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REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Thermal-links – Requirements and application guide

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THERMAL-LINKS – REQUIREMENTS AND APPLICATION GUIDE

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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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 60691:2015+AMD1:2019 CSV. 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 60691 has been prepared by subcommittee 32C: Miniature fuses, of IEC technical committee 32: Fuses. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2015 and Amendment 1:2019. This edition constitutes a technical revision.

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

a) requirements for thermal-link packaged assemblies;

b) renew the requirements and definitions for T_h-test;

The harmonization of the USA national standard, UL 1020, fifth edition (withdrawn 2003), and IEC 60691:1993, together with its Amendment 1:1995 and Amendment 2:2000 have served as a basis for the elaboration of this standard.

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

Draft	Report on voting
32C/604/FDIS	32C/605/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/publications.

The following differing practices of a less permanent nature exist in the country indicated below:

– Annex C is required to be declared in the USA;
– Annex E is required in the USA, if applicable;
– Annex F is required to be declared in the USA.

In this standard, the following type is used:

– *compliance statements: in italic type*.

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

Thermal-links, defined as non-resettable devices functioning once only without refunctioning, are widely applied for the thermal protection of equipment in which, under fault (abnormal) conditions, one or more parts may reach hazardous temperatures.

As these devices have several aspects in common with miniature fuse-links and are used for obtaining a comparable degree of protection, this standard has endeavoured to lay down a number of basic requirements for such devices.

THERMAL-LINKS – REQUIREMENTS AND APPLICATION GUIDE

1 Scope

This International Standard is applicable to thermal-links intended for incorporation in electrical appliances, electronic equipment and component parts thereof, normally intended for use indoors, in order to protect them against excessive temperatures under abnormal conditions.

NOTE 1 The equipment is not designed to generate heat.

NOTE 2 The effectiveness of the protection against excessive temperatures logically depends upon the position and method of mounting of the thermal-link, as well as upon the current which it is carrying.

This document may be applicable to thermal-links for use under conditions other than indoors, provided that the climatic and other circumstances in the immediate surroundings of such thermal-links are comparable with those in this standard.

This document may be applicable to thermal-links in their simplest forms (e.g. melting strips or wires), provided that molten materials expelled during function cannot adversely interfere with the safe use of the equipment, especially in the case of hand-held or portable equipment, irrespective of its position.

Annex H of this document is applicable to thermal-link packaged assemblies where the thermal-link(s) has already been approved to this standard but packaged in a metallic or non-metallic housing and provided with terminals/wiring leads.

This document is applicable to thermal-links with a rated voltage not exceeding 690 V AC or DC and a rated current not exceeding 63 A.

The objectives of this document are:

a) to establish uniform requirements for thermal-links,

b) to define methods of test, and

c) to provide useful information for the application of thermal-links in equipment.

This document is not applicable to thermal-links used under extreme conditions such as corrosive or explosive atmospheres.

This document is not applicable to thermal-links to be used in circuits on AC with a frequency lower than 45 Hz or higher than 62 Hz.

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 60065:2014, *Audio, video and similar electronic apparatus – Safety requirements*

IEC 60112:~~2003~~2020, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*
~~IEC 60112:2003/AMD1:2009~~

IEC 60127-2:2014, *Miniature fuses – Part 2: Cartridge fuse-links*

IEC 60216-5:2008, *Electrical insulating materials – Thermal endurance properties – Part 5: Determination of relative thermal endurance index (RTE) of an insulating material*

IEC 60664-1:~~2007~~2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 60695-2-12:~~2010~~2021, *Fire hazard testing – Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability index (GWFI) test method for materials*
~~IEC 60695-2-12:2010/AMD1:2014~~

IEC 60695-2-13:~~2010~~2021, *Fire hazard testing – Part 2-13: Glowing/hot-wire based test methods – Glow-wire ignition temperature (GWIT) test method for materials*
~~IEC 60695-2-13:2010/AMD1:2014~~

IEC 60695-10-2:2014, *Fire hazard testing – Part 10-2: Abnormal heat – Ball pressure test method*

IEC 60695-11-10:2013, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60730-1:2013, *Automatic electrical controls – Part 1: General requirements*
IEC 60730-1:2013/AMD1:2015
IEC 60730-1:2013/AMD2:2020

IEC 61210:2010, *Connecting devices – Flat quick-connect terminations for electrical copper conductors – Safety requirements*

3 Terms and definitions

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

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

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

3.1
clearance
shortest distance in air between two conductive parts

3.2
creepage distance
shortest distance along the surface of insulating material between two conductive parts

3.3
holding temperature
T_h
maximum ambient temperature of the thermal-link at which it will not change its state of conductivity during a specified time at ~~the~~ a specified rated current

~~Note 1 to entry: The minimum permissible value of T_h is 35 °C.~~

3.4
homogeneous series
series of thermal-links having the same external dimensions and common overall construction, deviating from each other only in such characteristics (including ratings) that, for a given test, the testing of one or a reduced number of particular thermal-links of that series shall be taken as representative for all the thermal-links of the series

3.5
interrupting current
I_b
value of the current that the thermal-link is capable of interrupting at rated voltage and under specified circuit conditions

3.6
maximum temperature limit
T_m
temperature of the thermal-link stated by the manufacturer, up to which the mechanical and electrical properties of the thermal-link, having changed its state of conductivity, will not be impaired for a given time

3.7
pilot duty
rating assigned to a switching device that controls the coil of another electro-mechanical device such as a solenoid, relay or contactor

3.8
portable equipment
equipment which is moved while in operation or which can easily be moved from one place to another while connected to the supply

3.9
rated current
I_r
current used to classify a thermal-link

3.10
rated functioning temperature
T_f
temperature of the thermal-link which causes it to change its state of conductivity with a detection current up to 10 mA as the only load

3.11
rated voltage
U_r
voltage used to classify a thermal-link

3.12
thermal element
metallic or non-metallic fusible material that is part of a thermal-link and is responsive to temperature by a change of state such as from solid to liquid at the temperature for which it is calibrated

3.13
thermal-link
non-resettable device incorporating a thermal element, which will open a circuit once only when exposed for a sufficient length of time to a temperature in excess of that for which it has been designed

3.14
transient overload current
I_p
direct current pulse train which the thermal-link is able to withstand without impairing its characteristics

~~**3.15**~~
~~**type test**~~
~~conformity testing on the basis of one or more specimens of a product representative of the production~~

3.15
extended holding temperature
$T_{h\text{-}100}$
maximum temperature at which a thermal-link can be maintained while conducting the rated ~~load~~ current at the rated voltage for a period of 100 weeks which will not cause the thermal-link to open circuit in accordance with extended holding temperature evaluation

Note 1 to entry: This is a rating for user consideration during the investigation of the end product.

Note 2 to entry: Annex D specifies the extended holding temperature evaluation.

3.16
conductive heat ageing test
CHAT
test to evaluate a thermal-link for use in an appliance

Note 1 to entry: If it performs satisfactorily, the thermal-link will be assigned a CHAT rating. This rating is for end-product user consideration during the investigation of the end-use product.

Note 2 to entry: Annex C specifies the conductive heat ageing test.

4 General requirements

4.1 Adequate protection of the equipment against excessive temperatures not only depends upon the properties of the thermal-link but also to a large extent upon the mounting of the thermal-link in the equipment. Therefore~~, in addition to good engineering practice,~~ the requirements of the application guide in Annex A shall be considered.

4.2 Thermal-links shall have adequate electrical and mechanical strength and shall be constructed so as to withstand all conditions of handling likely to be encountered during mounting and normal use, when used within the requirements of this document.

4.3 When a thermal-link changes its state of conductivity, no arc or flame shall be maintained, nor material expelled, that might impair the surrounding area or otherwise create a risk of electric shock or fire. In addition, there shall be no emission of substances (e.g. gases, liquids, dust, mist, vapour) which could cause a hazard.

For thermal-links using melting strips or wires, care should be taken to prevent molten material from short-circuiting or bridging creepage distances and clearances in air, so as to reduce the risk of impairing the insulation system of the equipment.

After it has functioned, the thermal-link shall not be damaged when subjected to temperatures not exceeding T_m, in such a way that the safety of the equipment with regard to risk of electric shock hazard and electrical breakdown is impaired. The thermal-link shall not reclose after it has operated.

4.4 For requirements for thermal-link packaged assemblies, see Annex H.

5 General notes on tests

5.1 The test conditions are as follows.

5.1.1 Unless otherwise specified, only tests that are not required to be performed inside an environmental chamber and/or test oven shall be carried out under the following atmospheric conditions:

– temperature: 15 °C to 35 °C,

– relative humidity: 25 % to 75 %,

– air pressure: 8,6 × 10^4 Pa to 1,06 × 10^5 Pa.

The required atmospheric conditions during testing can be controlled when carrying out the tests and during the duration of the tests. The required atmospheric conditions do not have to be maintained in a test laboratory when tests are not performed.

5.1.2 Where the conditions given in 5.1.1 have a significant influence, they shall be kept substantially constant during the tests.

5.1.3 If the temperature limits given in 5.1.1 are too wide for certain tests, these shall be repeated, in case of doubt, at a temperature of (23 ± 1) °C.

5.2 In every test report, the ambient temperature shall be stated. If the standard conditions for relative humidity or pressure are not fulfilled during the tests, a note to this effect shall be added to the report.

5.3 If the result of a test is influenced, to an appreciable extent, by the position and method of mounting of the specimen, the most unfavourable condition shall be chosen for the relevant tests and recorded.

5.4 If a thermal-link has been specifically designed for use in a special type of equipment and cannot be tested separately, the tests of this standard shall be performed in that equipment or in the relevant part of it, or similar.

5.5 When testing a homogeneous series of thermal-links, all the tests shall be applied to thermal-links with the lowest and highest T_f. Thermal-links with intermediate rated functioning temperatures need only be subjected to tests according to 10.3, 11.3, 11.4 and 11.5.

5.6 The number of specimens is as follows.

5.6.1 The total number of specimens required is 48. Out of a total of 48 specimens, 15 are kept as spares in case some of the tests have to be repeated. Out of a total of 48 specimens, 33 are divided into 11 groups assigned by alphabetical letters from A to K. Each group consists of three specimens. Tests shall be performed in the order indicated in Table 1 but, if so required, tests may be repeated, for example the test on marking (see Clause 7). Additional ~~samples~~ specimens may be needed according to ~~Note 2~~ the requirement of Table 1.

For optional tests, additional ~~samples~~ specimens should be required as per the applicable annexes.

5.6.2 If, in any of the tests carried out in accordance with any relevant test clause, a failure is reported, the cause of the failure will be identified and corrective action taken. Based on the failure analysis report and the corrective action, as a minimum, the test sequence shall be repeated on twice the number of revised specimens, and no further failures are allowed.

If no corrective actions are necessary, the test should be repeated with double the same size and no further deviation is allowed.

5.6.3 For requirements for thermal-link packaged assemblies, see Annex H.

5.7 The conductive heat ageing test of Annex C is applicable when declared by the manufacturer.

The conductive heat ageing test may be omitted if the thermal-link is constructed without contacts.

NOTE In the USA the conductive heat ageing test is required to be declared.

Table 1 – Test schedule

Clause or Sub-clause	Test	Specimen groups										
		A	B	C	D	E	F	G	H	I	J	K
7 [a]	Marking (Rub test)	X	X									
7 [a]	Marking (visual inspection only)	X	X									
9	**Constructional requirements**											
9.2.2 [a]	Tensile forces	X										
9.2.3 [a]	Thrust force		X									
9.2.4 [a]	Bending/twist force			X								
9.6 [a]	Resistance to tracking											X
9.7 [a]	Creepage distances and clearances						X	X				
9.8	Temperature and humidity cycle conditioning	X	X	X			X	X				
10	**Electrical requirements**											
10.1	Dielectric strength (if applicable)	X	X	X			X	X				
10.2	Insulation resistance (if applicable)	X	X	X			X	X				
10.3	Interrupting current						X	X				
10.4	Transient overload current	X	X						X			
11	**Temperature tests**											
11.2	Check on T_h [b]											X
11.3	Check on T_f	X		X								
11.4	Check on T_m followed by dielectric test and insulation resistance			X	X							
11.5	Ageing step 1 (optional) 21 days step 2 (mandatory) 21 days step 3 (mandatory) 14 days step 4 (mandatory) 7 days step 5 (mandatory) 7 days step 6 (mandatory) 24 hours		X			X			X	X	X	
10.1	Dielectric strength	X	X			X	X	X	X	X	X	
10.2	Insulation resistance	X	X			X	X	X	X	X	X	
12	**Resistance to rusting**											
12 [a]	Resistance to rusting (ferrous parts)	X	X	X								

If the conditions of voltage, power and current in 10.3.2.3, 10.3.2.4 and 10.3.2.5 are not covered by one test, a minimum of three ~~samples~~ specimens should be tested for each condition.
[a] For homogeneous series, these tests may be omitted for intermediate ratings.
[b] When declared by the manufacturer.

6 Classification

6.1 Electrical conditions

With regard to electrical conditions, the following terms are used:

a) Voltage: AC and /or DC.
~~1) AC~~
~~2) DC~~

b) Current: AC and/ or DC.
~~1) resistive~~
~~2) inductive~~

c) Resistive load

d) Inductive load

e) Motor load

f) Pilot duty load

g) Electric discharge lamp load.

h) Special load

6.2 Thermal conditions

With regard to thermal conditions, the following symbols and abbreviations are used:

a) T_f

b) T_h

c) T_m

d) CHAT

e) $T_{h\text{-}100}$

6.3 Resistance to tracking

With regard to resistance to tracking, the following ranges are used:

a) proof tracking index from 175 to 249;

b) proof tracking index greater than or equal to 250.

NOTE These ranges are based on test methods for surface tracking laid down in IEC 60112.

7 Marking

7.1 Each thermal-link shall be marked with the following:

a) type or catalogue reference;

b) manufacturer's name or trade mark;

c) rated functioning temperature T_f with or without the symbol T_f followed by the number of degrees Celsius (marked with °C or C);

d) date code which identifies the date of manufacture and which does not repeat for at least 10 years, and a factory location or code, stamped on the thermal-link or the smallest packaging.

If there is only one factory, the factory location may be omitted.

Catalogue or reference numbers should define those parameters such as temperature, current and voltage, which together classify a thermal-link.

7.2 The rated functioning temperature T_f may be omitted if a different type or catalogue reference is employed for each different functioning temperature.

7.3 Marking shall be indelible and legible.

Compliance with the requirements for indelibility of markings is checked by the test in Annex G using the apparatus shown in Figure G.1. Legibility is checked by inspection. After the ageing tests of 11.4, compliance is checked by inspection.

7.4 The marking in accordance with a), b), c) and d) in 7.1 shall be printed additionally on the packing, together with a reference to this document.

7.5 If the thermal-link is small in size, and not intended to be replaced, the thermal-link shall be marked with only item a) in 7.1 and the markings in accordance with b) to d) in 7.1 shall be printed on the packaging, together with a reference to this document.

Compliance is checked by inspection.

8 Documentation

The manufacturer shall provide in the technical documentation, catalogues or instructional leaflets the following information, in addition to that required in Clause 7:

a) classification in accordance with Clause 6;

b) for each of the classifications;

   1) characteristic temperatures T_f, T_h (if declared by manufacturer), T_m;

   2) characteristic currents I_r, I_b, I_p;

   3) rated voltage U_r;

c) suitability for sealing in, or use with impregnating fluids or cleaning solvents;

d) information for mounting the thermal-link in the equipment;

e) thermal-links small in size and not intended to be replaced.

For reasons of safety, it should be made clear in the documentation that a thermal-link is a non-repairable item and that, in case of replacement, an equivalent thermal-link from the same manufacturer and having the same catalogue reference should be used, mounted in exactly the same way.

f) the position of the metal screen, if it is located at a distance other than 12,7 mm away from the live parts in the case of a thermal-link having an exposed element;

g) Application instructions on how to mount the device in equipment for for thermal-links with leads cross sectional area smaller than 0,21 mm^2.

   The device's temperature response should be taken into consideration.

9 Constructional requirements

9.1 General

9.1.1 Thermal-links shall have adequate mechanical strength and stability so as to withstand the stresses likely to be encountered during handling, normal use and fault conditions of the relevant end-use equipment.

9.1.2 Tab terminals shall be constructed in accordance with IEC 61210 and the maximum permissible temperature of the used Tab materials shall be in accordance with Table A.1 of IEC 61210:2010 (Tabs / Integrated).

9.1.3 Current-carrying parts shall be constructed in such a way that contact pressure is not transmitted through non-metallic material other than ceramic, or any material considered as having sufficient dimensional stability over the range of temperatures to be expected, unless there is sufficient resilience in the corresponding metal parts to compensate for any shrinkage or distortion of the non-metallic material.

Current-carrying parts shall have the necessary mechanical strength, be capable of carrying the rated current and shall be of a material that is acceptable for the particular application.

For current-carrying parts, temperature limits shall be considered according to Table 13 of IEC 60730-1:2013.

9.1.4 Friction shall not be used to secure uninsulated live parts (including terminals) to supporting surfaces if there is a risk of such parts turning or shifting their position, resulting in the reduction of creepage distances and clearances to less than those required elsewhere in this standard. The security of contact assemblies shall be such that alignment of contacts is maintained.

9.1.5 Leads and terminal parts shall be secured so that stress on them during installation and normal use does not impair operation of the thermal-link. Thermal-links using seals with formed leads for use in appliances or components shall not be bent less than 3 mm from the thermal-link seal.

Leads may be bent less than 3 mm from the seal if:

a) the thermal-link manufacturer's bending fixture and procedure does not transmit stress to the thermal-link operating mechanism, and if;

b) formed test ~~samples~~ specimens shall be subjected to the bending/twist lead secureness test of 9.2.4 and the rated functioning temperature test of 11.3.

9.1.6 Thermal-links with leads smaller than 0,21 mm^2 shall be provided with application instructions that instruct the user how to mount the device in equipment, taking into consideration the device's temperature response. The instructions shall also include guidance on the effects that movement and vibration in the equipment may have on the thermal-link's terminals, connections and other mounting components.

9.1.7 A terminal for a soldered connection shall have provision, such as a hole, for holding the conductor independently of solder.

9.1.8 When applicable, provision shall be made for securely mounting a thermal-link in position.

9.1.9 Thermal-links intended to be embedded in windings and the like need not have provision for mounting.

9.1.10 Bolts, screws, or other parts used for mounting an assembly having a thermal-link shall be independent of those used for securing component parts of the assembly.

9.1.11 *Compliance is checked by the lead secureness tests of 9.2. Mounting and securement instructions shall be provided with thermal-links for the manufacturer of the end-product in accordance with Annex A.*

9.2 Lead secureness tests

9.2.1 General

If force applied to thermal-link wire leads causes breakdown of one or more parts leading directly or indirectly to stress being applied to the operating mechanism, the tests described in 9.2.2, 9.2.3 and 9.2.4 shall be conducted. There shall be no displacement of parts that would tend to reclose a thermal-link or reduce creepage distances or clearances as a result of the tests specified in 9.2.2 and 9.2.3. There shall be no displacement of parts other than the wire leads as a result of the test specified in 9.2.4.

9.2.2 Tensile test

The thermal-link shall be supported in any convenient manner in order not to damage it and a tensile force as specified in Table 2 shall be applied to each lead for 1 min.

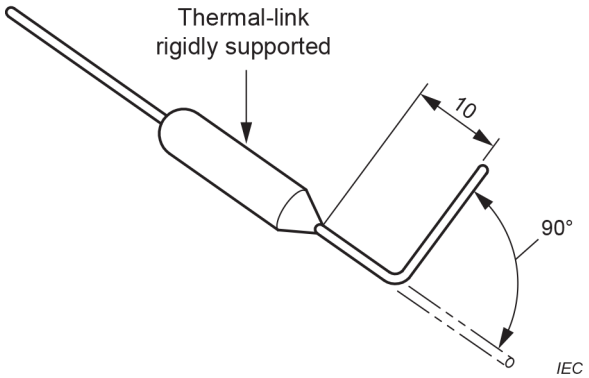
9.2.3 Thrust test

The thermal-link shall be supported using any convenient means such that it is not damaged and a thrust force as specified in Table 2 shall be applied to each lead for 1 min at a distance of 2 mm from the thermal-link.

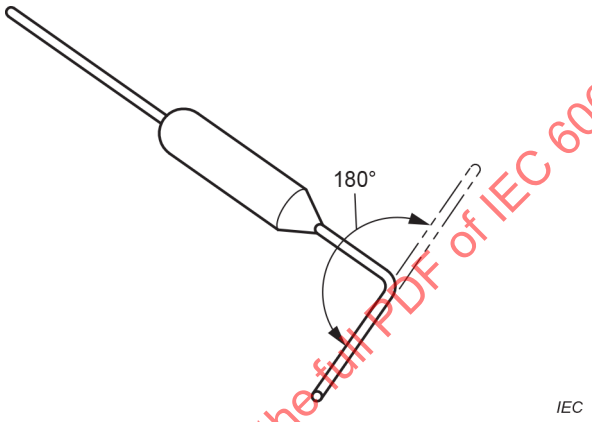
9.2.4 Bending/twist test

The thermal-link shall be rigidly supported such that it is not damaged. Each lead shall be bent through 90° at a location 10 mm from the body of the thermal-link and then twisted through 180° as shown in Figure 1.

Dimensions in millimetres



Step 1: Bend



Step 2: Twist

Figure 1 – Bending/twist test

Table 2 – Strength of leads and terminal parts – Minimum required tensile and thrust test forces

Nominal cross-sectional area of the lead, A, mm^2	Tensile force N	Thrust force N
Up to and including 0,05	1	0,25
Over 0,05 up to and including 1,2	20 × A	5 × A
Over 1,2	40	8
NOTE A is the nominal cross-sectional area of the terminal in mm^2.		

9.3 Contacts used for the current path

Contacts used for the current path in a thermal-link shall withstand the voltage stress determined by the voltage source in the circuit. Current-carrying elements or contacts, together with their terminals, are usually isolated from metal parts such as mounting brackets, metal enclosures and the like, by insulating material.

Compliance is checked by the tests of this document.

9.4 Accessible mounting brackets or metal parts

If mounting brackets or metal parts of the thermal-link's enclosure are accessible or connected through low impedances to metal enclosures of the equipment accessible to the user from the outside, the insulation between the current-carrying elements of the thermal-link and such conductive enclosures shall be adequate under specified conditions of ambient temperature and humidity.

Compliance is checked by the test of 10.1.

9.5 Insulating materials

9.5.1 The insulating materials used in the construction of thermal-links are checked by the tests of this document.

9.5.2 Requirements for insulating materials used in thermal-link packaged assemblies are in Annex H.

9.6 Resistance to tracking

9.6.1 If insulating material used for the support of current-carrying parts, contacts and terminals is exposed during normal use to deposition of moisture or dust, it shall be resistant to tracking.

9.6.2 For material other than ceramic, compliance is checked by performing a tracking test in accordance with IEC 60112 on specimens or flat test pieces of equivalent insulating material. The Proof Tracking Index (PTI) values shall be declared by the manufacturer, but not less than 175 V.

9.7 Creepage distances and clearances

9.7.1 The creepage distances and clearances between current-carrying parts (contacts together with their terminals) and the outside of the thermal-link housing including insulated metal parts thereof, shall be not less than the values in Table 3. The values indicated are absolute minimum values and inclusive of manufacturing tolerances.

Attention is drawn to the fact that the external creepage distances and clearances specified in Table 3 is allowed, in some cases, be smaller than those required by certain appliance or equipment standards. In such cases, additional means should be provided when a thermal-link is mounted in the equipment in order to adjust the creepage distances and clearances to the values required by the relevant equipment standard.

9.7.2 These distances do not apply between the open contacts of a thermal-link.

Compliance is checked by measuring the distances concerned.

Table 3 – Creepage distances and clearances (absolute minimum values)

Rated voltage, U_r V	Clearance mm	Creepage distances mm
0 to 32	0,2	0,53
33 to 50	0,2	1,2
51 to 125	0,5	1,5
126 to 250	1,5	2,5
251 to 400	3,0	4,0
401 to 690	4,0	6,9

If conditions are different from those specified in Note 2, adjustments in clearances/creepages will be necessary as per IEC 60664-1.

NOTE 1 The clearances/creepage distances are specified according to IEC 60664-1.

NOTE 2 The values specified are for typical applications of thermal-links assuming:

a) continuous voltage stress;
b) an altitude of less than or equal to 2 000 m;
c) basic insulation;
d) inhomogeneous field;
e) overvoltage category II;
f) pollution degree 2;
g) material group III.

9.8 Temperature and humidity cycle conditioning

9.8.1 Thermal-links shall not be adversely influenced by humidity present in the ambient conditions for which they are intended.

9.8.2 For temperature and humidity cycle conditioning, the thermal-link ~~samples~~ specimens shall be subjected to three complete conditioning cycles. Each cycle shall consist of 24 h at ~~T_h~~ T_f -15°C followed immediately (within 15 min) by at least 24 h at (35 ± 5) °C and (90 ± 5) % relative humidity, followed by 8 h at (0 ± 2) °C.

9.8.3 *Compliance is checked by subjecting the specimens to the dielectric strength (see 10.1) and insulation resistance (see 10.2) tests of this document.*

NOTE 1 For a thermal-link with a non-electrically conductive case body, the dielectric and insulation resistance tests are performed after removal of the ~~samples~~ specimens from the conditioning chamber.

NOTE 2 For a thermal-link with an electrically conductive case body, the insulation resistance test is conducted between the terminals after removal of the ~~samples~~ specimens from the conditioning chamber.

9.9 Terminals and terminations

9.9.1 Terminal and terminations (leads) used in the construction of thermal-links are checked by the tests of this document.

9.9.2 Requirements for terminals and terminations used in thermal-link packaged assemblies are in Annex H.

10 Electrical requirements

10.1 Dielectric strength

10.1.1 The dielectric strength of thermal-links shall be adequate both before and after having operated, and also after having been subjected to the tests of 9.8.

If applicable, the test is conducted between:

i) Current carrying parts and enclosure (wrapped in metal foil), or,

ii) Current carrying parts and insulated exposed metal parts.

10.1.2 *Compliance is checked by applying the appropriate test voltage between the relevant circuits specified in Table 4 immediately after the tests of 9.8, if applicable, and also after the temperature tests of Clause 11.*

Table 4 – Test voltages for dielectric strength

Between	Test voltage
Current carrying parts and enclosure (wrapped in metal foil, if applicable)	2 U_r + 1 000 V
or	
current carrying parts and insulated exposed metal parts	2 U_r + 1 000 V
Disconnection (between open contacts)	2 U_r

10.1.3 A power transformer with an output of not less than 100 VA is required for this test.

10.1.4 The insulation is subjected to a test voltage with a substantially sine-wave form having a frequency between 45 Hz and 62 Hz.

10.1.5 Initially not more than half the prescribed voltage is applied. It is then raised with a rate of rise of approximately 500 V/s to the full value.

10.1.6 Immediately after the humidity test, the enclosure shall be wrapped in metal foil and the test voltage shall be applied for 1 min across the disconnection and between the current carrying and the metal foil.

10.1.7 The specimens are deemed to comply with the requirements if no flashover or breakdown occurs.

10.2 Insulation resistance

10.2.1 The insulation resistance of thermal-links shall be adequate both before and after having changed their state of conductivity, and also after having been subjected to the relevant tests of 9.8.

If applicable, the test is conducted between:

i) Current carrying parts and enclosure (wrapped in metal foil), or,

ii) Current carrying parts and insulated exposed metal parts.

10.2.2 *Compliance is checked by measuring the insulation resistance of the thermal-link after the test of 9.8, before and after having operated in the temperature test of Clause 11. The insulation resistance shall be measured with a DC voltage of 2 U_r between the current carrying parts and the enclosure (wrapped in metal foil, if applicable), or between current carrying parts and insulated exposed metal parts, and between the terminals.*

NOTE A d.c. test voltage is used in order to eliminate possible deviations due to capacitive currents.

10.2.3 *The specimens are deemed to comply with the requirements if the insulation resistance measured between the current carrying parts and the enclosure, (wrapped in metal foil, if applicable) or between current carrying parts and insulated exposed metal parts is not less than 2 MΩ, and across the disconnection is not less than 0,2 MΩ.*

10.3 Interrupting current

10.3.1 General

A thermal-link shall interrupt the applicable test current specified in Table 5 at 1,1 times the rated voltage, U_r, under the conditions specified in 10.3.2.1, 10.3.2.2, 10.3.2.3, 10.3.2.4, 10.3.2.5, 10.3.2.6, 10.3.2.7, 10.3.2.8, 10.3.2.9, 10.3.2.10 and 10.3.2.11.

NOTE The main purpose of this test is to evaluate the mechanical and electrical integrity of the thermal-link to interrupt a certain load.

10.3.2 Specific conditions

10.3.2.1 Any noncurrent-carrying metal part that is an inherent part of the thermal ~~assembly~~ link and that may be bonded electrically to a normally-earthed exposed part of the end-product shall be connected through a quick acting and high breaking 1 A fuse (see IEC 60127-2:2014, Standard sheet 1) to earth.

Table 5 – Test current for interrupting test

Type of rating	Rated in	Test current	Power factor	Time constant
Resistive	AC amperes	1,5 times rated current	0,95 to 1,0	–
	DC amperes	1,5 times rated current	–	d
Inductive	AC amperes	1,5 times rated current	0,6	–
Motor	AC locked rotor amperes (LRA)	6 times full-load current [a]	0,4 to 0,5	–
	DC amperes	10 times full-load rated current	–	d
Pilot duty	AC volt-amperes	[b]	0,35	–
Electric discharge lamp	AC amperes	4 times rated current	0,4 to 0,5	–
~~Special~~	~~c~~	~~c~~	~~c~~	
Resistive/Inductive Combination	c	c	c	d

[a] Or the specified value, such as horsepower, if locked rotor ampere rating is omitted.

[b] See 10.3.2.8.

[c] ~~Additionally~~ According to manufacturer´s declaration (only in combination with resistive / inductive load).

[d] Under consideration

10.3.2.2 For a thermal-link having an exposed element, a metal screen shall be located 12,7 mm away from live parts. The screen shall be connected to the opposite pole of the test circuit through a quick acting and high breaking 1 A fuse (see IEC 60127-2:2014, Standard sheet 1). The distance is measured between the screen and the nearest point of the ~~element~~ noncurrent-carrying metal part when the ~~element~~ noncurrent-carrying metal part is in the open position.

10.3.2.3 Based on the intended use of a thermal-link, the screen may be located at a distance other than 12,7 mm if acceptable to both the manufacturer and the end user.

10.3.2.4 The test circuit shall have an open circuit voltage within 1,1 to 1,155 times the rated voltage of the thermal-link to be tested. This tolerance may be exceeded with the manufacture's consent. The closed circuit voltage of the test circuit when carrying the rated current shall not change by more than 2,5 % of the rated voltage.

10.3.2.5 The tolerance of the test current shall be within ±2,5 % of the specified test current.

10.3.2.6 If a thermal-link has the same current rating at more than one voltage, a test at the highest voltage is considered to be representative of tests at the lower voltages.

10.3.2.7 If a thermal-link has more than one voltage rating within a specific power factor group, the tests shall cover the conditions of maximum voltage, power, and current. One test may cover two of these conditions.

10.3.2.8 For thermal-links assigned a pilot duty rating, the test load shall consist of an electromagnet representative of the magnet coil load that the thermal-link is intended to control. The test current shall be the normal current which shall be determined from the voltage and volt-ampere rating of the thermal-link. For an alternating current thermal-link, the power factor shall be 0,35 or less and the inrush current characteristic of the coil shall be 10 times the normal current. The test shall be conducted with the armature closed.

10.3.2.9 *Compliance is checked by the following test.*

The ~~samples~~ specimens shall be placed in a test oven, stabilized at a temperature of T_f -30 K (or lower if declared by the manufacturer). The thermal-links in the test oven shall then be energized and the oven temperature increased at the rate of (2 ± 1) K/min and the test shall be continued until the thermal-link functions or the oven temperature reaches 30 K above T_f.

Furthermore the thermal-links shall open the test circuit at a temperature below or equal to T_f.

The thermal-link may operate immediately after being energized, in which case the temperature increase of (2 ± 1) K/min is not necessary and the test may be stopped.

10.3.2.10 *The oven temperature may be monitored by means of a thermocouple attached to an identical but non-functioning thermal-link mounted adjacent to the ~~samples~~ specimens under test.*

10.3.2.11 *A thermal-link that is rated for controlling an alternating-current motor is acceptable for alternating current pilot duty without further interrupting current tests if, during the original interrupting current test, the power factor was 0,5 or less, and if the pilot duty inrush current at the same voltage is not more than 67 % of the rated locked rotor current (LRA) of the device.*

10.3.2.12 There shall be no damage to the integral leads of a thermal-link. There shall be no emission of hazardous substances from a thermal-link. The case of an enclosed element shall remain intact. *The quick acting and high breaking 1 A fuse (see IEC 60127-2:2014, Standard sheet 1)* specified in 10.3.2.1 and 10.3.2.2 shall not function (open). An exposed element shall not arc to adjacent metal parts and material shall not be expelled which may harm the surrounding area.

10.3.2.13 *After these tests, the insulation resistance shall comply with the requirements of 10.2.*

10.4 Transient overload current

10.4.1 Thermal-links shall withstand repeated current surges, considered as being normal in most applications.

10.4.2 Compliance is checked by the following test, performed under normal conditions as specified in Clause 5 (i.e. room ambient conditions).

10.4.3 DC current pulses, with an amplitude of 15 I_r and a duration of 3 ms with 10 s intervals are applied for 100 successive cycles through the current path.

10.4.4 After the test, there shall be no interruption of the current path nor other damage in the sense of this document.

10.5 Limited short-circuit test

10.5.1 General

10.5.1.1 When declared by a manufacturer, a thermal-link is tested as described in 10.5.2 and 10.5.3.

10.5.1.2 If the limited short-circuit test is conducted on the thermal-link itself with acceptable results, the test need not be repeated during the investigation of the end-product.

10.5.2 Test method

10.5.2.1 Three ~~samples~~ specimens of the thermal-link shall be subjected to a limited short-circuit test.

10.5.2.2 The test shall be conducted at a voltage within ±5 % tolerance of the rated voltage U_r.

10.5.2.3 The thermal-link shall be connected in series with a non-renewable fuse properly selected for the application in accordance with 10.5.3. The circuit shall limit the current to the applicable value specified in Table 6, measured without the thermal-link in the circuit.

10.5.2.4 The power factor of the circuit shall be 0,9 to 1,0, unless a lower power factor is acceptable to both the manufacturer and the end user.

10.5.2.5 The thermal-link shall be connected in the circuit by two 915 mm lengths of copper wire having a cross-sectional area as indicated in Table 6 of IEC 60730-1:2013. Cotton shall surround the thermal-link, or a metal screen located 50 mm away – or less if acceptable to both the manufacturer and the end user – from all parts of the thermal-link during the test.

Table 6 – Limited short-circuit test capacity

Combined rating of thermal-link					Short-circuit capacity (amperes) a	
Voltamperes, single-phase	Voltamperes, three-phase	Voltamperes, direct current	Horsepower	kW	0 V to 250 V	251 V to 690 V
0 to 1 176	0 to 832	0 to 648	0 to 0,5	0 to 0,375	200	1 000
1 177 to 1 920	833 to 1 496	649 to 1 140	Over 0,5 to 1	Over 0,375 to 0,750	1 000	1 000
1 921 to 4 080	1 497 to 3 990	1 141 to 3 000	Over 1 to 3	Over 0,750 to 2,250	2 000	5 000
4 081 to 9 600	3 991 to 9 145	3 001 to 6 960	Over 3 to 7,5	Over 2,250 to 5,600	3 500	5 000
9 601 or more	9 146 or more	6 961 or more	Over 7,5	Over 5,600	5 000	5 000
[a] For the fluorescent lamp ballast test, the limited short-circuit test capacity shall be 200 A.						

10.5.2.6 Each thermal-link shall be subjected to one test.

10.5.3 Fuse size (rating)

The fuse size for the limited short-circuit tests shall be:

a) 20 A for a thermal-link rated 0 V to 125 V and 15 A for a thermal-link rated 126 V to 690 V, unless a larger fuse size is necessitated by b) to f).

b) 20 A for a thermal-link intended for use in fluorescent lamp ballast. The fuse shall have design characteristics such that it will not open in less than 12 s when carrying 40 A.

c) For a thermal-link having motor ratings, the largest standard size between 300 % and 400 % of the full load current rating for non-hermetic motors and between 175 % and 225 % of the full load current rating for hermetic-refrigeration motors.

d) For a thermal-link intended for use in motor-group circuits, the largest standard fuse size based on the sum of the full load ratings of all loads except the largest motor rating, plus 300 % to 400 % of the full load current rating of the largest motor if the motor is a non-hermetic type, or plus 175 % to 225 % of the full load current rating of the largest motor if the motor is a hermetic-refrigeration compressor type.

e) For a thermal-link intended for use in electric space-heating equipment, based on 125 % of the ampere rating. If 125 % of the ampere rating results in a value for which there is no standard fuse size, the next largest fuse size shall be used.

f) For a thermal-link having other ratings, based on the rating in amperes of the next largest standard fuse size.

g) If acceptable in accordance with the end-product requirements, a smaller fuse size than specified in c) to f).

10.5.4 Compliance

There shall be no ignition of the cotton mentioned in 10.5.2 or the evidence of a risk of fire during the test or electric shock after the test.

11 Temperature tests

11.1 General

11.1.1 The characteristic temperatures of thermal-links shall comply with the values and tolerances as declared by the manufacturer and with the requirements of Clause 11.

11.1.2 The functioning temperature, T_f, shall not be influenced by thermal ageing.

11.1.3 *Compliance is checked by subjecting specimens to one or more tests mentioned below, in the order given in Table 1.*

11.1.4 Operation of thermal-links shall be signalled by suitable means, for example, light emitting diodes with series resistors limiting the signal current to a maximum of 10 mA.

11.1.5 Operation of thermal-links shall be checked after each test step.

11.1.6 In order to obtain the required accuracy of temperature settings, indicated test temperatures shall be measured with an accuracy of ±1 K of the nominal temperature up to 100 °C and ±1 % of the nominal temperature above 100 °C.

11.1.7 Care shall furthermore be taken that temperature differences in that part of the oven where the specimens are tested, do not exceed at any point:

- ±0,5 % of the nominal temperature higher than 200 °C; and
- ±1 K at the nominal temperature of 200 °C or lower.

11.1.8 This may be obtained for example by placing the specimens within a thick-walled aluminium box mounted in such a way that it is not in direct contact with the internal walls of the oven.

11.1.9 For thermal-link packaged assembly, the maximum use temperature shall be in accordance with H.11.101.

11.2 Holding temperature, T_h

~~**11.2.1** Samples of group K (3 specimens in series) are connected to a resistive load circuit that is metered to draw the rated current through the thermal-link. The specimen shall be maintained at a temperature equivalent to the holding temperature (T_h) specified by the manufacturer. The circuit is loaded for 24 h or as declared by the manufacturer, whichever is higher.~~

~~**11.2.2** *Compliance is determined by checking the continuity of the thermal-link after completion of the test. The thermal-link shall not change its state of conductivity.*~~

11.2.1 When declared by the manufacturer, a thermal-link is tested as described in Annex I.

11.2.2 Requirements for thermal-link packaged assemblies, see Annex H.

11.3 Rated functioning temperature, T_f

11.3.1 For devices rated less than 250 °C, the thermal-links shall be exposed in the test oven or oil bath to T_f – 12 K or as declared by the manufacturer, but not higher than 2 K below the lowest tolerance. The temperature shall then be stabilized, shown when two consecutive readings taken 5 min apart are within 1 K of each other.

11.3.2 For devices rated 250 °C or higher, the thermal-links shall be exposed to T_f – 22 K, or as declared by the manufacturer, but not higher than 2 K below the lowest tolerance. The temperature shall then be stabilized, shown when two consecutive readings taken 5 min apart are within 1 K of each other.

11.3.3 The temperature shall then be increased steadily with a rate of rise between 0,5 K/min to 1 K/min, until all specimens have functioned.

11.3.4 *The individual functioning temperature of thermal-links, rated less than 250 °C, shall be recorded and they shall be not less than as declared by the manufacturer, or T_f – 10 K if no declaration is made.*

11.3.5 *For thermal-links rated at 250 °C or higher, the recorded temperature shall be not less than that declared by the manufacturer, or T_f – 20 K if no declaration is made.*

11.3.6 ~~For thermal-links rated lower than 250 °C, or higher than 250 °C,~~ *The temperature of thermal-link shall not be greater than T_f.*

NOTE The equipment recommended for the tests of 11.3 is shown in Clause C.6.

11.4 Maximum temperature limit, T_m

11.4.1 The specimens shall be subjected to $T_{m\ -5}^{\ 0}$ °C for a period of 10 min.

11.4.2 With the ~~samples~~ specimens maintained at $T_{m\ -5}^{\ 0}$ °C, a dielectric test as per 10.1, and an insulation resistance test as per 10.2, shall be conducted.

11.4.3 To overcome possible effects of thermal inertia of the specimens and any necessary connections, and also to facilitate the introduction of the specimens into a suitable heating chamber, the specimens can be inserted into a sand box maintained at T_m.

11.4.4 The T_f and T_m tests may be conducted in separate equipment and ~~samples~~ specimens may cool down during transfer from the T_f to T_m test.

11.4.5 No flashover, breakdown or refunctioning shall occur. At the conclusion of this test all specimens shall have functioned.

11.5 Ageing

11.5.1 In order to verify whether ageing at high temperature has a deleterious effect, thermal-links shall be subjected to the series of test steps of 11.5.4.

11.5.2 The temperature shall be maintained constant within ±1 K.

11.5.3 Any specimens remaining intact at the conclusion of each step shall be submitted to the next step.

Conformity shall be considered satisfactory if all specimens have functioned after the first two steps.

11.5.4 Test steps are as follows:

11.5.4.1 Step 1: ~~If requested by the manufacturer, the specimens are subjected to a temperature chosen between T_f – 15 K and T_h for a period of three weeks. At the conclusion of the test, at least 50 % of the specimens shall not have functioned.~~

If requested by the manufacturer, the specimens are subjected for three weeks to either:

a) T_f − 15 K, or

b) Between a temperature chosen between T_f − 15 K and a declared value by the manufacturer.

11.5.4.2 The following tests are mandatory:

11.5.4.2.1 Step 2: T_f − 15 K for three weeks. At the conclusion of the test, at least 50 % of the specimens shall not have functioned unless the specimens have already been submitted to step 1, in which case all specimens may have functioned.

11.5.4.2.2 Step 3: T_f − 10 K for two weeks.

11.5.4.2.3 Step 4: T_f − 5 K for one week.

11.5.4.2.4 Step 5: T_f − 3 K for one week.

11.5.4.2.5 Step 6: T_f + 3 K for 24 h.

11.5.5 The specimens shall then cool in the test chamber to less than T_f − 35 K.

11.5.6 *The test is considered successful if all specimens have functioned.*

12 Resistance to rusting

12.1 Iron and steel parts shall be protected against corrosion by enamelling, galvanizing, plating or other equivalent means.

12.2 Corrosion protection is not required for parts made of stainless steel.

12.3 Thermal-links provided with one or more ferrous parts shall not be adversely affected by possible rusting of such parts.

12.4 *Compliance is checked by inspecting specimens of Groups A, B and C after the temperature and humidity cycle conditioning test of 9.8. The specimens are dried in air at a suitable temperature and the ferrous parts shall show no sign of rusting that might impair the performance of the thermal-links in the sense of this document.*

13 Manufacturer's validation programme

13.1 The manufacturer shall conduct regular inspections for production control and tests for validating performance as per 13.2 and 13.3.

13.2 The manufacturer shall test three ~~samples~~ specimens each, for all temperature ratings for thermal-links, once every two years for 10.3 (Interrupting current), 11.3 (Rated functioning temperature) and 11.4 (Maximum temperature limit) followed by the tests of 10.1 (Dielectric strength) and 10.2 (Insulation resistance). The pre-conditioning tests described in 9.2 (Lead secureness tests) may be omitted.

13.3 The tests of 10.3 shall be conducted on

a) the highest rated voltage,

b) the highest rated current,

c) both a) and b)

with AC and/or DC in the case of a resistive or motor load, or with AC in the case of inductive, pilot duty or electric discharge lamp load; and

d) the current and circuit condition declared by the manufacturer in the case of a special load.

Non-compliance in any of the tests shall be subject to a review and repetition as per Clause 5.

Annex A
(normative)

Application guide

A.1 Instructions for mounting given by the manufacturer of the thermal-link shall be followed, especially in the case where thermal-links are provided with a coating or used in impregnated windings.

A.2 Thermal-links shall be chosen such that all prevailing electrical requirements with regard to insulation resistance, dielectric strength, creepage distances in air and clearances are met under normal and fault conditions, specified in the relevant equipment standard. For example, for audio, video and similar electronic devices, see IEC 60065.

A.3 Thermal-links shall be chosen such that, in the mounted position, their electrical and thermal insulation shall not be degraded by thermal overshoot effects produced under fault conditions in the equipment.

A.4 If thermal-links in the form of melting wires or strips are applied, barriers shall be provided so that sagging of such elements or possible droplets of molten metal cannot produce harmful effects.

A.5 If such melting wires are clamped or pressed under screws, rivets or terminals, it shall be verified that mechanical creepage phenomena do not result in unacceptable electrical contacts.

NOTE For hand-held or portable equipment, this provision applies irrespective of their position.

A.6 Electrical connections shall function as intended over the range of temperatures to which they may be exposed in the equipment.

A.7 Connectors and terminals shall not loosen easily due to vibration, shock, thermal cycling and the like.

A.8 Soldered connections, if any, shall not rely solely on the solder alloy for their mechanical rigidity but shall include mechanical anchoring, for example a wire bent through a hole in a terminal.

A.9 The mechanical strength and rigidity of the hardware used for mounting the thermal-link shall be adequate. Brackets, clamps or screws used for mounting the thermal-link shall withstand thrust and tensile forces, torques, vibrations and cyclic temperature changes expected during normal operating conditions of the equipment.

A.10 The mounted thermal-link shall be adequately protected from harmful effects produced by possible spillage of liquids from the equipment, for example by covers.

A.11 In order to avoid possible damage to the thermal-link, the manufacturer should be consulted when the end-use application involves sealing in or the use of cleaning solvents.

Annex B
(normative)

Alternative ageing test for thermal-links with T_h greater than 250 °C for use in electric irons

B.1 Thermal-links used to protect electric irons where the normal holding temperature is 250 °C or greater and which, in the event of failure, rises rapidly to a functioning temperature of 300 °C or higher, are not required to follow the usual ageing test described in 11.5.

B.2 The alternative ageing test is conducted as per the manufacturer's declaration.

B.3 Additionally, the tolerance of T_f in 11.3 is allowed to be −20 K instead of −10 K.

B.4 All other requirements of this document, however, shall be met in order to conform with this standard.

Annex C
(normative)

Conductive heat ageing test

NOTE In the USA, Annex C is required to be declared. For all other countries, Annex C is applicable when declared by the manufacturer.

C.1 Conductive heat ageing test

The following conductive heat ageing test shall be conducted on thermal-links with a T_f rating of 175 °C or above. The test is optional for thermal-links with a T_f rating less than 175 °C.

The conductive heat ageing test may be omitted if the thermal-link is of eutectic type and is constructed without contacts.

C.2 Method

C.2.1 General

Thirty ~~samples~~ specimens shall be subjected to the test. Each of three groups consisting of ten ~~sample~~ specimen thermal-links, shall be secured to a test fixture assembly and placed on an electrically heated static-air test oven constructed in accordance with C.6 and subjected to the test described in C.2.2, C.2.3, C.2.4, C.2.5, C.3 and C.4. The oven cover of the test oven, as shown in Figure C.2, shall be replaced with the test fixture assembly as shown in Figure C.1. The aluminium test box section and the ceramic oven liner section, shown in Figure C.2, shall be removed from the test oven.

C.2.2 Typical test fixture assembly

A typical test fixture assembly as shown in Figure C.1 consists of an aluminium plate, 229 mm × 229 mm and 6,4 mm thick on which ten thermal securing clips are mounted on the outer perimeter of the plate and serve to secure the thermal-link to the surface of the plate. An electrical insulator, consisting of two layers of 0,075 mm thick polyamide film and a nominal total thickness of 0,15 mm, shall be placed around each thermal-link to electrically insulate it from the aluminium plate. The leads of each adjacent thermal-link shall be welded together to form a series circuit. The wire size, type of wire, or termination method selected to connect the thermal-link to the electrical load, shall not significantly affect the temperature of the thermal-link to which the load is connected. The test fixture may be modified so that all 30 test ~~samples~~ specimens may be tested on one test fixture assembly. Multiple test fixtures may be used with the ~~samples~~ specimens divided into multiple groups.

C.2.3 Temperature setting

The test fixture assembly shall be placed on the thermal-link test oven as the cover, with the thermal-links positioned on the outside surface of the aluminium plate. The test oven shall be rated 10 A, 120 V AC or 230 V AC.

C.2.4 Temperature behaviour

The temperature on the aluminium plate and the thermal-links shall be controlled by the length of time the test oven remains "on". During the "on" period, the thermal-links shall also be heated as a result of conducting a load current of 10 A at 120 V AC from the heating element of the test oven connected in series with the thermal-links.

Exception: If the thermal-link is rated less than 10 A, a separate circuit with an external load set for the thermal-link rated current shall be connected to the thermal-link. The load current shall be cycled concurrently with the test oven heating element. Whenever a thermal-link opens, the test oven heating element shall remain off until the open thermal-link is removed and the thermal-link test location is bypassed.

C.2.5 Temperature monitoring

The temperature of each thermal-link shall be monitored by a thermocouple welded to the uppermost side of the thermal-link body. The thermal-link having the highest temperature shall be used for controlling the length of the oven "on" period. Verification of the stability of the temperature of the thermal-link body shall be determined 24 h after the start of the test. At that time, the temperature of eight out of ten (80 %) thermal-links shall be within 12 K of the highest monitored temperature.

C.3 Ageing

C.3.1 General

The thermal-links shall be aged as described in the following steps for a total of eight weeks plus one day or until they function:

Step A 336 h (2 weeks) at 35 K below T_f;

Step B 336 h (2 weeks) at 25 K below T_f;

Step C 168 h (1 week) at 20 K below T_f;

Step D 168 h (1 week) at 15 K below T_f;

Step E 168 h (1 week) at 10 K below T_f;

Step F 168 h (1 week) at 5 K below T_f;

Step G 24 h (1 day) at T_f + 5 K. All 30 thermal-links shall be subjected to this step.

T_f is the rated functioning temperature of the thermal-links. For each step, a tolerance of $^{0}_{-6}$ K shall be used for controlling the test oven "on" and "off" period.

The load current "on" time through the tested device shall be at least 5 s but not longer than 10 s as declared by the manufacturer. These values may be exceeded during the ramp-up periods if the required ageing temperature of the step involved (Step A to Step G allowing the $^{0}_{-6}$ K tolerance) has not yet been attained on the thermal-link having the highest temperature and which is being used for controlling the length of the oven "on" period. The thermal-link may or may not be energized during the ramp-up period.

C.3.2 Cooling operation

Twice each week, the test oven shall be de-energized and the test fixture allowed to cool to room temperature. The cool-down period shall be for 12 h on the third and fifth day of each week. The total ageing time for each step shall not include the cool-down period or the time when the test oven is off due to a thermal-link functioning.

C.3.3 Premature operation

If a thermal-link functions prior to completing the total ageing period, the thermal-link shall be bypassed in order to retain continuity of the series circuit. During the reconnection process, the remaining thermal-links shall not be disturbed. Additional wire leads of proper size and type are to be used.

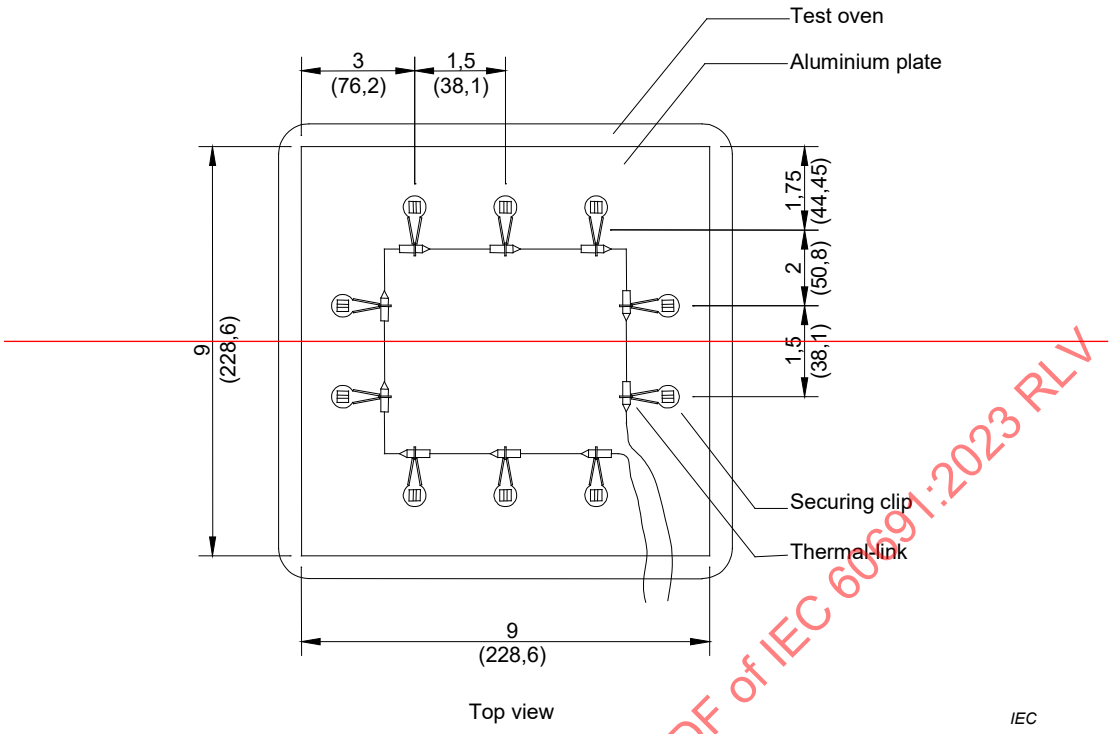
C.4 Results

As a result of the test, each thermal-link shall operate as intended, shall be electrically open, and there shall be no dielectric breakdown as a result of the test prescribed in Clause C.5.

C.5 Dielectric strength test

With reference to Clause C.4, following the test, each thermal-link shall be subjected to the dielectric strength test of 10.1, applied between the leads or terminals of the opened thermal-link after the test ~~samples~~ specimens have been brought to room temperature.

~~*Dimensions in inches and (millimetres)*~~



Dimensions in millimetres (inches)

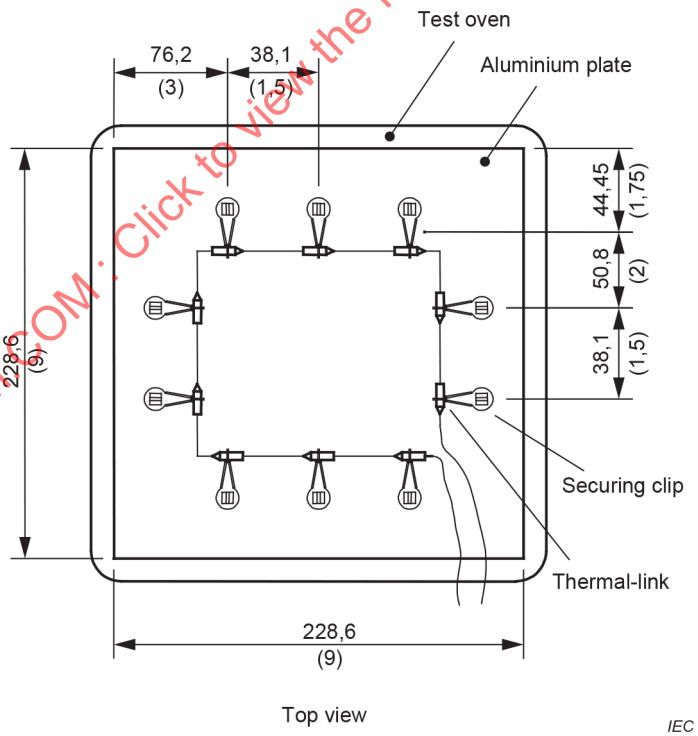


Figure C.1 – Typical test fixture assembly

C.6 Test oven

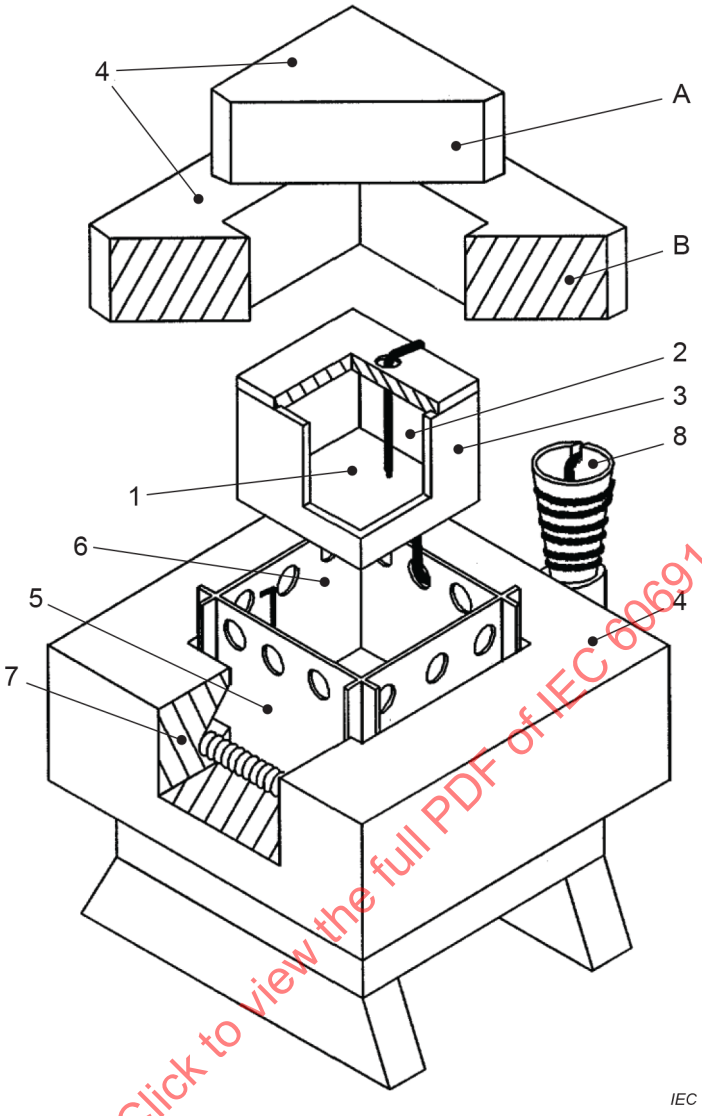
The test apparatus shall consist of an electrically heated, static-air oven. A typical example of such an oven is shown in Figure C.2. The oven shall be located in a room free of draughts and the ambient temperature shall be maintained reasonably constant during the test.

The oven described in Figure C.2 has a two-section core consisting of a non-metallic oven liner and a metal test box.

The interior surfaces of the oven described in Figure C.2 consist of a firebrick or a like type of surface which shields radiant heat and reduces heat loss. Seams and joints shall be tight.

The inner metal test box of the oven described in Figure C.2 has 6,4 mm thick walls. The test box shall rest on inorganic blocks and shall be shielded from radiant heat. The temperatures around the thermal-link shall be monitored by thermocouples located inside the metal test box.

The temperature regulating system of the oven shall be such that the temperature of the air at the test location is maintained within 0,5 K.



Key

1 test ~~sample~~ specimen chamber
2 temperature monitoring and recording thermocouples
3 aluminium test box section, supported on four ceramic buttons
4 low-density fire brick oven
5 ceramic oven liner section
6 temperature controlling thermocouple inserted at the base of the oven between test box and oven liner
7 heating coil recessed in inside face of oven
8 heating element in series with oven heater used as ballast resistor
A oven cover: 16 cm × 29 cm × 29 cm
B 6,35 cm × 22,85 cm × 22,85 cm with a hole 8,25 cm × 8,25 cm

Figure C.2 – Typical thermal-link test oven

Annex D
(informative)

Extended holding temperature evaluation

NOTE Annex D is applicable when declared by the manufacturer.

D.1 Extended holding temperature conditioning test

D.1.1 Twenty-five devices shall be placed in an electrically heated static-air oven for a period of 100 weeks while maintaining the rated ~~load~~ current at the rated voltage. The test oven shall be constructed in accordance with Clause C.6 and Figure C.2 except for overall dimension variations and also the inclusion of the terminal block support test fixture securing the thermal-links. A typical example of the terminal block support test fixture is shown in Figure D.1.

D.1.2 Each thermal-link shall be connected in series to the terminals of the test fixture as shown in Figure D.1. The internal cavity of the test oven shall be heated so that the body temperature of each ~~sample~~ specimen shall be maintained at the rated $T_{\text{h-100}}$ value. A thermocouple shall be attached to each thermal-link to monitor the body temperature.

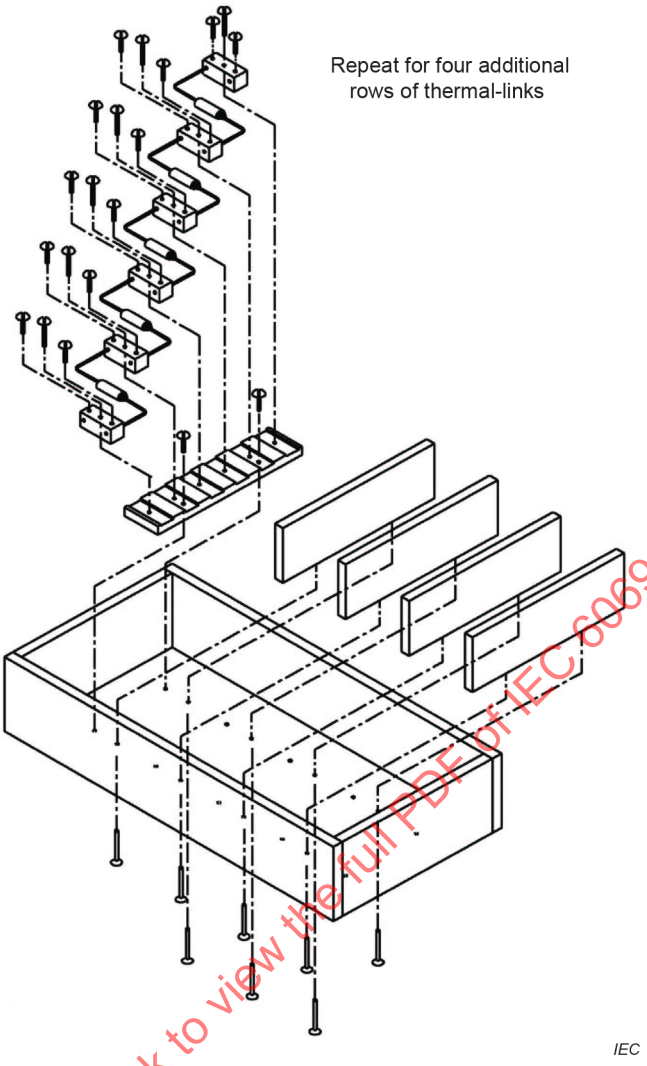
D.1.3 The temperature tolerances maintained for the ~~samples~~ specimens shall be $^{0}_{-10}$ K for all 25 ~~samples~~ specimens during the first two weeks of conditioning and ±10 % of the $T_{\text{h-100}}$ value (stated in °C) for at least 20 of the 25 ~~samples~~ specimens for the reminder of the test time.

D.1.4 All ~~samples~~ specimens that do not exceed +10 % of the $T_{\text{h–100}}$ rating shall not be open at the conclusion of the conditioning. After the conditioning period, all but two of the ~~samples~~ specimens shall be subjected to the load current interrupt test of Clause D.2. The remaining two ~~samples~~ specimens shall be subjected to the rated functioning temperature test of 11.3.

D.2 Load current interrupt test

D.2.1 The ~~samples~~ specimens shall be placed in a test oven that has been stabilized at 10 K below the rated functioning temperature, T_{f}, of the ~~sample~~ specimen. Each thermal-link is then energized and the oven temperature shall be increased at the rate of (2 ± 1) K/min and the test shall be continued until the thermal-link functions or the oven temperature reaches 30 K above T_{f}.

D.2.2 Each thermal-link shall break the specified load current at the specified voltage. There shall be no damage to the integral leads of the thermal-link. The internal assembly of each ~~sample~~ specimen shall be visually examined after the interrupt test. There shall be no welding or undue burning or pitting of the contacts or operating mechanism.



Use 3,3 mm^2 copper wire to jump from row to row of the thermal-links and in and out of the box through the hole in the lid.

Secure thermocouple leads to thermal-link body. Exit box through the nearest hole in the lid.

Figure D.1 – Typical terminal block support test fixture

Annex E
(normative)

Seal ageing test

NOTE In the USA, Annex E is required, if applicable. For all other countries, Annex E is applicable when declared by the manufacturer.

E.1 This test applies to seals and potting compounds. After the conditioning, as specified below, the ~~samples~~ specimens shall be tested to determine critical electrical and mechanical property values. The average value for each property on the conditioned ~~samples~~ specimens shall be at least 50 % of the average value determined on unconditioned ~~samples~~ specimens.

Seals and potting compounds need not be tested if they already comply with the relevant UL standard.

E.2 For each property to be evaluated, ten ~~samples~~ specimens shall be conditioned for 1 000 h at the oven temperature determined from the respective thermal endurance profile line in Figure E.1. The temperature index is the measured normal operating temperature or ~~T_h~~ T_f - 15 °C, but not less than 60 °C. The ~~samples~~ specimens are then brought to room temperature.

On the same thermal endurance profile line as shown in Figure E.1, a shorter or longer time at a higher or lower oven temperature, respectively, may be employed if agreeable to both the manufacturer and the end-user, but a period of at least 300 h shall be used.

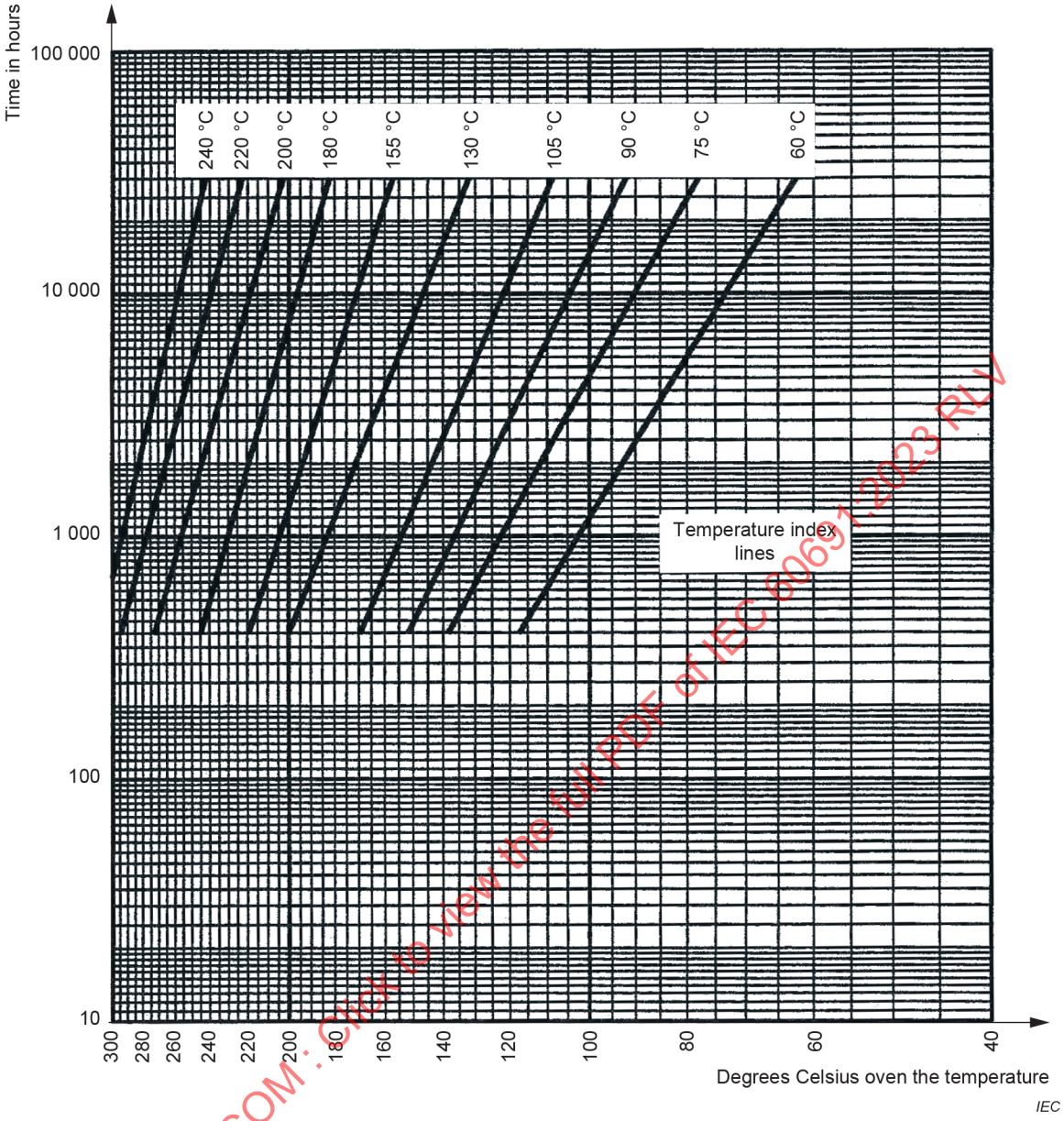


Figure E.1 – Conditioning time versus oven temperature for proposed temperature index

Annex F
(normative)

Identification requirements

NOTE In the USA, Annex F is required to be declared. For all other countries, Annex F is applicable when declared by the manufacturer.

F.1 The procedure described below shall be conducted on a number of ~~samples~~ specimens of thermal-links employing eutectic-type elements for identification purposes.

F.2 The thermal activity of the thermal-link's alloy, determined by use of thermal-analysis apparatus employing a differential scanning calorimeter, shall be compared with a reference material that is thermally inert over the range of temperature rating of the material. The temperature of the ~~sample~~ specimen and reference material shall be raised at a predetermined rate and the thermal differential between the two materials shall be graphically recorded on the Y axis against increasing temperature on the X axis. This graph shall include the thermally active temperature range, i.e. the endothermic melting point of the ~~sample~~ specimen material. This point is represented by a downward peak on the graph.

F.3 The identification test shall be conducted on thermal-links employing organic-material elements. An infrared spectrum shall be obtained from the material by use of an infrared spectrophotometer. Sampling methods and instrument settings used in obtaining the spectrum shall be recorded.

Annex G
(normative)

Indelibility of markings[1]

Compliance with the marking indelibility testing requirements of Clause 7 shall be checked with the apparatus shown in Figure G.1.

The principal part consists of a disc of hard white buffing felt, 65 mm in diameter and 7,5 mm thick. This is locked against rotation and is arranged to move across the surface to be tested with a stroke of 20 mm and to exert a measurable force of 2,5 N on this surface. The standard test shall be 12 strokes (i.e. 12 rotations of the eccentric) and shall take approximately 15 s.

During the test the appropriate part of the buffing disc is covered with one layer of white absorbent lint soaked with water with the nap surface external.

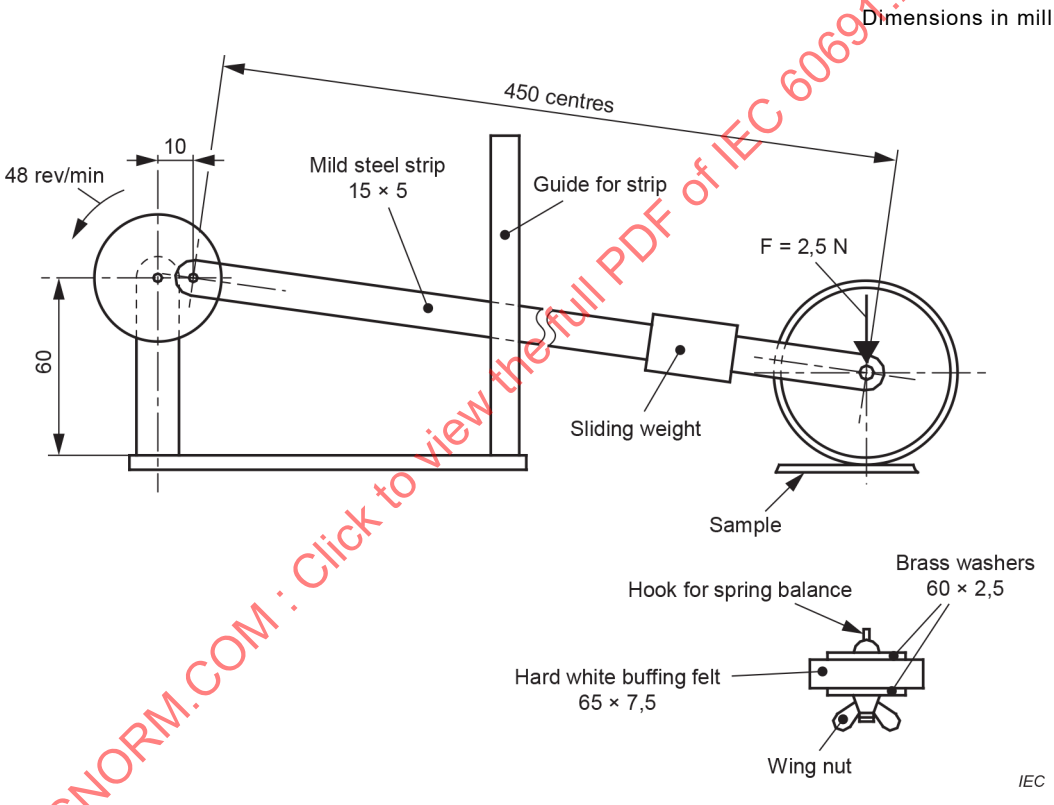


Figure G.1 – Apparatus for testing durability of markings

1 Figure G.1 and its description have been adapted from Figure 8 and the second and third paragraphs of A.1.4 in IEC 60730-1:2013, with slight modifications.

Annex H
(normative)

Requirements for thermal-link packaged assemblies

NOTE Annex H supplements or modifies the corresponding clauses of this document.

H.3 Terms and definitions

Addition

H.3.101
thermal-link package
a thermal-link packaged in a metallic or non-metallic housing and may be provided with leads or tabs, epoxy or any other additions

H.3.102
maximum use temperature, T_e
the maximum declared external ambient temperature that the **thermal-link package** is intended to be exposed during normal operation, while carrying its rated current

H.4 General requirements

Addition

H.4.101 A thermal-link that is used in a packaged assembly shall be separately evaluated to the requirements of this Annex H.

For each applicable test of H.9.9 and H.11.2~~-~~101 three new ~~samples~~ specimens of packaged thermal-link assemblies shall be tested.

H.5 General notes on tests

Addition

H.5.6.2.101 In addition to the tests of this annex, ~~samples~~ specimens of a packaged thermal-link assembly shall be subjected to the test sequence of groups F and G.

H.6 Classification

H.6.2 Thermal conditions

Addition

H.6.2.101 aa) T_e

H.8 Documentation

H.8.101 Addition to item b), sub-item 1) – characteristic temperatures:T_e

H.9 Constructional requirements

Addition

H.9.5 Insulating materials

H.9.5.101 Polymeric materials used in the housing of the thermal-link ~~packaged assembly~~ package shall have the following ratings or be tested to, at the specified thickness in accordance with the relevant standards:

a) flammability rating of V-0 or V-1 in accordance with IEC 60695-11-10;

b) glow-wire flammability index (GWFI) of 850 °C in accordance with IEC 60695-2-12 ~~or~~ and

c) glow-wire ignition test (GWIT) of ~~850~~ 775 °C in accordance with IEC 60695-2-13;

d) relative thermal endurance index (RTE) value which is greater than or equal to the maximum ~~use or holding~~ temperature ~~(T_h)~~ recorded on the plastic housing during the test of H.11.101 in accordance with IEC 60216-5;

e) proof tracking index of minimum 175 V in accordance with IEC 60112;

f) ball pressure test at a temperature of 20 K above the maximum ~~use or holding~~ temperature ~~(T_h)~~ recorded on the plastic housing during the test of H.11.101 in accordance with IEC 60695-10-2.

H.9.5.101.1 If there are no relevant IEC values available, as an alternative, comparable RTI values may be chosen from an equivalent standard.

H.9.5.102 Potting compounds or epoxy shall be suitable for the application temperature and shall be identified in accordance with Annex F, if applicable.

H.9.5.103 If the maximum ~~use or holding~~ temperature ~~of the thermal-link packaged assembly~~ recorded on the epoxy or potting compound during the test of H.11.101 is less than the ~~rating~~ rated temperature of the potting compound or epoxy, ~~whichever is smaller,~~ then the material is acceptable for the application.

H.9.5.104 If the maximum ~~use or holding~~ temperature ~~of the thermal-link packaged assembly~~ recorded on the epoxy or potting compound during the test of H.11.101 is greater than the ~~rating~~ rated temperature of the potting compound or epoxy ~~, whichever is greater~~, then the material shall be subjected to the seal ageing test of Annex E, if applicable.

H.9.9 Terminals and terminations

Additional subclauses

H.9.9.101 Tabs forming part of the thermal-link packaged assembly shall have adequate strength to allow the insertion and withdrawal of receptacles without damage to the thermal-link packaged assembly such as to impair compliance with this standard.

H.9.9.102 *Compliance is checked by applying, without jerks, axial forces equal to those shown in Table H.1. No significant displacement of the tabs or damage shall occur to the assembly. There shall be no evidence of flashover or breakdown when the product is subjected to the dielectric strength test of 10.1 between live part and the enclosure.*

Table H.1 – Push and pull force

Tab Size (see IEC 61210) (mm)	Push[a] (N)	Pull[a] (N)
2,8	50	40
4,8	60	50
6,3	80	70
9,5	100	100

[a] The values in the above table are the maximum allowed for the insertion and the withdrawal of a receptacle from a tab

H.9.9.103 Tabs forming part of the thermal-link packaged assembly shall be adequately spaced to allow the connection of the appropriate receptacles.

H.9.9.104 *Compliance is checked by applying an appropriate receptacle on each tab. During this application, no strain nor distortion shall occur to any of the tabs nor to their adjacent parts, nor shall the creepage and clearance values be reduced below those specified in Table 3.*

H.9.9.105 Wiring leads forming part of the thermal-link packaged assembly shall be sized in accordance with Table H.2 and be mechanically secure so as to not transmit axial forces to the connections.

Table H.2 – Minimum nominal cross-sectional area of conductor

Current carried by wiring leads, A	**Minimum nominal[a] cross-sectional area of conductor,** mm^2
Up to and including 3	[b]
Over 3 up to and including 6	0,75
Over 6 up to and including 10	1
Over 10 up to and including 16	1,5
Over 16 up to and including 25	2,5
Over 25 up to and including 32	4
Over 32 up to and including 40	6
Over 40 up to and including 63	10

[a] In the USA, other sizes of conductors apply

[b] No minimum specified, but the manufacturer shall declare the conductor size for test purposes.

H.9.9.106 *Compliance is checked by applying, without jerks, a gradual pull of 20 N to each lead for 1 minute. No significant displacement of the wiring leads or damage shall occur to the assembly. There shall be no evidence of flashover or breakdown when the product is subjected to the dielectric strength test of 10.1 between live part and the enclosure.*

~~**H.11.2 Holding temperature, T_h**~~

~~*Additional subclauses*~~

~~**H.11.2.3.101** The thermal-link packaged assembly is connected to a resistive load circuit that is metered to draw the rated current through the thermal-link under the ambient temperature specified by the manufacturer.~~

~~**H.11.2.3.102** The temperature of the medium in which the packaged thermal-link assembly is located shall be measured as near as possible to the center of the space occupied by the sample and at a distance of approximately 50 mm from the assembly.~~

~~**H.11.2.3.103** The temperature of the parts and surfaces shall be determined by means of fine wire thermocouples (0,081 mm^2) or other equivalent means, so chosen and positioned that they have the minimum effect on the temperature of the part under test.~~

~~**H.11.2.3.104** The circuit is kept energized and loaded for 7 h.~~

~~**H.11.2.3.105** After completion of the test, while still heated, the packaged thermal-link assembly is subjected to the dielectric strength test of 10.1.~~

~~**H.11.2.3.106** *Compliance is checked by ensuring that the measured temperatures on the housing material, tabs or wiring leads, epoxy, etc. have not exceeded the maximum allowed values for the materials used in these components. In addition, the assembly complies with the requirements of 10.1.*~~

H.11.101 Maximum use temperature test

H.11.101.1 The purpose of this test is to simulate the heat rise on components used in a thermal-link package during normal operating condition, at the declared maximum use temperature.

H.11.101.2 The thermal-link package shall be placed at the center of a metallic box measuring 300 mm (L) by 300 mm (W) by 300 mm (H). The metallic box with the thermal-link package shall be placed in a static-air oven.

H.11.101.3 The temperature of the air within the metallic box that represents the declared maximum use temperature (Te) shall be measured as near as possible to the center of the space occupied by the thermal-link package under test and at a distance of approximately 50 mm from the sample.

H.11.101.4 Temperatures on the housing material, tabs or wiring lead connections, epoxy, etc shall be determined by means of fine wire thermocouples (0,081 mm^2) or other equivalent means, so chosen and positioned that they have the minimum effect on the temperature of the thermal-link package part under test.

H.11.101.5 The thermal-link package is connected to a resistive load circuit that is metered to draw the rated current through the thermal-link. The oven is energized, and the temperature of the oven shall be adjusted such that the temperature within the metallic box is stabilized at the declared maximum use temperature, T_e.

H.11.101.6 Electric power to the sample is applied and the circuit is kept energized for 7 h or until the temperatures on the components stabilize, shown when two consecutive readings taken 5 min apart are within 1 K of each other. The thermal link shall not open during the duration of the test.

H.11.101.7 After completion of the test, while still heated, the packaged thermal-link package assembly is subjected to the dielectric strength test of 10.1.

H.11.101.8 *Compliance is checked by ensuring that the measured temperatures on the housing material, tabs or wiring leads connection, epoxy, etc. have not exceeded the maximum allowed values for the materials used in these components as specified in Table H.3. In addition, the thermal-link package shall comply with the requirements of 10.1.*

Table H.3 – Allowed values for the materials used in the thermal-link package

Parts	Maximum temperature permitted, °C
Terminal (tabs) and terminations	85
Epoxy or other sealant materials[a]	90
Materials used as insulation other than for wires	
– impregnated or varnished textile, paper or press board	95
– laminates bonded with:	
• melamine formaldehyde, phenol-formaldehyde or phenol-furfural resins	200
• urea-formaldehyde resins	175
– Mouldings of:	
• phenol-formaldehyde, with cellulose fillers	110
• phenol-formaldehyde, with mineral fillers	125
• melamine-formaldehyde	100
• urea-formaldehyde	90
• polyester with glass fibre reinforcement	135
• pure mica and tightly sintered ceramic material	425
• other thermosetting materials and all thermo-plastic materiala	-
[a] The maximum permissible temperatures shall not exceed those which can be shown to be acceptable in service for these materials.	

Annex I
(informative)

Holding temperature

NOTE Annex I is applicable when declared by the manufacturer.

I.11.2 The temperature of the static-air oven shall be measured as near as possible to the center of space occupied by the test fixture assembly and at a distance of approximately 50 mm from the test fixture assembly.

The temperature shall be determined by means of fine wire thermocouples (0,081 mm²) or other equivalent means, so chosen and positioned that they have the minimum effect on the test temperature.

Care shall furthermore be taken that temperature differences in the part of the static-air oven where the test fixture assembly of the specimens are tested, do not exceed at any point:

– ± 1 K at the nominal temperature of 200 °C or lower or
– ± 0,5 % of the nominal temperature higher than 200 °C

I.11.2.1 The selected wire size, type of wire or termination method of the test fixture assembly to connect the thermal-link to the electrical load, shall not significantly affect the temperature of the thermal-link to which the load is connected. There should be no possibility for a heatsink effect.

I.11.2.2 A static-air oven temperature shall then be considered to be stabilized, when two consecutive readings taken 5 min apart are within 1 K of each other.

I.11.2.3 The three specimens of group K shall be secured to a test fixture assembly, mounted in such a way that is not in direct contact and electrically isolated to the internal walls of the static-air oven. The three specimens of group K may be tested individually.

It is recommended to use a huge mass metal block to eliminate the temperature drop during the opening the static-air oven to place the test fixture assembly inside the static-air oven.

I.11.2.4 The test fixture assembly with three specimens in series will be placed in the static-air oven which is stabilized to the T_h temperature specified by the manufacturer. Then the thermal-links will be energized with the resistive rated current for 24 hours or as declared by manufacturer, whichever is higher.

I.11.2.5 *Compliance is determined by checking the continuity of the thermal-link after completion of the test. The thermal-link shall not change its state of conductivity.*

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IEC 60691

Edition 5.0 2023-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Thermal-links – Requirements and application guide

Protecteurs thermiques – Exigences et guide d'application

IEC 60691:2023-03(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

THERMAL-LINKS – REQUIREMENTS AND APPLICATION GUIDE

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 60691 has been prepared by subcommittee 32C: Miniature fuses, of IEC technical committee 32: Fuses. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2015 and Amendment 1:2019. This edition constitutes a technical revision.

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

a) requirements for thermal-link packaged assemblies;
b) renew the requirements and definitions for T_h-test;

The harmonization of the USA national standard, UL 1020, fifth edition (withdrawn 2003), and IEC 60691:1993, together with its Amendment 1:1995 and Amendment 2:2000 have served as a basis for the elaboration of this standard.

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

Draft	Report on voting
32C/604/FDIS	32C/605/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/publications.

The following differing practices of a less permanent nature exist in the country indicated below:

– Annex C is required to be declared in the USA;
– Annex E is required in the USA, if applicable;
– Annex F is required to be declared in the USA.

In this standard, the following type is used:

– *compliance statements: in italic type*.

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

Thermal-links, defined as non-resettable devices functioning once only without refunctioning, are widely applied for the thermal protection of equipment in which, under fault (abnormal) conditions, one or more parts may reach hazardous temperatures.

As these devices have several aspects in common with miniature fuse-links and are used for obtaining a comparable degree of protection, this standard has endeavoured to lay down a number of basic requirements for such devices.

THERMAL-LINKS – REQUIREMENTS AND APPLICATION GUIDE

1 Scope

This International Standard is applicable to thermal-links intended for incorporation in electrical appliances, electronic equipment and component parts thereof, normally intended for use indoors, in order to protect them against excessive temperatures under abnormal conditions.

NOTE 1 The equipment is not designed to generate heat.

NOTE 2 The effectiveness of the protection against excessive temperatures logically depends upon the position and method of mounting of the thermal-link, as well as upon the current which it is carrying.

This document may be applicable to thermal-links for use under conditions other than indoors, provided that the climatic and other circumstances in the immediate surroundings of such thermal-links are comparable with those in this standard.

This document may be applicable to thermal-links in their simplest forms (e.g. melting strips or wires), provided that molten materials expelled during function cannot adversely interfere with the safe use of the equipment, especially in the case of hand-held or portable equipment, irrespective of its position.

Annex H of this document is applicable to thermal-link packaged assemblies where the thermal-link(s) has already been approved to this standard but packaged in a metallic or non-metallic housing and provided with terminals/wiring leads.

This document is applicable to thermal-links with a rated voltage not exceeding 690 V AC or DC and a rated current not exceeding 63 A.

The objectives of this document are:

a) to establish uniform requirements for thermal-links,

b) to define methods of test, and

c) to provide useful information for the application of thermal-links in equipment.

This document is not applicable to thermal-links used under extreme conditions such as corrosive or explosive atmospheres.

This document is not applicable to thermal-links to be used in circuits on AC with a frequency lower than 45 Hz or higher than 62 Hz.

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 60065:2014, *Audio, video and similar electronic apparatus – Safety requirements*

IEC 60112:2020, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60127-2:2014, *Miniature fuses – Part 2: Cartridge fuse-links*

IEC 60216-5:2008, *Electrical insulating materials – Thermal endurance properties – Part 5: Determination of relative thermal endurance index (RTE) of an insulating material*

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 60695-2-12:2021, *Fire hazard testing – Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability index (GWFI) test method for materials*

IEC 60695-2-13:2021, *Fire hazard testing – Part 2-13: Glowing/hot-wire based test methods – Glow-wire ignition temperature (GWIT) test method for materials*

IEC 60695-10-2:2014, *Fire hazard testing – Part 10-2: Abnormal heat – Ball pressure test method*

IEC 60695-11-10:2013, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60730-1:2013, *Automatic electrical controls – Part 1: General requirements*
IEC 60730-1:2013/AMD1:2015
IEC 60730-1:2013/AMD2:2020

IEC 61210:2010, *Connecting devices – Flat quick-connect terminations for electrical copper conductors – Safety requirements*

3 Terms and definitions

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

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

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

3.1
clearance
shortest distance in air between two conductive parts

3.2
creepage distance
shortest distance along the surface of insulating material between two conductive parts

3.3
holding temperature
T_h
maximum ambient temperature of the thermal-link at which it will not change its state of conductivity during a specified time at a specified rated current

3.4
homogeneous series
series of thermal-links having the same external dimensions and common overall construction, deviating from each other only in such characteristics (including ratings) that, for a given test, the testing of one or a reduced number of particular thermal-links of that series shall be taken as representative for all the thermal-links of the series

3.5
interrupting current
I_b
value of the current that the thermal-link is capable of interrupting at rated voltage and under specified circuit conditions

3.6
maximum temperature limit
T_m
temperature of the thermal-link stated by the manufacturer, up to which the mechanical and electrical properties of the thermal-link, having changed its state of conductivity, will not be impaired for a given time

3.7
pilot duty
rating assigned to a switching device that controls the coil of another electro-mechanical device such as a solenoid, relay or contactor

3.8
portable equipment
equipment which is moved while in operation or which can easily be moved from one place to another while connected to the supply

3.9
rated current
I_r
current used to classify a thermal-link

3.10
rated functioning temperature
T_f
temperature of the thermal-link which causes it to change its state of conductivity with a detection current up to 10 mA as the only load

3.11
rated voltage
U_r
voltage used to classify a thermal-link

3.12
thermal element
metallic or non-metallic fusible material that is part of a thermal-link and is responsive to temperature by a change of state such as from solid to liquid at the temperature for which it is calibrated

3.13
thermal-link
non-resettable device incorporating a thermal element, which will open a circuit once only when exposed for a sufficient length of time to a temperature in excess of that for which it has been designed

3.14
transient overload current
I_p
direct current pulse train which the thermal-link is able to withstand without impairing its characteristics

3.15
extended holding temperature
$T_{h\text{-}100}$
maximum temperature at which a thermal-link can be maintained while conducting the rated current at the rated voltage for a period of 100 weeks which will not cause the thermal-link to open circuit in accordance with extended holding temperature evaluation

Note 1 to entry: This is a rating for user consideration during the investigation of the end product.

Note 2 to entry: Annex D specifies the extended holding temperature evaluation.

3.16
conductive heat ageing test
CHAT
test to evaluate a thermal-link for use in an appliance

Note 1 to entry: If it performs satisfactorily, the thermal-link will be assigned a CHAT rating. This rating is for end-product user consideration during the investigation of the end-use product.

Note 2 to entry: Annex C specifies the conductive heat ageing test.

4 General requirements

4.1 Adequate protection of the equipment against excessive temperatures not only depends upon the properties of the thermal-link but also to a large extent upon the mounting of the thermal-link in the equipment. Therefore the requirements of the application guide in Annex A shall be considered.

4.2 Thermal-links shall have adequate electrical and mechanical strength and shall be constructed so as to withstand all conditions of handling likely to be encountered during mounting and normal use, when used within the requirements of this document.

4.3 When a thermal-link changes its state of conductivity, no arc or flame shall be maintained, nor material expelled, that might impair the surrounding area or otherwise create a risk of electric shock or fire. In addition, there shall be no emission of substances (e.g. gases, liquids, dust, mist, vapour) which could cause a hazard.

For thermal-links using melting strips or wires, care should be taken to prevent molten material from short-circuiting or bridging creepage distances and clearances in air, so as to reduce the risk of impairing the insulation system of the equipment.

After it has functioned, the thermal-link shall not be damaged when subjected to temperatures not exceeding T_m, in such a way that the safety of the equipment with regard to risk of electric shock hazard and electrical breakdown is impaired. The thermal-link shall not reclose after it has operated.

4.4 For requirements for thermal-link packaged assemblies, see Annex H.

5 General notes on tests

5.1 The test conditions are as follows.

5.1.1 Unless otherwise specified, only tests that are not required to be performed inside an environmental chamber and/or test oven shall be carried out under the following atmospheric conditions:

– temperature: 15 °C to 35 °C,

– relative humidity: 25 % to 75 %,

– air pressure: 8,6 × 10^4 Pa to 1,06 × 10^5 Pa.

The required atmospheric conditions during testing can be controlled when carrying out the tests and during the duration of the tests. The required atmospheric conditions do not have to be maintained in a test laboratory when tests are not performed.

5.1.2 Where the conditions given in 5.1.1 have a significant influence, they shall be kept substantially constant during the tests.

5.1.3 If the temperature limits given in 5.1.1 are too wide for certain tests, these shall be repeated, in case of doubt, at a temperature of (23 ± 1) °C.

5.2 In every test report, the ambient temperature shall be stated. If the standard conditions for relative humidity or pressure are not fulfilled during the tests, a note to this effect shall be added to the report.

5.3 If the result of a test is influenced, to an appreciable extent, by the position and method of mounting of the specimen, the most unfavourable condition shall be chosen for the relevant tests and recorded.

5.4 If a thermal-link has been specifically designed for use in a special type of equipment and cannot be tested separately, the tests of this standard shall be performed in that equipment or in the relevant part of it, or similar.

5.5 When testing a homogeneous series of thermal-links, all the tests shall be applied to thermal-links with the lowest and highest T_f. Thermal-links with intermediate rated functioning temperatures need only be subjected to tests according to 10.3, 11.3, 11.4 and 11.5.

5.6 The number of specimens is as follows.

5.6.1 The total number of specimens required is 48. Out of a total of 48 specimens, 15 are kept as spares in case some of the tests have to be repeated. Out of a total of 48 specimens, 33 are divided into 11 groups assigned by alphabetical letters from A to K. Each group consists of three specimens. Tests shall be performed in the order indicated in Table 1 but, if so required, tests may be repeated, for example the test on marking (see Clause 7). Additional specimens may be needed according to the requirement of Table 1.

For optional tests, additional specimens should be required as per the applicable annexes.

5.6.2 If, in any of the tests carried out in accordance with any relevant test clause, a failure is reported, the cause of the failure will be identified and corrective action taken. Based on the failure analysis report and the corrective action, as a minimum, the test sequence shall be repeated on twice the number of revised specimens, and no further failures are allowed.

If no corrective actions are necessary, the test should be repeated with double the same size and no further deviation is allowed.

5.6.3 For requirements for thermal-link packaged assemblies, see Annex H.

5.7 The conductive heat ageing test of Annex C is applicable when declared by the manufacturer.

The conductive heat ageing test may be omitted if the thermal-link is constructed without contacts.

NOTE In the USA the conductive heat ageing test is required to be declared.

Table 1 – Test schedule

Clause or Sub-clause	Test	Specimen groups										
		A	B	C	D	E	F	G	H	I	J	K
7 [a]	Marking (Rub test)	X	X									
7 [a]	Marking (visual inspection only)	X	X									
9	**Constructional requirements**											
9.2.2 [a]	Tensile forces	X										
9.2.3 [a]	Thrust force		X									
9.2.4 [a]	Bending/twist force			X								
9.6 [a]	Resistance to tracking											X
9.7 [a]	Creepage distances and clearances						X	X				
9.8	Temperature and humidity cycle conditioning	X	X	X			X	X				
10	**Electrical requirements**											
10.1	Dielectric strength (if applicable)	X	X	X			X	X				
10.2	Insulation resistance (if applicable)	X	X	X			X	X				
10.3	Interrupting current						X	X				
10.4	Transient overload current	X	X						X			
11	**Temperature tests**											
11.2	Check on T_h [b]											X
11.3	Check on T_f	X		X								
11.4	Check on T_m followed by dielectric test and insulation resistance			X	X							
11.5	Ageing step 1 (optional) 21 days step 2 (mandatory) 21 days step 3 (mandatory) 14 days step 4 (mandatory) 7 days step 5 (mandatory) 7 days step 6 (mandatory) 24 hours		X			X			X	X	X	
10.1	Dielectric strength	X	X			X	X	X	X	X	X	
10.2	Insulation resistance	X	X			X	X	X	X	X	X	
12	**Resistance to rusting**											
12 [a]	Resistance to rusting (ferrous parts)	X	X	X								

If the conditions of voltage, power and current in 10.3.2.3, 10.3.2.4 and 10.3.2.5 are not covered by one test, a minimum of three specimens should be tested for each condition.
[a] For homogeneous series, these tests may be omitted for intermediate ratings.
[b] When declared by the manufacturer.

6 Classification

6.1 Electrical conditions

With regard to electrical conditions, the following terms are used:

a) Voltage: AC and /or DC.
b) Current: AC and/ or DC.
c) Resistive load
d) Inductive load
e) Motor load
f) Pilot duty load
g) Electric discharge lamp load.
h) Special load

6.2 Thermal conditions

With regard to thermal conditions, the following symbols and abbreviations are used:

a) T_f
b) T_h
c) T_m
d) CHAT
e) $T_{h\text{-}100}$

6.3 Resistance to tracking

With regard to resistance to tracking, the following ranges are used:

a) proof tracking index from 175 to 249;
b) proof tracking index greater than or equal to 250.

NOTE These ranges are based on test methods for surface tracking laid down in IEC 60112.

7 Marking

7.1 Each thermal-link shall be marked with the following:

a) type or catalogue reference;
b) manufacturer's name or trade mark;
c) rated functioning temperature T_f with or without the symbol T_f followed by the number of degrees Celsius (marked with °C or C);
d) date code which identifies the date of manufacture and which does not repeat for at least 10 years, and a factory location or code, stamped on the thermal-link or the smallest packaging.

If there is only one factory, the factory location may be omitted.

Catalogue or reference numbers should define those parameters such as temperature, current and voltage, which together classify a thermal-link.

7.2 The rated functioning temperature T_f may be omitted if a different type or catalogue reference is employed for each different functioning temperature.

7.3 Marking shall be indelible and legible.

Compliance with the requirements for indelibility of markings is checked by the test in Annex G using the apparatus shown in Figure G.1. Legibility is checked by inspection. After the ageing tests of 11.4, compliance is checked by inspection.

7.4 The marking in accordance with a), b), c) and d) in 7.1 shall be printed additionally on the packing, together with a reference to this document.

7.5 If the thermal-link is small in size, and not intended to be replaced, the thermal-link shall be marked with only item a) in 7.1 and the markings in accordance with b) to d) in 7.1 shall be printed on the packaging, together with a reference to this document.

Compliance is checked by inspection.

8 Documentation

The manufacturer shall provide in the technical documentation, catalogues or instructional leaflets the following information, in addition to that required in Clause 7:

a) classification in accordance with Clause 6;

b) for each of the classifications;

   1) characteristic temperatures T_f, T_h (if declared by manufacturer), T_m;

   2) characteristic currents I_r, I_b, I_p;

   3) rated voltage U_r;

c) suitability for sealing in, or use with impregnating fluids or cleaning solvents;

d) information for mounting the thermal-link in the equipment;

e) thermal-links small in size and not intended to be replaced.

For reasons of safety, it should be made clear in the documentation that a thermal-link is a non-repairable item and that, in case of replacement, an equivalent thermal-link from the same manufacturer and having the same catalogue reference should be used, mounted in exactly the same way.

f) the position of the metal screen, if it is located at a distance other than 12,7 mm away from the live parts in the case of a thermal-link having an exposed element;

g) Application instructions on how to mount the device in equipment for for thermal-links with leads cross sectional area smaller than 0,21 mm^2.

   The device's temperature response should be taken into consideration.

9 Constructional requirements

9.1 General

9.1.1 Thermal-links shall have adequate mechanical strength and stability so as to withstand the stresses likely to be encountered during handling, normal use and fault conditions of the relevant end-use equipment.

9.1.2 Tab terminals shall be constructed in accordance with IEC 61210 and the maximum permissible temperature of the used Tab materials shall be in accordance with Table A.1 of IEC 61210:2010 (Tabs / Integrated).

9.1.3 Current-carrying parts shall be constructed in such a way that contact pressure is not transmitted through non-metallic material other than ceramic, or any material considered as having sufficient dimensional stability over the range of temperatures to be expected, unless there is sufficient resilience in the corresponding metal parts to compensate for any shrinkage or distortion of the non-metallic material.

Current-carrying parts shall have the necessary mechanical strength, be capable of carrying the rated current and shall be of a material that is acceptable for the particular application.

For current-carrying parts, temperature limits shall be considered according to Table 13 of IEC 60730-1:2013.

9.1.4 Friction shall not be used to secure uninsulated live parts (including terminals) to supporting surfaces if there is a risk of such parts turning or shifting their position, resulting in the reduction of creepage distances and clearances to less than those required elsewhere in this standard. The security of contact assemblies shall be such that alignment of contacts is maintained.

9.1.5 Leads and terminal parts shall be secured so that stress on them during installation and normal use does not impair operation of the thermal-link. Thermal-links using seals with formed leads for use in appliances or components shall not be bent less than 3 mm from the thermal-link seal.

Leads may be bent less than 3 mm from the seal if:

a) the thermal-link manufacturer's bending fixture and procedure does not transmit stress to the thermal-link operating mechanism, and if;

b) formed test specimens shall be subjected to the bending/twist lead secureness test of 9.2.4 and the rated functioning temperature test of 11.3.

9.1.6 Thermal-links with leads smaller than 0,21 mm^2 shall be provided with application instructions that instruct the user how to mount the device in equipment, taking into consideration the device's temperature response. The instructions shall also include guidance on the effects that movement and vibration in the equipment may have on the thermal-link's terminals, connections and other mounting components.

9.1.7 A terminal for a soldered connection shall have provision, such as a hole, for holding the conductor independently of solder.

9.1.8 When applicable, provision shall be made for securely mounting a thermal-link in position.

9.1.9 Thermal-links intended to be embedded in windings and the like need not have provision for mounting.

9.1.10 Bolts, screws, or other parts used for mounting an assembly having a thermal-link shall be independent of those used for securing component parts of the assembly.

9.1.11 *Compliance is checked by the lead secureness tests of 9.2. Mounting and securement instructions shall be provided with thermal-links for the manufacturer of the end-product in accordance with Annex A.*

9.2 Lead secureness tests

9.2.1 General

If force applied to thermal-link wire leads causes breakdown of one or more parts leading directly or indirectly to stress being applied to the operating mechanism, the tests described in 9.2.2, 9.2.3 and 9.2.4 shall be conducted. There shall be no displacement of parts that would tend to reclose a thermal-link or reduce creepage distances or clearances as a result of the tests specified in 9.2.2 and 9.2.3. There shall be no displacement of parts other than the wire leads as a result of the test specified in 9.2.4.

9.2.2 Tensile test

The thermal-link shall be supported in any convenient manner in order not to damage it and a tensile force as specified in Table 2 shall be applied to each lead for 1 min.

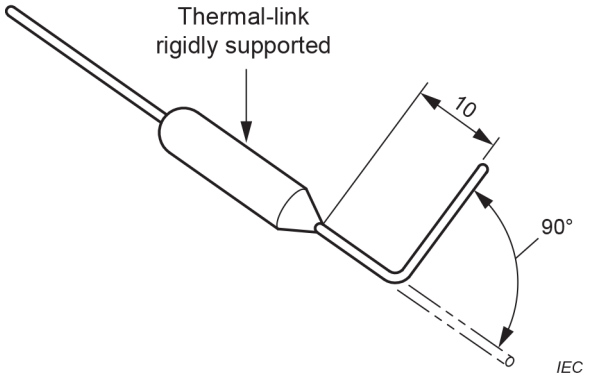
9.2.3 Thrust test

The thermal-link shall be supported using any convenient means such that it is not damaged and a thrust force as specified in Table 2 shall be applied to each lead for 1 min at a distance of 2 mm from the thermal-link.

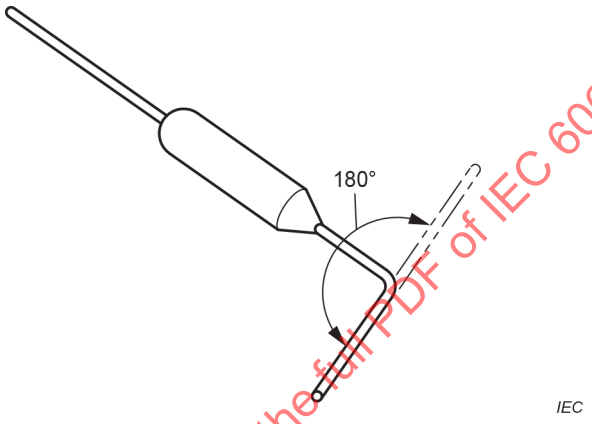
9.2.4 Bending/twist test

The thermal-link shall be rigidly supported such that it is not damaged. Each lead shall be bent through 90° at a location 10 mm from the body of the thermal-link and then twisted through 180° as shown in Figure 1.

Dimensions in millimetres



Step 1: Bend



Step 2: Twist

Figure 1 – Bending/twist test

Table 2 – Strength of leads and terminal parts – Minimum required tensile and thrust test forces

Nominal cross-sectional area of the lead, A, mm^2	Tensile force N	Thrust force N
Up to and including 0,05	1	0,25
Over 0,05 up to and including 1,2	20 × A	5 × A
Over 1,2	40	8
NOTE A is the nominal cross-sectional area of the terminal in mm^2.		

9.3 Contacts used for the current path

Contacts used for the current path in a thermal-link shall withstand the voltage stress determined by the voltage source in the circuit. Current-carrying elements or contacts, together with their terminals, are usually isolated from metal parts such as mounting brackets, metal enclosures and the like, by insulating material.

Compliance is checked by the tests of this document.

9.4 Accessible mounting brackets or metal parts

If mounting brackets or metal parts of the thermal-link's enclosure are accessible or connected through low impedances to metal enclosures of the equipment accessible to the user from the outside, the insulation between the current-carrying elements of the thermal-link and such conductive enclosures shall be adequate under specified conditions of ambient temperature and humidity.

Compliance is checked by the test of 10.1.

9.5 Insulating materials

9.5.1 The insulating materials used in the construction of thermal-links are checked by the tests of this document.

9.5.2 Requirements for insulating materials used in thermal-link packaged assemblies are in Annex H.

9.6 Resistance to tracking

9.6.1 If insulating material used for the support of current-carrying parts, contacts and terminals is exposed during normal use to deposition of moisture or dust, it shall be resistant to tracking.

9.6.2 For material other than ceramic, compliance is checked by performing a tracking test in accordance with IEC 60112 on specimens or flat test pieces of equivalent insulating material. The Proof Tracking Index (PTI) values shall be declared by the manufacturer, but not less than 175 V.

9.7 Creepage distances and clearances

9.7.1 The creepage distances and clearances between current-carrying parts (contacts together with their terminals) and the outside of the thermal-link housing including insulated metal parts thereof, shall be not less than the values in Table 3. The values indicated are absolute minimum values and inclusive of manufacturing tolerances.

Attention is drawn to the fact that the external creepage distances and clearances specified in Table 3 is allowed, in some cases, be smaller than those required by certain appliance or equipment standards. In such cases, additional means should be provided when a thermal-link is mounted in the equipment in order to adjust the creepage distances and clearances to the values required by the relevant equipment standard.

9.7.2 These distances do not apply between the open contacts of a thermal-link.

Compliance is checked by measuring the distances concerned.

Table 3 – Creepage distances and clearances (absolute minimum values)

Rated voltage, U_r V	Clearance mm	Creepage distances mm
0 to 32	0,2	0,53
33 to 50	0,2	1,2
51 to 125	0,5	1,5
126 to 250	1,5	2,5
251 to 400	3,0	4,0
401 to 690	4,0	6,9

If conditions are different from those specified in Note 2, adjustments in clearances/creepages will be necessary as per IEC 60664-1.

NOTE 1 The clearances/creepage distances are specified according to IEC 60664-1.

NOTE 2 The values specified are for typical applications of thermal-links assuming:

a) continuous voltage stress;
b) an altitude of less than or equal to 2 000 m;
c) basic insulation;
d) inhomogeneous field;
e) overvoltage category II;
f) pollution degree 2;
g) material group III.

9.8 Temperature and humidity cycle conditioning

9.8.1 Thermal-links shall not be adversely influenced by humidity present in the ambient conditions for which they are intended.

9.8.2 For temperature and humidity cycle conditioning, the thermal-link specimens shall be subjected to three complete conditioning cycles. Each cycle shall consist of 24 h at T_f -15°C followed immediately (within 15 min) by at least 24 h at (35 ± 5) °C and (90 ± 5) % relative humidity, followed by 8 h at (0 ± 2) °C.

9.8.3 *Compliance is checked by subjecting the specimens to the dielectric strength (see 10.1) and insulation resistance (see 10.2) tests of this document.*

NOTE 1 For a thermal-link with a non-electrically conductive case body, the dielectric and insulation resistance tests are performed after removal of the specimens from the conditioning chamber.

NOTE 2 For a thermal-link with an electrically conductive case body, the insulation resistance test is conducted between the terminals after removal of the specimens from the conditioning chamber.

9.9 Terminals and terminations

9.9.1 Terminal and terminations (leads) used in the construction of thermal-links are checked by the tests of this document.

9.9.2 Requirements for terminals and terminations used in thermal-link packaged assemblies are in Annex H.

10 Electrical requirements

10.1 Dielectric strength

10.1.1 The dielectric strength of thermal-links shall be adequate both before and after having operated, and also after having been subjected to the tests of 9.8.

If applicable, the test is conducted between:

i) Current carrying parts and enclosure (wrapped in metal foil), or,

ii) Current carrying parts and insulated exposed metal parts.

10.1.2 *Compliance is checked by applying the appropriate test voltage between the relevant circuits specified in Table 4 immediately after the tests of 9.8, if applicable, and also after the temperature tests of Clause 11.*

Table 4 – Test voltages for dielectric strength

Between	Test voltage
Current carrying parts and enclosure (wrapped in metal foil, if applicable)	2 U_r + 1 000 V
or	
current carrying parts and insulated exposed metal parts	2 U_r + 1 000 V
Disconnection (between open contacts)	2 U_r

10.1.3 A power transformer with an output of not less than 100 VA is required for this test.

10.1.4 The insulation is subjected to a test voltage with a substantially sine-wave form having a frequency between 45 Hz and 62 Hz.

10.1.5 Initially not more than half the prescribed voltage is applied. It is then raised with a rate of rise of approximately 500 V/s to the full value.

10.1.6 Immediately after the humidity test, the enclosure shall be wrapped in metal foil and the test voltage shall be applied for 1 min across the disconnection and between the current carrying and the metal foil.

10.1.7 The specimens are deemed to comply with the requirements if no flashover or breakdown occurs.

10.2 Insulation resistance

10.2.1 The insulation resistance of thermal-links shall be adequate both before and after having changed their state of conductivity, and also after having been subjected to the relevant tests of 9.8.

If applicable, the test is conducted between:

i) Current carrying parts and enclosure (wrapped in metal foil), or,

ii) Current carrying parts and insulated exposed metal parts.

10.2.2 *Compliance is checked by measuring the insulation resistance of the thermal-link after the test of 9.8, before and after having operated in the temperature test of Clause 11. The insulation resistance shall be measured with a DC voltage of 2 U_r between the current carrying parts and the enclosure (wrapped in metal foil, if applicable), or between current carrying parts and insulated exposed metal parts, and between the terminals.*

NOTE A d.c. test voltage is used in order to eliminate possible deviations due to capacitive currents.

10.2.3 *The specimens are deemed to comply with the requirements if the insulation resistance measured between the current carrying parts and the enclosure, (wrapped in metal foil, if applicable) or between current carrying parts and insulated exposed metal parts is not less than 2 MΩ, and across the disconnection is not less than 0,2 MΩ.*

10.3 Interrupting current

10.3.1 General

A thermal-link shall interrupt the applicable test current specified in Table 5 at 1,1 times the rated voltage, U_r, under the conditions specified in 10.3.2.1, 10.3.2.2, 10.3.2.3, 10.3.2.4, 10.3.2.5, 10.3.2.6, 10.3.2.7, 10.3.2.8, 10.3.2.9, 10.3.2.10 and 10.3.2.11.

NOTE The main purpose of this test is to evaluate the mechanical and electrical integrity of the thermal-link to interrupt a certain load.

10.3.2 Specific conditions

10.3.2.1 Any noncurrent-carrying metal part that is an inherent part of the thermal-link and that may be bonded electrically to a normally-earthed exposed part of the end-product shall be connected through a quick acting and high breaking 1 A fuse (see IEC 60127-2:2014, Standard sheet 1) to earth.

Table 5 – Test current for interrupting test

Type of rating	Rated in	Test current	Power factor	Time constant
Resistive	AC amperes	1,5 times rated current	0,95 to 1,0	–
	DC amperes	1,5 times rated current	–	[d]
Inductive	AC amperes	1,5 times rated current	0,6	–
Motor	AC locked rotor amperes (LRA)	6 times full-load current [a]	0,4 to 0,5	–
	DC amperes	10 times full-load rated current	–	[d]
Pilot duty	AC volt-amperes	[b]	0,35	–
Electric discharge lamp	AC amperes	4 times rated current	0,4 to 0,5	–
Resistive/Inductive Combination	[c]	[c]	[c]	[d]

[a] Or the specified value, such as horsepower, if locked rotor ampere rating is omitted.

[b] See 10.3.2.8.

[c] According to manufacturer´s declaration (only in combination with resistive / inductive load).

[d] Under consideration

10.3.2.2 For a thermal-link having an exposed element, a metal screen shall be located 12,7 mm away from live parts. The screen shall be connected to the opposite pole of the test circuit through a quick acting and high breaking 1 A fuse (see IEC 60127-2:2014, Standard sheet 1). The distance is measured between the screen and the nearest point of the noncurrent-carrying metal part when the noncurrent-carrying metal part is in the open position.

10.3.2.3 Based on the intended use of a thermal-link, the screen may be located at a distance other than 12,7 mm if acceptable to both the manufacturer and the end user.

10.3.2.4 The test circuit shall have an open circuit voltage within 1,1 to 1,155 times the rated voltage of the thermal-link to be tested. This tolerance may be exceeded with the manufacture's consent. The closed circuit voltage of the test circuit when carrying the rated current shall not change by more than 2,5 % of the rated voltage.

10.3.2.5 The tolerance of the test current shall be within ±2,5 % of the specified test current.

10.3.2.6 If a thermal-link has the same current rating at more than one voltage, a test at the highest voltage is considered to be representative of tests at the lower voltages.

10.3.2.7 If a thermal-link has more than one voltage rating within a specific power factor group, the tests shall cover the conditions of maximum voltage, power, and current. One test may cover two of these conditions.

10.3.2.8 For thermal-links assigned a pilot duty rating, the test load shall consist of an electromagnet representative of the magnet coil load that the thermal-link is intended to control. The test current shall be the normal current which shall be determined from the voltage and volt-ampere rating of the thermal-link. For an alternating current thermal-link, the power factor shall be 0,35 or less and the inrush current characteristic of the coil shall be 10 times the normal current. The test shall be conducted with the armature closed.

10.3.2.9 *Compliance is checked by the following test.*

The specimens shall be placed in a test oven, stabilized at a temperature of T_f -30 K (or lower if declared by the manufacturer). The thermal-links in the test oven shall then be energized and the oven temperature increased at the rate of (2 ± 1) K/min and the test shall be continued until the thermal-link functions or the oven temperature reaches 30 K above T_f.

Furthermore the thermal-links shall open the test circuit at a temperature below or equal to T_f.

The thermal-link may operate immediately after being energized, in which case the temperature increase of (2 ± 1) K/min is not necessary and the test may be stopped.

10.3.2.10 *The oven temperature may be monitored by means of a thermocouple attached to an identical but non-functioning thermal-link mounted adjacent to the specimens under test.*

10.3.2.11 *A thermal-link that is rated for controlling an alternating-current motor is acceptable for alternating current pilot duty without further interrupting current tests if, during the original interrupting current test, the power factor was 0,5 or less, and if the pilot duty inrush current at the same voltage is not more than 67 % of the rated locked rotor current (LRA) of the device.*

10.3.2.12 There shall be no damage to the integral leads of a thermal-link. There shall be no emission of hazardous substances from a thermal-link. The case of an enclosed element shall remain intact. *The quick acting and high breaking 1 A fuse (see IEC 60127-2:2014, Standard sheet 1)* specified in 10.3.2.1 and 10.3.2.2 shall not function (open). An exposed element shall not arc to adjacent metal parts and material shall not be expelled which may harm the surrounding area.

10.3.2.13 *After these tests, the insulation resistance shall comply with the requirements of 10.2.*

10.4 Transient overload current

10.4.1 Thermal-links shall withstand repeated current surges, considered as being normal in most applications.

10.4.2 Compliance is checked by the following test, performed under normal conditions as specified in Clause 5 (i.e. room ambient conditions).

10.4.3 DC current pulses, with an amplitude of 15 I_r and a duration of 3 ms with 10 s intervals are applied for 100 successive cycles through the current path.

10.4.4 After the test, there shall be no interruption of the current path nor other damage in the sense of this document.

10.5 Limited short-circuit test

10.5.1 General

10.5.1.1 When declared by a manufacturer, a thermal-link is tested as described in 10.5.2 and 10.5.3.

10.5.1.2 If the limited short-circuit test is conducted on the thermal-link itself with acceptable results, the test need not be repeated during the investigation of the end-product.

10.5.2 Test method

10.5.2.1 Three specimens of the thermal-link shall be subjected to a limited short-circuit test.

10.5.2.2 The test shall be conducted at a voltage within ±5 % tolerance of the rated voltage U_r.

10.5.2.3 The thermal-link shall be connected in series with a non-renewable fuse properly selected for the application in accordance with 10.5.3. The circuit shall limit the current to the applicable value specified in Table 6, measured without the thermal-link in the circuit.

10.5.2.4 The power factor of the circuit shall be 0,9 to 1,0, unless a lower power factor is acceptable to both the manufacturer and the end user.

10.5.2.5 The thermal-link shall be connected in the circuit by two 915 mm lengths of copper wire having a cross-sectional area as indicated in Table 6 of IEC 60730-1:2013. Cotton shall surround the thermal-link, or a metal screen located 50 mm away – or less if acceptable to both the manufacturer and the end user – from all parts of the thermal-link during the test.

Table 6 – Limited short-circuit test capacity

Combined rating of thermal-link					Short-circuit capacity (amperes) a	
Voltamperes, single-phase	Voltamperes, three-phase	Voltamperes, direct current	Horsepower	kW	0 V to 250 V	251 V to 690 V
0 to 1 176	0 to 832	0 to 648	0 to 0,5	0 to 0,375	200	1 000
1 177 to 1 920	833 to 1 496	649 to 1 140	Over 0,5 to 1	Over 0,375 to 0,750	1 000	1 000
1 921 to 4 080	1 497 to 3 990	1 141 to 3 000	Over 1 to 3	Over 0,750 to 2,250	2 000	5 000
4 081 to 9 600	3 991 to 9 145	3 001 to 6 960	Over 3 to 7,5	Over 2,250 to 5,600	3 500	5 000
9 601 or more	9 146 or more	6 961 or more	Over 7,5	Over 5,600	5 000	5 000
[a] For the fluorescent lamp ballast test, the limited short-circuit test capacity shall be 200 A.						

10.5.2.6 Each thermal-link shall be subjected to one test.

10.5.3 Fuse size (rating)

The fuse size for the limited short-circuit tests shall be:

a) 20 A for a thermal-link rated 0 V to 125 V and 15 A for a thermal-link rated 126 V to 690 V, unless a larger fuse size is necessitated by b) to f).

b) 20 A for a thermal-link intended for use in fluorescent lamp ballast. The fuse shall have design characteristics such that it will not open in less than 12 s when carrying 40 A.

c) For a thermal-link having motor ratings, the largest standard size between 300 % and 400 % of the full load current rating for non-hermetic motors and between 175 % and 225 % of the full load current rating for hermetic-refrigeration motors.

d) For a thermal-link intended for use in motor-group circuits, the largest standard fuse size based on the sum of the full load ratings of all loads except the largest motor rating, plus 300 % to 400 % of the full load current rating of the largest motor if the motor is a non-hermetic type, or plus 175 % to 225 % of the full load current rating of the largest motor if the motor is a hermetic-refrigeration compressor type.

e) For a thermal-link intended for use in electric space-heating equipment, based on 125 % of the ampere rating. If 125 % of the ampere rating results in a value for which there is no standard fuse size, the next largest fuse size shall be used.

f) For a thermal-link having other ratings, based on the rating in amperes of the next largest standard fuse size.

g) If acceptable in accordance with the end-product requirements, a smaller fuse size than specified in c) to f).

10.5.4 Compliance

There shall be no ignition of the cotton mentioned in 10.5.2 or the evidence of a risk of fire during the test or electric shock after the test.

11 Temperature tests

11.1 General

11.1.1 The characteristic temperatures of thermal-links shall comply with the values and tolerances as declared by the manufacturer and with the requirements of Clause 11.

11.1.2 The functioning temperature, T_f, shall not be influenced by thermal ageing.

11.1.3 *Compliance is checked by subjecting specimens to one or more tests mentioned below, in the order given in Table 1.*

11.1.4 Operation of thermal-links shall be signalled by suitable means, for example, light emitting diodes with series resistors limiting the signal current to a maximum of 10 mA.

11.1.5 Operation of thermal-links shall be checked after each test step.

11.1.6 In order to obtain the required accuracy of temperature settings, indicated test temperatures shall be measured with an accuracy of ±1 K of the nominal temperature up to 100 °C and ±1 % of the nominal temperature above 100 °C.

11.1.7 Care shall furthermore be taken that temperature differences in that part of the oven where the specimens are tested, do not exceed at any point:

- ±0,5 % of the nominal temperature higher than 200 °C; and
- ±1 K at the nominal temperature of 200 °C or lower.

11.1.8 This may be obtained for example by placing the specimens within a thick-walled aluminium box mounted in such a way that it is not in direct contact with the internal walls of the oven.

11.1.9 For thermal-link packaged assembly, the maximum use temperature shall be in accordance with H.11.101.

11.2 Holding temperature, T_h

11.2.1 When declared by the manufacturer, a thermal-link is tested as described in Annex I.

11.2.2 Requirements for thermal-link packaged assemblies, see Annex H.

11.3 Rated functioning temperature, T_f

11.3.1 For devices rated less than 250 °C, the thermal-links shall be exposed in the test oven or oil bath to T_f – 12 K or as declared by the manufacturer, but not higher than 2 K below the lowest tolerance. The temperature shall then be stabilized, shown when two consecutive readings taken 5 min apart are within 1 K of each other.

11.3.2 For devices rated 250 °C or higher, the thermal-links shall be exposed to T_f – 22 K, or as declared by the manufacturer, but not higher than 2 K below the lowest tolerance. The temperature shall then be stabilized, shown when two consecutive readings taken 5 min apart are within 1 K of each other.

11.3.3 The temperature shall then be increased steadily with a rate of rise between 0,5 K/min to 1 K/min, until all specimens have functioned.

11.3.4 *The individual functioning temperature of thermal-links, rated less than 250 °C, shall be recorded and they shall be not less than as declared by the manufacturer, or T_f – 10 K if no declaration is made.*

11.3.5 *For thermal-links rated at 250 °C or higher, the recorded temperature shall be not less than that declared by the manufacturer, or T_f – 20 K if no declaration is made.*

11.3.6 *The temperature of thermal-link shall not be greater than T_f.*

NOTE The equipment recommended for the tests of 11.3 is shown in Clause C.6.

11.4 Maximum temperature limit, T_m

11.4.1 The specimens shall be subjected to $T_m {}^{0}_{-5}$ °C for a period of 10 min.

11.4.2 With the specimens maintained at $T_m {}^{0}_{-5}$ °C, a dielectric test as per 10.1, and an insulation resistance test as per 10.2, shall be conducted.

11.4.3 To overcome possible effects of thermal inertia of the specimens and any necessary connections, and also to facilitate the introduction of the specimens into a suitable heating chamber, the specimens can be inserted into a sand box maintained at T_m.

11.4.4 The T_f and T_m tests may be conducted in separate equipment and specimens may cool down during transfer from the T_f to T_m test.

11.4.5 No flashover, breakdown or refunctioning shall occur. At the conclusion of this test all specimens shall have functioned.

11.5 Ageing

11.5.1 In order to verify whether ageing at high temperature has a deleterious effect, thermal-links shall be subjected to the series of test steps of 11.5.4.

11.5.2 The temperature shall be maintained constant within ±1 K.

11.5.3 Any specimens remaining intact at the conclusion of each step shall be submitted to the next step.

Conformity shall be considered satisfactory if all specimens have functioned after the first two steps.

11.5.4 Test steps are as follows:

11.5.4.1 Step 1: If requested by the manufacturer, the specimens are subjected for three weeks to either:

a) T_f − 15 K, or

b) Between a temperature chosen between T_f − 15 K and a declared value by the manufacturer.

11.5.4.2 The following tests are mandatory:

11.5.4.2.1 Step 2: T_f − 15 K for three weeks. At the conclusion of the test, at least 50 % of the specimens shall not have functioned unless the specimens have already been submitted to step 1, in which case all specimens may have functioned.

11.5.4.2.2 Step 3: T_f − 10 K for two weeks.

11.5.4.2.3 Step 4: T_f − 5 K for one week.

11.5.4.2.4 Step 5: T_f − 3 K for one week.

11.5.4.2.5 Step 6: T_f + 3 K for 24 h.

11.5.5 The specimens shall then cool in the test chamber to less than T_f − 35 K.

11.5.6 *The test is considered successful if all specimens have functioned.*

12 Resistance to rusting

12.1 Iron and steel parts shall be protected against corrosion by enamelling, galvanizing, plating or other equivalent means.

12.2 Corrosion protection is not required for parts made of stainless steel.

12.3 Thermal-links provided with one or more ferrous parts shall not be adversely affected by possible rusting of such parts.

12.4 *Compliance is checked by inspecting specimens of Groups A, B and C after the temperature and humidity cycle conditioning test of 9.8. The specimens are dried in air at a suitable temperature and the ferrous parts shall show no sign of rusting that might impair the performance of the thermal-links in the sense of this document.*

13 Manufacturer's validation programme

13.1 The manufacturer shall conduct regular inspections for production control and tests for validating performance as per 13.2 and 13.3.

13.2 The manufacturer shall test three specimens each, for all temperature ratings for thermal-links, once every two years for 10.3 (Interrupting current), 11.3 (Rated functioning temperature) and 11.4 (Maximum temperature limit) followed by the tests of 10.1 (Dielectric strength) and 10.2 (Insulation resistance). The pre-conditioning tests described in 9.2 (Lead secureness tests) may be omitted.

13.3 The tests of 10.3 shall be conducted on

a) the highest rated voltage,

b) the highest rated current,

c) both a) and b)

with AC and/or DC in the case of a resistive or motor load, or with AC in the case of inductive, pilot duty or electric discharge lamp load; and

d) the current and circuit condition declared by the manufacturer in the case of a special load.

Non-compliance in any of the tests shall be subject to a review and repetition as per Clause 5.

Annex A
(normative)

Application guide

A.1 Instructions for mounting given by the manufacturer of the thermal-link shall be followed, especially in the case where thermal-links are provided with a coating or used in impregnated windings.

A.2 Thermal-links shall be chosen such that all prevailing electrical requirements with regard to insulation resistance, dielectric strength, creepage distances in air and clearances are met under normal and fault conditions, specified in the relevant equipment standard. For example, for audio, video and similar electronic devices, see IEC 60065.

A.3 Thermal-links shall be chosen such that, in the mounted position, their electrical and thermal insulation shall not be degraded by thermal overshoot effects produced under fault conditions in the equipment.

A.4 If thermal-links in the form of melting wires or strips are applied, barriers shall be provided so that sagging of such elements or possible droplets of molten metal cannot produce harmful effects.

A.5 If such melting wires are clamped or pressed under screws, rivets or terminals, it shall be verified that mechanical creepage phenomena do not result in unacceptable electrical contacts.

NOTE For hand-held or portable equipment, this provision applies irrespective of their position.

A.6 Electrical connections shall function as intended over the range of temperatures to which they may be exposed in the equipment.

A.7 Connectors and terminals shall not loosen easily due to vibration, shock, thermal cycling and the like.

A.8 Soldered connections, if any, shall not rely solely on the solder alloy for their mechanical rigidity but shall include mechanical anchoring, for example a wire bent through a hole in a terminal.

A.9 The mechanical strength and rigidity of the hardware used for mounting the thermal-link shall be adequate. Brackets, clamps or screws used for mounting the thermal-link shall withstand thrust and tensile forces, torques, vibrations and cyclic temperature changes expected during normal operating conditions of the equipment.

A.10 The mounted thermal-link shall be adequately protected from harmful effects produced by possible spillage of liquids from the equipment, for example by covers.

A.11 In order to avoid possible damage to the thermal-link, the manufacturer should be consulted when the end-use application involves sealing in or the use of cleaning solvents.

Annex B
(normative)

Alternative ageing test for thermal-links with T_h greater than 250 °C for use in electric irons

B.1 Thermal-links used to protect electric irons where the normal holding temperature is 250 °C or greater and which, in the event of failure, rises rapidly to a functioning temperature of 300 °C or higher, are not required to follow the usual ageing test described in 11.5.

B.2 The alternative ageing test is conducted as per the manufacturer's declaration.

B.3 Additionally, the tolerance of T_f in 11.3 is allowed to be −20 K instead of −10 K.

B.4 All other requirements of this document, however, shall be met in order to conform with this standard.

Annex C
(normative)

Conductive heat ageing test

NOTE In the USA, Annex C is required to be declared. For all other countries, Annex C is applicable when declared by the manufacturer.

C.1 Conductive heat ageing test

The following conductive heat ageing test shall be conducted on thermal-links with a T_f rating of 175 °C or above. The test is optional for thermal-links with a T_f rating less than 175 °C.

The conductive heat ageing test may be omitted if the thermal-link is of eutectic type and is constructed without contacts.

C.2 Method

C.2.1 General

Thirty specimens shall be subjected to the test. Each of three groups consisting of ten specimen thermal-links, shall be secured to a test fixture assembly and placed on an electrically heated static-air test oven constructed in accordance with C.6 and subjected to the test described in C.2.2, C.2.3, C.2.4, C.2.5, C.3 and C.4. The oven cover of the test oven, as shown in Figure C.2, shall be replaced with the test fixture assembly as shown in Figure C.1. The aluminium test box section and the ceramic oven liner section, shown in Figure C.2, shall be removed from the test oven.

C.2.2 Typical test fixture assembly

A typical test fixture assembly as shown in Figure C.1 consists of an aluminium plate, 229 mm × 229 mm and 6,4 mm thick on which ten thermal securing clips are mounted on the outer perimeter of the plate and serve to secure the thermal-link to the surface of the plate. An electrical insulator, consisting of two layers of 0,075 mm thick polyamide film and a nominal total thickness of 0,15 mm, shall be placed around each thermal-link to electrically insulate it from the aluminium plate. The leads of each adjacent thermal-link shall be welded together to form a series circuit. The wire size, type of wire, or termination method selected to connect the thermal-link to the electrical load, shall not significantly affect the temperature of the thermal-link to which the load is connected. The test fixture may be modified so that all 30 test specimens may be tested on one test fixture assembly. Multiple test fixtures may be used with the specimens divided into multiple groups.

C.2.3 Temperature setting

The test fixture assembly shall be placed on the thermal-link test oven as the cover, with the thermal-links positioned on the outside surface of the aluminium plate. The test oven shall be rated 10 A, 120 V AC or 230 V AC.

C.2.4 Temperature behaviour

The temperature on the aluminium plate and the thermal-links shall be controlled by the length of time the test oven remains "on". During the "on" period, the thermal-links shall also be heated as a result of conducting a load current of 10 A at 120 V AC from the heating element of the test oven connected in series with the thermal-links.

Exception: If the thermal-link is rated less than 10 A, a separate circuit with an external load set for the thermal-link rated current shall be connected to the thermal-link. The load current shall be cycled concurrently with the test oven heating element. Whenever a thermal-link opens, the test oven heating element shall remain off until the open thermal-link is removed and the thermal-link test location is bypassed.

C.2.5 Temperature monitoring

The temperature of each thermal-link shall be monitored by a thermocouple welded to the uppermost side of the thermal-link body. The thermal-link having the highest temperature shall be used for controlling the length of the oven "on" period. Verification of the stability of the temperature of the thermal-link body shall be determined 24 h after the start of the test. At that time, the temperature of eight out of ten (80 %) thermal-links shall be within 12 K of the highest monitored temperature.

C.3 Ageing

C.3.1 General

The thermal-links shall be aged as described in the following steps for a total of eight weeks plus one day or until they function:

Step A 336 h (2 weeks) at 35 K below T_f;

Step B 336 h (2 weeks) at 25 K below T_f;

Step C 168 h (1 week) at 20 K below T_f;

Step D 168 h (1 week) at 15 K below T_f;

Step E 168 h (1 week) at 10 K below T_f;

Step F 168 h (1 week) at 5 K below T_f;

Step G 24 h (1 day) at T_f + 5 K. All 30 thermal-links shall be subjected to this step.

T_f is the rated functioning temperature of the thermal-links. For each step, a tolerance of $^{0}_{-6}$ K shall be used for controlling the test oven "on" and "off" period.

The load current "on" time through the tested device shall be at least 5 s but not longer than 10 s as declared by the manufacturer. These values may be exceeded during the ramp-up periods if the required ageing temperature of the step involved (Step A to Step G allowing the $^{0}_{-6}$ K tolerance) has not yet been attained on the thermal-link having the highest temperature and which is being used for controlling the length of the oven "on" period. The thermal-link may or may not be energized during the ramp-up period.

C.3.2 Cooling operation

Twice each week, the test oven shall be de-energized and the test fixture allowed to cool to room temperature. The cool-down period shall be for 12 h on the third and fifth day of each week. The total ageing time for each step shall not include the cool-down period or the time when the test oven is off due to a thermal-link functioning.

C.3.3 Premature operation

If a thermal-link functions prior to completing the total ageing period, the thermal-link shall be bypassed in order to retain continuity of the series circuit. During the reconnection process, the remaining thermal-links shall not be disturbed. Additional wire leads of proper size and type are to be used.

C.4 Results

As a result of the test, each thermal-link shall operate as intended, shall be electrically open, and there shall be no dielectric breakdown as a result of the test prescribed in Clause C.5.

C.5 Dielectric strength test

With reference to Clause C.4, following the test, each thermal-link shall be subjected to the dielectric strength test of 10.1, applied between the leads or terminals of the opened thermal-link after the test specimens have been brought to room temperature.

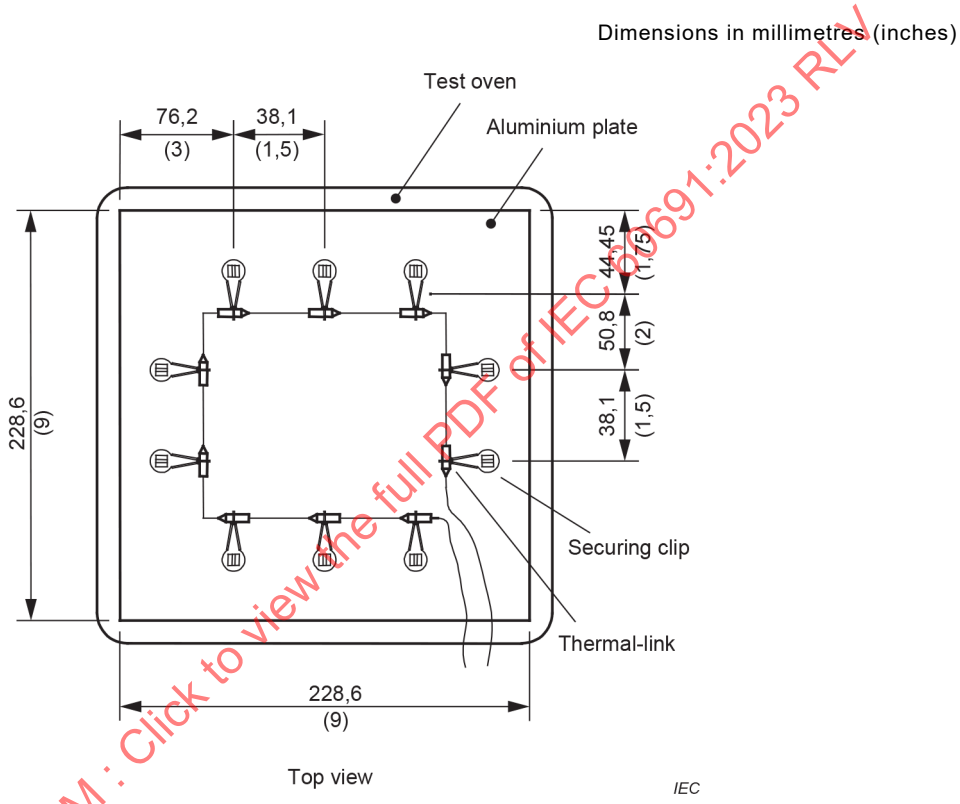


Figure C.1 – Typical test fixture assembly

C.6 Test oven

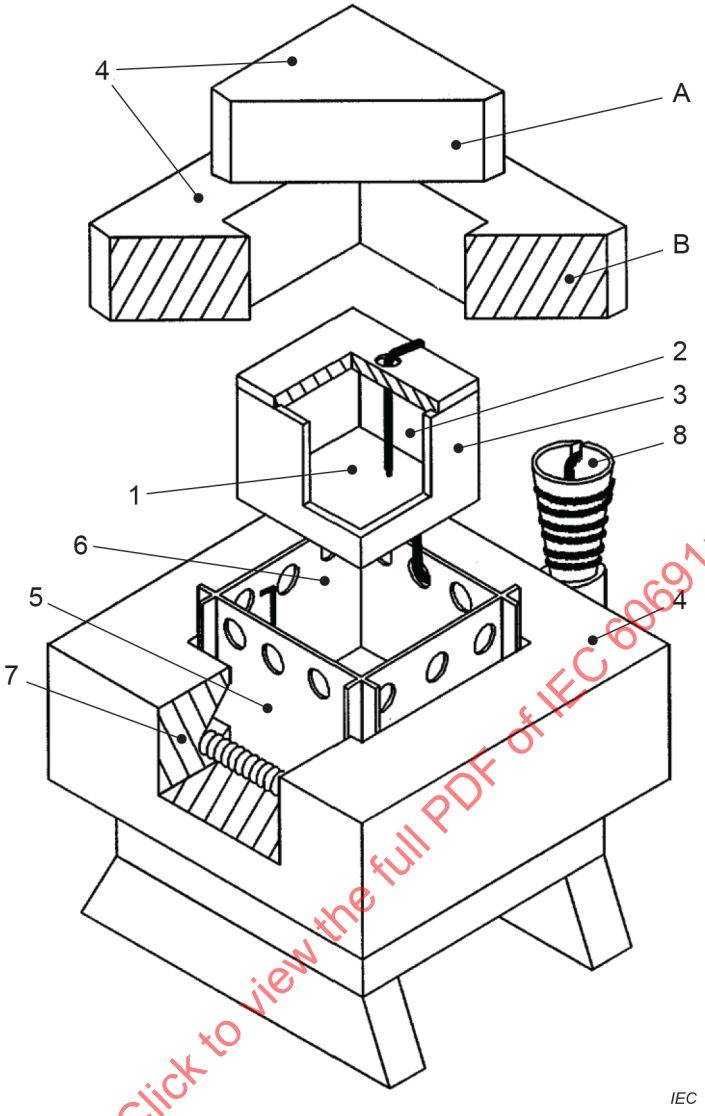
The test apparatus shall consist of an electrically heated, static-air oven. A typical example of such an oven is shown in Figure C.2. The oven shall be located in a room free of draughts and the ambient temperature shall be maintained reasonably constant during the test.

The oven described in Figure C.2 has a two-section core consisting of a non-metallic oven liner and a metal test box.

The interior surfaces of the oven described in Figure C.2 consist of a firebrick or a like type of surface which shields radiant heat and reduces heat loss. Seams and joints shall be tight.

The inner metal test box of the oven described in Figure C.2 has 6,4 mm thick walls. The test box shall rest on inorganic blocks and shall be shielded from radiant heat. The temperatures around the thermal-link shall be monitored by thermocouples located inside the metal test box.

The temperature regulating system of the oven shall be such that the temperature of the air at the test location is maintained within 0,5 K.



Key

1 test specimen chamber
2 temperature monitoring and recording thermocouples
3 aluminium test box section, supported on four ceramic buttons
4 low-density fire brick oven
5 ceramic oven liner section
6 temperature controlling thermocouple inserted at the base of the oven between test box and oven liner
7 heating coil recessed in inside face of oven
8 heating element in series with oven heater used as ballast resistor
A oven cover: 16 cm × 29 cm × 29 cm
B 6,35 cm × 22,85 cm × 22,85 cm with a hole 8,25 cm × 8,25 cm

Figure C.2 – Typical thermal-link test oven

Annex D
(informative)

Extended holding temperature evaluation

NOTE Annex D is applicable when declared by the manufacturer.

D.1 Extended holding temperature conditioning test

D.1.1 Twenty-five devices shall be placed in an electrically heated static-air oven for a period of 100 weeks while maintaining the rated current at the rated voltage. The test oven shall be constructed in accordance with Clause C.6 and Figure C.2 except for overall dimension variations and also the inclusion of the terminal block support test fixture securing the thermal-links. A typical example of the terminal block support test fixture is shown in Figure D.1.

D.1.2 Each thermal-link shall be connected in series to the terminals of the test fixture as shown in Figure D.1. The internal cavity of the test oven shall be heated so that the body temperature of each specimen shall be maintained at the rated $T_{\text{h-100}}$ value. A thermocouple shall be attached to each thermal-link to monitor the body temperature.

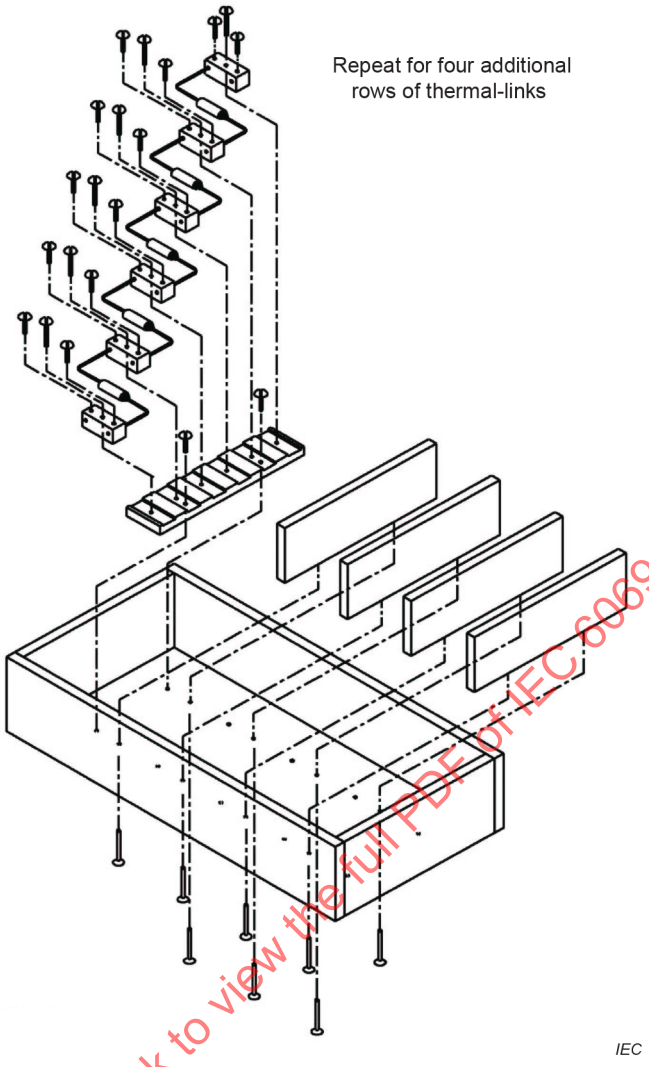
D.1.3 The temperature tolerances maintained for the specimens shall be $^{0}_{-10}$ K for all 25 specimens during the first two weeks of conditioning and ±10 % of the $T_{\text{h-100}}$ value (stated in °C) for at least 20 of the 25 specimens for the reminder of the test time.

D.1.4 All specimens that do not exceed +10 % of the $T_{\text{h–100}}$ rating shall not be open at the conclusion of the conditioning. After the conditioning period, all but two of the specimens shall be subjected to the load current interrupt test of Clause D.2. The remaining two specimens shall be subjected to the rated functioning temperature test of 11.3.

D.2 Load current interrupt test

D.2.1 The specimens shall be placed in a test oven that has been stabilized at 10 K below the rated functioning temperature, T_{f}, of the specimen. Each thermal-link is then energized and the oven temperature shall be increased at the rate of (2 ± 1) K/min and the test shall be continued until the thermal-link functions or the oven temperature reaches 30 K above T_{f}.

D.2.2 Each thermal-link shall break the specified load current at the specified voltage. There shall be no damage to the integral leads of the thermal-link. The internal assembly of each specimen shall be visually examined after the interrupt test. There shall be no welding or undue burning or pitting of the contacts or operating mechanism.



Use 3,3 mm^2 copper wire to jump from row to row of the thermal-links and in and out of the box through the hole in the lid.

Secure thermocouple leads to thermal-link body. Exit box through the nearest hole in the lid.

Figure D.1 – Typical terminal block support test fixture

Annex E
(normative)

Seal ageing test

NOTE In the USA, Annex E is required, if applicable. For all other countries, Annex E is applicable when declared by the manufacturer.

E.1 This test applies to seals and potting compounds. After the conditioning, as specified below, the specimens shall be tested to determine critical electrical and mechanical property values. The average value for each property on the conditioned specimens shall be at least 50 % of the average value determined on unconditioned specimens.

Seals and potting compounds need not be tested if they already comply with the relevant UL standard.

E.2 For each property to be evaluated, ten specimens shall be conditioned for 1 000 h at the oven temperature determined from the respective thermal endurance profile line in Figure E.1. The temperature index is the measured normal operating temperature or T_f -15 °C, but not less than 60 °C. The specimens are then brought to room temperature.

On the same thermal endurance profile line as shown in Figure E.1, a shorter or longer time at a higher or lower oven temperature, respectively, may be employed if agreeable to both the manufacturer and the end-user, but a period of at least 300 h shall be used.

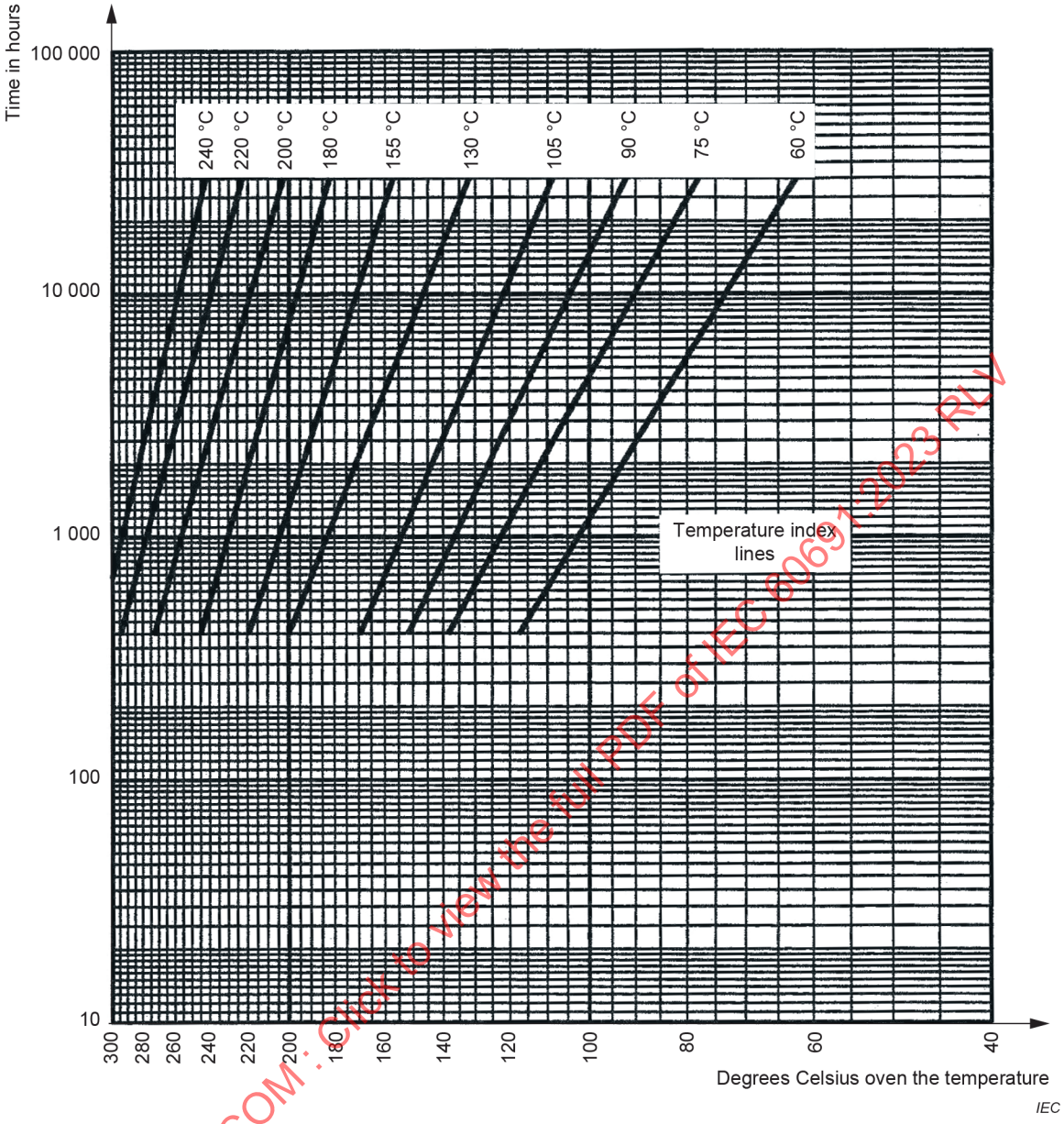


Figure E.1 – Conditioning time versus oven temperature for proposed temperature index

Annex F
(normative)

Identification requirements

NOTE In the USA, Annex F is required to be declared. For all other countries, Annex F is applicable when declared by the manufacturer.

F.1 The procedure described below shall be conducted on a number of specimens of thermal-links employing eutectic-type elements for identification purposes.

F.2 The thermal activity of the thermal-link's alloy, determined by use of thermal-analysis apparatus employing a differential scanning calorimeter, shall be compared with a reference material that is thermally inert over the range of temperature rating of the material. The temperature of the specimen and reference material shall be raised at a predetermined rate and the thermal differential between the two materials shall be graphically recorded on the Y axis against increasing temperature on the X axis. This graph shall include the thermally active temperature range, i.e. the endothermic melting point of the specimen material. This point is represented by a downward peak on the graph.

F.3 The identification test shall be conducted on thermal-links employing organic-material elements. An infrared spectrum shall be obtained from the material by use of an infrared spectrophotometer. Sampling methods and instrument settings used in obtaining the spectrum shall be recorded.

Annex G
(normative)

Indelibility of markings[1]

Compliance with the marking indelibility testing requirements of Clause 7 shall be checked with the apparatus shown in Figure G.1.

The principal part consists of a disc of hard white buffing felt, 65 mm in diameter and 7,5 mm thick. This is locked against rotation and is arranged to move across the surface to be tested with a stroke of 20 mm and to exert a measurable force of 2,5 N on this surface. The standard test shall be 12 strokes (i.e. 12 rotations of the eccentric) and shall take approximately 15 s.

During the test the appropriate part of the buffing disc is covered with one layer of white absorbent lint soaked with water with the nap surface external.

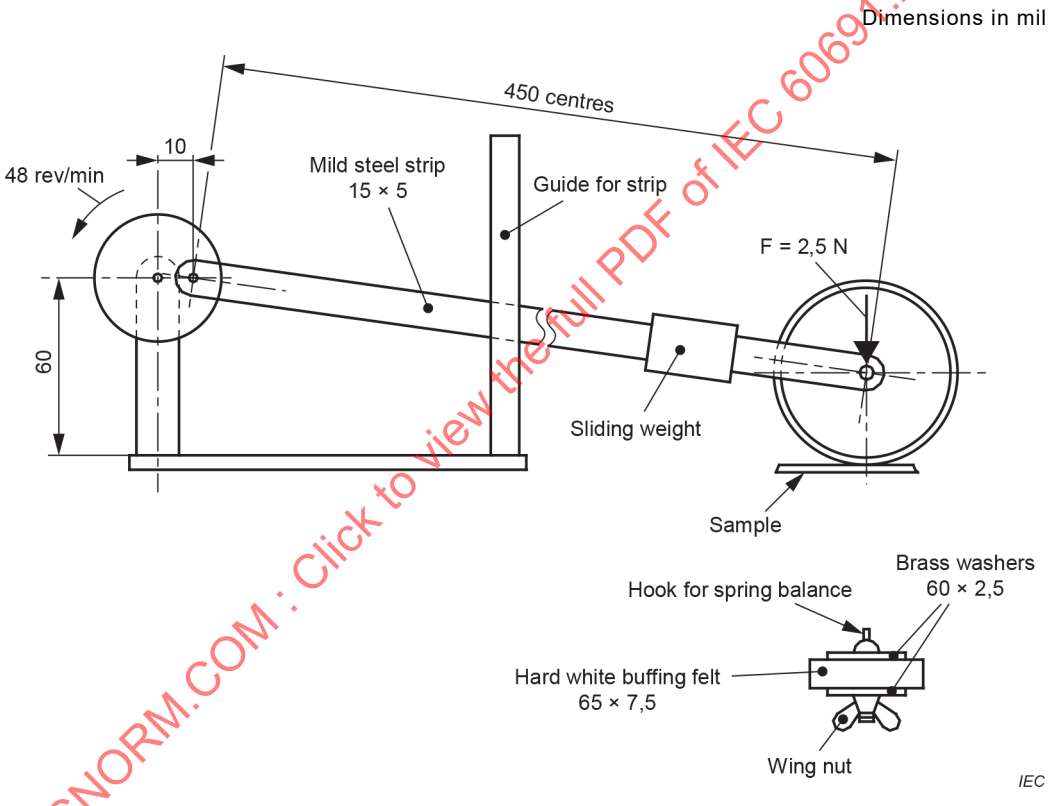


Figure G.1 – Apparatus for testing durability of markings

[1] Figure G.1 and its description have been adapted from Figure 8 and the second and third paragraphs of A.1.4 in IEC 60730-1:2013, with slight modifications.

Annex H
(normative)

Requirements for thermal-link packaged assemblies

NOTE Annex H supplements or modifies the corresponding clauses of this document.

H.3 Terms and definitions

Addition

H.3.101
thermal-link package
a thermal-link packaged in a metallic or non-metallic housing and may be provided with leads or tabs, epoxy or any other additions

H.3.102
maximum use temperature, T_e
the maximum declared external ambient temperature that the **thermal-link package** is intended to be exposed during normal operation, while carrying its rated current

H.4 General requirements

Addition

H.4.101 A thermal-link that is used in a packaged assembly shall be separately evaluated to the requirements of this Annex H.

For each applicable test of H.9.9 and H.12.101 three new specimens of packaged thermal-link assemblies shall be tested.

H.5 General notes on tests

Addition

H.5.6.2.101 In addition to the tests of this annex, specimens of a packaged thermal-link assembly shall be subjected to the test sequence of groups F and G.

H.6 Classification

H.6.2 Thermal conditions

Addition

H.6.2.101 aa) T_e

H.8 Documentation

H.8.101 Addition to item b), sub-item 1) – characteristic temperatures: T_e

H.9 Constructional requirements

Addition

H.9.5 Insulating materials

H.9.5.101 Polymeric materials used in the housing of the thermal-link package shall have the following ratings or be tested to, at the specified thickness in accordance with the relevant standards:

a) flammability rating of V-0 or V-1 in accordance with IEC 60695-11-10;

b) glow-wire flammability index (GWFI) of 850 °C in accordance with IEC 60695-2-12 and

c) glow-wire ignition test (GWIT) of 775 °C in accordance with IEC 60695-2-13;

d) relative thermal endurance index (RTE) value which is greater than or equal to the maximum temperature recorded on the plastic housing during the test of H.11.101 in accordance with IEC 60216-5;

e) proof tracking index of minimum 175 V in accordance with IEC 60112;

f) ball pressure test at a temperature of 20 K above the maximum temperature recorded on the plastic housing during the test of H.11.101 in accordance with IEC 60695-10-2.

H.9.5.101.1 If there are no relevant IEC values available, as an alternative, comparable RTI values may be chosen from an equivalent standard.

H.9.5.102 Potting compounds or epoxy shall be suitable for the application temperature and shall be identified in accordance with Annex F, if applicable.

H.9.5.103 If the maximum temperature recorded on the epoxy or potting compound during the test of H.11.101 is less than the rated temperature of the potting compound or epoxy, then the material is acceptable for the application.

H.9.5.104 If the maximum temperature recorded on the epoxy or potting compound during the test of H.11.101 is greater than the rated temperature of the potting compound or epoxy, then the material shall be subjected to the seal ageing test of Annex E, if applicable.

H.9.9 Terminals and terminations

Additional subclauses

H.9.9.101 Tabs forming part of the thermal-link packaged assembly shall have adequate strength to allow the insertion and withdrawal of receptacles without damage to the thermal-link packaged assembly such as to impair compliance with this standard.

H.9.9.102 *Compliance is checked by applying, without jerks, axial forces equal to those shown in Table H.1. No significant displacement of the tabs or damage shall occur to the assembly. There shall be no evidence of flashover or breakdown when the product is subjected to the dielectric strength test of 10.1 between live part and the enclosure.*

Table H.1 – Push and pull force

Tab Size (see IEC 61210) (mm)	Push[a] (N)	Pull[a] (N)
2,8	50	40
4,8	60	50
6,3	80	70
9,5	100	100

[a] The values in the above table are the maximum allowed for the insertion and the withdrawal of a receptacle from a tab

H.9.9.103 Tabs forming part of the thermal-link packaged assembly shall be adequately spaced to allow the connection of the appropriate receptacles.

H.9.9.104 *Compliance is checked by applying an appropriate receptacle on each tab. During this application, no strain nor distortion shall occur to any of the tabs nor to their adjacent parts, nor shall the creepage and clearance values be reduced below those specified in Table 3.*

H.9.9.105 Wiring leads forming part of the thermal-link packaged assembly shall be sized in accordance with Table H.2 and be mechanically secure so as to not transmit axial forces to the connections.

Table H.2 – Minimum nominal cross-sectional area of conductor

Current carried by wiring leads, A	Minimum nominal[a] cross-sectional area of conductor, mm^2
Up to and including 3	[b]
Over 3 up to and including 6	0,75
Over 6 up to and including 10	1
Over 10 up to and including 16	1,5
Over 16 up to and including 25	2,5
Over 25 up to and including 32	4
Over 32 up to and including 40	6
Over 40 up to and including 63	10

[a] In the USA, other sizes of conductors apply

[b] No minimum specified, but the manufacturer shall declare the conductor size for test purposes.

H.9.9.106 *Compliance is checked by applying, without jerks, a gradual pull of 20 N to each lead for 1 minute. No significant displacement of the wiring leads or damage shall occur to the assembly. There shall be no evidence of flashover or breakdown when the product is subjected to the dielectric strength test of 10.1 between live part and the enclosure.*

H.11.101 Maximum use temperature test

H.11.101.1 The purpose of this test is to simulate the heat rise on components used in a thermal-link package during normal operating condition, at the declared maximum use temperature.

H.11.101.2 The thermal-link package shall be placed at the center of a metallic box measuring 300 mm (L) by 300 mm (W) by 300 mm (H). The metallic box with the thermal-link package shall be placed in a static-air oven.

H.11.101.3 The temperature of the air within the metallic box that represents the declared maximum use temperature (Te) shall be measured as near as possible to the center of the space occupied by the thermal-link package under test and at a distance of approximately 50 mm from the sample.

H.11.101.4 Temperatures on the housing material, tabs or wiring lead connections, epoxy, etc shall be determined by means of fine wire thermocouples (0,081 mm^2) or other equivalent means, so chosen and positioned that they have the minimum effect on the temperature of the thermal-link package part under test.

H.11.101.5 The thermal-link package is connected to a resistive load circuit that is metered to draw the rated current through the thermal-link. The oven is energized, and the temperature of the oven shall be adjusted such that the temperature within the metallic box is stabilized at the declared maximum use temperature, T_e.

H.11.101.6 Electric power to the sample is applied and the circuit is kept energized for 7 h or until the temperatures on the components stabilize, shown when two consecutive readings taken 5 min apart are within 1 K of each other. The thermal link shall not open during the duration of the test.

H.11.101.7 After completion of the test, while still heated, the packaged thermal-link package assembly is subjected to the dielectric strength test of 10.1.

H.11.101.8 *Compliance is checked by ensuring that the measured temperatures on the housing material, tabs or wiring leads connection, epoxy, etc. have not exceeded the maximum allowed values for the materials used in these components as specified in Table H.3. In addition, the thermal-link package shall comply with the requirements of 10.1.*

Table H.3 – Allowed values for the materials used in the thermal-link package

Parts	Maximum temperature permitted, °C
Terminal (tabs) and terminations	85
Epoxy or other sealant materials[a]	90
Materials used as insulation other than for wires	
– impregnated or varnished textile, paper or press board	95
– laminates bonded with:	
• melamine formaldehyde, phenol-formaldehyde or phenol-furfural resins	200
• urea-formaldehyde resins	175
– Mouldings of:	
• phenol-formaldehyde, with cellulose fillers	110
• phenol-formaldehyde, with mineral fillers	125
• melamine-formaldehyde	100
• urea-formaldehyde	90
• polyester with glass fibre reinforcement	135
• pure mica and tightly sintered ceramic material	425
• other thermosetting materials and all thermo-plastic materiala	-

[a] The maximum permissible temperatures shall not exceed those which can be shown to be acceptable in service for these materials.

Annex I
(informative)

Holding temperature

NOTE Annex I is applicable when declared by the manufacturer.

I.11.2 The temperature of the static-air oven shall be measured as near as possible to the center of space occupied by the test fixture assembly and at a distance of approximately 50 mm from the test fixture assembly.

The temperature shall be determined by means of fine wire thermocouples (0,081 mm²) or other equivalent means, so chosen and positioned that they have the minimum effect on the test temperature.

Care shall furthermore be taken that temperature differences in the part of the static-air oven where the test fixture assembly of the specimens are tested, do not exceed at any point:

– ± 1 K at the nominal temperature of 200 °C or lower or
– ± 0,5 % of the nominal temperature higher than 200 °C

I.11.2.1 The selected wire size, type of wire or termination method of the test fixture assembly to connect the thermal-link to the electrical load, shall not significantly affect the temperature of the thermal-link to which the load is connected. There should be no possibility for a heatsink effect.

I.11.2.2 A static-air oven temperature shall then be considered to be stabilized, when two consecutive readings taken 5 min apart are within 1 K of each other.

I.11.2.3 The three specimens of group K shall be secured to a test fixture assembly, mounted in such a way that is not in direct contact and electrically isolated to the internal walls of the static-air oven. The three specimens of group K may be tested individually.

It is recommended to use a huge mass metal block to eliminate the temperature drop during the opening the static-air oven to place the test fixture assembly inside the static-air oven.

I.11.2.4 The test fixture assembly with three specimens in series will be placed in the static-air oven which is stabilized to the T_h temperature specified by the manufacturer. Then the thermal-links will be energized with the resistive rated current for 24 hours or as declared by manufacturer, whichever is higher.

I.11.2.5 *Compliance is determined by checking the continuity of the thermal-link after completion of the test. The thermal-link shall not change its state of conductivity.*

Bibliography

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

IEC 60695-10-3:2016, *Fire hazard testing – Part 10-3: Abnormal heat – Mould stress relief distortion test*

IEC 60695-11-20:2015, *Fire hazard testing – Part 11-20: Test flames – 500 W flame test methods*

IEC 60127-1:2006, *Miniature fuses – Part 1: Definitions for miniature fuses and general requirements for miniature fuse-links*
IEC 60127-1:2006/AMD1:2011
IEC 60127-1:2006/AMD2:2015

IEC 60216-1:2013, *Electrical insulating materials – Thermal endurance properties – Part 1: Ageing procedures and evaluation of test results*

IEC 60695-2-11:2021, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products (GWEPT)*

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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PROTECTEURS THERMIQUES – EXIGENCES ET GUIDE D'APPLICATION

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L'IEC 60691 a été établie par le sous-comité 32C: Coupe-circuits à fusibles miniatures, du comité d'études 32 de l'IEC: Coupe-circuits à fusibles. Il s'agit d'une Norme internationale.

Cette cinquième édition annule et remplace la quatrième édition parue en 2015 et l'Amendement 1:2019. Cette édition constitue une révision technique.

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

a) exigences relatives aux ensembles conditionnés de protecteurs thermiques;
b) reformulation des exigences et des définitions relatives à l'essai T_h.

L'harmonisation de la norme nationale américaine UL 1020, cinquième édition (annulée en 2003), et de l'IEC 60691:1993 ainsi que son Amendement 1:1995 et son Amendement 2:2000 ont servi de base à l'élaboration de la présente norme.

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

Projet	Rapport de vote
32C/604/FDIS	32C/605/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.

Ce 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/publications.

Les pratiques divergentes suivantes de nature moins permanente existent dans le pays indiqué ci-dessous:

– aux États-Unis, il est exigé de spécifier l'Annexe C;
– aux États Unis, l'Annexe E est exigée, le cas échéant;
– aux États-Unis, il est exigé de spécifier l'Annexe F.

Dans la présente norme, les caractères d'imprimerie suivants sont utilisés:

– *déclarations de conformité: caractères italiques*

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- remplacé par une édition révisée, ou
- amendé.

INTRODUCTION

Les protecteurs thermiques, définis comme des dispositifs non réarmables qui fonctionnent une seule fois sans réutilisation, sont largement employés pour la protection thermique des matériels dans lesquels, lors de conditions de défaut (anormales), une ou plusieurs parties peuvent atteindre des températures dangereuses.

Puisque ces dispositifs possèdent plusieurs points communs avec les éléments de remplacement (fusibles) miniatures et qu'ils sont utilisés pour obtenir un degré de protection comparable, l'effort s'est orienté, dans la présente norme, de façon à établir une série d'exigences de base pour de tels dispositifs.

PROTECTEURS THERMIQUES – EXIGENCES ET GUIDE D'APPLICATION

1 Domaine d'application

La présente Norme internationale s'applique aux protecteurs thermiques destinés à être incorporés dans les appareils électriques, le matériel électronique et ses composants, normalement utilisés en intérieur, afin de les protéger contre les températures excessives lors de conditions anormales.

NOTE 1 Le matériel n'est pas prévu pour produire de la chaleur.

NOTE 2 L'efficacité de la protection contre les températures excessives dépend logiquement de la position et du mode de montage du protecteur thermique ainsi que du courant qui le traverse.

Le présent document peut s'appliquer aux protecteurs thermiques utilisés dans d'autres conditions que celles qui sont réunies en intérieur, tant que les conditions climatiques ou autres de l'environnement immédiat de tels protecteurs thermiques sont comparables à celles de la présente norme.

Le présent document peut s'appliquer aux protecteurs thermiques dans leurs formes les plus simples (par exemple, lames ou fils de fusion), tant que les matériaux fondus expulsés pendant le fonctionnement ne peuvent pas compromettre l'utilisation en toute sécurité du matériel, en particulier dans le cas du matériel tenu à la main ou mobile, indépendamment de sa position.

L'Annexe H du présent document s'applique aux ensembles conditionnés de protecteurs thermiques où ces derniers sont déjà conformes à la présente norme, mais conditionnés dans un boîtier métallique ou non métallique et équipés de bornes/conducteurs à fils.

Le présent document s'applique aux protecteurs thermiques dont la tension assignée n'excède pas 690 V en courant alternatif ou en courant continu, et dont le courant assigné n'excède pas 63 A.

Les objectifs du présent document sont les suivants:

a) établir des exigences uniformes pour les protecteurs thermiques;

b) définir des méthodes d'essai; et

c) fournir des renseignements utiles pour l'utilisation des protecteurs thermiques dans les matériels.

Le présent document ne s'applique pas aux protecteurs thermiques utilisés dans des conditions extrêmes telles que des atmosphères corrosives ou explosives.

Le présent document ne s'applique pas aux protecteurs thermiques destinés à être utilisés dans des circuits en courant alternatif avec une fréquence inférieure à 45 Hz ou supérieure à 62 Hz.

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).

IEC 60065:2014, *Appareils audio, vidéo et appareils électroniques analogues – Exigences de sécurité*

IEC 60112:2020, *Méthode de détermination des indices de résistance et de tenue au cheminement des matériaux isolants solides*

IEC 60127-2:2014, *Coupe-circuit miniatures – Partie 2: Cartouches*

IEC 60216-5:2008, *Matériaux isolants électriques – Propriétés d'endurance thermique – Partie 5: Détermination de l'indice d'endurance thermique relatif (ITR) d'un matériau isolant*

IEC 60664-1:2020, *Coordination de l'isolement des matériels dans les réseaux d'énergie électrique à basse tension – Partie 1: Principes, exigences et essais*

IEC 60695-2-12:2021, *Essais relatifs aux risques du feu – Partie 2-12: Essais au fil incandescent/chauffant – Méthode d'essai d'indice d'inflammabilité au fil incandescent (GWFI) pour matériaux*

IEC 60695-2-13:2021, *Essais relatifs aux risques du feu – Partie 2-13: Essais au fil incandescent/chauffant – Méthode d'essai de température d'allumage au fil incandescent (GWIT) pour matériaux*

IEC 60695-10-2:2014, *Essais relatifs aux risques du feu – Partie 10-2: Chaleurs anormales – Essai à la bille*

IEC 60695-11-10:2013, *Essais relatifs aux risques du feu – Partie 11-10: Flammes d'essai – Méthodes d'essai horizontal et vertical à la flamme de 50 W*

IEC 60730-1:2013, *Dispositifs de commande électrique automatiques – Partie 1: Exigences générales*
IEC 60730-1:2013/AMD1:2015
IEC 60730-1:2013/AMD2:2020

IEC 61210:2010, *Dispositifs de connexion – Bornes plates à connexion rapide pour conducteurs électriques en cuivre – Exigences de sécurité*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions 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
distance d'isolement
distance la plus courte dans l'air entre deux parties conductrices

3.2
ligne de fuite
distance la plus courte le long de la surface d'un matériau isolant entre deux parties conductrices

3.3
température de maintien
T_h
température ambiante maximale du protecteur thermique pour laquelle, pendant une durée spécifiée et au courant assigné spécifié, l'état de conductibilité ne varie pas

3.4
série homogène
série de protecteurs thermiques, de dimensions externes identiques et de dimensions hors tout communes, dont chacun ne diffère de l'autre que par des caractéristiques (y compris les valeurs assignées) telles que, pour un essai donné, l'essai d'un ou d'un nombre réduit de protecteurs thermiques déterminés de la série doit être considéré comme représentatif de tous les protecteurs thermiques de la série

3.5
courant de coupure
I_b
valeur du courant que le protecteur thermique est capable de couper, sous tension assignée et suivant des caractéristiques spécifiées du circuit

3.6
température limite maximale
T_m
température du protecteur thermique, indiquée par le fabricant, jusqu'à laquelle les propriétés mécaniques et électriques du protecteur thermique, qui a changé son état de conductibilité, ne sont pas altérées pendant un temps donné

3.7
pilote de service
caractéristique assignée attribuée à un appareil de connexion qui commande la bobine d'un autre dispositif électromécanique, tel qu'un solénoïde, un relais ou un contacteur

3.8
matériel mobile
matériel qui est déplacé pendant son fonctionnement ou qui peut être facilement déplacé tout en restant relié au circuit d'alimentation

3.9
courant assigné
I_r
courant utilisé pour la classification d'un protecteur thermique

3.10
température assignée de fonctionnement
T_f
température de protecteur thermique qui change son état de conductibilité, avec détection de courant jusqu'à 10 mA comme seule charge

3.11
tension assignée
U_r
tension utilisée pour la classification d'un protecteur thermique

3.12
élément thermique
matériau fusible métallique ou non métallique qui fait partie d'un protecteur thermique et est sensible à la température par un changement d'état, par exemple solide à liquide, à la température pour laquelle il a été étalonné

3.13
protecteur thermique
dispositif non réarmable qui incorpore un élément thermique, qui ouvre un circuit une seule fois lorsqu'il est exposé, pendant une durée suffisamment longue, à une température qui excède celle pour laquelle il a été conçu

3.14
surcharge en courant pulsé
I_p
train d'impulsions de courant continu que le protecteur thermique est capable de supporter sans que ses caractéristiques en soient altérées

3.15
tenue de température étendue
$T_{h\text{-}100}$
température maximale qu'un protecteur thermique peut tolérer pendant une durée de 100 semaines lorsqu'il transporte le courant assigné à la tension assignée, sans provoquer l'ouverture du circuit conformément à l'évaluation de la tenue de température étendue

Note 1 à l'article: Il s'agit d'une caractéristique assignée prise en compte par l'utilisateur pendant l'étude du produit final.

Note 2 à l'article: L'Annexe D spécifie l'évaluation de la tenue de température étendue.

3.16
essai de vieillissement après exposition à la chaleur conductrice
CHAT
essai qui vise à évaluer l'aptitude d'un protecteur thermique à fonctionner dans un appareil

Note 1 à l'article: S'il fonctionne de façon satisfaisante, le protecteur thermique reçoit une caractéristique assignée CHAT. Cette caractéristique assignée est prise en compte par l'utilisateur pour le produit final pendant l'étude du produit pour utilisation finale.

Note 2 à l'article: L'Annexe C spécifie l'essai de vieillissement après exposition à la chaleur conductrice.

Note 3 à l'article: L'abréviation "CHAT" est dérivée du terme anglais développé correspondant "conductive heat ageing test".

4 Exigences générales

4.1 Une protection adéquate du matériel contre des températures excessives ne dépend pas seulement des propriétés du protecteur thermique, mais aussi en grande partie du montage du protecteur thermique dans le matériel. Par conséquent, les exigences du guide d'application de l'Annexe A doivent être prises en compte.

4.2 Les protecteurs thermiques doivent avoir une résistance électrique et mécanique adéquate et doivent être construits pour supporter toutes les conditions de manipulations qu'ils sont susceptibles de rencontrer durant le montage et l'utilisation normale, lorsqu'ils sont utilisés dans les limites des exigences du présent document.

4.3 Lorsqu'un protecteur thermique change d'état de conductibilité, aucun arc ni aucune flamme ne doit être entretenu(e), et aucun matériau susceptible de causer des dommages à son entourage immédiat ou de créer un risque de choc électrique ou de feu ne doit être expulsé. En outre, il ne doit se produire aucune émission de substances (par exemple gaz, liquides, poussières, brouillards, vapeurs) de nature à provoquer un danger.

Pour l'emploi de protecteurs thermiques sous forme de lames ou de fils de fusion, il convient de veiller à ce que le matériau fondu ne produise ni court-circuit ni pontage des lignes de fuite et distances d'isolement, afin de réduire les risques d'endommagement du système d'isolation du matériel.

Après avoir fonctionné, le protecteur thermique, s'il est soumis à des températures qui ne dépassent pas T_m, ne doit pas subir de dommages de nature à compromettre la sécurité du matériel en ce qui concerne les risques de danger de chocs électriques ou les risques de claquages électriques. Le protecteur thermique ne doit pas se réenclencher après fonctionnement.

4.4 Pour les exigences relatives aux ensembles conditionnés de protecteurs thermiques, voir l'Annexe H.

5 Conditions générales d'essais

5.1 Les conditions d'essai sont les suivantes.

5.1.1 Sauf spécification contraire, seuls les essais qu'il n'est pas nécessaire d'effectuer dans une chambre climatique et/ou une étuve d'essai doivent être effectués dans les conditions atmosphériques suivantes:

– température: 15 °C à 35 °C;

– humidité relative: 25 % à 75 %;

– pression de l'air: 8,6 × 10^4 Pa à 1,06 × 10^5 Pa.

Les conditions atmosphériques exigées pendant les essais peuvent être commandées lors des essais et pendant la durée des essais. Les conditions atmosphériques exigées ne doivent pas nécessairement être maintenues dans un laboratoire d'essai en dehors des moments où les essais sont effectués.

5.1.2 Lorsque les conditions indiquées en 5.1.1 ont une influence significative, elles doivent être maintenues presque constantes pendant les essais.

5.1.3 Si les limites de température indiquées en 5.1.1 sont trop larges pour certains essais, ces essais doivent être à nouveau effectués, en cas de doute, à une température de (23 ± 1) °C.

5.2 Dans chaque rapport d'essai, la température ambiante doit être indiquée. Si les conditions normalisées d'humidité relative ou de pression ne sont pas remplies au cours des essais, une note à ce sujet doit être ajoutée dans le rapport.

5.3 Si le résultat d'un essai dépend de façon appréciable de la position ou du mode de montage de l'échantillon, la condition la plus défavorable doit être retenue pour les essais en question et notée.

5.4 Si un protecteur thermique a été spécialement conçu pour être utilisé dans un type particulier de matériel et ne peut pas être soumis à l'essai séparément, les essais de la présente norme doivent être effectués dans ce matériel ou dans la partie correspondante, ou dans un matériel ou une partie analogue.

5.5 En cas d'essais d'une série homogène de protecteurs thermiques, tous les essais doivent être réalisés sur les protecteurs thermiques avec la T_f la plus basse et la plus élevée. Pour les protecteurs thermiques avec des températures assignées de fonctionnement intermédiaires, seuls les essais décrits en 10.3, 11.3, 11.4 et 11.5 sont nécessaires.

5.6 Le nombre d'échantillons présente les caractéristiques suivantes.

5.6.1 Le nombre total d'échantillons nécessaires est de 48. 15 échantillons, sur un total de 48, sont conservés dans l'éventualité où certains essais doivent être répétés. 33 échantillons, sur un total de 48, sont divisés en 11 groupes auxquels sont assignées des lettres alphabétiques de A à K. Chaque groupe comprend trois échantillons. Les essais doivent être réalisés dans l'ordre indiqué dans le Tableau 1, mais, si cela est exigé, certains essais peuvent être répétés, par exemple l'essai sur le marquage (voir Article 7). Des échantillons supplémentaires peuvent être nécessaires selon l'exigence du Tableau 1.

Pour les essais facultatifs, il convient d'exiger des échantillons supplémentaires selon les annexes correspondantes.

5.6.2 Si un défaut est constaté au cours de l'un des essais effectués selon un article d'essai approprié, la cause du défaut est identifiée et une mesure de correction est prise. À partir du rapport d'analyse de défaut et de la mesure de correction, la séquence d'essai doit être répétée au moins sur le double du nombre d'échantillons révisés et aucun autre défaut n'est admis.

Si aucune mesure de correction n'est nécessaire, il convient de répéter l'essai avec le double de la taille et aucun autre écart n'est admis.

5.6.3 Pour les exigences relatives aux ensembles conditionnés de protecteurs thermiques, voir l'Annexe H.

5.7 L'essai de vieillissement après exposition à la chaleur conductrice de l'Annexe C s'applique quand cela est indiqué par le fabricant.

L'essai de vieillissement après exposition à la chaleur conductrice peut ne pas être effectué si le protecteur thermique est fabriqué sans contacts.

NOTE Aux États-Unis, l'essai de vieillissement après exposition à la chaleur conductrice doit être spécifié.

Tableau 1 – Programme d'essai

Article ou paragraphe	Essai	Groupes d'échantillons										
		A	B	C	D	E	F	G	H	I	J	K
7 [a]	Marquage (essai de frottement)	X	X									
7 [a]	Marquage (examen visuel seulement)	X	X									
9	**Exigences de construction**											
9.2.2 [a]	Efforts de traction	X										
9.2.3 [a]	Effort de poussée		X									
9.2.4 [a]	Effort de torsion			X								
9.6 [a]	Résistance au cheminement											X
9.7 [a]	Lignes de fuite et distances d'isolement						X	X				
9.8	Cycle de conditionnement en température et en humidité	X	X	X			X	X				
10	**Exigences d'ordre électrique**											
10.1	Rigidité diélectrique (si applicable)	X	X	X			X	X				
10.2	Résistance d'isolement (si applicable)	X	X	X			X	X				
10.3	Courant de coupure						X	X				
10.4	Surcharge en courant pulsé	X	X						X			
11	**Essais de températures**											
11.2	Contrôle de T_h [b]											X
11.3	Contrôle de T_f	X		X								
11.4	Contrôle de T_m suivi par l'essai diélectrique et l'essai de résistance d'isolement			X	X							
11.5	Vieillissement phase 1 (facultative) 21 jours phase 2 (obligatoire) 21 jours phase 3 (obligatoire) 14 jours phase 4 (obligatoire) 7 jours phase 5 (obligatoire) 7 jours phase 6 (obligatoire) 24 heures		X			X			X	X	X	
10.1	Rigidité diélectrique	X	X			X	X	X	X	X	X	
10.2	Résistance d'isolement	X	X			X	X	X	X	X	X	
12	**Protection contre la rouille**											
12 [a]	Protection contre la rouille (parties en métaux ferreux)	X	X	X								

Si les conditions de tension, de puissance et de courant indiquées en 10.3.2.3, 10.3.2.4 et 10.3.2.5 ne sont pas couvertes par un essai, il convient de soumettre à l'essai un minimum de trois échantillons pour chaque condition.

[a] En cas de série homogène, ces essais peuvent ne pas être effectués pour les valeurs assignées intermédiaires.

[b] Lorsque cela est indiqué par le fabricant.

6 Classification

6.1 Conditions électriques

En ce qui concerne les conditions électriques, les termes suivants s'appliquent:

a) Tension: courant alternatif et/ou continu

b) Courant: courant alternatif et/ou continu

c) Charge résistive

d) Charge inductive

e) Charge de moteur

f) Charge de pilote de service

g) Charge de lampe électrique à décharge

h) Charge spéciale

6.2 Conditions thermiques

En ce qui concerne les conditions thermiques, les symboles et les abréviations suivants s'appliquent:

a) T_f

b) T_h

c) T_m

d) CHAT

e) $T_{h\text{-}100}$

6.3 Résistance au cheminement

En ce qui concerne la résistance au cheminement, les plages de valeurs suivantes s'appliquent:

a) indice de tenue au cheminement de 175 à 249;

b) indice de tenue au cheminement supérieur ou égal à 250.

NOTE Ces plages de valeurs sont fondées sur les méthodes d'essai de cheminement de surface indiquées dans l'IEC 60112.

7 Marquage

7.1 Chaque protecteur thermique doit porter les indications suivantes:

a) le type ou la référence de catalogue;

b) le nom du fabricant ou la marque commerciale;

c) la température assignée de fonctionnement T_f avec ou sans le symbole T_f suivie du nombre de degrés Celsius (suivi de °C ou C);

d) un code de date qui identifie la date de fabrication et qui ne se répète pas pendant au moins 10 ans, et un lieu de fabrication ou un code, apposé sur le protecteur thermique ou sur le plus petit conditionnement.

S'il n'y a qu'une seule usine, le lieu de fabrication peut être omis.

Il convient que les numéros de référence ou de catalogue définissent les caractéristiques de température, courant et tension qui, ensemble, classifient un protecteur thermique.

7.2 La température assignée de fonctionnement T_f peut être omise si un type différent ou une référence de catalogue différente est utilisé(e) pour chaque température de fonctionnement différente.

7.3 Le marquage doit être indélébile et lisible.

La conformité aux exigences d'indélébilité du marquage est vérifiée par l'essai de l'Annexe G en utilisant l'appareil représenté à la Figure G.1. La lisibilité est vérifiée par examen. Après les essais de vieillissement décrits en 11.4, la conformité est vérifiée par examen.

7.4 Les indications selon a), b), c) et d) en 7.1 doivent également figurer sur les conditionnements, avec une référence au présent document.

7.5 Si le protecteur thermique est de petite taille, et s'il n'est pas destiné à être remplacé, seul l'élément a) en 7.1 doit figurer sur le protecteur thermique, et les indications selon b) à d) en 7.1 doivent figurer sur le conditionnement, avec une référence au présent document.

La conformité est vérifiée par examen.

8 Documentation

Le fabricant doit fournir dans la documentation technique, les catalogues ou les notices d'emploi les renseignements qui suivent, et qui viennent s'ajouter à ceux qui sont exigés à l'Article 7:

a) la classification selon l'Article 6;

b) pour chacune des classifications:

   1) les températures caractéristiques T_f, T_h (si elles sont déclarées par le fabricant), T_m;

   2) les courants caractéristiques I_r, I_b, I_p;

   3) la tension assignée U_r;

c) l'aptitude au scellement, ou le comportement avec les liquides d'imprégnation ou les solvants de nettoyage;

d) les indications de montage du protecteur thermique dans le matériel;

e) s'il s'agit de protecteurs thermiques de petite taille et non destinés à être remplacés;

Pour des raisons de sécurité, il convient qu'il apparaisse clairement dans la documentation qu'un protecteur thermique n'est pas un produit réparable et qu'en cas de remplacement, il convient d'utiliser un protecteur thermique équivalent du même fabricant et avec la même référence du catalogue, monté exactement de la même façon.

f) la position de l'écran métallique, s'il est situé à une distance différente de 12,7 mm des parties actives dans le cas d'un protecteur thermique qui a un élément exposé;

g) des instructions d'application concernant le montage du dispositif dans le matériel, pour les protecteurs thermiques dont les conducteurs ont une section inférieure à 0,21 mm^2.

   Il convient de prendre en considération la réponse en température du dispositif.

9 Exigences de construction

9.1 Généralités

9.1.1 Les protecteurs thermiques doivent avoir une stabilité et une résistance mécanique suffisantes pour supporter les contraintes qu'ils sont susceptibles de rencontrer lors de manipulations et dans des conditions d'utilisation normale et de défaut du matériel d'utilisation finale correspondant.

9.1.2 Les bornes à languettes doivent être construites conformément à l'IEC 61210 et la température maximale admissible des matériaux des languettes utilisées doit être conforme aux indications du Tableau A.1 de l'IEC 61210:2010 (Languettes/Intégrées).

9.1.3 Les parties conductrices doivent être construites de telle sorte que la pression du contact ne soit pas transmise au travers d'un matériau non métallique autre que la céramique ou de tout matériau considéré comme étant de dimensions assez stables dans toute la plage des températures attendues, à moins que les parties métalliques correspondantes ne présentent une élasticité suffisante pour compenser toute rétraction ou distorsion du matériau non métallique.

Les parties conductrices doivent avoir la résistance mécanique nécessaire, être capables de transporter le courant assigné, et doivent être d'un matériau acceptable pour cette application particulière.

Pour les parties conductrices, les limites de température du Tableau 13 de l'IEC 60730-1:2013 doivent être prises en compte.

9.1.4 Le frottement ne doit pas être utilisé pour fixer des parties actives non isolées (y compris les bornes) aux surfaces de support s'il y a un risque de rotation ou de déplacement de telles parties, réduisant les lignes de fuite et les distances d'isolement à des valeurs inférieures à celles exigées par ailleurs dans la présente norme. La sécurité des ensembles de contacts doit être telle que l'alignement des contacts soit maintenu.

9.1.5 Les conducteurs et les bornes doivent être fixés de façon telle qu'aucune contrainte pendant leur installation et leur utilisation normale n'altère le fonctionnement du protecteur thermique. Les protecteurs thermiques qui utilisent des joints avec des conducteurs formés pour une utilisation dans des appareils ou des composants ne doivent pas être pliés à moins de 3 mm du joint du protecteur thermique.

Les conducteurs peuvent être pliés à moins de 3 mm du joint si:

a) la méthode et la procédure de pliage du fabricant du protecteur thermique ne transmettent pas de contrainte au mécanisme de fonctionnement du protecteur thermique; et

b) les échantillons d'essai formés doivent être soumis à l'essai de fixation par torsion du conducteur du 9.2.4 et à l'essai de température assignée de fonctionnement du 11.3.

9.1.6 Des instructions d'application doivent être fournies pour les protecteurs thermiques dont les conducteurs ont une section inférieure à 0,21 mm^2 afin d'informer l'utilisateur de la façon de monter le dispositif dans le matériel, en prenant en considération la réponse en température du dispositif. Ces instructions doivent également contenir des recommandations concernant les effets que les mouvements et les vibrations du matériel peuvent avoir sur les bornes, les connexions et les autres moyens de montage du protecteur thermique.

9.1.7 Les bornes pour connexions soudées doivent disposer de moyens, par exemple un trou, pour maintenir le conducteur indépendamment de la soudure.

9.1.8 Le cas échéant, des moyens doivent être prévus pour le montage fixe d'un protecteur thermique en position.

9.1.9 Il n'est pas nécessaire de prévoir des moyens de montage pour les protecteurs thermiques destinés à être installés dans des enroulements et analogues.

9.1.10 Les boulons, vis ou autres pièces utilisées pour monter un ensemble avec un protecteur thermique doivent être indépendants de ceux utilisés pour fixer les composants de l'ensemble.

9.1.11 *La conformité est vérifiée par les essais de fixation des conducteurs décrits en 9.2. Les instructions de montage et de fixation doivent être données avec les protecteurs thermiques pour le fabricant du produit final selon l'Annexe A.*

9.2 Essais de fixation des conducteurs

9.2.1 Généralités

Si l'effort appliqué au fil conducteur du protecteur thermique entraîne une contrainte appliquée au mécanisme de fonctionnement directement ou indirectement en raison de la rupture d'une ou de plusieurs pièces, les essais décrits en 9.2.2, 9.2.3 et 9.2.4 doivent être effectués. Il ne doit pas y avoir de déplacement de parties qui tend à réenclencher un protecteur thermique ou à réduire les lignes de fuite ou les distances d'isolement à l'issue des essais spécifiés en 9.2.2 et 9.2.3. Il ne doit pas y avoir de déplacement de parties autres que le fil conducteur à l'issue de l'essai spécifié en 9.2.4.

9.2.2 Essai d'effort de traction

Le protecteur thermique doit être fixé de manière appropriée pour ne pas l'endommager et un effort de traction spécifié dans le Tableau 2 doit être appliqué à chaque conducteur pendant 1 min.

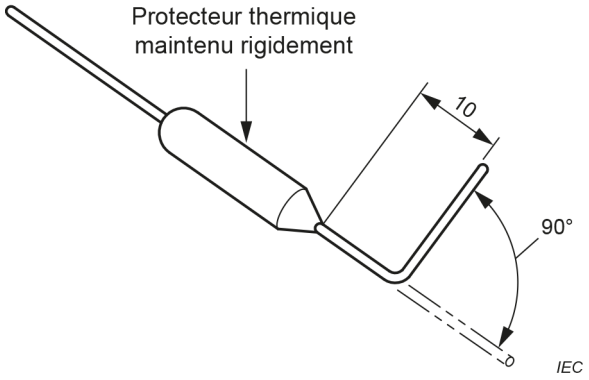
9.2.3 Essai d'effort de poussée

Le protecteur thermique doit être fixé en utilisant tout moyen approprié pour ne pas l'endommager et un effort de poussée spécifié dans le Tableau 2 doit être appliqué à chaque conducteur pendant 1 min à une distance de 2 mm du protecteur thermique.

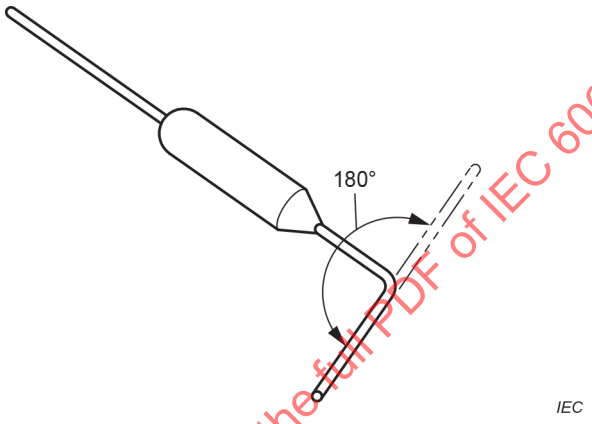
9.2.4 Essai de torsion

Le protecteur thermique doit être fixé fermement de façon telle qu'il ne soit pas endommagé. Chaque conducteur doit être plié à 90° à 10 mm du corps du protecteur thermique puis retourné de 180° comme cela est représenté à la Figure 1.

Dimensions en millimètres



Étape 1: Pliage



Étape 2: Torsion

Figure 1 – Essai de torsion

Tableau 2 – Résistance des conducteurs et des bornes de raccordement – Valeurs minimales exigées pour les essais d'efforts de traction et de poussée

Section nominale du conducteur, A, mm^2	Effort de traction N	Effort de poussée N
Jusqu'à 0,05 inclus	1	0,25
Au-dessus de 0,05 et jusqu'à 1,2 inclus	20 × A	5 × A
Au-dessus de 1,2	40	8
NOTE A est la section nominale de la borne en mm^2.		

9.3 Contacts utilisés pour le passage du courant

Les contacts utilisés pour le passage du courant dans un protecteur thermique doivent supporter la contrainte de tension produite par la source d'alimentation du circuit. Les parties conductrices ou les contacts, ainsi que leurs bornes, sont généralement isolés des parties métalliques telles que les supports de montage, les enveloppes métalliques ou les éléments analogues par un matériau isolant.

La conformité est vérifiée par les essais du présent document.

9.4 Supports de montage ou parties métalliques accessibles

Si les supports de montage ou les parties métalliques de l'enveloppe du protecteur thermique sont accessibles ou reliés par de faibles impédances à l'enveloppe métallique du matériel, accessible de l'extérieur à l'utilisateur, l'isolement entre les parties conductrices du protecteur thermique et l'enveloppe conductrice doit être approprié dans les conditions spécifiées de température ambiante et d'humidité.

La conformité est vérifiée par l'essai décrit en 10.1.

9.5 Matériau isolant

9.5.1 Les matériaux isolants utilisés dans la construction des protecteurs thermiques sont vérifiés par les essais du présent document.

9.5.2 Les exigences applicables aux matériaux isolants utilisés dans les ensembles conditionnés de protecteurs thermiques sont indiquées à l'Annexe H.

9.6 Résistance au cheminement

9.6.1 Si le matériau isolant utilisé pour le support des parties conductrices, des contacts et des bornes est exposé, au cours d'une utilisation normale, à la formation d'humidité ou de poussière, il doit résister au cheminement.

9.6.2 Pour un matériau autre que la céramique, la conformité est vérifiée en réalisant un essai de résistance au cheminement conformément à l'IEC 60112 sur des échantillons ou des éprouvettes plates de matériau isolant équivalent. Les valeurs de l'indice de tenue au cheminement (ITC) doivent être fixées par le fabricant, mais ne doivent pas être inférieures à 175 V.

9.7 Lignes de fuite et distances d'isolement

9.7.1 Les distances d'isolement et les lignes de fuite entre les parties conductrices (des contacts et de leurs bornes) et l'extérieur du boîtier du protecteur thermique, y compris les parties métalliques isolées des parties conductrices, ne doivent pas être inférieures aux valeurs du Tableau 3. Les valeurs indiquées sont des valeurs minimales absolues qui incluent les tolérances de fabrication.

L'attention est attirée sur le fait qu'il est admis que les lignes de fuite et les distances d'isolement extérieures spécifiées dans le Tableau 3 soient, dans quelques cas, inférieures à celles exigées par les normes de certains appareils ou matériels. Dans de tels cas, il convient de prévoir des moyens supplémentaires lorsqu'un protecteur thermique est monté dans le matériel de façon à ajuster les lignes de fuite et les distances d'isolement aux valeurs exigées par la norme du matériel concerné.

9.7.2 Ces distances ne s'appliquent pas entre les contacts ouverts du protecteur thermique.

La conformité est vérifiée en mesurant les distances concernées.

Tableau 3 – Lignes de fuite et distances d'isolement (valeurs minimales absolues)

Tension assignée, U_r V	Distances d'isolement mm	Lignes de fuite mm
0 à 32	0,2	0,53
33 à 50	0,2	1,2
51 à 125	0,5	1,5
126 à 250	1,5	2,5
251 à 400	3,0	4,0
401 à 690	4,0	6,9

Si les conditions diffèrent de celles spécifiées à la Note 2, il est nécessaire de régler les distances d'isolement/lignes de fuite conformément à l'IEC 60664-1.

NOTE 1 Les distances d'isolement/lignes de fuite sont spécifiées conformément à l'IEC 60664-1.

NOTE 2 Les valeurs spécifiées concernent les applications types des protecteurs thermiques selon les conditions suivantes:

a) contrainte continue de tension;

b) altitude inférieure ou égale à 2 000 m;

c) isolation principale;

d) champ non homogène;

e) catégorie de surtension II;

f) degré de pollution 2;

g) groupe de matériaux III.

9.8 Cycle de conditionnement en température et en humidité

9.8.1 Les protecteurs thermiques ne doivent pas être détériorés par l'humidité présente dans les conditions ambiantes pour lesquelles ils sont prévus.

9.8.2 Pour le cycle de conditionnement en température et en humidité, les échantillons de protecteur thermique doivent être soumis à trois cycles complets de conditionnement. Chaque cycle doit consister en 24 h à T_f -15°C suivies immédiatement (en l'espace de 15 min) par au moins 24 h à (35 ± 5) °C et (90 ± 5) % d'humidité relative, suivies par 8 h à (0 ± 2) °C.

9.8.3 *La conformité est vérifiée en soumettant les échantillons aux essais de rigidité diélectrique (voir 10.1) et de résistance d'isolement (voir 10.2) du présent document.*

NOTE 1 Pour un protecteur thermique avec un corps de coffret non conducteur, les essais de rigidité diélectrique et de résistance d'isolement sont effectués après avoir retiré les échantillons de la chambre de conditionnement.

NOTE 2 Pour un protecteur thermique avec un corps de coffret conducteur, l'essai de résistance d'isolement est effectué entre les bornes après avoir retiré les échantillons de la chambre de conditionnement.

9.9 Bornes et raccordements

9.9.1 Les bornes et raccordements (conducteurs) utilisés dans la construction des protecteurs thermiques sont vérifiés par les essais du présent document.

9.9.2 Les exigences applicables aux bornes et raccordements utilisés dans les ensembles conditionnés de protecteurs thermiques sont indiquées à l'Annexe H.

10 Exigences d'ordre électrique

10.1 Rigidité diélectrique

10.1.1 La rigidité diélectrique des protecteurs thermiques doit être suffisante, à la fois avant et après leur fonctionnement, et également après les essais du 9.8.

Le cas échéant, l'essai est effectué entre:

i) les parties conductrices et l'enveloppe (enroulée dans une feuille métallique), ou

ii) les parties conductrices et les parties métalliques isolées exposées.

10.1.2 *La conformité est vérifiée en appliquant les tensions d'essai appropriées entre les circuits concernés spécifiés dans le Tableau 4, immédiatement après les essais du 9.8, le cas échéant, et aussi après les essais de température de l'Article 11.*

Tableau 4 – Tensions d'essai pour la rigidité diélectrique

Entre	Tension d'essai
les parties conductrices et l'enveloppe (enroulée dans une feuille métallique, le cas échéant)	2 U_r + 1 000 V
ou	
les parties conductrices et les parties métalliques isolées exposées	2 U_r + 1 000 V
les bornes de contacts (entre les contacts ouverts)	2 U_r

10.1.3 Pour cet essai, il est exigé d'utiliser un transformateur dont la puissance est au moins de 100 VA.

10.1.4 L'isolant est soumis à une tension d'essai pratiquement sinusoïdale de fréquence comprise entre 45 Hz et 62 Hz.

10.1.5 Au début de l'essai, une tension qui ne dépasse pas la moitié de la tension indiquée est appliquée. La tension est ensuite augmentée à une vitesse d'environ 500 V/s jusqu'à la pleine valeur.

10.1.6 Aussitôt après l'épreuve d'humidité, l'enveloppe doit être enroulée dans une feuille métallique et la tension d'essai doit être appliquée pendant 1 min entre les contacts ouverts, et entre les parties conductrices et la feuille métallique.

10.1.7 Les échantillons sont jugés conformes aux exigences s'il ne se produit aucun contournement ni claquage.

10.2 Résistance d'isolement

10.2.1 La résistance d'isolement des protecteurs thermiques doit être suffisante à la fois avant et après leur changement d'état de conductibilité, et également les essais appropriés du 9.8.

Le cas échéant, l'essai est effectué entre:

i) les parties conductrices et l'enveloppe (enroulée dans une feuille métallique), ou

ii) les parties conductrices et les parties métalliques isolées exposées.