# IEC 60800

Edition 4.0 2021-11
REDLINE VERSION

# INTERNATIONAL STANDARD

colour inside



## Heating cables with a rated voltage ~~of~~ up to and including 300/500 V for comfort heating and prevention of ice formation

IEC 60800:2021-11 RLV(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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# HEATING CABLES WITH A RATED VOLTAGE ~~OF~~ UP TO AND INCLUDING 300/500 V FOR COMFORT HEATING AND PREVENTION OF ICE FORMATION

## FOREWORD

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**This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60800:2009. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.**

IEC 60800 has been prepared by IEC technical committee 20: Electric cables. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2009. This edition constitutes a technical revision.

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

a) modification of the title: "up to and including", has been introduced;
b) update of IEC 60811 references;
c) introduction of a test for mechanical properties of sheaths after the water immersion and temperature cycling test;
d) introduction of a weathering and UV resistance test according to ISO 4892-2:2013, Annex A.

The text of this International Standard is based on the following documents:

| Draft | Report on voting |
|---|---|
| 20/1972/FDIS | 20/1991/RVD |

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 International Standard 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/standardsdev/publications.

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- withdrawn,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

This document is intended to provide a comprehensive overview of the essential requirements and testing appropriate to electrical resistance heating cables used for comfort heating and prevention of ice formation. While some of this work already exists in national standards or international standards, this document has collated much of this existing work.

This document provides a means to verify the electrical, thermal and mechanical durability of resistive heating cables, so that in normal use their performance is without danger to the user or surroundings. Compliance is checked by carrying out all the tests specified in this document.

# HEATING CABLES WITH A RATED VOLTAGE ~~OF~~ UP TO AND INCLUDING 300/500 V FOR COMFORT HEATING AND PREVENTION OF ICE FORMATION

## 1 Scope ~~and object~~

This document is applicable to, and specifies requirements for resistive heating cables for low temperature applications such as comfort heating and the prevention of ice formation. These heating cables and heating cable sets ~~may~~ can comprise either factory ~~fabricated~~ assembled or field (work-site) assembled units, and are heating cables assembled in accordance with manufacturer's instructions.

Bare conductors and protected conductors to be supplied at voltages equal to, or less than, 50 V are excluded from the scope of this document.

~~NOTE Terminations and gland fittings are outside the scope of this standard.~~

Typical applications include, but are not limited to:

- surface heating installed in or under surfaces;
- direct and storage heating;
- snow melting and frost protection of roofs, gutters, pipes, etc.

~~Heating cables~~ Electrical resistance trace heating systems for industrial and commercial applications are specified in the IEC 62395 series [1][1] and for explosive atmospheres applications in the IEC/IEEE 60079-30 series [2], as are mineral insulated heating cables.

Applications in which the ~~operating~~ sheath temperature exceeds 100 °C are outside the scope of this document.

The object of this document is to ensure that electrical resistance heating cables operate safely under their normal defined conditions of use. This is achieved by:

- employing heating cables of the appropriate construction that meet the test criteria detailed in this document;
- including, for heating cables with an electrical protective component, a metallic braid, concentric wires or sheath, or other suitable electrically conductive material for protective purposes in case of fault;
- ensuring that the heating cables operate at safe temperatures with respect to the materials used in the construction of the cables and their installations according to national regulations.

## 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.

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1 Numbers in square brackets refer to the bibliography.

IEC 60050-461, *International Electrotechnical Vocabulary (IEV) – Part 461: Electric cables* (available at http://www.electropedia.org)

IEC 60228, *Conductors of insulated cables*

IEC 60332-1-1, *Tests on electric and optical fibre cables under fire conditions – Part 1-1: Test for vertical flame propagation for a single insulated wire or cable – Apparatus*

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60364-7-701, *Low-voltage electrical installations – Part 7-701: Requirements for special installations or locations – Locations containing a bath or shower*

IEC 60364-7-753, *Low-voltage electrical installations – Part 7-753: Requirements for special installations or locations – Heating cables and embedded heating systems*

IEC 62230, *Electric cables – Spark test method*

~~IEC 60811-1-1, *Common test methods for insulating and sheathing materials of electric cables and optical cables – Part 1-1: Methods for general application – Measurement of thickness and overall dimensions – Tests for determining the mechanical properties*~~

~~IEC 60811-1-2:1985, *Common test methods for insulating and sheathing materials of electric and optical cables – Part 1-2: Methods for general application – Thermal ageing methods*~~
~~Amendment 1 (1989)~~
~~Amendment 2 (2000)~~

~~IEC 60811-1-3, *Common test methods for insulating and sheathing materials of electric and optical cables – Part 1-3: General application – Methods for determining the density – Water absorption tests – Shrinkage test*~~

~~IEC 60811-1-4, *Common test methods for insulating and sheathing materials of electric and optical cables – Part 1-4: Methods for general application – Tests at low temperature*~~

~~IEC 60811-2-1, *Common test methods for insulating and sheathing materials of electric and optical cables – Part 2-1: Methods specific to elastomeric compounds – Ozone resistance, hot set and mineral oil immersion tests*~~

~~IEC 60811-3-1, *Common test methods for insulating and sheathing materials of electric and optical cables – Part 3-1: Methods specific to PVC compounds – Pressure test at high temperature – Tests for resistance to cracking*~~

IEC 60811-201, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 201: General tests – Measurement of insulation thickness*

IEC 60811-202, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 202: General tests – Measurement of thickness of non-metallic sheath*

IEC 60811-401, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in air oven*

IEC 60811-501, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*

IEC 60811-502, *Electric and optical fibre cables – Test methods for non-metallic materials- Part 502: Mechanical tests – Shrinkage test for insulations*

IEC 60811-503, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 503: Mechanical tests – Shrinkage test for sheaths*

IEC 60811-506, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 506: Mechanical tests – Impact test at low temperature for insulations and sheaths*

IEC 60811-507, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 507: Mechanical tests – Hot set test for cross-linked materials*

IEC 60811-508, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 508: Mechanical tests – Pressure test at high temperature for insulation and sheaths*

IEC 60811-509, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 509: Mechanical tests – Test for resistance of insulations and sheaths to cracking (heat shock test)*

IEC 62395-1:~~2006~~2013, *Electrical resistance trace heating systems for industrial and commercial applications – Part 1: General and testing requirements*

ISO 4892-3:~~2006~~2016, *Plastics – Methods of exposure to laboratory light sources – Part 3: Fluorescent UV lamps*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-461 and the following 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**
**armouring**
mechanical reinforcement of the heating cable

Note 1 to entry: The reinforcement can be made of one or more layers of steel wires or braid, or of a metallic sheath or other suitable material.

**3.2**
**cold lead**
electrically insulated conductor or conductors used to connect a heating cable to the branch circuit and designed so that it does not produce significant heat

**3.3**
**connection splice**
sealed splice, connecting the heating cable to the cold lead, or an identical heating cable

**3.4**
**earthing conductor**
uninsulated conductor (drain wire) which is in good electric contact with the electrical screen along ~~practically~~ the ~~whole~~ length

**3.5**
**electrically conductive screen**
metallic braid, concentric wires, metallic sheath, or alternative covering with sufficient conductivity so that, when bonded to ground, will cause a residual current device (RCD) to operate under fault conditions

**3.6**
**end termination**
sealed termination, which may be heat producing, connected to the heating cable at the end opposite to that where the power is supplied

**3.7**
**factory assembled ~~unit or~~ heating cable set**
heating cable~~, including the necessary integral components,~~ set (unit) supplied with components, which are assembled by the manufacturer

**3.8**
**field assembled ~~unit or set~~ heating cable**
heating cable supplied in bulk~~,~~ with ~~the integral~~ components to be assembled ~~at the work site~~ during installation

**3.9**
**heating cable**
cable, with or without an electrically conductive screen, metallic or equivalent, sheath or armour intended for emitting heat for heating purposes

**3.10**
**heating cable set**
heating cable with suitable power connection and end termination included

**3.11**
**heating conductor**
part of a serial heating cable in which the electrical energy is transformed into heat

**3.12**
**insulation**
material which insulates each conductor from other conductors or from conducting parts at earth potential

**3.13**
**integral components**
factory-~~fabricated~~assembled or field-assembled electrical terminations and connections, such as heat shrink terminations, moulded end seals or splices, which conform to the general shape of the heating cable and are exposed to the same environments as the heating cable

~~**3.14**~~
~~**linear power density**~~
~~power output in watts per linear metre for the heating cable and heating cable sets~~

~~**3.15**~~
~~**operating conductor temperature**~~
~~highest allowable continuous temperature of the cable conductor~~

~~**3.16**~~

~~**operating surface temperature**~~
~~highest allowable continuous temperature of the cable surface~~

~~**3.17**~~
~~**operating voltage**~~
~~actual voltage applied to the heating cable when in service~~

~~**3.18**~~
~~**rated temperature**~~
~~temperature assigned to any insulated and sheathed cable which does not result in either the insulation or the sheath being operated in excess of the appropriate operating surface temperature~~

**3.14**
**maximum sheath temperature**
maximum temperature of the outermost covering of a heating cable

**3.15**
**nominal voltage**
actual voltage applied to the heating cable when in service

**3.16**
**parallel heating cable**
heating elements electrically connected in parallel, with the heating element either continuous or in discrete units or zones, such that the watt density per unit length is not significantly changed with any change in circuit length

**3.17**
**rated resistance** ~~**of individual conductor(s)**~~
resistance at 20 °C of 1 m of ~~cable~~ conductor

Note 1 to entry: Most heating cables contain more than one conductor and the resistance is measured for all conductors.

**3.18**
**rated voltage**
~~highest allowable voltage between the conductors in a twin and multi conductor cable, or between one conductor and an electrical conductive screen, or between the two ends of a single core cable, or earth in unscreened cables~~

reference voltage for which the heating cable is designed

Note 1 to entry: The rated voltage is expressed by the combination of two values $U_0/U$, expressed in volts:

$U_0$ being the RMS value between any insulated conductor and "earth" (metal covering of the cable or the surrounding medium);

$U$ being the RMS value between any two-phase conductors of a multicore cable or of a system of single-core cables.

Note 2 to entry: See IEC 62440:2008, 5.2 [3].

**3.19**
**routine test**
test made by the manufacturer on each manufactured length of cable to check that each length meets the specified requirements

**3.20**
**sample test**
test made by the manufacturer on samples of completed cable or components taken from a complete cable, at specified frequency, so as to verify that the finished product meets the specified requirements

**3.21**
**sheath**
uniform and continuous ~~tubular~~ covering, metallic or non-metallic, enclosing the insulated conductor(s), used for mechanical protection and to protect the cable against influences from the surroundings ~~(corrosion, moisture etc.)~~

**3.22**
**type test**
test made before supplying, on a general commercial basis, a type of cable covered by this document, in order to demonstrate satisfactory performance characteristics to meet the intended application

Note 1 to entry: ~~These~~ Type tests are of such a nature that, after they have been made, they need not be repeated, unless changes are made in the cable materials or design or manufacturing process which might change the performance characteristics.

## 4 Mechanical classification

The heating cables in this document have been divided into two classes which indicate their ability to withstand mechanical forces during and after installation. These classes are as follows:

– mechanical class M1: for heating cables intended for installation with low risk of mechanical damage;
– mechanical class M2: for heating cables intended for installation with higher risk of mechanical damage.

The class of any heating cable is determined by its performance as measured against the requirements in 8.2.7~~, 8.2.8~~ and 8.2.14.

NOTE 1 Mechanical class M1: for heating cables intended for use in applications with low risk of mechanical damage, ~~as~~ for example ~~installed~~ the installation on even surfaces like flat, smooth sub-floors of concrete or wooden materials or thermal insulations, embedded in screeds with no sharp objects~~, etc~~.

NOTE 2 Mechanical class M2: for heating cables intended for use in applications with higher risk of mechanical damage, such as the installation on steel reinforcing grids, direct embedding in soil, in concrete with sharp objects, on roofs and gutters~~, etc~~.

## 5 Requirements for marking

The product shall be ~~marked~~ identified by printing, embossing or indenting on the sheath or on a label attached to the product or on a component inside the heating cable.

~~NOTE 1~~ Embossing ~~is~~ shall not ~~recommended~~ be used on the insulation.

A label shall be attached to the product in a permanent way and be clearly detectable to the electrical installer.

~~NOTE 2~~ The label ~~should preferably~~ shall be attached to the part of the product which is clearly visible when unpacking the product ready for installation.

The marking shall at least contain:

- the identification of the manufacturer by name and/or a symbol;
- the type reference;
- the resistance per metre of heating cable at 20°C in ohms per metre ~~if~~ for single or twin conductor series resistive heating cables~~, or~~ and for a parallel heating cable, the power output in watts per metre at a reference temperature. ~~For series resistive cables with more than two conductors the resistance of each conductor shall be clearly marked~~ This is not required for heating cable sets;

- the mechanical classification;
- the rated voltage for parallel heating cables or maximum ~~operating~~ nominal voltage for series heating cables;
- if applicable, ~~"only for installation in concrete"~~ the indication "not flame-retardant".

The distance between the end of one complete set of marks and the beginning of the next shall not exceed:

– 550 mm, if the marking is on the sheath;

– 275 mm, if the marking is on a component inside the heating cable.

If the units are factory assembled, the following additional information shall be provided:

For series resistive ~~units~~ sets:

– nominal voltage;

– total wattage and wattage per metre;

– total resistance.

For parallel resistive ~~units~~ sets:

– nominal voltage;

– power output in watts per metre at a reference temperature or total wattage.

Printed marking shall be durable. Compliance with this requirement shall be checked by the test given in 8.2.21.

The above are the minimum requirements and suppliers are free to add any additional information which may be useful, such as the following:

Traceability identification shall be added such as week and year of manufacture, or batch number.

~~NOTE 3 Traceability is recommended, for example week/year.~~

NOTE ~~4~~ National or regional regulations ~~may~~ can give other requirements.

## 6 Requirements for installation instructions

The manufacturer shall provide product-specific installation instructions for heating cables, heating cable sets and components. The instructions shall be clearly identified as to the products and locations that apply, and shall include the following information:

a) the intended use(s), either by general application type or by specific listed application;

b) a means of isolating all line conductors from the supply;

c) the indication that over-current protection is provided;

d) the statement "Residual current device (RCD) ~~protection~~ having a residual current not exceeding 30 mA is required";

e) for mechanical classification M1 heating cables, intended for reduced levels of mechanical forces, the statement "Caution: Do not use in areas subject to high mechanical loads or impact";

f) an applicable statement to indicate that any metal sheath, braid, screen or equivalent electrically conductive covering of the heating cable shall be connected to an earth terminal;

g) if unscreened heating cables are installed, the indication that they shall be covered by an electrically earthed mesh or equivalent and protected by a 30 mA RCD according to the installation standard. See also IEC 60364-7-701 and IEC 60364-7-753;

h) minimum installation temperature;

i) minimum bending radius;

j) maximum sheath temperature, if applicable;

k) ~~the~~ a statement such as: "The presence of the heating cable shall be made evident by the posting of caution signs or markings~~, such as in the fuse box,~~ at appropriate locations, such as at the power connection fittings and/or at frequent intervals along the circuit and be part of any electrical documentation following the installation";

l) if applicable, the statement "The heating cable shall only be installed in concrete or other non-combustible materials".

m) for series resistive heating cables with more than two conductors, the indication that the resistance of each conductor shall be given.

The above are the minimum requirements and suppliers are free to add any additional information which may be useful.

NOTE National regulations, or in their absence, the IEC 60364 series [4], ~~may~~ can give ~~other~~ additional requirements.

## 7 General requirements for construction of heating cables

### 7.1 General

The heating cables shall be designed and constructed so as to give electrical, thermal and mechanical durability, and so that, in normal use, their performance is without danger to the user or surroundings.

Tapes, fillers, filler strings, etc. may be used in the heating cable.

All integral components shall comply with this document. ~~All others shall comply with relevant product standards.~~

Compliance is checked by all the requirements and tests specified in this document.

It is presupposed that all exposed parts of a heating cable and heating cable set intended for use in contact with ~~potable~~ tap water ~~shall be~~ are constructed of materials that meet relevant national or local requirements.

### 7.2 Conductors

Conductors shall consist of one or more wires of pure or alloyed metal, or other suitable material. ~~In the case of conductors consisting of pure copper coated with a metallic coating, the metallic coating shall be appropriate to the conductor operating temperature.~~

The resistance of the heating conductors at 20 °C ~~± 1 °C~~ shall be in accordance with the values given by the manufacturer with a maximum tolerance of $^{+10}_{-5}$ %.

The heating conductor-material used shall not have a negative temperature coefficient of resistance. Compliance shall be checked according to the test in 8.2.1.

### 7.3 Insulation

The insulating materials used in heating cables shall be suitable for the intended use. This shall be verified by meeting the tests and the requirements given in this document.

The minimum ~~average~~ mean value of the insulation thickness shall be stated by the manufacturer and measured in accordance with ~~IEC 60811-1-1~~ IEC 60811-201, and meet the minimum requirements specified in 8.3.4.

### 7.4 Electrically conducting screen

When applicable and required, heating cables shall be provided with an evenly distributed electrically conductive metallic screen, or electrically conductive metallic sheath, tape or laminate or other suitable electrically conductive material. The metallic screen or electrically conductive material shall enable protection device(s) to operate as intended.

NOTE 1 For heating cables without an electrically conducting screen, additional national requirements ~~may~~ can apply.

The resistance of the conductive sheath or screen, inclusive of a separate earthing conductor which shall be in contact with the sheath or screen, shall be not higher than the resistance of each conductor in the heating cable or higher than the resistance of a plain copper conductor having a 0,5 $mm^2$ cross-sectional area as given for a class 1 conductor according to IEC 60228, whichever is the lesser. ~~The combined resistance of any earthing conductor included with this screen or sheath shall not be greater than that of a 0,5 $mm^2$ copper conductor.~~ A number of copper wires may be included in order to comply with the requirements.

NOTE 2 In some countries, national regulations require the resistance to be less than that of 0,5 $mm^2$ copper conductors.

Compliance shall be checked as described in 8.2.1.

If a conductive sheath or screen alone is used as the earthing conductor, the resistance measured shall be the total resistance including the earthing ~~connections delivered with the cable~~ connection wire (drain wire).

Electrically conductive screens shall be so constructed as to prevent the penetration of foreign substances greater than 1 mm in diameter into the insulation without touching the screen. Compliance shall be checked by the test specified in 8.2.5.

### 7.5 Armouring

Separate armouring, if any, may consist of metallic or non-metallic wires, sheath, tape or laminate. ~~If metallic, it shall not be applied directly on to the metallic sheath if any, but shall be separated from this by a protective layer of suitable insulating material which can withstand the mechanical abuse and the temperatures which can occur under normal use, and protects the metallic sheath against corrosion.~~

Electrically conductive armouring shall be so constructed as to prevent the penetration of foreign substances greater than 1 mm in diameter into the insulation without touching the armouring. Compliance shall be checked by the test specified in 8.2.5.

~~If the armouring is based on a conductive material the same requirements as specified for the electrically conductive screen shall apply.~~

NOTE National regulations ~~may~~ can give other requirements.

### 7.6 Sheath

The sheathing materials used in heating cables shall be suitable for the intended use. This shall be verified by meeting the tests and the requirements given in this document. A non-metallic outer sheath shall give mechanical and/or corrosion protection dependent on the type of heating cable.

The minimum ~~average~~ mean value of the sheath thickness shall be stated by the manufacturer and measured in accordance with ~~IEC 60811-1-1~~ IEC 60811-202, and meet the minimum requirements specified in 8.3.5.

### 7.7 Moisture resistance

Heating cables shall comply with the requirements as stated in 8.2.2.

NOTE This requirement is regarded at least comparable with class IPX7 as defined in IEC 60529 [5].

## 8 Testing

### 8.1 Type tests – General requirements

All described routine and sample tests shall be included in the type test, except for the spark test specified in 8.3.1.

For heating cables intended to be supplied in bulk, a sample of suitable length, for example a 5 m sample ~~of the heating cable~~, shall be used for testing, if not otherwise specified.

For heating cable sets which are factory assembled, including cold lead, connection splice and end ~~seal~~ termination, the complete heating cable set shall be used for testing. Alternatively, a 5 m sample of heating cable may be tested. The various parts (components) such as cold lead, connection splice and end termination may be assembled on a dummy length of heating cable and tested separately.

For heating cables intended to be field assembled, the cold lead, connection splice and end terminations to be used and specified by the manufacturer shall be assembled, according to the manufacturer's instructions, with the heating cable to form a heating cable set. The complete heating cable set shall be tested. Alternatively, a 5 m sample of heating cable may be tested. The various parts such as cold lead, connection splice and end termination may be assembled on a 5 m dummy length of heating cable and tested separately, if not otherwise specified.

All sample components used shall be typical examples from what is supplied to the market or intended to be supplied to the market.

Tests shall be conducted at a room temperature between ~~20 °C and 25~~ (23 ± 5) °C, unless otherwise specified.

Unless otherwise specified, the test voltage shall be alternating current at a frequency between 49 Hz and 61 Hz of approximately sinusoidal waveform.

For a parallel resistive heating cable, the power output in watts per metre shall be checked according to the test in 8.2.3.

For a parallel resistive heating cable, the start-up current shall be checked according to the test in 8.2.4.

Separate samples may be used for each test unless otherwise specified. These shall be prepared in accordance with the manufacturer's recommendations.

~~If a sample does not meet a specified requirement, two new complete sets of samples shall be tested. If both pass the test requirement, the cable shall be deemed to meet the test.~~

### 8.2 Type tests – Detailed test requirements

#### 8.2.1 Electrical resistance of heating conductors and screen

The resistance of the conductor(s) and screen, if any, shall be measured by any suitable means on samples at least 1,0 m long. Two measurements shall be taken for ~~the~~ each individual conductor, the first at ambient temperature and the second at a temperature of (100 ± 2) °C. The measurement at ambient temperature, corrected to (20 ± 1) °C, shall determine whether or

not the resistance value specified by the manufacturer has been achieved, both for the conductors and the screen.

The measurement at the higher temperature shall be compared with that at ambient temperature to confirm that ~~the~~ each individual conductor~~(s)~~ does not have a negative temperature coefficient of resistance.

### 8.2.2 Water immersion and temperature cycling test

#### 8.2.2.1 General remark

A (5 ± 0,1) m sample shall be subjected to ~~two ageing cycles~~ a cycle ageing test and shall be immersed for a total of 56 h in ~~potable~~ tap water at a temperature of (20 ± 5) °C for 8 h, (80 ± 5) °C for 16 h, (20 ± 5) °C for 8 h, (80 ± 5) °C for 16 h and (20 ± 5) °C for 8 h, i.e. 8 h + 16 h + 8 h + 16 h + 8 h. The sample shall be transferred to preheated water containers between each sub-cycle. The temperature in the water containers ~~must~~ shall be controlled, for example by placing them in preheated cabinets in accordance with ~~IEC 60811-1-2~~ IEC 60811-401.

Heating cable sets, including factory assembled cold lead, splice and end seal shall be subjected to this test after being assembled to a suitable heating cable.

Splices and end seals intended for heating cables for field assembly shall be subjected to this test after being assembled to a suitable heating cable and with cold leads.

All heating cable types and heating cable sets ~~must~~ shall be tested, except if they are clearly identified as not to be used in wet or humid conditions.

The sample may be transferred from the ageing water immersion unit to another water immersion unit for the dielectric testing described in 8.2.2.2 and the electrical insulation resistance test described in 8.2.2.3. The water temperature of both shall be (20 ± 5) °C.

After the cycle ageing the heating cable sheath shall be subjected to a mechanical test in accordance with IEC 60811-501.

There shall be no variation greater than ±25 % from the original, unaged value for the tensile strength and no variation greater than ±25 % from the original, unaged value for the elongation at break.

#### 8.2.2.2 Dielectric test

A 5 m sample shall be submerged in ~~potable~~ tap water with uncovered ends of the sample protruding sufficiently to avoid flashover ~~at the prescribed voltage~~. The metallic or other equivalent electrically conductive screen and/or metal sheath shall be removed from the ends of the sample in order to prevent breakdown at these points.

Heating cables which have not been factory assembled and which are supplied with special connections shall be tested with these connections submerged in water.

For a twin- and multi-conductor series resistive heating cable where the conductors are electrically insulated from each other, the voltage shall be applied between the conductors and between the conductors connected together and the metallic or equivalent conducting material, sheath, armour or screen, and water if no armour or screen is part of the heating cable construction.

For single conductor series heating cables with a metallic, or equivalent conducting material, sheath, armour or screen, the voltage shall be applied between the conductor and the sheath, armour or screen.

For single conductor series heating cables without a metallic, or equivalent conducting material, sheath, armour or screen the heating cable shall be submerged in water with the ends protruding from the water to avoid flashover at the ends. The voltage shall be applied between the conductor and the water.

For parallel resistive heating cables, the voltage shall be applied between the conductors connected together and the metal~~lic~~ sheath, braid, screen or equivalent electrically conductive covering.

Dielectric strength for insulated heating wires shall be tested by placing the insulated wire in ~~potable~~ tap water. The voltage shall be applied between the conductor and the water.

An alternating current test voltage of 2 000 V with a tolerance of ±3 % shall be applied for 5 min. The test voltage shall be increased gradually, and the ~~prescribed~~ specified value reached in a time of 2 s to 10 s.

No breakdown shall occur.

#### 8.2.2.3 Electrical insulation resistance test

The electrical insulation resistance shall be measured on the test sample(s) prepared in accordance with ~~8.2.2.1~~ 8.2.2.2, after the dielectric test in 8.2.2.2 has been carried out.

Non-screened heating cables shall be tested, submerged in water, with any layer(s) outside the insulation removed.

For single conductors, series resistive heating cables, the resistance of the electrical insulation shall be measured between the conductor and the metallic or equivalent conducting material, sheath or armour or conductive screen.

For a multi-conductor series resistive heating cable, where the conductors are electrically insulated from each other, the resistance of the insulation shall be measured between the conductors connected together and the metallic, or equivalent conducting material, sheath or armour or conductive screen, and also between each conductor in turn with the remaining conductor(s) connected together.

For parallel heating cables the resistance shall be measured between the conductors connected together and the metal~~lic~~ sheath, braid, screen or equivalent electrically conductive covering.

The insulation resistance shall be measured by means of a direct current voltage of 1 000 V with a tolerance of ±3 %, 1 min after application of the voltage~~, with the positive pole to the water~~. The measured value shall be not less than 50,0 MΩ.

### 8.2.3 Verification of rated output for parallel heating cables

The rated output shall be verified by the method described in 5.2.10.3.2 of IEC 62395-1:2013.

### 8.2.4 Verification of start-up current for parallel heating cables

The start-up current of the heating cable shall be measured as described in IEC 62395-1:2013.

### 8.2.5 Penetration test for electrically conductive screen

~~A steel test pin with a diameter of 1 mm shall be pushed through the conductive screen into the insulation when the cable is straight and also when it is wound onto a mandrel of diameter equal to five times the diameter, or the minor axis of the cable.~~

~~Three samples shall be tested.~~

~~It shall not be possible to push the test pin into the insulation, touching a live conductor, without touching the screen. This shall be verified by activating a residual current device (RCD) which operates at a maximum of 30 mA .The test shall be conducted at rated voltage, and with the test pin not connected to earth when the RCD is connected between the branch supply and the sample, and according to the RCD supplier's instruction.~~

~~NOTE Electrically insulated and earth connected tools should be used when voltage is applied to the sample.~~

One sample, at least 5 m in length, shall be tested at three places, at approximately the mid-point and at approximately 500 mm from each end. Before testing, 1 m of the sample, to include the mid-point of the sample, shall be bent on a mandrel to the minimum bend radius as given by the manufacturer and then straightened.

A steel test pin with a diameter of 1 mm shall be pushed through the outer sheath, the electrically conductive screen and the insulation, to touch the conductor(s). If the electrically conductive screen consists of individual wires (braid, or helical, or parallel distributed, or drain wire) they shall be joined together at the end of the sample before connection to the RCD and voltage applied.

The verification is achieved by activation of a residual current device (RCD) which operates at a maximum of 30 mA, showing that the steel pin has made contact with both the heating cable conductor (or resistance wire) and the electrically conductive screen. The test shall be conducted at nominal voltage, i.e. the voltage applied to the heating cable when in service and as declared by the manufacturer. The test pin shall not be connected to earth when the RCD is connected.

Electrically insulated and earth connected tools shall be used when voltage is applied to the sample

NOTE A combination of an electrically conductive- screen and –sheath is a possible design.

### 8.2.6 Flammability test

Heating cables intended to be installed and embedded in concrete, ~~mortar~~ or other non-combustible materials shall be exempted from this test. This exemption does not apply to cold leads in heating cables sets, i.e. cold leads shall be flame retardant.

A flammability test shall be performed on heating cables and cold leads with the test apparatus described in IEC 60332-1-1 and the procedure and requirements described in IEC 60332-1-2. The requirement for charring extending downwards does not apply when the end seal forms the lower part of the sample.

The test shall be performed on the heating cable and all integral components of a heating cable set.

If a product constitutes splice and end seal components, samples shall be prepared so that each component and the heating cables are tested ~~separately~~, and so that the middle part of the splice or end seal forms the part of the heating cable sample to which the test flame is applied, and the heating cable and/or the cold lead forms the upper part of the sample (see Figure 1 and Figure 2).When the end seal is tested, the sample may be supported by a 0,5 mm to 1,0 mm diameter steel wire attached to the lower end of the sample with a weight necessary to keep the sample in a stable position.

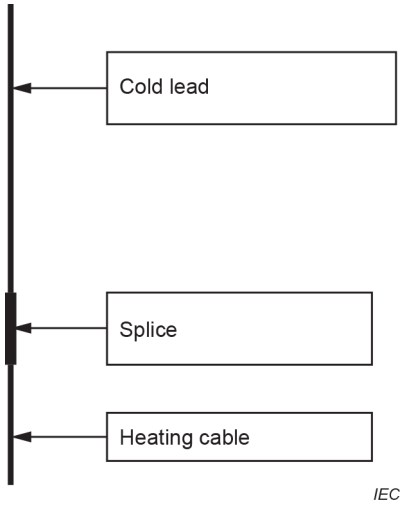



**Figure 1 – Typical arrangement for splice testing ~~the splice~~**

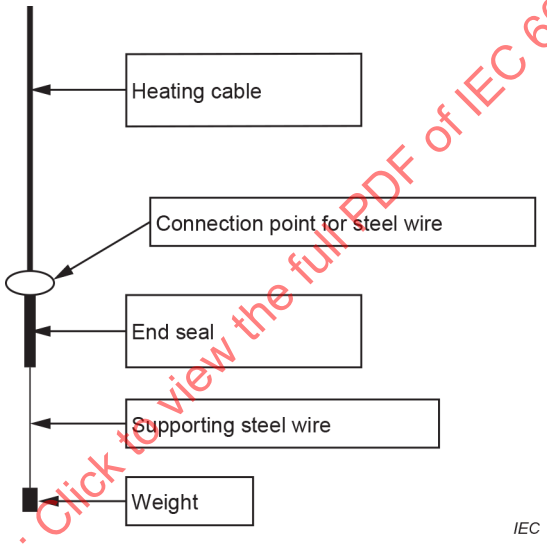



**Figure 2 – Typical arrangement for ~~testing the~~ end seal testing**



### 8.2.7 Deformation test for installation classification

#### 8.2.7.1 General remark

Heating cables shall be capable of withstanding the mechanical forces to which they will normally be subjected during installation and while in service. The heating cables are therefore grouped into two classes: mechanical class M1 with mechanical compression requirements as defined in 8.2.7.2, and mechanical class M2 as defined in 8.2.7.3.

The test also applies to integral components such as connection splice, end seal and cold lead which are factory mounted or intended to be field assembled and with the accessories specified by the manufacturer.

#### 8.2.7.2 Class M1: Heating cables intended for installation with low risk of mechanical damage

Three samples of minimum (200 ± 20) mm in length of the completed heating cable shall be placed individually~~, at a temperature of 20 °C ± 5 °C~~, on top of, and at right angles to, a cylindrical steel rod 6 mm in diameter resting upon a flat steel support.

A force of 600 N with a tolerance of ±5 % shall be applied without shock and maintained at any point of intersection of the test piece and the steel rod by means of a rigid plate 100 mm by 100 mm. After the force has been applied for 30 s, the test piece still under load shall be capable of withstanding, without breakdown, an alternating current voltage of (1 500 ± 5) V for 30 s. The voltage shall be applied between the conductor(s) and the metallic or other equivalent material, screen, braid or sheath. For heating cables without screen, the voltage shall be applied between the conductor(s) and the steel rod. If the heating cable has more than one conductor, the voltage test shall also be applied between the ~~phase~~ conductors.

There shall be no cracks in the outer layer visible by visual inspection.

None of the screen wires or conductors shall be broken as seen by visual inspection after cutting out the sheath and insulation.

If one of the samples fails to meet the requirement, two new complete sets of samples (3 + 3) shall be tested. If both sets pass the test requirement, the heating cable shall be deemed to meet the test.

#### 8.2.7.3 Class M2: Heating cables intended for installation with higher risk of mechanical damage

~~Three samples of minimum 200 mm length of the completed cable shall be placed individually, at a temperature of 20 °C ± 5 °C, on top of, and at right angles to, a cylindrical steel rod 6 mm in diameter resting upon a flat steel support.~~

~~A force of 1 500 N shall be applied without shock at any point of intersection of the test piece and the steel rod by means of a rigid plate 100 mm by 100 mm. After the force has been applied for 30 s, the test piece still under load shall be capable of withstanding, without breakdown, a voltage of 1 500 V a.c. for 30 s. The voltage shall be applied between the conductor(s) and the metallic or other equivalent material, screen, braid or sheath. For cables without screen, the voltage shall be applied between the conductor(s) and the steel rod. If the cable has more than one conductor, the voltage test shall also be applied between the phase conductors.~~

~~There shall be no cracks in the outer layer visible by visual inspection.~~

~~None of the screen wires or conductors shall be broken as seen by visual inspection after cutting out the sheath and insulation.~~

As for 8.2.7.2, but with a force of 1 500 N with a tolerance of ±5 %.

### 8.2.8 Cold impact test

This test is to be carried out at (−5 ± 2) °C, or the lowest installation temperature specified by the manufacturer, whichever is lower.

The test shall be carried out on three samples, of a minimum length of 0,5 m, using the impact test apparatus described in ~~IEC 60811-1-4~~ IEC 60811-506.

A heating cable having a non-circular cross-section shall be so positioned that the impact is applied along the minor axis.

Heating cables and heating cable sets according to class M1 shall be subjected to this test with an impact energy of 2 J.

NOTE 1 This ~~may~~ can be achieved e.g. by a falling mass of 500 g from a height of 400 mm.

Heating cables and heating cable sets according to class M2 shall be subjected to this test with an impact energy of 4 J.

NOTE 2 This ~~may~~ can be achieved e.g. by a falling mass of 1 000 g from a height of 400 mm.

This test also applies to connection splice, end-termination and cold lead which are factory mounted or intended to be field assembled and accessories specified by the manufacturer.

After the impact test, the test piece shall be capable of withstanding, without breakdown, an AC voltage of 1 500 V with a tolerance of ±5 % for 30 s and according to the procedure in 8.2.2.2.

For heating cables with metallic or other equivalent material, screen, armour or sheath the voltage shall be applied between the conductor(s) and the screen, armour or sheath and the apparatus.

In the case of unscreened heating cables, the test pieces shall be submerged in water for 5 min before the test voltage is applied, with the test piece still in water and with earth connected to the water.

There shall be no cracks in the outer layer visible by visual inspection.

All samples shall pass the test requirements.

If one ~~or more~~ of the samples fails to meet the requirement, two new complete sets of samples (3 + 3) shall be tested. If both sets pass the test requirement, the heating cable shall be deemed to meet the test.

### 8.2.9 Cold bend test

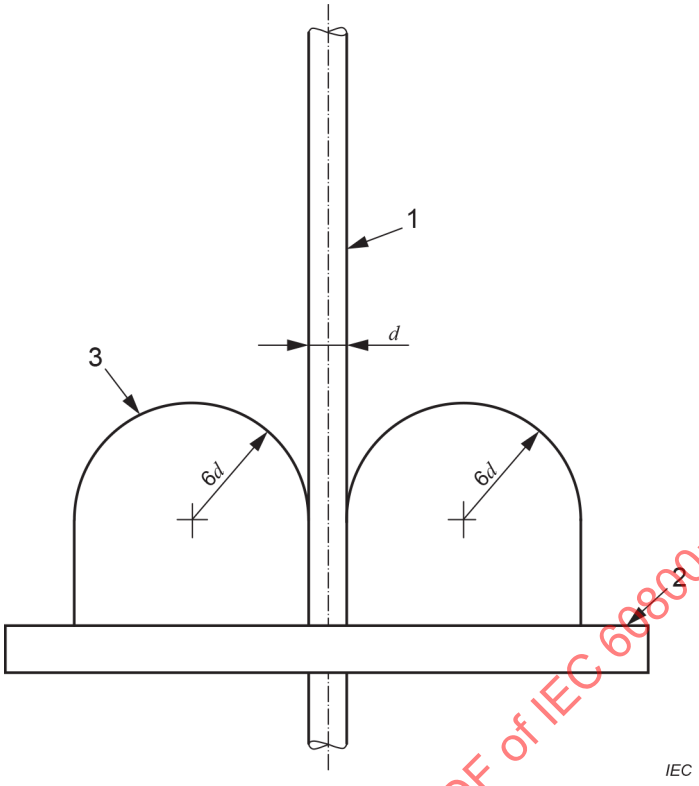
The apparatus used for the cold bend test is shown in Figure 3, with the radius of the mandrel as shown, or with the radius equal to the manufacturer's stated minimum bend radius. A sample of heating cable shall be fixed ~~in~~ to the apparatus as shown. The apparatus and sample shall be placed in a refrigerated compartment and maintained at (−10 ± 2) °C, or at the manufacturer's minimum recommended installation temperature, whichever is lower for a period not less than 4 h. At the end of this period, the sample shall be bent through 90º around one of the mandrels, then bent through 180º in the opposite direction over the second mandrel and then straightened to its original position. All the bending operations shall be carried out in the same plane. This cycle of operation shall be performed three times and the rate of bend shall not be faster than 5 s per cycle.

This test only applies to the heating cable and the cold lead, if any.

Conformity is verified by testing the electrical insulation in accordance with 8.2.2.2 without submersion in water for screened heating cables and with unscreened heating cables submersed in water for 5 min before the test voltage is applied, with the test piece still in water.

~~The installation instructions provided by the manufacturer shall state the minimum installation temperature and the minimum bending radius.~~

There shall be no cracks in the outer layer visible by visual inspection.




**Key**

1 sample

2 base

3 mandrel

*d* cable diameter or thickness for primary bending plane

**Figure 3 – Cold bend test**



### 8.2.10 Ageing test for insulation

The insulation shall be aged in a heating cabinet in accordance with ~~8.1.3.1 of IEC 60811-1-2:1985~~ IEC 60811-401. Unaged and aged samples shall be tested for tensile strength and elongation at break in accordance with ~~IEC 60811-1-1~~ IEC 60811-501.

The ageing shall be performed for 14 days at (135 ± 2) °C.

~~The unaged value for the tensile strength shall be minimum 12,5 MPa.~~

~~The unaged minimum value for the elongation at break shall be minimum 150 %.~~

There shall be no variation greater than ±25 % from the ~~original/~~unaged value for the tensile strength and no variation greater than ±25 % from the ~~original/~~unaged value for the elongation at break.

The minimum elongation at break requirement is 150 %, before and after ageing.

### 8.2.11 Ageing test for non-metallic sheath

If provided, the sheath shall be aged in a heating cabinet in accordance with ~~8.1.3.1 of IEC 60811-1-2:1985~~ IEC 60811-401. Unaged and aged samples shall be tested for tensile strength and elongation at break in accordance with ~~IEC 60811-1-1~~ IEC 60811-501. The material shall pass one of the following tests described in method A or method B.

~~The material has to pass the test described in method A or method B, as described below.~~

If the test specimen melts during test method A, then use method B.

Method A:

The ageing shall be performed for ~~60 days at 10 K above the manufacturer's defined maximum cable surface temperature, but at least at 110 °C~~ 14 days at (135 ± 2) °C. The unaged value for the tensile strength shall be minimum 10 MPa. The unaged minimum value for the elongation at break shall be minimum 100 %. There shall be no variation ~~bigger~~ greater than ±25 % from the original, unaged value for the tensile strength and no variation bigger than ±25 % from the original, unaged value for the elongation at break.

Method B:

The ageing shall be performed for ~~14 days at 35 K above the manufacturer's defined maximum cable surface temperature, but at least at 135 °C~~ 80 days at (110 ± 2) °C. The unaged value for the tensile strength shall be minimum 10 MPa. The unaged minimum value for the elongation at break shall be minimum 100 %. There shall be no variation ~~bigger~~ greater than ±25 % from the original, unaged value for the tensile strength and no variation bigger than ±25 % from the original, unaged value for the elongation at break.

### 8.2.12 Compatibility test

A complete heating cable sample shall be aged for 14 days at (110 ± 2) °C in a heating cabinet in accordance with IEC 60811-401.

Three samples shall be tested from the insulation and sheath.

There shall be no variation greater than ±25 % from the original, unaged value for the tensile strength and no variation greater than ±25 % from the original, unaged value for the elongation at break both for the insulation and the sheath measured in accordance with ~~IEC 60811-1-1~~ IEC 60811-501.

### 8.2.13 Weathering and UV resistance test

This test is to determine the UV stability of the outer non-metallic sheathing material of the heating cable in the condition as manufactured. This is done by means of measuring tensile strength and elongation at break in the condition as manufactured and after exposure to ultraviolet light and water.

The test is limited to applications where heating cables are exposed to sunlight or to other sources of UV-radiation.

Two test methods are described, one based on ISO 4892-3, given in 8.2.13 and a test method given in Annex A.

NOTE 1 The test methods described are considered to give comparable results.

NOTE 2 Additional information on weathering and UV resistance testing can be found in ISO 4892-1 [6] and ISO 4892-2 [7].

The test used shall be agreed between the manufacturer and the customer and certifying agency as applicable.

A sample of the finished heating cable shall be selected to prepare 10 test pieces in accordance with IEC 60811-501.

~~Three samples of the outermost components~~ Five dumb-bell samples of the outer non-metallic sheath of the heating cable or heating cable set shall be tested with the apparatus described in ISO 4892-3, using type 1A (UVA-340) fluorescent UV lamp.

The samples shall be exposed to UV light for 8 h at (60 ± 2) °C followed by 4 h of condensation at (50 ± 2) °C. This cycle shall be repeated continuously for a total of 2000 h.

~~After ageing for 2 000 h, a visual inspection for cracks shall be performed.~~

~~This test shall be applied to all cables except cables that are explicitly stated by the manufacturer not to be used for outdoor application, or to be subjected to other sources of UV radiation.~~

~~Heating cables having a continuous metal sheath with no outer non-metallic sheath shall be exempt from this test.~~

~~Heating cables that are only intended for being embedded in mortar or inside a floor or ceiling structure shall be exempted from this test.~~

~~NOTE There is an alternative UV test using a Xenon-arc light source as described in ISO 4892-2 [5]. A test procedure and requirements of equivalent severity to those above will be considered for the next revision of this standard.~~

After the exposure, the test specimens shall be re

moved from the equipment and conditioned at ambient temperature for at least 16 h.

The five exposed test pieces and the five not exposed test pieces shall be tested separately and in close succession for tensile strength and elongation at break. The respective median values shall be calculated from the five tensile-strength and elongation at break values obtained for the conditioned test pieces and shall be divided by the median values of the five tensile-strength and elongation at break values obtained for the unconditioned test pieces.

It is required that the tensile strength and elongation at break after treatment of exposure have a variation of maximum ±30 % of the values measured on not exposed test pieces.

A colour fading may appear after the test.

Heating cables having a continuous metal sheath with no outer non-metallic sheath shall be exempted from this test.

#### 8.2.14 Tensile test

Samples of ~~completed~~ heating cables~~, including cold lead, and splice (factory made or field assembled supplied with the cable) where this is a part of the finished product,~~ shall be tested on a tensile machine equipped with jaws of a similar design to that shown in Figure 4. The sample shall be arranged in the jaws as shown in Figure 4. The initial separation of the jaws shall be 150 mm. The jaw separation rate shall be 50 mm/min. The conductors shall be monitored for continuity and the samples shall be continuously examined for evidence of failure of any constituent part of the heating cable. The load at which such evidence is first detected shall be deemed to be the failure load.

Three samples shall be tested, and the minimum measured failure load quoted as the test result.

All completed heating cables shall be subjected to a tensile test and shall withstand a minimum force of 120 N.

Furthermore, heating cables designated mechanical class M2 shall withstand a minimum tensile force of 300 N.

If one of the samples fails to meet the requirement, two new complete sets of samples (3 + 3) shall be tested. If both sets pass the test requirement, the heating cable shall be deemed to meet the test.

Dimensions in millimetres

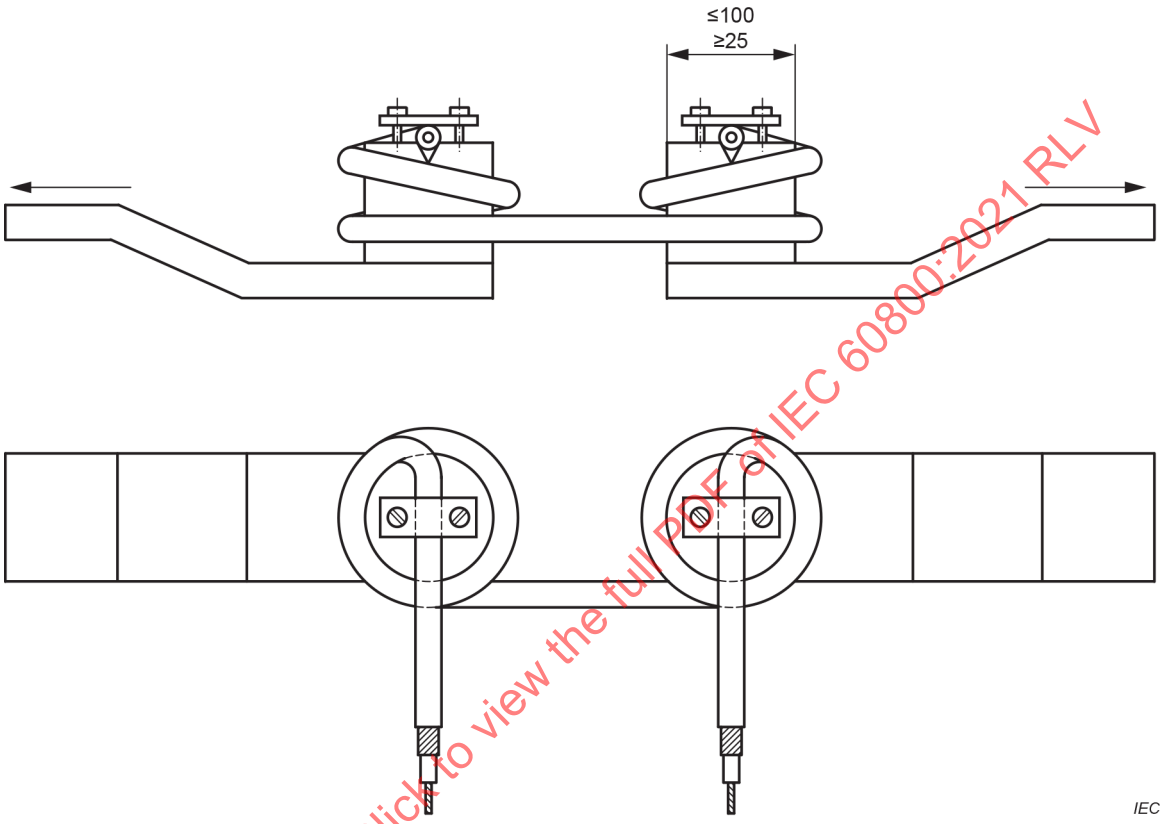



**Figure 4 – Jaws for tensile machine**



### 8.2.15 Reverse winding test

A piece of the completed heating cable shall be wound onto a mandrel, under a sufficient tensile load to form a close helix of at least three turns. The mandrel diameter shall be six times the overall diameter for unscreened and screened heating cables, and 15 times the overall diameter for armoured heating cables, or the minimum bending diameter specified by the manufacturer. For flat heating cables, the minor dimension of the heating cable shall be used in place of diameter.

The complete test shall comprise six test cycles, each cycle consisting of the winding of the heating cable onto the mandrel, unwinding and re-winding in the reverse direction so that the surface of the heating cable inside the helix during the first winding shall be on the outside surface of the helix upon re-winding. ~~After~~ By visual inspection, there shall be no signs of damage on any part of ~~the cable after this test~~ the heating cable, such as cracks in the outer sheath, broken screen wires or conductors. Slight puckering of the sheath shall not be considered as a failure.

On completion of the reverse winding, the test piece shall be subjected to the dielectric test in 8.2.2.2, but with a water immersion period of 1 h prior to the voltage test.

The dielectric test shall be performed between conductors and between conductors and screen, or water, as applicable.

### 8.2.16 Heat shock test

IEC 60811-509 shall be used, with the following modifications.

The heating part of a circular heating cable shall be wound onto a mandrel with six close turns, six times the sample outer diameter and placed in a heating cabinet at (150 ± 2) °C for 1 h. If the individual turns of the sample melt or stick together, the test shall be performed at ~~125~~ (110 ± 2) °C for 8 h.

The heating part of a non-circular heating cable shall be so positioned that the widest surface is touching the mandrel. The mandrel shall have a diameter of 6 times the minor axis.

~~Three samples~~ One sample shall be tested.

There shall be no cracks in the outer layer visible by visual inspection, both from the outside and from the inside after removing the sheath. If the sample fails during the test, two new samples shall be tested and if both samples pass the test, the product shall be deemed to pass the test.

### 8.2.17 Shrinkage test for insulation and sheath

**a) Insulation**

Two samples, each ~~200~~ 300 mm in length shall be tested in accordance with ~~IEC 60811-1-3~~ IEC 60811-502.

The test shall be carried out at a temperature of (130 ± 2) °C for 1 h.

The average shrinkage of the two samples shall be less than 4 %.

If one of the samples fails to meet the requirement, two new complete sets of samples (2 + 2) shall be tested. If both sets pass the test requirement, the heating cable shall be deemed to meet the test.

**b) Sheath**

Two samples, each 300 mm in length, shall be tested in accordance with ~~IEC 60811-1-3~~ IEC 60811-503. ~~The length of the samples shall be in accordance with IEC 60811-1-3.~~ The test is carried out at a temperature of ~~130~~ (110 ± 2) °C for 1 h.

The average shrinkage of the two samples shall be less than 4 %.

If one of the samples fails to meet the requirement, two new complete sets of samples (2 + 2) shall be tested. If both sets pass the test requirement, the heating cable shall be deemed to meet the test.

### 8.2.18 Hot set test

Cross-linked insulation and sheathing materials shall be checked for cross-linking degree by the hot set test method described in ~~IEC 60811-2-1~~ IEC 60811-507 at a temperature of (200 ± 3) °C.

The maximum allowable elongation under load shall be 175 % and maximum permanent elongation after cooling shall be 15 %.

### 8.2.19 Cyclic ageing test for the heating cable

For heating cables intended to be installed in screed or concrete, five samples of the non-metallic outer layer of the heating cable, prepared in accordance with ~~IEC 60811-1-1~~ IEC 60811-202, shall be subjected to a cyclic ageing test for six weeks at the following test conditions:

– one cycle = one week;

– dry ageing: 120 h at ~~120~~ (110 ± 2) °C in air;

– wet ageing in an alkaline water solution at (50 ± 2) °C for 48 h.

The water solution shall have a pH > 12, measured at room temperature, and be made of ~~potable~~ tap water, $CaCO_3$ and $Ca(OH)_2$, adjusting the pH with the $Ca(OH)_2$. The samples shall be placed in a jar, filled with the water solution, in a heating cabinet in accordance with ~~IEC 60811-1-2~~ IEC 60811-401.

~~NOTE 1 It is recommended that~~ The jar shall be covered with an aluminium foil or a lid during the ageing period for reasons of evaporation of the fluid.

NOTE ~~2~~ 50 g of $CaCO_3$ per litre and 2 g to 3 g of $Ca(OH)_2$ per litre of water has been found as approximate amounts to achieve a saturated solution of $CaCO_3$ and the necessary pH of the water solution, but adjustments ~~may~~ can be necessary after each cycle due to evaporation of water. The pH is tested by using commercially available pH-paper with good sensitivity in the alkaline part of the pH-scale.

After six cycles the tensile strength and elongation at break shall be measured in accordance with ~~IEC 60811-1-1~~ IEC 60811-501.

The variation from unaged samples shall be less than ±25 % for the tensile strength and ±25 % for the elongation at break.

### 8.2.20 Cyclic ageing test for splices and end seals

Five dummy samples between 0,25 m and 0,5 m in length of heating cable sets intended to be installed in screed or concrete, with incorporated end seals and/or splices shall be subjected to a cyclic ageing test for six weeks at the following test conditions:

– one cycle = one week ~~in alkaline water solution~~;

– dry ageing: 120 h at (110 ± 2) °C in air;

– wet ageing in an alkaline water solution at (50 ± 2) °C for 48 h.

The water solution shall have a pH > 12, measured at room temperature, and be made of ~~potable~~ tap water, $CaCO_3$ and $Ca(OH)_2$, adjusting the pH with the $Ca(OH)_2$.

~~NOTE 1 It is recommended that~~ The jar shall be covered with an aluminium foil or a lid during the ageing period for reasons of evaporation of the fluid.

NOTE ~~2~~ 50 g of $CaCO_3$ per litre and 2 g to 3 g of $Ca(OH)_2$ per litre of water has been found as approximate amounts to achieve a saturated solution of $CaCO_3$ and the necessary pH of the water solution, but adjustments might be necessary after each cycle due to evaporation of water. The pH is tested by using commercially available pH-paper with good sensitivity in the alkaline part of the pH-scale.

For wet ageing, the samples shall be placed in a jar at (50 ± 2) °C ~~for one week~~ in a heating cabinet in accordance with ~~IEC 60811-1-2~~ IEC 60811-401. Cover the jar with aluminium foil during the ageing period. After this time, the jar with the samples shall be naturally cooled to room temperature. The insulation resistance shall be measured between the conductor(s) and the screen, and between the conductor(s) and the water solution ~~/earth~~.

The insulation resistance shall be measured in accordance with 8.2.2.3.

The measured value shall ~~never~~ not be less than 50 MΩ.

### 8.2.21 Checking of the durability of markings

Compliance shall be checked by trying to remove the marking by rubbing lightly ten times with a piece of cotton wool or cloth soaked in water.

The marking shall be legible with normal or corrected vision after the test has been performed.

~~**8.2.22 Abrasion test**~~

~~Under consideration.~~

### 8.2.22 Pressure test at high temperature for insulation and sheath

The tests shall be made in accordance with IEC 60811-508 and at a temperature of (90 ± 2) °C both for the insulation and sheath.

The deformation shall not be more than 50 % of the initial thickness of the sample.

~~**8.2.23 Deformation test for insulation and sheathing materials**~~

~~The tests shall be made according to IEC 60811-3-1 and at a temperature of 90 °C both for the insulation and sheath.~~

~~The deformation shall not be more than 50 % of the initial thickness of the sample.~~

## 8.3 Routine and sample tests

### 8.3.1 General remarks

The high voltage test and resistance test are routine tests while the other tests are sample tests.

During the insulation and sheathing processes a spark test in accordance with IEC 62230 shall be performed according to the following voltage levels:

Insulation: minimum 6 000 V.

Sheath: minimum 3 000 V.

Every heating cable set shall be tested for high voltage and unit resistance as routine tests.

### 8.3.2 Voltage test

Each supplied length or item, whether in bulk or individually produced heating cable set, shall be subjected to a dielectric test.

The voltage test shall be performed between conductors and between conductors and screen, as applicable.

For heating cable sets < 300 m in length, the test shall be carried out at an AC voltage of 2,5 kV with a tolerance of ±3 % for at least 5 s.

For long bulk heating cables, the test shall be carried out at an AC voltage of 2,5 kV with a tolerance of ±3 % for 1 min or at a DC voltage of 3,5 kV with a tolerance of ±3 % for 1 min.

No breakdown shall occur.

### 8.3.3 Heating cable resistance and output verification

The output rating for each shipped length of ~~electric~~ heating cable shall be verified by measurement of the DC resistance or current at a given voltage and temperature.

For DC resistance and conductance, the resistance of the heating element per metre of conductor length at 20 °C ~~± 1 °C~~ shall be in accordance with the values given by the manufacturer with a maximum tolerance of $^{+10}_{-5}$ %, unless otherwise specified.

For parallel resistive heating cables, the value of current at a given voltage and temperature shall be within the manufacturer's tolerance.

### 8.3.4 Insulation thickness

The ~~minimum average~~ mean value of the insulation thickness shall be stated by the manufacturer.

The measurement of mean and minimum insulation thickness shall be measured according to the method described in ~~IEC 60811-1-1~~ IEC 60811-201.

The thickness at any place shall not be less than the ~~minimum average~~ mean value minus 15 %.

### 8.3.5 Sheath thickness

The ~~minimum average~~ mean value of the sheath thickness shall be stated by the manufacturer.

The ~~measurement of~~ sheath thickness shall be measured according to the method described in ~~IEC 60811-1-1~~ IEC 60811-202.

The thickness at any place shall not be less than the ~~minimum average~~ mean value minus 20 %.

### 8.3.6 Hot set test

Cross-linked insulation and sheathing materials shall be checked for cross-linking degree by the hot set test method described in ~~IEC 60811-2-1~~ IEC 60811-507 at a temperature of (200 ± 3) °C.

The maximum allowable elongation under load is 175 % and maximum permanent elongation after cooling is 15 %.

# Annex A
(normative)

## Weathering and UV resistance test

This test is to determine the UV stability of the sheathing material of the heating cable in the condition as manufactured. This is done by means of measuring tensile strength and elongation at break in the condition as manufactured and after exposure to ultraviolet light and water.

The test is limited to applications where heating cables are exposed to sunlight or to other sources of UV-radiation.

The testing apparatus is equipped with the following:

– a ray source consisting of a xenon arc lamp with borosilicate filters so that the typical irradiance should be 60 W/m$^2$ with a tolerance of ±15 % with a spectrum between 300 nm and 400 nm;
– a means to provide automatic control of temperature, humidity and cycles;
– a generator of deionized water with a conductivity not greater than 5 µS/cm; the rate of flow should be sufficient to guarantee that all the test specimens can be washed;
– a means to control the irradiance.

A sample of the finished heating cable shall be selected to prepare 10 test pieces in accordance with IEC 60811-501.

Five test pieces shall be exposed to the treatment for 720 h in 360 cycles of 120 min defined as follows:

– 102 min of dry radiation exposure at a temperature of (60 ± 3) ºC and relative humidity of (50 ± 10) %, followed by
– 18 min of rain exposure, without radiation, at a temperature of (50 ± 3) ºC without control of the relative humidity.

NOTE Additional information on weathering and UV resistance testing can be found in ISO 4892-1 [6] and ISO 4892-2 [7].

After the exposure, the test specimens shall be removed from the equipment and conditioned at ambient temperature for at least 16 h.

The five exposed test pieces and the five not exposed test pieces shall be tested separately and in close succession for tensile strength and elongation at break. The respective median values shall be calculated from the five tensile-strength and elongation at break values obtained for the conditioned test pieces and shall be divided by the median values of the five tensile-strength and elongation at break values obtained for the unconditioned test pieces.

It is required that the tensile strength and elongation at break after treatment of exposure have a variation of maximum ±30 % of the values measured on not exposed test pieces.

A colour fading may appear after the test.

Heating cables having a continuous metal sheath with no outer non-metallic sheath shall be exempted from this test.

# Bibliography

[1] IEC 62395 (all parts), *Electrical resistance trace heating systems for industrial and commercial applications*

[2] IEC/IEEE 60079-30 (all parts), *Explosive atmospheres – Part 30: Electrical resistance trace heating*

[3] IEC 62440:2008, *Electric cables with a rated voltage not exceeding 450/750 V – Guide to use*

[4] IEC 60364 (all parts), *Low-voltage electrical installations*

[5] IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

[6] ISO 4892-1, *Plastics – Methods of exposure to laboratory light sources – Part 1: General guidance*

[7] ISO 4892-2:2006, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

[8] IEC 60811-100, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 100: General*

[9] IEC 60811-203, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 203: General tests – Measurement of overall dimensions*

[10] IEC 60811-504, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 504: Mechanical tests – Bending tests at low temperature for insulation and sheaths*

~~IEC 62395-1, *Electrical resistance trace heating systems for industrial and commercial applications – Part 1: General and testing requirements*~~

# IEC 60800

Edition 4.0 2021-11

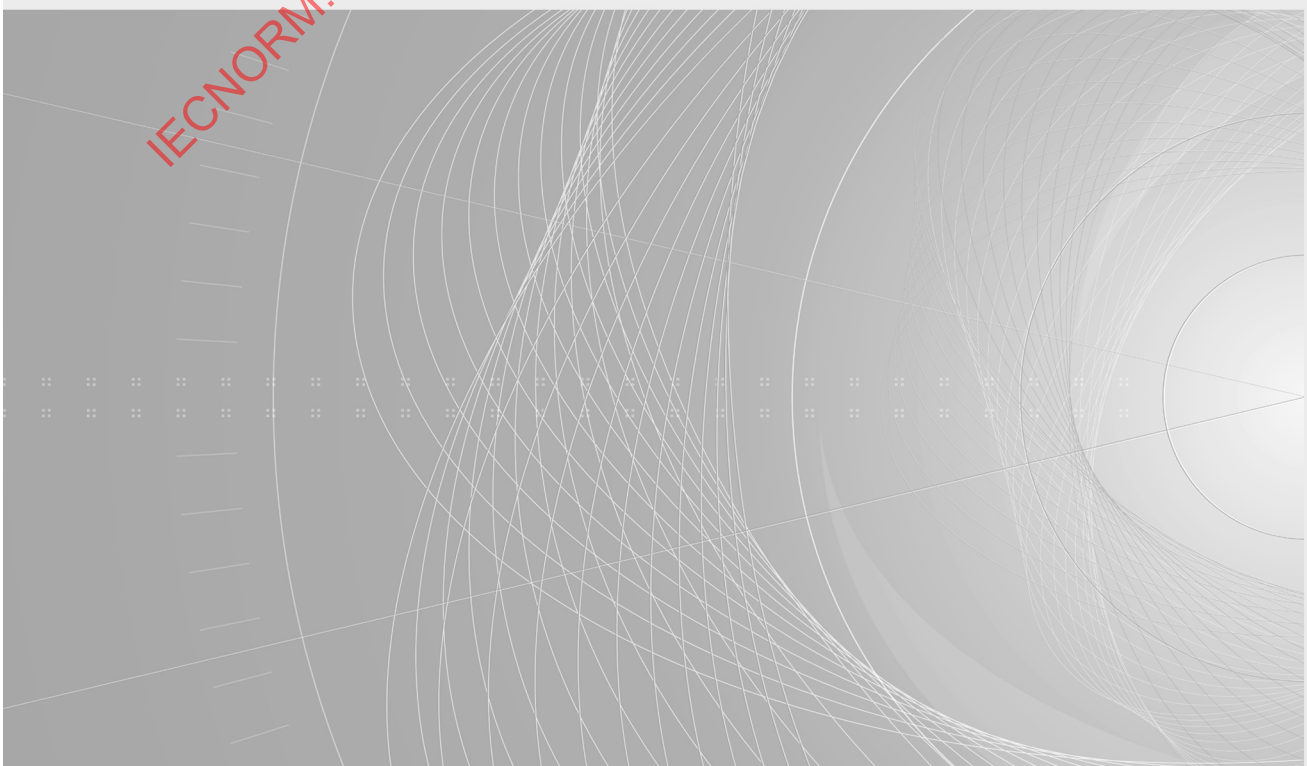
# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



## Heating cables with a rated voltage up to and including 300/500 V for comfort heating and prevention of ice formation

**Câbles chauffants de tension assignée jusques et y compris 300 V/500 V pour le chauffage des locaux et la protection contre la formation de glace**



IEC 60800:2021-11(en-fr)

# CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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# HEATING CABLES WITH A RATED VOLTAGE UP TO AND INCLUDING 300/500 V FOR COMFORT HEATING AND PREVENTION OF ICE FORMATION

## FOREWORD

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IEC 60800 has been prepared by IEC technical committee 20: Electric cables. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2009. This edition constitutes a technical revision.

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

a) modification of the title: "up to and including", has been introduced;
b) update of IEC 60811 references;
c) introduction of a test for mechanical properties of sheaths after the water immersion and temperature cycling test;
d) introduction of a weathering and UV resistance test according to ISO 4892-2:2013, Annex A.

The text of this International Standard is based on the following documents:

| Draft | Report on voting |
|---|---|
| 20/1972/FDIS | 20/1991/RVD |

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 International Standard 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/standardsdev/publications.

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.

# INTRODUCTION

This document is intended to provide a comprehensive overview of the essential requirements and testing appropriate to electrical resistance heating cables used for comfort heating and prevention of ice formation. While some of this work already exists in national standards or international standards, this document has collated much of this existing work.

This document provides a means to verify the electrical, thermal and mechanical durability of resistive heating cables, so that in normal use their performance is without danger to the user or surroundings. Compliance is checked by carrying out all the tests specified in this document.

# HEATING CABLES WITH A RATED VOLTAGE UP TO AND INCLUDING 300/500 V FOR COMFORT HEATING AND PREVENTION OF ICE FORMATION

## 1 Scope

This document is applicable to, and specifies requirements for resistive heating cables for low temperature applications such as comfort heating and the prevention of ice formation. These heating cables and heating cable sets can comprise either factory assembled or field (work-site) assembled units, and are heating cables assembled in accordance with manufacturer's instructions.

Bare conductors and protected conductors to be supplied at voltages equal to, or less than, 50 V are excluded from the scope of this document.

Typical applications include, but are not limited to:

- surface heating installed in or under surfaces;
- direct and storage heating;
- snow melting and frost protection of roofs, gutters, pipes, etc.

Electrical resistance trace heating systems for industrial and commercial applications are specified in the IEC 62395 series [1][1] and for explosive atmospheres applications in the IEC/IEEE 60079-30 series [2], as are mineral insulated heating cables.

Applications in which the sheath temperature exceeds 100 °C are outside the scope of this document.

The object of this document is to ensure that electrical resistance heating cables operate safely under their normal defined conditions of use. This is achieved by:

- employing heating cables of the appropriate construction that meet the test criteria detailed in this document;
- including, for heating cables with an electrical protective component, a metallic braid, concentric wires or sheath, or other suitable electrically conductive material for protective purposes in case of fault;
- ensuring that the heating cables operate at safe temperatures with respect to the materials used in the construction of the cables and their installations according to national regulations.



## 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 60050-461, *International Electrotechnical Vocabulary (IEV) – Part 461: Electric cables* (available at http://www.electropedia.org)

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1 Numbers in square brackets refer to the bibliography.

IEC 60228, *Conductors of insulated cables*

IEC 60332-1-1, *Tests on electric and optical fibre cables under fire conditions – Part 1-1: Test for vertical flame propagation for a single insulated wire or cable – Apparatus*

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60364-7-701, *Low-voltage electrical installations – Part 7-701: Requirements for special installations or locations – Locations containing a bath or shower*

IEC 60364-7-753, *Low-voltage electrical installations – Part 7-753: Requirements for special installations or locations – Heating cables and embedded heating systems*

IEC 62230, *Electric cables – Spark test method*

IEC 60811-201, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 201: General tests – Measurement of insulation thickness*

IEC 60811-202, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 202: General tests – Measurement of thickness of non-metallic sheath*

IEC 60811-401, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in air oven*

IEC 60811-501, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*

IEC 60811-502, *Electric and optical fibre cables – Test methods for non-metallic materials- Part 502: Mechanical tests – Shrinkage test for insulations*

IEC 60811-503, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 503: Mechanical tests – Shrinkage test for sheaths*

IEC 60811-506, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 506: Mechanical tests – Impact test at low temperature for insulations and sheaths*

IEC 60811-507, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 507: Mechanical tests – Hot set test for cross-linked materials*

IEC 60811-508, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 508: Mechanical tests – Pressure test at high temperature for insulation and sheaths*

IEC 60811-509, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 509: Mechanical tests – Test for resistance of insulations and sheaths to cracking (heat shock test)*

IEC 62395-1:2013, *Electrical resistance trace heating systems for industrial and commercial applications – Part 1: General and testing requirements*

ISO 4892-3:2016, *Plastics – Methods of exposure to laboratory light sources – Part 3: Fluorescent UV lamps*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-461 and the following 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**
**armouring**
mechanical reinforcement of the heating cable

Note 1 to entry: The reinforcement can be made of one or more layers of steel wires or braid, or of a metallic sheath or other suitable material.

**3.2**
**cold lead**
electrically insulated conductor or conductors used to connect a heating cable to the branch circuit and designed so that it does not produce significant heat

**3.3**
**connection splice**
sealed splice, connecting the heating cable to the cold lead, or an identical heating cable

**3.4**
**earthing conductor**
uninsulated conductor (drain wire) which is in good electric contact with the electrical screen along the length

**3.5**
**electrically conductive screen**
metallic braid, concentric wires, metallic sheath, or alternative covering with sufficient conductivity so that, when bonded to ground, will cause a residual current device (RCD) to operate under fault conditions

**3.6**
**end termination**
sealed termination, which may be heat producing, connected to the heating cable at the end opposite to that where the power is supplied

**3.7**
**factory assembled heating cable set**
heating cable set (unit) supplied with components, which are assembled by the manufacturer

**3.8**
**field assembled heating cable**
heating cable supplied in bulk with components to be assembled during installation

**3.9**
**heating cable**
cable, with or without an electrically conductive screen, metallic or equivalent, sheath or armour intended for emitting heat for heating purposes

**3.10**
**heating cable set**
heating cable with suitable power connection and end termination included

**3.11**
**heating conductor**
part of a serial heating cable in which the electrical energy is transformed into heat

**3.12**
**insulation**
material which insulates each conductor from other conductors or from conducting parts at earth potential

**3.13**
**integral components**
factory-assembled or field-assembled electrical terminations and connections, such as heat shrink terminations, moulded end seals or splices, which conform to the general shape of the heating cable and are exposed to the same environments as the heating cable

**3.14**
**maximum sheath temperature**
maximum temperature of the outermost covering of a heating cable

**3.15**
**nominal voltage**
actual voltage applied to the heating cable when in service

**3.16**
**parallel heating cable**
heating elements electrically connected in parallel, with the heating element either continuous or in discrete units or zones, such that the watt density per unit length is not significantly changed with any change in circuit length

**3.17**
**rated resistance**
resistance at 20 °C of 1 m of conductor

Note 1 to entry: Most heating cables contain more than one conductor and the resistance is measured for all conductors.

**3.18**
**rated voltage**
reference voltage for which the heating cable is designed

Note 1 to entry: The rated voltage is expressed by the combination of two values $U_0/U$, expressed in volts:

$U_0$ being the RMS value between any insulated conductor and "earth" (metal covering of the cable or the surrounding medium);

$U$ being the RMS value between any two-phase conductors of a multicore cable or of a system of single-core cables.

Note 2 to entry: See IEC 62440:2008, 5.2 [3].

**3.19**
**routine test**
test made by the manufacturer on each manufactured length of cable to check that each length meets the specified requirements

**3.20**
**sample test**
test made by the manufacturer on samples of completed cable or components taken from a complete cable, at specified frequency, so as to verify that the finished product meets the specified requirements

**3.21**
**sheath**
uniform and continuous covering, metallic or non-metallic, enclosing the insulated conductor(s), used for mechanical protection and to protect the cable against influences from the surroundings

**3.22**
**type test**
test made before supplying, on a general commercial basis, a type of cable covered by this document, in order to demonstrate satisfactory performance characteristics to meet the intended application

Note 1 to entry: Type tests are of such a nature that, after they have been made, they need not be repeated, unless changes are made in the cable materials or design or manufacturing process which might change the performance characteristics.

## 4 Mechanical classification

The heating cables in this document have been divided into two classes which indicate their ability to withstand mechanical forces during and after installation. These classes are as follows:

– mechanical class M1: for heating cables intended for installation with low risk of mechanical damage;
– mechanical class M2: for heating cables intended for installation with higher risk of mechanical damage.

The class of any heating cable is determined by its performance as measured against the requirements in 8.2.7 and 8.2.14.

NOTE 1 Mechanical class M1: for heating cables intended for use in applications with low risk of mechanical damage, for example the installation on even surfaces like flat, smooth sub-floors of concrete or wooden materials or thermal insulations, embedded in screeds with no sharp objects.

NOTE 2 Mechanical class M2: for heating cables intended for use in applications with higher risk of mechanical damage, such as the installation on steel reinforcing grids, direct embedding in soil, in concrete with sharp objects, on roofs and gutters.

## 5 Requirements for marking

The product shall be identified by printing, embossing or indenting on the sheath or on a label attached to the product or on a component inside the heating cable.

Embossing shall not be used on the insulation.

A label shall be attached to the product in a permanent way and be clearly detectable to the electrical installer.

The label shall be attached to the part of the product which is clearly visible when unpacking the product ready for installation.

The marking shall at least contain:

- the identification of the manufacturer by name and/or a symbol;
- the type reference;
- the resistance per metre of heating cable at 20°C in ohms per metre for single or twin conductor series resistive heating cables and for a parallel heating cable, the power output in watts per metre at a reference temperature. This is not required for heating cable sets;
- the mechanical classification;
- the rated voltage for parallel heating cables or maximum nominal voltage for series heating cables;
- if applicable, the indication "not flame-retardant".

The distance between the end of one complete set of marks and the beginning of the next shall not exceed:

– 550 mm, if the marking is on the sheath;
– 275 mm, if the marking is on a component inside the heating cable.

If the units are factory assembled, the following additional information shall be provided:

For series resistive sets:

– nominal voltage;
– total wattage and wattage per metre;
– total resistance.

For parallel resistive sets:

– nominal voltage;
– power output in watts per metre at a reference temperature or total wattage.

Printed marking shall be durable. Compliance with this requirement shall be checked by the test given in 8.2.21.

The above are the minimum requirements and suppliers are free to add any additional information which may be useful, such as the following:

Traceability identification shall be added such as week and year of manufacture, or batch number.

NOTE National or regional regulations can give other requirements.



## 6 Requirements for installation instructions

The manufacturer shall provide product-specific installation instructions for heating cables, heating cable sets and components. The instructions shall be clearly identified as to the products and locations that apply, and shall include the following information:

a) the intended use(s), either by general application type or by specific listed application;
b) a means of isolating all line conductors from the supply;
c) the indication that over-current protection is provided;
d) the statement "Residual current device (RCD) having a residual current not exceeding 30 mA is required";

e) for mechanical classification M1 heating cables, intended for reduced levels of mechanical forces, the statement "Caution: Do not use in areas subject to high mechanical loads or impact";

f) an applicable statement to indicate that any metal sheath, braid, screen or equivalent electrically conductive covering of the heating cable shall be connected to an earth terminal;

g) if unscreened heating cables are installed, the indication that they shall be covered by an electrically earthed mesh or equivalent and protected by a 30 mA RCD according to the installation standard. See also IEC 60364-7-701 and IEC 60364-7-753;

h) minimum installation temperature;

i) minimum bending radius;

j) maximum sheath temperature, if applicable;

k) a statement such as: "The presence of the heating cable shall be made evident by the posting of caution signs or markings, at appropriate locations, such as at the power connection fittings and/or at frequent intervals along the circuit and be part of any electrical documentation following the installation";

l) if applicable, the statement "The heating cable shall only be installed in concrete or other non-combustible materials";

m) for series resistive heating cables with more than two conductors, the indication that the resistance of each conductor shall be given.

The above are the minimum requirements and suppliers are free to add any additional information which may be useful.

NOTE National regulations, or in their absence, the IEC 60364 series [4], can give additional requirements.

## 7 General requirements for construction of heating cables

### 7.1 General

The heating cables shall be designed and constructed so as to give electrical, thermal and mechanical durability, and so that, in normal use, their performance is without danger to the user or surroundings.

Tapes, fillers, filler strings, etc. may be used in the heating cable.

All integral components shall comply with this document.

Compliance is checked by all the requirements and tests specified in this document.

It is presupposed that all exposed parts of a heating cable and heating cable set intended for use in contact with tap water are constructed of materials that meet relevant national or local requirements.

### 7.2 Conductors

Conductors shall consist of one or more wires of pure or alloyed metal, or other suitable material.

The resistance of the heating conductors at 20 °C shall be in accordance with the values given by the manufacturer with a maximum tolerance of $^{+10}_{-5}$ %.

The heating conductor-material used shall not have a negative temperature coefficient of resistance. Compliance shall be checked according to the test in 8.2.1.

### 7.3 Insulation

The insulating materials used in heating cables shall be suitable for the intended use. This shall be verified by meeting the tests and the requirements given in this document.

The minimum mean value of the insulation thickness shall be stated by the manufacturer and measured in accordance with IEC 60811-201, and meet the minimum requirements specified in 8.3.4.

### 7.4 Electrically conducting screen

When applicable and required, heating cables shall be provided with an evenly distributed electrically conductive metallic screen, or electrically conductive metallic sheath, tape or laminate or other suitable electrically conductive material. The metallic screen or electrically conductive material shall enable protection device(s) to operate as intended.

NOTE 1 For heating cables without an electrically conducting screen, additional national requirements can apply.

The resistance of the conductive sheath or screen, inclusive of a separate earthing conductor which shall be in contact with the sheath or screen, shall be not higher than the resistance of each conductor in the heating cable or higher than the resistance of a plain copper conductor having a 0,5 $mm^2$ cross-sectional area as given for a class 1 conductor according to IEC 60228, whichever is the lesser. A number of copper wires may be included in order to comply with the requirements.

NOTE 2 In some countries, national regulations require the resistance to be less than that of 0,5 $mm^2$ copper conductors.

Compliance shall be checked as described in 8.2.1.

If a conductive sheath or screen alone is used as the earthing conductor, the resistance measured shall be the total resistance including the earthing connection wire (drain wire).

Electrically conductive screens shall be so constructed as to prevent the penetration of foreign substances greater than 1 mm in diameter into the insulation without touching the screen. Compliance shall be checked by the test specified in 8.2.5.

### 7.5 Armouring

Separate armouring, if any, may consist of metallic or non-metallic wires, sheath, tape or laminate. Electrically conductive armouring shall be so constructed as to prevent the penetration of foreign substances greater than 1 mm in diameter into the insulation without touching the armouring. Compliance shall be checked by the test specified in 8.2.5.

NOTE National regulations can give other requirements.

### 7.6 Sheath

The sheathing materials used in heating cables shall be suitable for the intended use. This shall be verified by meeting the tests and the requirements given in this document. A non-metallic outer sheath shall give mechanical and/or corrosion protection dependent on the type of heating cable.

The minimum mean value of the sheath thickness shall be stated by the manufacturer and measured in accordance with IEC 60811-202, and meet the minimum requirements specified in 8.3.5.

### 7.7 Moisture resistance

Heating cables shall comply with the requirements as stated in 8.2.2.

NOTE This requirement is regarded at least comparable with class IPX7 as defined in IEC 60529 [5].

# 8 Testing

## 8.1 Type tests – General requirements

All described routine and sample tests shall be included in the type test, except for the spark test specified in 8.3.1.

For heating cables intended to be supplied in bulk, a sample of suitable length, for example a 5 m sample, shall be used for testing, if not otherwise specified.

For heating cable sets which are factory assembled, including cold lead, connection splice and end termination, the complete heating cable set shall be used for testing. Alternatively, a 5 m sample of heating cable may be tested. The various parts (components) such as cold lead, connection splice and end termination may be assembled on a dummy length of heating cable and tested separately.

For heating cables intended to be field assembled, the cold lead, connection splice and end terminations to be used and specified by the manufacturer shall be assembled, according to the manufacturer's instructions, with the heating cable to form a heating cable set. The complete heating cable set shall be tested. Alternatively, a 5 m sample of heating cable may be tested. The various parts such as cold lead, connection splice and end termination may be assembled on a 5 m dummy length of heating cable and tested separately, if not otherwise specified.

All sample components used shall be typical examples from what is supplied to the market or intended to be supplied to the market.

Tests shall be conducted at a room temperature between (23 ± 5) °C, unless otherwise specified.

Unless otherwise specified, the test voltage shall be alternating current at a frequency between 49 Hz and 61 Hz of approximately sinusoidal waveform.

For a parallel resistive heating cable, the power output in watts per metre shall be checked according to the test in 8.2.3.

For a parallel resistive heating cable, the start-up current shall be checked according to the test in 8.2.4.

Separate samples may be used for each test unless otherwise specified. These shall be prepared in accordance with the manufacturer's recommendations.

## 8.2 Type tests – Detailed test requirements

### 8.2.1 Electrical resistance of heating conductors and screen

The resistance of the conductor(s) and screen, if any, shall be measured by any suitable means on samples at least 1,0 m long. Two measurements shall be taken for each individual conductor, the first at ambient temperature and the second at a temperature of (100 ± 2) °C. The measurement at ambient temperature, corrected to (20 ± 1) °C, shall determine whether or not the resistance value specified by the manufacturer has been achieved, both for the conductors and the screen.

The measurement at the higher temperature shall be compared with that at ambient temperature to confirm that each individual conductor does not have a negative temperature coefficient of resistance.

### 8.2.2 Water immersion and temperature cycling test

#### 8.2.2.1 General remark

A (5 ± 0,1) m sample shall be subjected to a cycle ageing test and shall be immersed for a total of 56 h in tap water at a temperature of (20 ± 5) °C for 8 h, (80 ± 5) °C for 16 h, (20 ± 5) °C for 8 h, (80 ± 5) °C for 16 h and (20 ± 5) °C for 8 h, i.e. 8 h + 16 h + 8 h + 16 h + 8 h. The sample shall be transferred to preheated water containers between each sub-cycle. The temperature in the water containers shall be controlled, for example by placing them in preheated cabinets in accordance with IEC 60811-401.

Heating cable sets, including factory assembled cold lead, splice and end seal shall be subjected to this test after being assembled to a suitable heating cable.

Splices and end seals intended for heating cables for field assembly shall be subjected to this test after being assembled to a suitable heating cable and with cold leads.

All heating cable types and heating cable sets shall be tested, except if they are clearly identified as not to be used in wet or humid conditions.

The sample may be transferred from the ageing water immersion unit to another water immersion unit for the dielectric testing described in 8.2.2.2 and the electrical insulation resistance test described in 8.2.2.3. The water temperature of both shall be (20 ± 5) °C.

After the cycle ageing the heating cable sheath shall be subjected to a mechanical test in accordance with IEC 60811-501.

There shall be no variation greater than ±25 % from the original, unaged value for the tensile strength and no variation greater than ±25 % from the original, unaged value for the elongation at break.

#### 8.2.2.2 Dielectric test

A 5 m sample shall be submerged in tap water with uncovered ends of the sample protruding sufficiently to avoid flashover. The metallic or other equivalent electrically conductive screen and/or metal sheath shall be removed from the ends of the sample in order to prevent breakdown at these points.

Heating cables which have not been factory assembled and which are supplied with special connections shall be tested with these connections submerged in water.

For a twin- and multi-conductor series resistive heating cable where the conductors are electrically insulated from each other, the voltage shall be applied between the conductors and between the conductors connected together and the metallic or equivalent conducting material, sheath, armour or screen, and water if no armour or screen is part of the heating cable construction.

For single conductor series heating cables with a metallic, or equivalent conducting material, sheath, armour or screen, the voltage shall be applied between the conductor and the sheath, armour or screen.

For single conductor series heating cables without a metallic, or equivalent conducting material, sheath, armour or screen the heating cable shall be submerged in water with the ends protruding from the water to avoid flashover at the ends. The voltage shall be applied between the conductor and the water.

For parallel resistive heating cables, the voltage shall be applied between the conductors connected together and the metal sheath, braid, screen or equivalent electrically conductive covering.

Dielectric strength for insulated heating wires shall be tested by placing the insulated wire in tap water. The voltage shall be applied between the conductor and the water.

An alternating current test voltage of 2 000 V with a tolerance of ±3 % shall be applied for 5 min. The test voltage shall be increased gradually, and the specified value reached in a time of 2 s to 10 s.

No breakdown shall occur.

#### 8.2.2.3 Electrical insulation resistance test

The electrical insulation resistance shall be measured on the test sample(s) prepared in accordance with 8.2.2.2, after the dielectric test in 8.2.2.2 has been carried out.

Non-screened heating cables shall be tested, submerged in water, with any layer(s) outside the insulation removed.

For single conductors, series resistive heating cables, the resistance of the electrical insulation shall be measured between the conductor and the metallic or equivalent conducting material, sheath or armour or conductive screen.

For a multi-conductor series resistive heating cable, where the conductors are electrically insulated from each other, the resistance of the insulation shall be measured between the conductors connected together and the metallic, or equivalent conducting material, sheath or armour or conductive screen, and also between each conductor in turn with the remaining conductor(s) connected together.

For parallel heating cables the resistance shall be measured between the conductors connected together and the metal sheath, braid, screen or equivalent electrically conductive covering.

The insulation resistance shall be measured by means of a direct current voltage of 1 000 V with a tolerance of ±3 %, 1 min after application of the voltage. The measured value shall be not less than 50,0 MΩ.

### 8.2.3 Verification of rated output for parallel heating cables

The rated output shall be verified by the method described in 5.2.10.3.2 of IEC 62395-1:2013.

### 8.2.4 Verification of start-up current for parallel heating cables

The start-up current of the heating cable shall be measured as described in IEC 62395-1:2013.

### 8.2.5 Penetration test for electrically conductive screen

One sample, at least 5 m in length, shall be tested at three places, at approximately the mid-point and at approximately 500 mm from each end. Before testing, 1 m of the sample, to include the mid-point of the sample, shall be bent on a mandrel to the minimum bend radius as given by the manufacturer and then straightened.

A steel test pin with a diameter of 1 mm shall be pushed through the outer sheath, the electrically conductive screen and the insulation, to touch the conductor(s). If the electrically conductive screen consists of individual wires (braid, or helical, or parallel distributed, or drain wire) they shall be joined together at the end of the sample before connection to the RCD and voltage applied.

The verification is achieved by activation of a residual current device (RCD) which operates at a maximum of 30 mA, showing that the steel pin has made contact with both the heating cable conductor (or resistance wire) and the electrically conductive screen. The test shall be conducted at nominal voltage, i.e. the voltage applied to the heating cable when in service and as declared by the manufacturer. The test pin shall not be connected to earth when the RCD is connected.

Electrically insulated and earth connected tools shall be used when voltage is applied to the sample

NOTE A combination of an electrically conductive- screen and –sheath is a possible design.

### 8.2.6 Flammability test

Heating cables intended to be installed and embedded in concrete, or other non-combustible materials shall be exempted from this test. This exemption does not apply to cold leads in heating cables sets, i.e. cold leads shall be flame retardant.

A flammability test shall be performed on heating cables and cold leads with the test apparatus described in IEC 60332-1-1 and the procedure and requirements described in IEC 60332-1-2. The requirement for charring extending downwards does not apply when the end seal forms the lower part of the sample.

The test shall be performed on the heating cable and all integral components of a heating cable set.

If a product constitutes splice and end seal components, samples shall be prepared so that each component and the heating cables are tested, and so that the middle part of the splice or end seal forms the part of the heating cable sample to which the test flame is applied, and the heating cable and/or the cold lead forms the upper part of the sample (see Figure 1 and Figure 2).When the end seal is tested, the sample may be supported by a 0,5 mm to 1,0 mm diameter steel wire attached to the lower end of the sample with a weight necessary to keep the sample in a stable position.



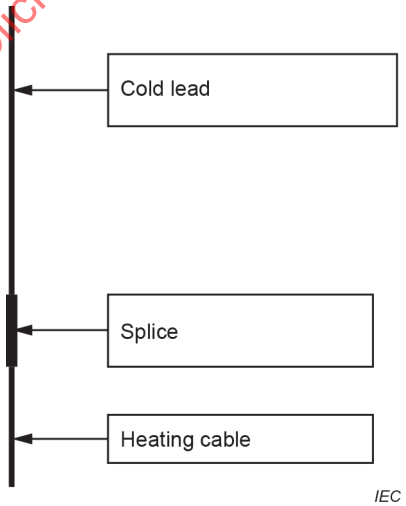



**Figure 1 – Typical arrangement for splice testing**

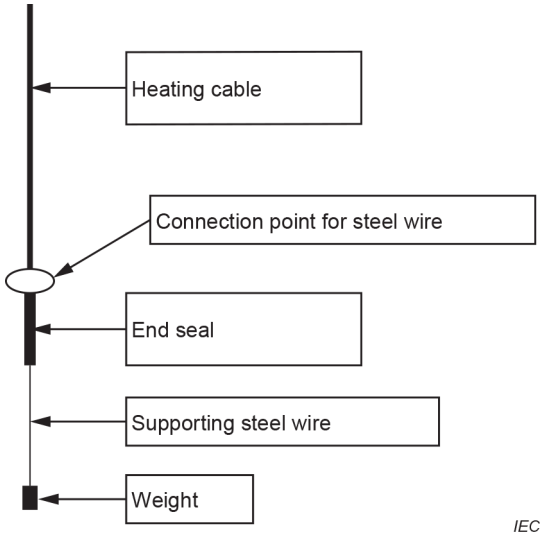



**Figure 2 – Typical arrangement for end seal testing**

### 8.2.7 Deformation test for installation classification

#### 8.2.7.1 General remark

Heating cables shall be capable of withstanding the mechanical forces to which they will normally be subjected during installation and while in service. The heating cables are therefore grouped into two classes: mechanical class M1 with mechanical compression requirements as defined in 8.2.7.2, and mechanical class M2 as defined in 8.2.7.3.

The test also applies to integral components such as connection splice, end seal and cold lead which are factory mounted or intended to be field assembled and with the accessories specified by the manufacturer.

#### 8.2.7.2 Class M1: Heating cables intended for installation with low risk of mechanical damage

Three samples of minimum (200 ± 20) mm in length of the completed heating cable shall be placed individually, on top of, and at right angles to, a cylindrical steel rod 6 mm in diameter resting upon a flat steel support.

A force of 600 N with a tolerance of ±5 % shall be applied without shock and maintained at any point of intersection of the test piece and the steel rod by means of a rigid plate 100 mm by 100 mm. After the force has been applied for 30 s, the test piece still under load shall be capable of withstanding, without breakdown, an alternating current voltage of (1 500 ± 5) V for 30 s. The voltage shall be applied between the conductor(s) and the metallic or other equivalent material, screen, braid or sheath. For heating cables without screen, the voltage shall be applied between the conductor(s) and the steel rod. If the heating cable has more than one conductor, the voltage test shall also be applied between the conductors.

There shall be no cracks in the outer layer visible by visual inspection.

None of the screen wires or conductors shall be broken as seen by visual inspection after cutting out the sheath and insulation.

If one of the samples fails to meet the requirement, two new complete sets of samples (3 + 3) shall be tested. If both sets pass the test requirement, the heating cable shall be deemed to meet the test.

#### 8.2.7.3 Class M2: Heating cables intended for installation with higher risk of mechanical damage

As for 8.2.7.2, but with a force of 1 500 N with a tolerance of ±5 %.

### 8.2.8 Cold impact test

This test is to be carried out at (−5 ± 2) °C, or the lowest installation temperature specified by the manufacturer, whichever is lower.

The test shall be carried out on three samples, of a minimum length of 0,5 m, using the impact test apparatus described in IEC 60811-506.

A heating cable having a non-circular cross-section shall be so positioned that the impact is applied along the minor axis.

Heating cables and heating cable sets according to class M1 shall be subjected to this test with an impact energy of 2 J.

NOTE 1 This can be achieved e.g. by a falling mass of 500 g from a height of 400 mm.

Heating cables and heating cable sets according to class M2 shall be subjected to this test with an impact energy of 4 J.

NOTE 2 This can be achieved e.g. by a falling mass of 1 000 g from a height of 400 mm.

This test also applies to connection splice, end-termination and cold lead which are factory mounted or intended to be field assembled and accessories specified by the manufacturer.

After the impact test, the test piece shall be capable of withstanding, without breakdown, an AC voltage of 1 500 V with a tolerance of ±5 % for 30 s and according to the procedure in 8.2.2.2.

For heating cables with metallic or other equivalent material, screen, armour or sheath the voltage shall be applied between the conductor(s) and the screen, armour or sheath and the apparatus.

In the case of unscreened heating cables, the test pieces shall be submerged in water for 5 min before the test voltage is applied, with the test piece still in water and with earth connected to the water.

There shall be no cracks in the outer layer visible by visual inspection.

All samples shall pass the test requirements.

If one of the samples fails to meet the requirement, two new complete sets of samples (3 + 3) shall be tested. If both sets pass the test requirement, the heating cable shall be deemed to meet the test.

### 8.2.9 Cold bend test

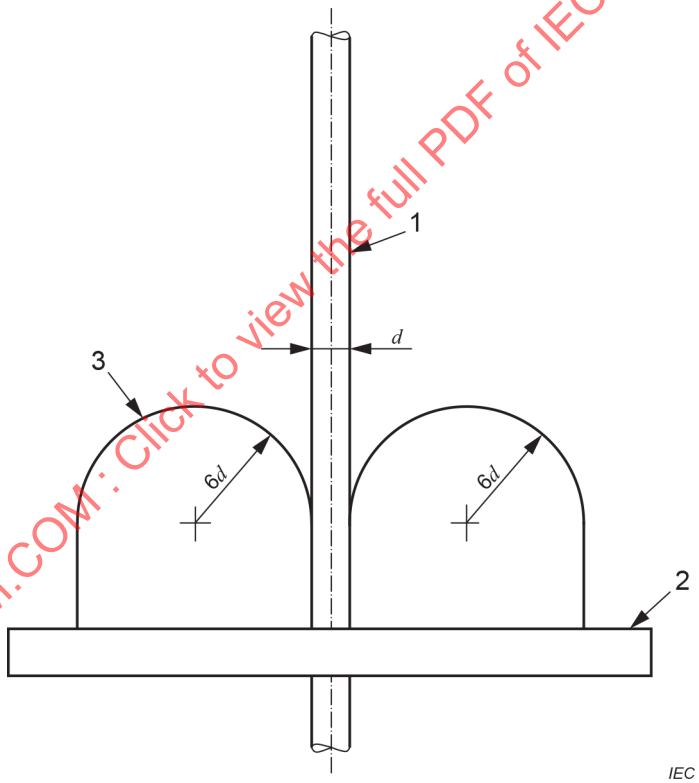
The apparatus used for the cold bend test is shown in Figure 3, with the radius of the mandrel as shown, or with the radius equal to the manufacturer's stated minimum bend radius. A sample of heating cable shall be fixed to the apparatus as shown. The apparatus and sample shall be placed in a refrigerated compartment and maintained at (−10 ± 2) °C, or at the manufacturer's minimum recommended installation temperature, whichever is lower for a period not less than 4 h. At the end of this period, the sample shall be bent through 90º around one of the mandrels, then bent through 180° in the opposite direction over the second mandrel and then straightened to its original position. All the bending operations shall be carried out in the same plane. This cycle of operation shall be performed three times and the rate of bend shall not be faster than 5 s per cycle.

This test only applies to the heating cable and the cold lead, if any.

Conformity is verified by testing the electrical insulation in accordance with 8.2.2.2 without submersion in water for screened heating cables and with unscreened heating cables submersed in water for 5 min before the test voltage is applied, with the test piece still in water.

There shall be no cracks in the outer layer visible by visual inspection.






**Key**

1 sample

2 base

3 mandrel

*d* cable diameter or thickness for primary bending plane

**Figure 3 – Cold bend test**

### 8.2.10 Ageing test for insulation

The insulation shall be aged in a heating cabinet in accordance with IEC 60811-401. Unaged and aged samples shall be tested for tensile strength and elongation at break in accordance with IEC 60811-501.

The ageing shall be performed for 14 days at (135 ± 2) °C.

There shall be no variation greater than ±25 % from the unaged value for the tensile strength and no variation greater than ±25 % from the unaged value for the elongation at break.

The minimum elongation at break requirement is 150 %, before and after ageing.

### 8.2.11 Ageing test for non-metallic sheath

If provided, the sheath shall be aged in a heating cabinet in accordance with IEC 60811-401. Unaged and aged samples shall be tested for tensile strength and elongation at break in accordance with IEC 60811-501. The material shall pass one of the following tests described in method A or method B.

If the test specimen melts during test method A, then use method B.

Method A:

The ageing shall be performed for 14 days at (135 ± 2) °C. The unaged value for the tensile strength shall be minimum 10 MPa. The unaged minimum value for the elongation at break shall be minimum 100 %. There shall be no variation greater than ±25 % from the original, unaged value for the tensile strength and no variation bigger than ±25 % from the original, unaged value for the elongation at break.

Method B:

The ageing shall be performed for 80 days at (110 ± 2) °C. The unaged value for the tensile strength shall be minimum 10 MPa. The unaged minimum value for the elongation at break shall be minimum 100 %. There shall be no variation greater than ±25 % from the original, unaged value for the tensile strength and no variation bigger than ±25 % from the original, unaged value for the elongation at break.

### 8.2.12 Compatibility test

A complete heating cable sample shall be aged for 14 days at (110 ± 2) °C in a heating cabinet in accordance with IEC 60811-401.

Three samples shall be tested from the insulation and sheath.

There shall be no variation greater than ±25 % from the original, unaged value for the tensile strength and no variation greater than ±25 % from the original, unaged value for the elongation at break both for the insulation and the sheath measured in accordance with IEC 60811-501.

### 8.2.13 Weathering and UV resistance test

This test is to determine the UV stability of the outer non-metallic sheathing material of the heating cable in the condition as manufactured. This is done by means of measuring tensile strength and elongation at break in the condition as manufactured and after exposure to ultraviolet light and water.

The test is limited to applications where heating cables are exposed to sunlight or to other sources of UV-radiation.

Two test methods are described, one based on ISO 4892-3, given in 8.2.13 and a test method given in Annex A.

NOTE 1 The test methods described are considered to give comparable results.

NOTE 2 Additional information on weathering and UV resistance testing can be found in ISO 4892-1 [6] and ISO 4892-2 [7].

The test used shall be agreed between the manufacturer and the customer and certifying agency as applicable.

A sample of the finished heating cable shall be selected to prepare 10 test pieces in accordance with IEC 60811-501.

Five dumb-bell samples of the outer non-metallic sheath of the heating cable or heating cable set shall be tested with the apparatus described in ISO 4892-3, using type 1A (UVA-340) fluorescent UV lamp.

The samples shall be exposed to UV light for 8 h at (60 ± 2) °C followed by 4 h of condensation at (50 ± 2) °C. This cycle shall be repeated continuously for a total of 2000 h.

After the exposure, the test specimens shall be removed from the equipment and conditioned at ambient temperature for at least 16 h.

The five exposed test pieces and the five not exposed test pieces shall be tested separately and in close succession for tensile strength and elongation at break. The respective median values shall be calculated from the five tensile-strength and elongation at break values obtained for the conditioned test pieces and shall be divided by the median values of the five tensile-strength and elongation at break values obtained for the unconditioned test pieces.

It is required that the tensile strength and elongation at break after treatment of exposure have a variation of maximum ±30 % of the values measured on not exposed test pieces.

A colour fading may appear after the test.

Heating cables having a continuous metal sheath with no outer non-metallic sheath shall be exempted from this test.

### 8.2.14 Tensile test

Samples of heating cables shall be tested on a tensile machine equipped with jaws of a similar design to that shown in Figure 4. The sample shall be arranged in the jaws as shown in Figure 4. The initial separation of the jaws shall be 150 mm. The jaw separation rate shall be 50 mm/min. The conductors shall be monitored for continuity and the samples shall be continuously examined for evidence of failure of any constituent part of the heating cable. The load at which such evidence is first detected shall be deemed to be the failure load.

Three samples shall be tested, and the minimum measured failure load quoted as the test result.

All completed heating cables shall be subjected to a tensile test and shall withstand a minimum force of 120 N.

Furthermore, heating cables designated mechanical class M2 shall withstand a minimum tensile force of 300 N.

If one of the samples fails to meet the requirement, two new complete sets of samples (3 + 3) shall be tested. If both sets pass the test requirement, the heating cable shall be deemed to meet the test.

Dimensions in millimetres

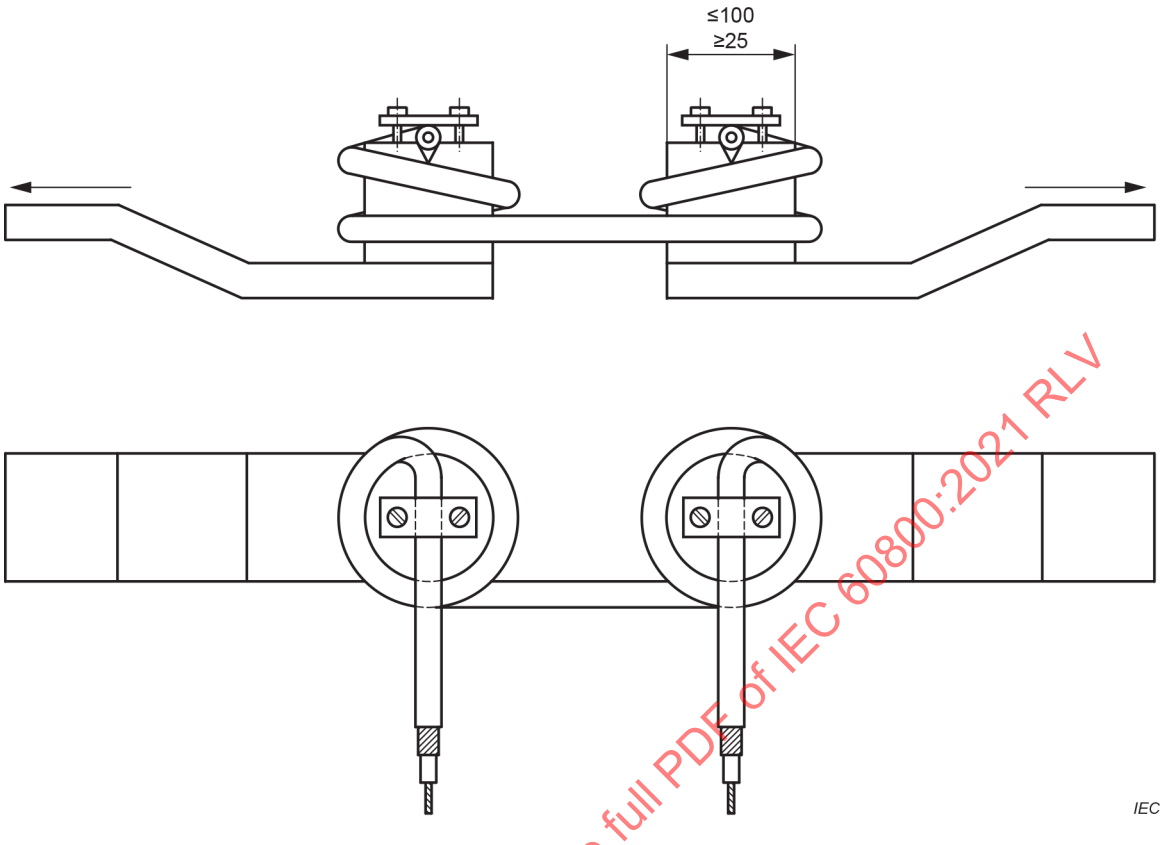



**Figure 4 – Jaws for tensile machine**



### 8.2.15 Reverse winding test

A piece of the completed heating cable shall be wound onto a mandrel, under a sufficient tensile load to form a close helix of at least three turns. The mandrel diameter shall be six times the overall diameter for unscreened and screened heating cables, and 15 times the overall diameter for armoured heating cables, or the minimum bending diameter specified by the manufacturer. For flat heating cables, the minor dimension of the heating cable shall be used in place of diameter.

The complete test shall comprise six test cycles, each cycle consisting of the winding of the heating cable onto the mandrel, unwinding and re-winding in the reverse direction so that the surface of the heating cable inside the helix during the first winding shall be on the outside surface of the helix upon re-winding.

By visual inspection, there shall be no signs of damage on any part of the heating cable, such as cracks in the outer sheath, broken screen wires or conductors. Slight puckering of the sheath shall not be considered as a failure.

On completion of the reverse winding, the test piece shall be subjected to the dielectric test in 8.2.2.2, but with a water immersion period of 1 h prior to the voltage test.

The dielectric test shall be performed between conductors and between conductors and screen, or water, as applicable.

### 8.2.16 Heat shock test

IEC 60811-509 shall be used, with the following modifications.

The heating part of a circular heating cable shall be wound onto a mandrel with six close turns, six times the sample outer diameter and placed in a heating cabinet at (150 ± 2) °C for 1 h. If the individual turns of the sample melt or stick together, the test shall be performed at (110 ± 2) °C for 8 h.

The heating part of a non-circular heating cable shall be so positioned that the widest surface is touching the mandrel. The mandrel shall have a diameter of 6 times the minor axis.

One sample shall be tested.

There shall be no cracks in the outer layer visible by visual inspection, both from the outside and from the inside after removing the sheath. If the sample fails during the test, two new samples shall be tested and if both samples pass the test, the product shall be deemed to pass the test.

#### 8.2.17 Shrinkage test for insulation and sheath

**a) Insulation**

Two samples, each 300 mm in length shall be tested in accordance with IEC 60811-502.

The test shall be carried out at a temperature of (130 ± 2) °C for 1 h.

The average shrinkage of the two samples shall be less than 4 %.

If one of the samples fails to meet the requirement, two new complete sets of samples (2 + 2) shall be tested. If both sets pass the test requirement, the heating cable shall be deemed to meet the test.

**b) Sheath**

Two samples, each 300 mm in length, shall be tested in accordance with IEC 60811-503. The test is carried out at a temperature of (110 ± 2) °C for 1 h.

The average shrinkage of the two samples shall be less than 4 %.

If one of the samples fails to meet the requirement, two new complete sets of samples (2 + 2) shall be tested. If both sets pass the test requirement, the heating cable shall be deemed to meet the test.

#### 8.2.18 Hot set test

Cross-linked insulation and sheathing materials shall be checked for cross-linking degree by the hot set test method described in IEC 60811-507 at a temperature of (200 ± 3) °C.

The maximum allowable elongation under load shall be 175 % and maximum permanent elongation after cooling shall be 15 %.

#### 8.2.19 Cyclic ageing test for the heating cable

For heating cables intended to be installed in screed or concrete, five samples of the non-metallic outer layer of the heating cable, prepared in accordance with IEC 60811-202, shall be subjected to a cyclic ageing test for six weeks at the following test conditions:

– one cycle = one week;
– dry ageing: 120 h at (110 ± 2) °C in air;
– wet ageing in an alkaline water solution at (50 ± 2) °C for 48 h.

The water solution shall have a pH > 12, measured at room temperature, and be made of tap water, $CaCO_3$ and $Ca(OH)_2$, adjusting the pH with the $Ca(OH)_2$. The samples shall be placed in a jar, filled with the water solution, in a heating cabinet in accordance with IEC 60811-401.

The jar shall be covered with an aluminium foil or a lid during the ageing period for reasons of evaporation of the fluid.

NOTE 50 g of $CaCO_3$ per litre and 2 g to 3 g of $Ca(OH)_2$ per litre of water has been found as approximate amounts to achieve a saturated solution of $CaCO_3$ and the necessary pH of the water solution, but adjustments can be necessary after each cycle due to evaporation of water. The pH is tested by using commercially available pH-paper with good sensitivity in the alkaline part of the pH-scale.

After six cycles the tensile strength and elongation at break shall be measured in accordance with IEC 60811-501.

The variation from unaged samples shall be less than ±25 % for the tensile strength and ±25 % for the elongation at break.

### 8.2.20 Cyclic ageing test for splices and end seals

Five dummy samples between 0,25 m and 0,5 m in length of heating cable sets intended to be installed in screed or concrete, with incorporated end seals and/or splices shall be subjected to a cyclic ageing test for six weeks at the following test conditions:

– one cycle = one week;
– dry ageing: 120 h at (110 ± 2) °C in air;
– wet ageing in an alkaline water solution at (50 ± 2) °C for 48 h.

The water solution shall have a pH > 12, measured at room temperature, and be made of tap water, $CaCO_3$ and $Ca(OH)_2$, adjusting the pH with the $Ca(OH)_2$.

The jar shall be covered with an aluminium foil or a lid during the ageing period for reasons of evaporation of the fluid.

NOTE 50 g of $CaCO_3$ per litre and 2 g to 3 g of $Ca(OH)_2$ per litre of water has been found as approximate amounts to achieve a saturated solution of $CaCO_3$ and the necessary pH of the water solution, but adjustments might be necessary after each cycle due to evaporation of water. The pH is tested by using commercially available pH-paper with good sensitivity in the alkaline part of the pH-scale.

For wet ageing, the samples shall be placed in a jar at (50 ± 2) °C in a heating cabinet in accordance with IEC 60811-401. Cover the jar with aluminium foil during the ageing period. After this time, the jar with the samples shall be naturally cooled to room temperature. The insulation resistance shall be measured between the conductor(s) and the screen, and between the conductor(s) and the water solution.

The insulation resistance shall be measured in accordance with 8.2.2.3.

The measured value shall not be less than 50 MΩ.

### 8.2.21 Checking of the durability of markings

Compliance shall be checked by trying to remove the marking by rubbing lightly ten times with a piece of cotton wool or cloth soaked in water.

The marking shall be legible with normal or corrected vision after the test has been performed.

### 8.2.22 Pressure test at high temperature for insulation and sheath

The tests shall be made in accordance with IEC 60811-508 and at a temperature of (90 ± 2) °C both for the insulation and sheath.

The deformation shall not be more than 50 % of the initial thickness of the sample.

### 8.3 Routine and sample tests

#### 8.3.1 General remarks

The high voltage test and resistance test are routine tests while the other tests are sample tests.

During the insulation and sheathing processes a spark test in accordance with IEC 62230 shall be performed according to the following voltage levels:

Insulation: minimum 6 000 V.

Sheath: minimum 3 000 V.

Every heating cable set shall be tested for high voltage and unit resistance as routine tests.

#### 8.3.2 Voltage test

Each supplied length or item, whether in bulk or individually produced heating cable set, shall be subjected to a dielectric test.

The voltage test shall be performed between conductors and between conductors and screen, as applicable.

For heating cable sets < 300 m in length, the test shall be carried out at an AC voltage of 2,5 kV with a tolerance of ±3 % for at least 5 s.

For long bulk heating cables, the test shall be carried out at an AC voltage of 2,5 kV with a tolerance of ±3 % for 1 min or at a DC voltage of 3,5 kV with a tolerance of ±3 % for 1 min.

No breakdown shall occur.

#### 8.3.3 Heating cable resistance and output verification

The output rating for each shipped length of heating cable shall be verified by measurement of the DC resistance or current at a given voltage and temperature.

For DC resistance and conductance, the resistance of the heating element per metre of conductor length at 20 °C shall be in accordance with the values given by the manufacturer with a maximum tolerance of $^{+10}_{-5}$ %, unless otherwise specified.

For parallel resistive heating cables, the value of current at a given voltage and temperature shall be within the manufacturer's tolerance.

#### 8.3.4 Insulation thickness

The mean value of the insulation thickness shall be stated by the manufacturer.

The measurement of mean and minimum insulation thickness shall be measured according to the method described in IEC 60811-201.

The thickness at any place shall not be less than the mean value minus 15 %.

#### 8.3.5 Sheath thickness

The mean value of the sheath thickness shall be stated by the manufacturer.

The sheath thickness shall be measured according to the method described in IEC 60811-202.

The thickness at any place shall not be less than the mean value minus 20 %.

#### 8.3.6 Hot set test

Cross-linked insulation and sheathing materials shall be checked for cross-linking degree by the hot set test method described in IEC 60811-507 at a temperature of (200 ± 3) °C.

The maximum allowable elongation under load is 175 % and maximum permanent elongation after cooling is 15 %.

# Annex A
(normative)

## Weathering and UV resistance test

This test is to determine the UV stability of the sheathing material of the heating cable in the condition as manufactured. This is done by means of measuring tensile strength and elongation at break in the condition as manufactured and after exposure to ultraviolet light and water.

The test is limited to applications where heating cables are exposed to sunlight or to other sources of UV-radiation.

The testing apparatus is equipped with the following:

– a ray source consisting of a xenon arc lamp with borosilicate filters so that the typical irradiance should be 60 W/m$^2$ with a tolerance of ±15 % with a spectrum between 300 nm and 400 nm;
– a means to provide automatic control of temperature, humidity and cycles;
– a generator of deionized water with a conductivity not greater than 5 µS/cm; the rate of flow should be sufficient to guarantee that all the test specimens can be washed;
– a means to control the irradiance.

A sample of the finished heating cable shall be selected to prepare 10 test pieces in accordance with IEC 60811-501.

Five test pieces shall be exposed to the treatment for 720 h in 360 cycles of 120 min defined as follows:

– 102 min of dry radiation exposure at a temperature of (60 ± 3) ºC and relative humidity of (50 ± 10) %, followed by
– 18 min of rain exposure, without radiation, at a temperature of (50 ± 3) ºC without control of the relative humidity.

NOTE Additional information on weathering and UV resistance testing can be found in ISO 4892-1 [6] and ISO 4892-2 [7].

After the exposure, the test specimens shall be removed from the equipment and conditioned at ambient temperature for at least 16 h.

The five exposed test pieces and the five not exposed test pieces shall be tested separately and in close succession for tensile strength and elongation at break. The respective median values shall be calculated from the five tensile-strength and elongation at break values obtained for the conditioned test pieces and shall be divided by the median values of the five tensile-strength and elongation at break values obtained for the unconditioned test pieces.

It is required that the tensile strength and elongation at break after treatment of exposure have a variation of maximum ±30 % of the values measured on not exposed test pieces.

A colour fading may appear after the test.

Heating cables having a continuous metal sheath with no outer non-metallic sheath shall be exempted from this test.

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[10] IEC 60811-504, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 504: Mechanical tests – Bending tests at low temperature for insulation and sheaths*

# SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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# CÂBLES CHAUFFANTS DE TENSION ASSIGNÉE JUSQUES ET Y COMPRIS 300 V/500 V POUR LE CHAUFFAGE DES LOCAUX ET LA PROTECTION CONTRE LA FORMATION DE GLACE

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La Norme internationale IEC 60800 a été établie par le comité d'études 20 de l'IEC: Câbles électriques. Il s'agit d'une Norme internationale.

Cette quatrième édition annule et remplace la troisième édition, parue en 2009. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) modification du titre: introduction de "jusques et y compris";
b) mise à jour des références à la série IEC 60811;
c) introduction d'un essai relatif aux propriétés mécaniques des gaines après l'immersion dans l'eau et l'essai de cycle thermique;

d) introduction d'un essai de vieillissement et de résistance aux UV conformément à l'Annexe A de l'ISO 4892-2:2013.

Le texte de cette Norme internationale est issu des documents suivants:

| Projet | Rapport de vote |
|---|---|
| 20/1972/FDIS | 20/1991/RVD |

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Le présent document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/standardsdev/publications.

Le comité a décidé que le contenu du présent document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous webstore.iec.ch dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

# INTRODUCTION

Le présent document est destiné à fournir un aperçu complet des exigences essentielles et des essais appropriés pour les câbles chauffants à résistance électrique utilisés pour le chauffage des locaux et la protection contre la formation de glace. Dans la mesure où une partie de ce travail existe déjà dans des normes nationales ou internationales, le présent document rassemble une grande partie de ces travaux déjà existants.

Le présent document fournit un moyen de vérifier la tenue électrique, thermique et mécanique des câbles chauffants résistifs, de telle sorte que leurs performances en utilisation normale ne présentent pas de danger pour l'utilisateur ou l'environnement. La vérification est effectuée par la réalisation de tous les essais spécifiés dans le présent document.

# CÂBLES CHAUFFANTS DE TENSION ASSIGNÉE JUSQUES ET Y COMPRIS 300 V/500 V POUR LE CHAUFFAGE DES LOCAUX ET LA PROTECTION CONTRE LA FORMATION DE GLACE

## 1 Domaine d'application

Le présent document s'applique aux câbles chauffants résistifs utilisés dans des applications basse température telles que le chauffage des locaux et la protection contre la formation de glace, et spécifie les exigences qui s'y appliquent. Ces câbles chauffants et câbles chauffants équipés peuvent comprendre soit des unités fabriquées en usine, soit des unités assemblées sur site (chantier), et sont des câbles chauffants assemblés conformément aux instructions du fabricant.

Les conducteurs nus et les conducteurs protégés destinés à être alimentés à des tensions inférieures ou égales à 50 V sont exclus du domaine d'application du présent document.

Les applications typiques comprennent entre autres:

- le chauffage superficiel interne aux surfaces ou situé sous les surfaces;
- le chauffage direct et à accumulation;
- la fonte de neige et le dégivrage des toits, gouttières, chéneaux, etc.

Les systèmes de traçage par résistance électrique pour applications industrielles et commerciales sont spécifiés dans la série IEC 62395 [1][1] et ceux pour applications en atmosphères explosives dans la série IEC/IEEE 60079-30 [1], tout comme les câbles chauffants à isolation minérale.

Les applications pour lesquelles la température de la gaine dépasse 100 °C ne relèvent pas du domaine d'application du présent document.

Le présent document a pour objet d'assurer que les câbles chauffants résistants électriques fonctionnent en toute sécurité dans leurs conditions normales d'utilisation définies. Ce but est atteint par les moyens suivants:

- utilisation de câbles chauffants de construction appropriée qui satisfont aux critères d'essai décrits dans le présent document;
- intégration, pour les câbles chauffants qui comportent un élément de protection électrique, d'une tresse métallique, de fils concentriques ou d'une gaine, ou de tout autre matériau électriquement conducteur adapté à des fins de protection en cas de défaut;
- vérification du fonctionnement des câbles chauffants à des températures de sécurité par rapport aux matériaux utilisés dans la construction des câbles et leurs installations selon les règlements nationaux.

## 2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. 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).

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1 Les chiffres entre crochets renvoient à la bibliographie.

IEC 60050-461, *Vocabulaire électrotechnique international (IEV) – Partie 461: Câbles électriques* (disponible à l'adresse http://www.electropedia.org)

IEC 60228: *Âmes des câbles isolés*

IEC 60332-1-1, *Essais des câbles électriques et à fibres optiques soumis au feu – Partie 1-1: Essai de propagation verticale de la flamme sur conducteur ou câble isolé – Appareillage d'essai*

IEC 60332-1-2, *Essais des câbles électriques et à fibres optiques soumis au feu – Partie 1-2: Essai de propagation verticale de la flamme sur conducteur ou câble isolé – Procédure pour flamme à prémélange de 1 kW*

IEC 60364-7-701, *Installations électriques à basse tension – Partie 7-701: Exigences pour les installations et emplacements spéciaux – Emplacements contenant une baignoire ou une douche*

IEC 60364-7-753, *Installations électriques à basse tension – Partie 7-753: Exigences pour les installations ou emplacements spéciaux – Câbles chauffants et systèmes de chauffage intégrés*

IEC 62230, *Câbles électriques – Méthode d'essai au défilement à sec (sparker)*

IEC 60811-201, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques - Partie 201: Essais généraux – Mesure de l'épaisseur des enveloppes isolantes*

IEC 60811-202, *Câbles électriques et à fibres optiques - Méthodes d'essai pour les matériaux non-métalliques – Partie 202: Essais généraux – Mesure de l'épaisseur des gaines non métalliques*

IEC 60811-401, *Câbles électriques et à fibres optiques - Méthodes d'essai pour les matériaux non-métalliques – Partie 401: Essais divers – Méthodes de vieillissement thermique – Vieillissement en étuve à air*

IEC 60811-501, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques – Partie 501: Essais mécaniques – Détermination des propriétés mécaniques des mélanges pour les enveloppes isolantes et les gaines*

IEC 60811-502, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques – Partie 502: Essais mécaniques – Essai de rétraction des enveloppes isolantes*

IEC 60811-503, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques – Partie 503: Essais mécaniques – Essai de rétraction des gaines*

IEC 60811-506, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques – Partie 506: Essais mécaniques – Essai de choc à basse température pour les enveloppes isolantes et les gaines*

IEC 60811-507, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques – Partie 507: Essais mécaniques – Essai d'allongement à chaud pour les matériaux réticulés*

IEC 60811-508, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques – Partie 508: Essais mécaniques – Essai de pression à température élevée pour les enveloppes isolantes et les gaines*

IEC 60811-509, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques – Partie 509: Essais mécaniques – Essai de résistance à la fissuration des enveloppes isolantes et des gaines (essai de choc thermique)*

IEC 62395-1:2013, *Systèmes de traçage par résistance électrique pour applications industrielles et commerciales – Partie 1: Exigences générales et d'essai*

ISO 4892-3:2016, *Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire – Partie 3: Lampes fluorescentes UV*

## 3 Termes et définitions

Pour les besoins du présent document, les termes et définitions de l'IEC 60050-461, ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

**3.1**
**armure**
renforcement mécanique du câble chauffant

Note 1 à l'article: Le renforcement peut être constitué d'une ou de plusieurs couches de fils d'acier, d'une tresse, d'une gaine métallique ou d'un autre matériau approprié.

**3.2**
**liaison froide**
conducteur(s) isolé(s) électriquement utilisé(s) pour relier un câble chauffant au circuit de branchement et conçu(s) pour ne produire aucune chaleur importante

**3.3**
**jonction de connexion**
jonction scellée qui relie le câble chauffant à la liaison froide, ou à un câble chauffant identique

**3.4**
**conducteur de mise à la terre**
conducteur non isolé (fil de masse) qui a un bon contact électrique avec l'écran électrique sur la longueur

**3.5**
**écran conducteur électrique**
tresse métallique, fils concentriques, gaine métallique ou autre type de couverture de conductivité suffisante de telle sorte que sa liaison à la terre entraîne le fonctionnement d'un dispositif différentiel résiduel (DDR) en conditions de défaut

**3.6**
**connecteur d'extrémité**
borne scellée qui peut produire de la chaleur, connectée à l'extrémité du câble chauffant du côté opposé à l'alimentation

**3.7**
**câble chauffant équipé assemblé en usine**
câble chauffant équipé (unité) qui comprend des composants, assemblés par le fabricant

**3.8**
**câble chauffant assemblé sur site**
câble chauffant fourni en touret qui comprend des composants à assembler lors de l'installation

**3.9**
**câble chauffant**
câble avec ou sans écran conducteur électrique, métallique ou équivalent, gaine ou armure, destiné à émettre de la chaleur à des fins de chauffage

**3.10**
**câble chauffant équipé**
câble chauffant avec les connexions de puissance appropriées et qui comprend le connecteur d'extrémité

**3.11**
**conducteur chauffant**
partie d'un câble chauffant en série dans laquelle l'énergie électrique est transformée en chaleur

**3.12**
**isolant**
matériau qui isole chaque conducteur des autres conducteurs ou des parties conductrices au potentiel de terre

**3.13**
**composants adaptés intégrés**
connexions et terminaisons électriques assemblées en usine ou sur site, telles que les terminaisons thermorétractables, les embouts d'étanchéité moulés et les jonctions compatibles avec la forme générale du câble chauffant et qui sont exposées au même environnement que celui-ci

**3.14**
**température de gaine maximale**
température maximale du revêtement externe d'un câble chauffant

**3.15**
**tension nominale**
tension réelle appliquée au câble chauffant en service

**3.16**
**câble chauffant en parallèle**
éléments chauffants à connexion électrique parallèle, chaque élément chauffant étant disposé de manière continue ou installé dans des unités ou des zones discrètes, de sorte que la densité en watt par unité de longueur ne varie pas de manière significative du fait d'une modification de la longueur de circuit

**3.17**
**résistance assignée**
résistance à 20 °C pour 1 m du conducteur

Note 1 à l'article: La plupart des câbles chauffants contiennent plus d'un conducteur et la résistance est mesurée pour chaque conducteur.

**3.18**
**tension assignée**
tension de référence pour laquelle le câble chauffant est conçu

Note 1 à l'article: La tension assignée est exprimée par la combinaison de deux valeurs $U_0/U$, exprimées en volts:

$U_0$ est la valeur efficace entre un conducteur isolé quelconque et la "terre" (revêtement métallique du câble ou le milieu environnant);

$U$ est la valeur efficace entre deux conducteurs diphasés quelconques d'un câble multiconducteur ou d'un système de câbles unipolaires.

Note 2 à l'article: Voir l'IEC 62440:2008, 5.2 [3].

**3.19**
**essai individuel de série**
essai effectué par le fabricant sur chaque longueur de câble fabriqué pour vérifier que chaque longueur satisfait aux exigences spécifiées

**3.20**
**essai sur prélèvements**
essai effectué par le fabricant sur des échantillons de câbles complets ou des composants prélevés sur un câble complet, à une fréquence déterminée, afin de vérifier que le produit fini satisfait aux exigences spécifiées

**3.21**
**gaine**
revêtement uniforme et continu, métallique ou non qui enferme le ou les conducteurs isolés, utilisé pour la protection mécanique et pour protéger le câble contre les influences externes

**3.22**
**essai de type**
essais réalisés, sur une base commerciale générale, avant de fournir un type de câble couvert par le présent document dans le but de démontrer des caractéristiques de performance satisfaisantes pour satisfaire à l'application souhaitée

Note 1 à l'article: La nature des essais de type est telle que, après avoir été réalisés, il n'est pas nécessaire de les répéter, sauf si des modifications effectuées au niveau de la conception, des matériaux ou du procédé de fabrication du câble sont susceptibles de modifier les caractéristiques des performances.

## 4 Classification mécanique

Les câbles chauffants mentionnés dans le présent document ont été répartis en deux classes qui indiquent leur aptitude à résister à des forces mécaniques pendant et après leur installation. Ces classes sont les suivantes:

– la classe mécanique M1: pour les câbles chauffants destinés à des installations comportant de faibles risques de dommages mécaniques;
– la classe mécanique M2: pour les câbles chauffants destinés à des installations comportant des risques élevés de dommages mécaniques.

La classe de chaque câble chauffant est déterminée par la mesure de ses performances par rapport aux exigences des 8.2.7 et 8.2.14.

NOTE 1 La classe mécanique M1: pour les câbles chauffants destinés à être utilisés dans des applications avec de faibles risques de dommages comme l'installation sur des surfaces unies telles que des sous-couches homogènes plates en béton ou en matériaux à base de bois ou sur des isolants thermiques et enfouis dans des chapes sans éléments acérés.

NOTE 2 La classe mécanique M2: pour des câbles chauffants destinés à être utilisés dans les applications avec des risques élevés de dommages mécaniques comme l'installation sur des treillis de renfort en acier, l'enfouissement direct dans le sol ou dans du béton contenant des éléments acérés, sur des toits ou des gouttières.

## 5 Exigences relatives au marquage

Le produit doit être identifié par impression, par relief ou par creux sur la gaine ou sur une étiquette qui lui est apposée, voire sur un élément à l'intérieur du câble chauffant.

La méthode par relief ne doit pas être utilisée sur l'isolant.

Le produit doit comporter de manière permanente une étiquette qui doit être aisément repérable par l'installateur électricien.

L'étiquette doit être apposée sur la partie du produit qui est aisément visible lors du déballage du produit prêt pour l'installation.

Le marquage doit comporter au moins:

- l'identification du fabricant par son nom et/ou un symbole;
- la référence du type de produit;
- la résistance par mètre de câble chauffant à 20 °C en ohms par mètre pour un câble chauffant résistif en série à un ou deux conducteurs et la puissance de sortie en watts par mètre à une température de référence pour un câble chauffant en parallèle. Ces informations ne sont pas exigées pour les câbles chauffants équipés;
- la classe mécanique;
- la tension assignée pour les câbles chauffants en parallèle ou la tension nominale maximale pour les câbles chauffants en série;
- le cas échéant, la mention "non ignifuge".

La distance entre la fin d'un ensemble complet de repères et le début de l'ensemble suivant ne doit pas dépasser:

– 550 mm, si le marquage est apposé sur la gaine;
– 275 mm si le marquage est apposé sur un élément à l'intérieur du câble chauffant.

Lorsque les unités sont assemblées en usine, les informations complémentaires suivantes doivent être fournies:

Pour les unités résistives en série:

– la tension nominale;
– la puissance totale et la puissance par mètre;
– la résistance totale.

Pour les unités résistives en parallèle:

– la tension nominale;
– la puissance de sortie en watts par mètre à une température de référence ou la puissance totale.

Le marquage par impression doit être durable. La vérification de cette exigence doit être effectuée par l'essai donné en 8.2.21.

Les points ci-dessus constituent les exigences minimales et les fournisseurs sont libres d'ajouter toute information complémentaire qui peut être utile, telle que:

Des informations d'identification de traçabilité doivent être ajoutées, telles que la semaine et l'année de fabrication, ou le numéro de lot.

NOTE Des réglementations nationales ou régionales peuvent spécifier d'autres exigences.

## 6 Exigences relatives aux instructions d'installation

Le fabricant doit fournir des instructions d'installation spécifiques pour les câbles chauffants, les câbles chauffants équipés et les composants. Les instructions doivent identifier clairement à quels produits et emplacements elles s'appliquent. Elles doivent inclure les informations suivantes:

a) l'utilisation ou les utilisations prévues, soit par un type d'application général, soit par une liste d'applications spécifiques;

b) un moyen d'isolement de tous les conducteurs de l'alimentation;

c) le fait qu'une protection contre les surintensités est fournie;

d) l'indication "un dispositif différentiel résiduel (DDR) dont le courant résiduel ne dépasse pas 30 mA est exigé";

e) pour les câbles chauffants de la classe mécanique M1, conçus pour les contraintes mécaniques de niveau réduit, l'indication suivante: "Attention: ne pas utiliser dans des zones qui présentent des risques de chocs ou de contraintes mécaniques élevés";

f) une indication applicable qui indique que toute gaine métallique, toute tresse, tout écran ou toute couverture équivalente électriquement conductrice du câble chauffant doivent être connectés à une borne de terre;

g) lorsque des câbles chauffants sans écran sont installés, ils doivent être recouverts d'une maille électriquement reliée à la terre ou d'un dispositif équivalent et protégés par un DDR de 30 mA selon la norme d'installation, et l'indication de ces dispositifs doit être explicite. Voir également l'IEC 60364-7-701 et l'IEC 60364-7-753;

h) la température d'installation minimale;

i) le rayon de courbure minimal;

j) la température de gaine maximale, le cas échéant;

k) une indication telle que: "La présence du câble chauffant doit être signalée de façon évidente par la mise en place de panneaux d'avertissement ou de marquages, à des emplacements appropriés, tels que les points de raccordement de l'énergie et/ou à des intervalles réguliers le long du circuit, et être mentionnée dans toute documentation électrique d'accompagnement de l'installation";

l) le cas échéant, l'indication "Le câble chauffant doit être uniquement installé dans du béton ou dans d'autres matériaux non combustibles";

m) pour les câbles chauffants résistifs en série qui comportent plus de deux conducteurs, la résistance de chaque conducteur doit être indiquée.

Les points ci-dessus constituent les exigences minimales et les fournisseurs sont libres d'ajouter toute information complémentaire qui peut être utile.

NOTE Des règlements nationaux, ou, en l'absence de ces derniers, la série IEC 60364 [4], peuvent spécifier des exigences supplémentaires.



## 7 Exigences générales pour la construction des câbles chauffants

### 7.1 Généralités

Les câbles chauffants doivent être conçus et construits de sorte qu'ils présentent une tenue électrique, thermique et mécanique et pour que leurs performances en utilisation normale ne présentent pas de danger pour l'utilisateur ou l'environnement.

Des rubans, des bourrages, des chaînes de bourrage, etc. peuvent être utilisés dans les câbles chauffants.

Tous les composants adaptés intégrés doivent satisfaire au présent document.

La vérification est effectuée par l'ensemble des exigences et des essais spécifiés dans le présent document.

Il est présupposé que toutes les parties exposées d'un câble chauffant et d'un câble chauffant équipé conçus pour une utilisation en contact avec de l'eau du robinet sont construites avec des matériaux qui satisfont aux exigences nationales ou locales pertinentes.

### 7.2 Conducteurs

Les conducteurs doivent être constitués d'un ou de plusieurs fils d'un métal pur ou allié ou d'un autre matériau approprié.

La valeur de la résistance des conducteurs à 20 °C doit être conforme aux valeurs fournies par le fabricant avec une tolérance maximale de $^{+10}_{-5}$ %.

Le matériau du conducteur chauffant utilisé ne doit pas avoir un coefficient de température négatif. La vérification doit être effectuée selon l'essai de 8.2.1.

### 7.3 Isolant

Les matériaux isolants utilisés dans les câbles chauffants doivent être adaptés pour l'utilisation prévue. Cette caractéristique doit être vérifiée par la conformité aux essais et aux exigences indiqués dans le présent document.

La valeur moyenne minimale de l'épaisseur de l'isolant doit être fixée par le fabricant, mesurée conformément à l'IEC 60811-201, et satisfaire aux exigences minimales spécifiées en 8.3.4.

### 7.4 Écran conducteur électrique

Si cela est applicable et exigé, les câbles chauffants doivent être équipés d'un écran métallique conducteur électrique réparti sur toute leur longueur, ou une gaine, un ruban ou une couche stratifiée électriquement conducteurs, voire tout autre matériau électriquement conducteur adapté. L'écran métallique ou le matériau électriquement conducteur doit permettre au(x) dispositif(s) de protection de fonctionner comme prévu.

NOTE 1 Des exigences nationales complémentaires peuvent s'appliquer aux câbles chauffants sans écran conducteur électrique.

La résistance de la gaine conductrice ou de l'écran conducteur, y compris un conducteur de mise à la terre indépendant qui doit être en contact avec la gaine ou l'écran, ne doit pas être supérieure à la plus petite des valeurs entre celle de chaque conducteur du câble chauffant et celle d'un conducteur massif en cuivre d'une section de 0,5 $mm^2$ telle que celle donnée pour un conducteur de classe 1 conformément à l'IEC 60228. Plusieurs fils de cuivre peuvent être associés afin de satisfaire aux exigences.

NOTE 2 Dans certains pays, les règlements nationaux exigent que la résistance soit inférieure à celle de conducteurs en cuivre de 0,5 $mm^2$.

La vérification doit être effectuée comme cela est décrit en 8.2.1.

Lorsque seule une gaine conductrice ou seul un écran conducteur est utilisé comme conducteur de mise à la terre, la résistance mesurée doit être la résistance totale y compris le fil de connexion de terre (fil de masse).

Les écrans conducteurs électriques doivent être construits de telle sorte qu'ils empêchent la pénétration de corps étrangers de plus de 1 mm de diamètre dans l'isolant sans entrer en contact avec l'écran. La vérification doit être effectuée au moyen de l'essai spécifié en 8.2.5.