



IEC 60691

Edition 5.1 2024-10
CONSOLIDATED VERSION

INTERNATIONAL STANDARD



Thermal-links – Requirements and application guide





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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

THERMAL-LINKS – REQUIREMENTS AND APPLICATION GUIDE

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 60691 edition 5.1 contains the fifth edition (2023-03) [documents 32C/604/FDIS and 32C/605/RVD] and its amendment 1 (2024-10) [documents 32C/645/FDIS and 32C/648/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

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The harmonization of the USA national standard, UL 1020, fifth edition (withdrawn 2003), and IEC 60691:1993, together with its Amendment 1:1995 and Amendment 2:2000 have served as a basis for the elaboration of this standard.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

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- *compliance statements: in italic type.*

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- revised.

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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 60112:2020, *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-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: $8,6 \times 10^4$ Pa to $1,06 \times 10^5$ 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_n^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-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 thermal-links with leads cross sectional area smaller than 0,21 mm².

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 mm² 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.

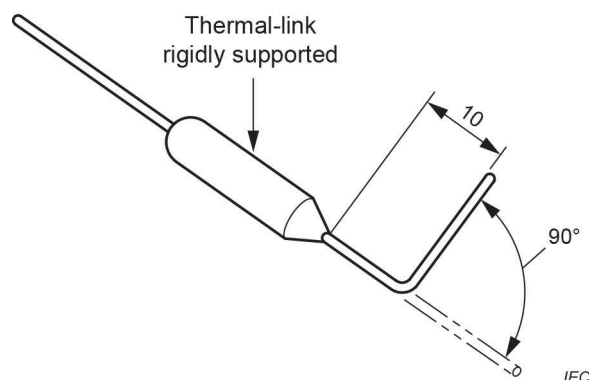
9.2.3 Thrust test

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.

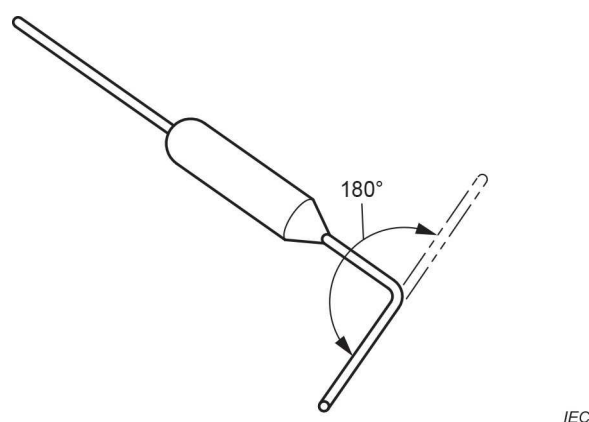
9.2.4 Bending/twist test

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	$20 \times A$	$5 \times A$
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 $T_f - 15^\circ\text{C}$ followed immediately (within 15 min) by at least 24 h at $(35 \pm 5)^\circ\text{C}$ and $(90 \pm 5)\%$ relative humidity, followed by 8 h at $(0 \pm 2)^\circ\text{C}$.

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)	$2 U_r + 1\,000\text{ V}$
or	
current carrying parts and insulated exposed metal parts	$2 U_r + 1\,000\text{ V}$
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	-	$t < 1 \text{ ms}$
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	-	$t \geq 2 \text{ ms to } 5 \text{ ms}$
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	$t \leq c$
^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 $\pm 2,5$ % 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:

- $\pm 0,5$ % 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-5}^0 °C for a period of 10 min.

11.4.2 With the 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 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.*