding method

Non-insulated single terminal electrical connections shall be insulated by application of a non-flammable and electrically insulating tape or sleeve prior to the application of the NiCr wire, to prevent any electrical short-circuit with NiCr wire.

NiCr wire is applied as described in C.2, winding the NiCr wire over the non-flammable tape or sleeve.

Wind the NiCr wire over the entire length of the insulated electrical connection. The distance between windings shall be 4,0 mm ± 1 mm. Intimate contact between the NiCr wire and the insulating tape or sleeve surface shall be maintained as far as practical.

Length of the used NiCr wire shall be reported as specified in 9.1.