BS EN 60691:2016

BSI Standards Publication

Thermal-links — Requirements and application guide (IEC 60691:2015 + COR1:2016)

bsi.

National foreword

This British Standard is the UK implementation of EN 60691:2016. It is identical to IEC 60691:2015, incorporating corrigendum August 2016. It supersedes BS EN 60691:2003+A2:2010 which will be withdrawn on 7 October 2019.

The UK participation in its preparation was entrusted to Technical Committee PEL/32, Fuses.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2016

ISBN 978 0 580 80761 9

ICS 29.120.50

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

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2016.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 60691

October 2016

ICS 29.120.50

English Version

Thermal-links - Requirements and application guide (IEC 60691:2015 + COR1:2016)

Protecteurs thermiques - Exigences et guide d'application (IEC 60691:2015 + COR1:2016)

Temperatursicherungen - Anforderungen und Anwendungshinweise (IEC 60691:2015 + COR1:2016)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

European foreword

The text of document 32C/512/FDIS, future edition 4 of IEC 60691, prepared by SC 32C "Miniature fuses", of IEC/TC 32 "Fuses" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60691:2016.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2017-04-07
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2019-10-07

This document supersedes EN 60691:2003.

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Endorsement notice

The text of the International Standard IEC 60691:2015 + COR1:2016 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60085:2007	NOTE	Harmonized as EN 60085:2008 (not modified).
IEC 60695-10-3:2002	NOTE	Harmonized as EN 60695-10-3:2002 (not modified).
IEC 60695-11-20:1999/A1:2003	NOTE	Harmonized as EN 60695-11-20:1999/A1:2003 (not modified).
IEC 60127-1:2006/A1:2011	NOTE	Harmonized as EN 60127-1:2006/A1:2011 (not modified).
IEC 60216-1:2013	NOTE	Harmonized as EN 60216-1:2013 (not modified).
IEC 60695-2-11:2014	NOTE	Harmonized as EN 60695-2-11:2014 (not modified).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60065 (mod)	2014	Audio, video and similar electronic apparatus - Safety requirements	EN 60065	2014
IEC 60112	2003	Method for the determination of the proof and the comparative tracking indices of solid insulating materials	EN 60112	2003
+ A1	2009		+ A1	2009
IEC 60127-2	2014	Miniature fuses - Part 2: Cartridge fuse-links	EN 60127-2	2014
IEC 60216-5	2008	Electrical insulating materials - Thermal endurance properties - Part 5: Determination of relative thermal endurance index (RTE) of an insulating material	EN 60216-5	2008
IEC 60664-1	2007	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests	EN 60664-1	2007
IEC 60695-2-12	2010	Fire hazard testing - Part 2-12: Glowing/hot-wire based test methods - Glow-wire flammability index (GWFI) test method for materials	EN 60695-2-12	2010
+ A1	2014		+ A1	2014
IEC 60695-2-13	2010	Fire hazard testing - Part 2-13: Glowing/hot-wire based test methods - Glow-wire ignition temperature (GWIT) test method for materials	EN 60695-2-13	2010
+ A1	2014		+ A1	2014
IEC 60695-10-2	2014	Fire hazard testing - Part 10-2: Abnormal heat - Ball pressure test method	EN 60695-10-2	2014

Publication	Year	Title	EN/HD	Year
IEC 60695-11-10	2013	Fire hazard testing - Part 11-10: Test flames - 50 W horizontal and vertical flame test methods	EN 60695-11-10	2013
IEC 60730-1 (mod)	2013	Automatic electrical controls - Part 1: General requirements	EN 60730-1	2016
IEC 61210 (mod)	2010	Connecting devices - Flat quick-connect terminations for electrical copper conductors - Safety requirements	EN 61210	2010

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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THERMAL-LINKS – REQUIREMENTS AND APPLICATION GUIDE

FOREWORD

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International Standard IEC 60691 has been prepared by subcommittee 32C: Miniature fuses, of IEC technical committee 32: Fuses.

This fourth edition cancels and replaces the third edition published in 2002, Amendment 1: 2006 and Amendment 2: 2010. This fourth edition constitutes a technical revision.

This fourth 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;

c) change starting temperature for interrupt current test;

d) clarify requirements for marking (packing label);

e) minimum Proof Tracking Index 175 instead 120.

The text of this standard is based on the following documents:

FDIS	Report on voting
32C/512/FDIS	32C/515/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The basis for this standard is 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.

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 publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication 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 standard 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 standard 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 standard 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 standard is applicable to thermal-links with a rated voltage not exceeding 690 V a.c. or d.c. and a rated current not exceeding 63 A.

The objectives of this standard are:

a) to establish uniform requirements for thermal-links,

b) to define methods of test,

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

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

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

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60112:2003, *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, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60695-2-12:2010, *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, *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 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.

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 temperature of the thermal-link at which it will not change its state of conductivity during a specified time at the 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

3.16
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.

3.17
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 standard.

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.

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 samples may be needed according to Note 2 of Table 1.

For optional tests, additional samples 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											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 should be tested for each condition.												
[a] For homogeneous series, these tests may be omitted for intermediate ratings.												

6 Classification

6.1 Electrical conditions

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

a) voltage

1) AC

2) DC

b) current

1) resistive

2) inductive

c) motor

d) pilot duty

e) electric discharge lamp

f) special

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 standard.

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

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, 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.

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 should 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 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.

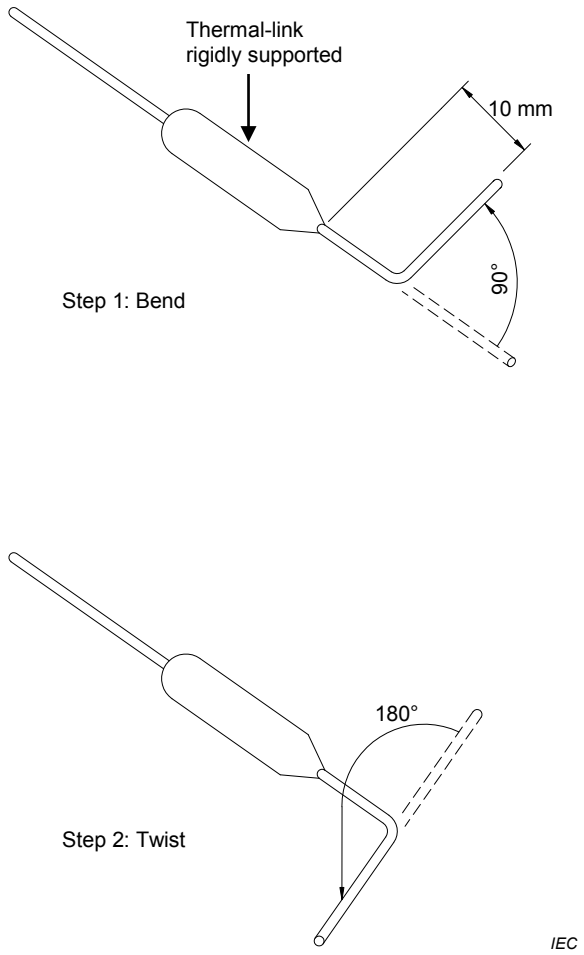


Figure 1 – Bending/twist test

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

Nominal cross-sectional area of the lead, A_T 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.

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.

9.5 Insulating materials

For requirements for thermal-link packaged assemblies, see 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 shall be subjected to three complete conditioning cycles. Each cycle shall consist of 24 h at T_h 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 standard.*

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 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 from the conditioning chamber.

9.9 Terminals and terminations

For requirements for thermal-link packaged assemblies, see 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 d.c. 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 to 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 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
Resistive	AC amperes	1,5 times rated current	0,95 to 1,0
	DC amperes	1,5 times rated current	–
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	–
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]

[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).

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 when the element 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 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* $\pm$ *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 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. 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 standard*.

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 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 – 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.

11.2 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.*

11.2.3 For 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 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 samples 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 samples 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.

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 9.18. 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 standard.*

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 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 a.c. and/or d.c. in the case of a resistive or motor load, or with a.c. 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 standard, 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 shall be subjected to the test. Each of three groups consisting of ten sample 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 to 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 may be tested on one test fixture assembly. Multiple test fixtures may be used with the samples 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 a.c. or 230 V a.c.

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 a.c. 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 have been brought to room temperature.

Dimensions in inches and (millimetres)

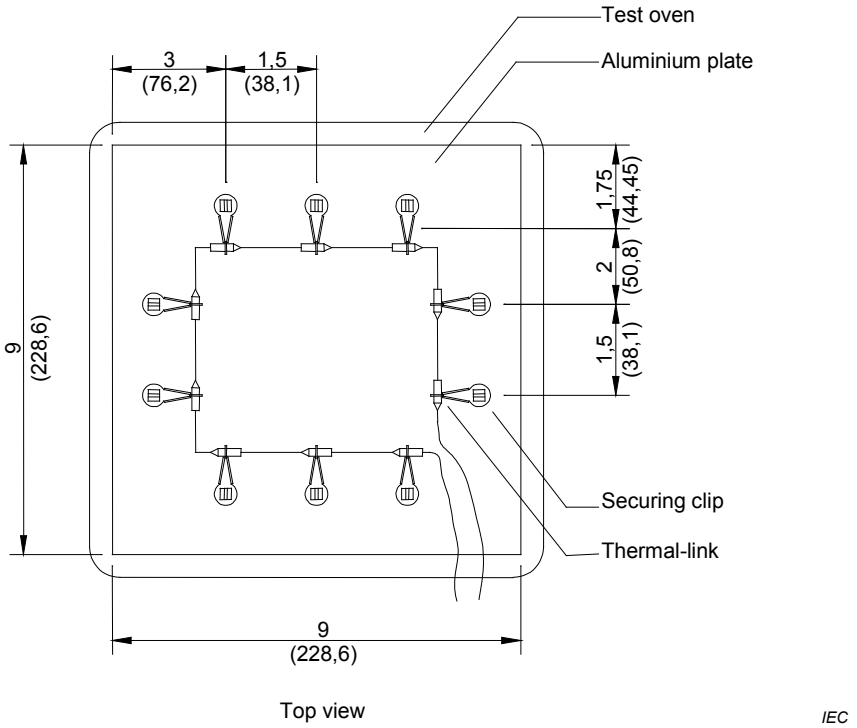


Figure C.1 – Typical test fixture assembly

C.6 Test oven

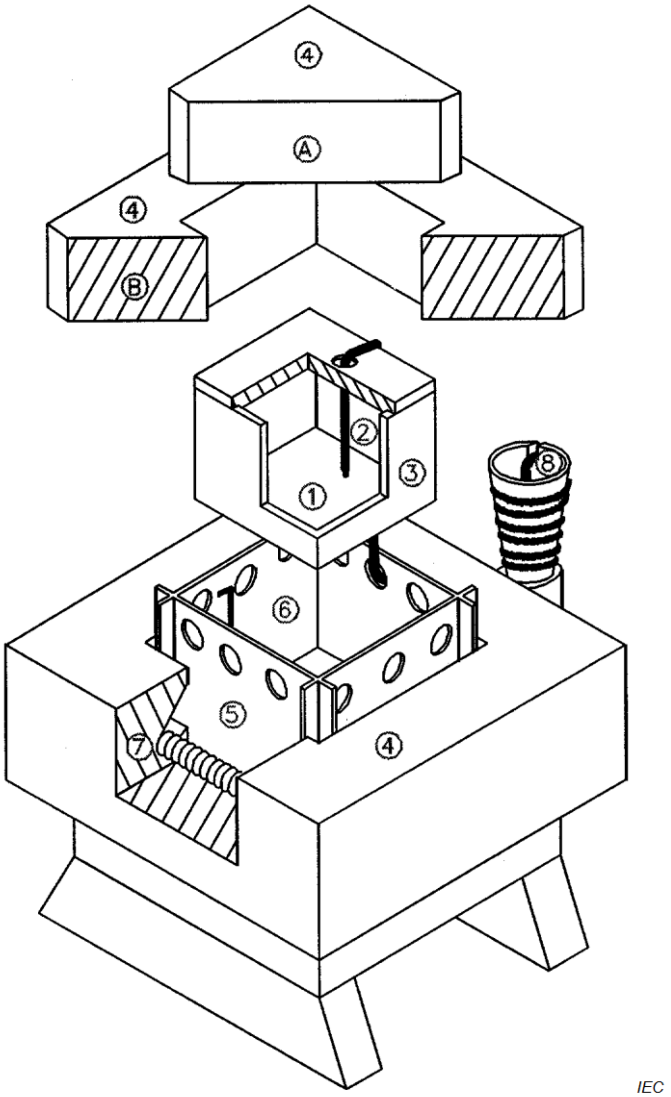
The test apparatus shall consist of an electrically heated, static-air oven. A typical example of such an oven is shown in Figure C.2. The oven shall be located in a room free of draughts and the ambient temperature shall be maintained reasonably constant during the test.

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 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 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.

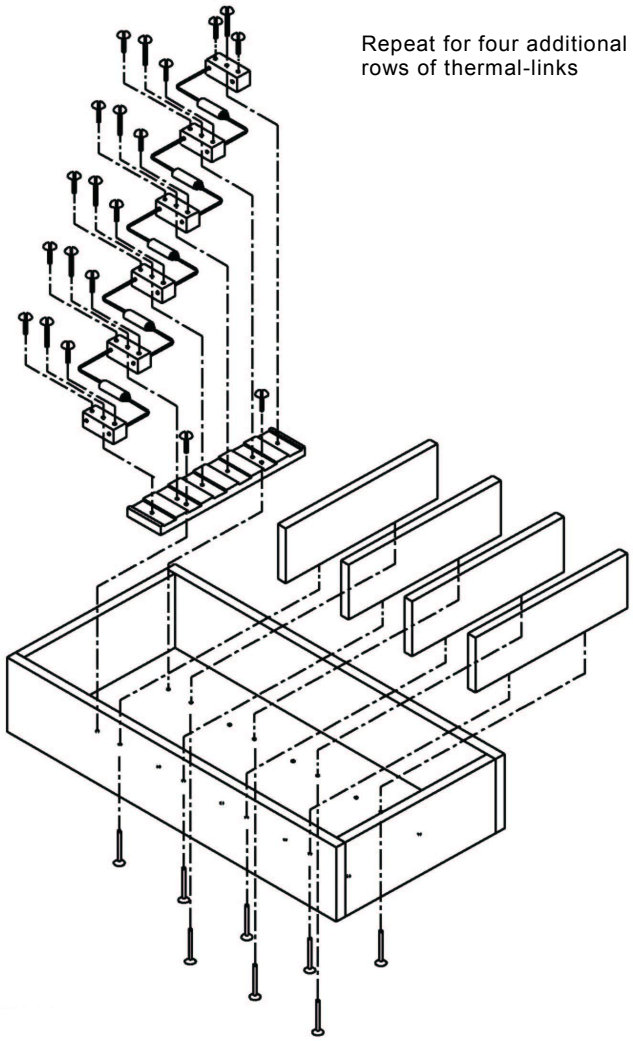
D.1.3 The temperature tolerances maintained for the samples shall be $^{0}_{-10}$ K for all 25 samples during the first two weeks of conditioning and ±10 % of the $T_{\text{h-100}}$ value (stated in °C) for at least 20 of the 25 samples for the reminder of the test time.

D.1.4 All samples 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 shall be subjected to the load current interrupt test of Clause D.2. The remaining two samples shall be subjected to the rated functioning temperature test of 11.3.

D.2 Load current interrupt test

D.2.1 The samples shall be placed in a test oven that has been stabilized at 10 K below the rated functioning temperature, T_{f}, of the sample. 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 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 shall be tested to determine critical electrical and mechanical property values. The average value for each property on the conditioned samples shall be at least 50 % of the average value determined on unconditioned samples.

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 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, but not less than 60 °C. The samples 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.

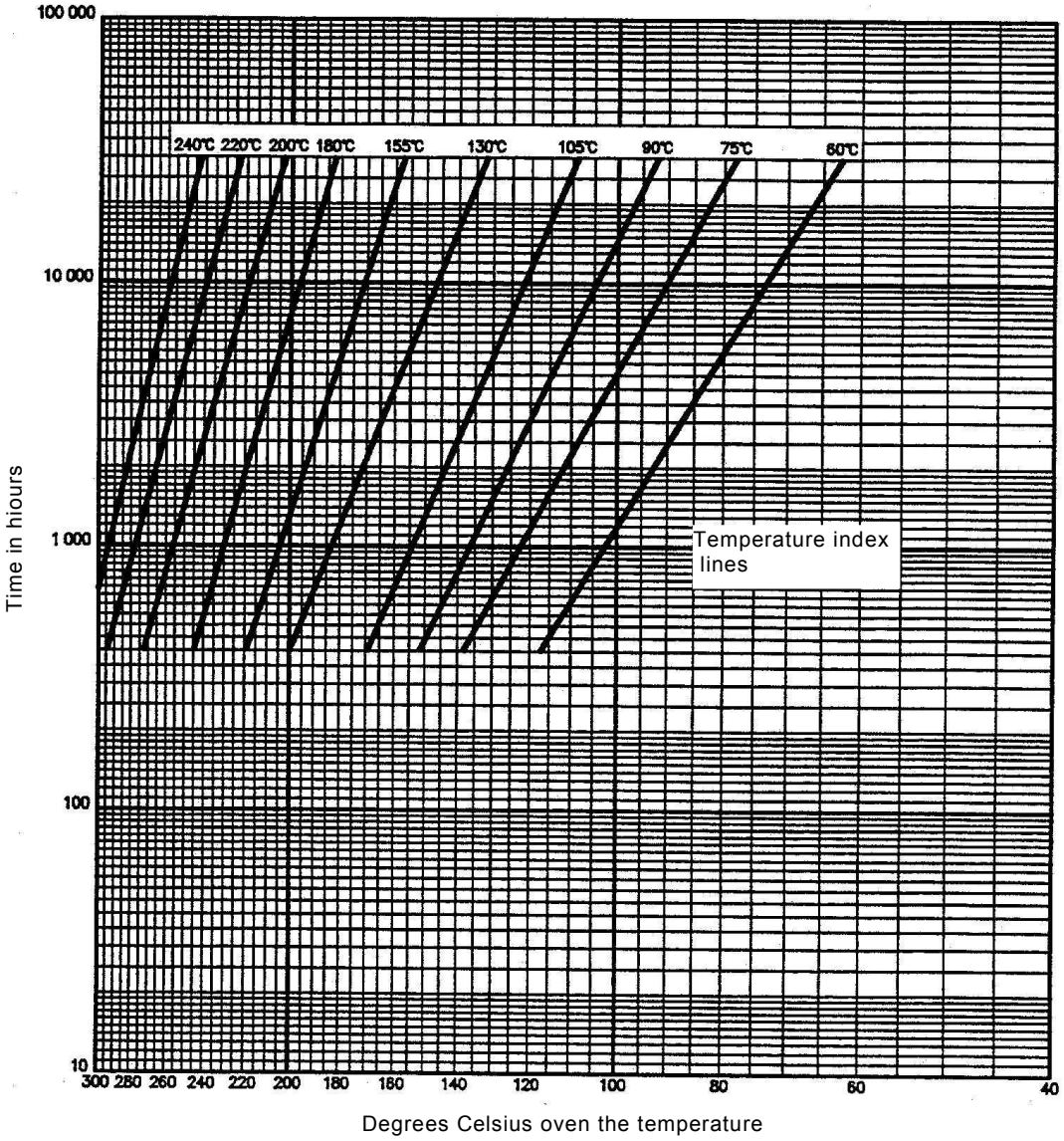


Figure E.1 – Conditioning time versus oven temperature for proposed temperature index

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 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 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 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.

F.4 To confirm adequate sealing, 25 samples shall be submerged 25,4 mm below the surface in hot mineral oil, maintained at 125 °C for 1 min. There shall be no air-bubbles escaping, indicating that the thermal-link is sealed. This procedure shall be conducted on thermal-links identified as sealed.

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.

Dimensions in millimetres

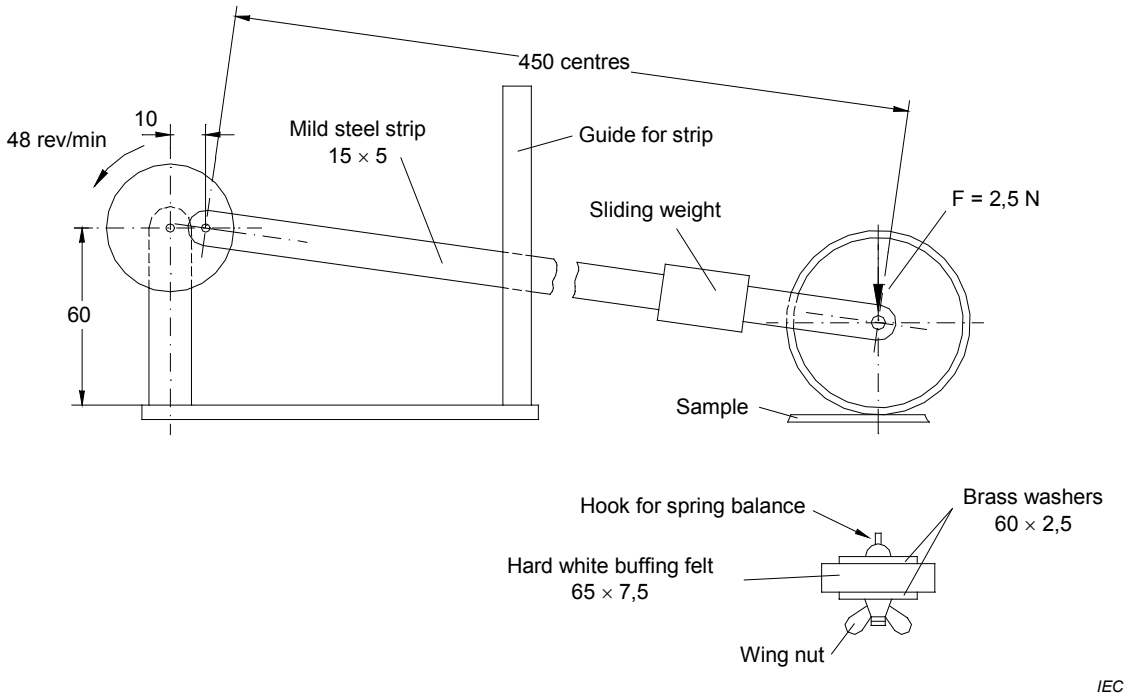


Figure G.1 – Apparatus for testing durability of markings

[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 standard.

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.4 General requirements

Additional subclause

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 three new samples of packaged thermal-link assemblies shall be tested.

H.5 General notes on tests

Additional subclause

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

H.9 Constructional requirements

Additional subclauses

H.9.5 Insulating materials

H.9.5.101 Polymeric materials used in the housing of the thermal-link packaged assembly 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

c) glow-wire ignition test (GWIT) of 850 °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) 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) in accordance with IEC 60695-10-2.

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 is less than the rating 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 is greater than the rating 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.*

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