UL 60691

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Thermal-Links for Use in Electrical Appliances and Components

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety for Thermal-Links for Use in Electrical Appliances and Components, UL 60691

Third Edition, Dated September 26, 2003

Summary of Topics

This edition of UL 60691 is a UL/IEC harmonized edition. It is the subsequent edition after the Fifth Edition of the Standard for Thermal Cutoffs for Use in Electrical Appliances and Components, UL 1020.

In order to more closely align the UL standard number and edition with the IEC standard number and edition, UL has published UL 60691 which will replace the Fifth Edition of UL 1020 on September 26, 2005. The first and second editions of UL 60691 were not printed.

The following table lists the future effective dates with the corresponding item.

Future Effective Date	References
September 26, 2005	Entire Standard

The new and revised requirements are substantially in accordance with UL's Bulletin(s) on this subject dated March 5, 1999, June 15, 2001, and May 30, 2003. The bulletin(s) is now obsolete and may be discarded.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

Revisions of UL Standards for Safety are issued from time to time. A UL Standard for Safety is current only if it incorporates the most recently adopted revisions.

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An employee of an organization purchasing a UL Standard can make a copy of the page or pages being viewed for their own fair and/or practical internal use.

The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the preface. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Recognition and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

This Standard consists of pages dated as shown in the following checklist:

Page	Date
1-46	September 26, 2003

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Standard for Thermal-Links for Use in Electrical Appliances and Components

The first and second editions of the Standard for Thermal-Links for Use in Electrical Appliances and Components were not printed. Efforts have been made to synchronize the UL edition number with that of the corresponding IEC standard. As a result, one or more edition numbers have been skipped in the process. The list of UL editions included here is a complete list of published UL editions.

Prior to the Third Edition of UL 60691, the requirements for the products covered by this Standard were included in UL 1020.

First Edition – Not Printed
Second Edition – Not Printed

Third Edition

September 26, 2003

The most recent designation of ANSI/UL 60691 as an American National Standard (ANSI) occurred on August 21, 2003. The ANSI approval for this standard does not include the Cover Page, transmittal pages, Title Page, or Foreword.

This ANSI/UL Standard for Safety, which consists of the Third Edition, is under continuous maintenance, whereby each revision is ANSI approved upon publication. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Written comments are to be sent to UL-Northbrook Standards Department, 333 Pfingsten Road, Northbrook, IL 60062.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc. and is not part of the ANSI Standard.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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Preface (UL)

This UL Standard is based on IEC Publication 60691: third edition Thermal-links – Requirements and application guide. IEC Publication 60691 is copyrighted by the IEC.

The text, figures and tables of IEC Publication Thermal-links – Requirements and application guide, 60691, copyright 2002, are used in this Standard with the consent of the IEC and the American National Standards Institute (ANSI). The IEC copyrighted material has been reproduced with permission from ANSI. ANSI should be contacted regarding the reproduction of any portion of the IEC material. The IEC Foreword and Introduction are not a part of the requirements of this Standard but are included for information purposes only. Copies of IEC 60691 may be purchased from ANSI, 11 West 42nd Street, New York, New York, 10036, (212) 642-4900.

Note – Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.

Foreword (UL)

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

THERMAL-LINKS – REQUIREMENTS AND APPLICATION GUIDE

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.

3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

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

This third edition cancels and replaces the second edition published in 1993, its amendment 1 (1995) and its amendment 2 (2000). This third edition constitutes a technical revision.

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

FDIS	Report on voting
32C/321/FDIS	32C/329/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 US national standard UL 1020 (fifth edition) which deals with thermal cutoffs/thermal-links, has served as a basis for the elaboration of this new edition.

The committee has decided that the contents of this publication will remain unchanged until 2005. 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 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 endeavored to lay down a number of basic requirements for such devices.

THERMAL-LINKS – REQUIREMENTS AND APPLICATION GUIDE

1 Scope and object

1 effective September 26, 2005

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 need not be 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.

NOTE 3 Attention is drawn to the fact that the external CREEPAGE DISTANCES and CLEARANCES specified in Table 3 may 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.

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.

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 object of this standard is:

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

2 effective September 26, 2005

The following referenced documents are indispensable for the application 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 60065:2001,
Audio, video and similar electronic apparatus – Safety requirements

IEC 60085:1984,
Thermal evaluation and classification of electrical insulation

IEC 60112:2003,
Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions

IEC 60216-1:2001,
Electrical insulating materials – Properties of thermal endurance – Part 1: Ageing procedures and evaluation of test results

IEC 60664-1:1992,
Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests

IEC 60695-2-11:2000,
Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products

IEC 60695-10-2:1995,
Fire hazard testing – Part 10-2: Guidance and test methods for the minimization of the effects of abnormal heat on electrotechnical products involved in fires – Method for testing products made from non-metallic materials for resistance to heat using the ball pressure test

IEC 60695-10-3:2002,
Fire hazard testing – Part 10-3: Abnormal heat – Mould stress relief distortion test

IEC 60695-11-10:1999,
Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods

IEC 60695-11-20:1999,
Fire hazard testing – Part 11-20: Test flames – 500 W flame test methods

IEC 60730-1:1999,
Automatic electrical controls for household and similar use – Part 1: General requirements

IEC 61210:1993,
Connecting devices – Flat quick-connect terminations for electrical copper conductors – Safety requirements

UL 1020:1994,
Thermal Cutoffs for Use in Electrical Appliances and Components

3 Definitions

3 effective September 26, 2005

For the purposes of this International Standard, the following definitions apply.

3.1 CLEARANCE: The shortest distance in air between two conductive parts.

3.2 CREEPAGE DISTANCE: The shortest distance along the surface of insulating material between two conductive parts.

3.3 HOLDING TEMPERATURE, T_h: The maximum temperature of the THERMAL-LINK at which it will not change its state of conductivity during a specified time under specified conditions.

3.4 HOMOGENEOUS SERIES (OF THERMAL-LINKS): A series of THERMAL-LINKS having common overall construction, deviating from each other only in such characteristics 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: The 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: The 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: Class of operation in which the ultimate electrical load is controlled by an auxiliary means such as a 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: The current used to classify a THERMAL-LINK.

3.10 RATED FUNCTIONING TEMPERATURE, T_f: The 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, V_r: The voltage used to classify a THERMAL-LINK.

3.12 THERMAL ELEMENT: A 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: A 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 which it has been designed.

3.14 TRANSIENT OVERLOAD CURRENT, I_p: A 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, $T_{h\text{-}100}$: The 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 (see Annex D).

NOTE – This is a rating for user consideration during the investigation of the end-product.

3.17 CONDUCTIVE HEAT AGEING TEST (CHAT): A test to evaluate a THERMAL-LINK for use in an appliance (see Annex C).

NOTE – 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.

4 General requirements

4 effective September 26, 2005

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.

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.

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.

NOTE – 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.

5 General notes on tests

5 effective September 26, 2005

Unless otherwise indicated, all tests described in this standard are TYPE TESTS and shall be carried out under room ambient conditions.

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

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.

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 10.6, 11.2, 11.3 and 11.4.

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 groups assigned an alphabetical letter from A to K. Each group consists of three specimens. In general, 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 3 of Table 1.

No failures are permitted in the tests carried out in accordance with Clauses 10 and 11.

If, in any of the tests carried out in accordance with the other clauses, one failure is reported, that test shall be repeated on twice the number of specimens and no further failures are allowed.

The CONDUCTIVE HEAT AGEING TEST is applicable when declared by the manufacturer. This test shall be conducted on THERMAL-LINKS with a functioning temperature, T_f, rating of 175°C or above. The CONDUCTIVE HEAT AGEING TEST is optional for THERMAL-LINKS with a T_f rating less than 175°C.

Exception: The CONDUCTIVE HEAT AGEING TEST may be omitted if the THERMAL-LINK is of eutectic type and is constructed without contacts.

NOTE – In the USA, the CONDUCTIVE HEAT AGEING TEST is required to be declared.

Manufacturer's inspection and factory test program

The manufacturer shall provide regular production control, inspection and tests. Details of the program shall be agreed to between manufacturer and the testing house.

Table 1
Test schedule

Clause or subclause	Test	Specimen groups										
		A	B	C	D	E	F	G	H	I	J	K
7*	Marking (rub test)	X	X									
9	Mechanical requirements											
9.2*	Tensile force	X										
9.3*	Thrust force		X									
9.4*	Bending/twist force			X								
12*	Resistance to rusting (ferrous parts only)						X					
10	Electrical requirements											
10.1*	CREEPAGE DISTANCES and CLEARANCES							X	X			
10.2.1*	Humidity test	X	X	X				X	X			
10.2.2*	Temperature and humidity cycle conditioning (note 2)	X	X	X				X	X			
10.3*	Dielectric strength (if applicable)	X	X	X				X	X			
10.4*	Insulation resistance (if applicable)	X	X	X				X	X			
10.5*	Resistance to tracking				X	X						
10.6	INTERRUPTING CURRENT							X	X			
10.7*	TRANSIENT OVERLOAD CURRENT	X	X							X		
11	Temperature tests											
11.2	Check on T_f	X		X								
11.3	Check on T_m followed by dielectric test			X	X							
11.4	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	X
10.3	Dielectric strength	X	X	X	X	X	X	X	X	X	X	X
10.4	Insulation resistance	X	X	X	X	X	X	X	X	X	X	X

Table 1 Continued on Next Page

Table 1 Continued

Clause or subclause	Test	Specimen groups										
		A	B	C	D	E	F	G	H	I	J	K
7*	Marking (visual inspection only)	X	X									

NOTE 1 For HOMOGENEOUS SERIES, tests marked with an asterisk may be omitted for intermediate ratings.

NOTE 2 At the manufacturer's request, the humidity test of 10.2.1 can be omitted if the third humidity cycle of the temperature and humidity condition of 10.2.2 is conducted for 168 hours.

NOTE 3 If the conditions of voltage, power and current in (c), (d) and (e) of 10.6.2 are not covered by one test, a minimum of three samples should be tested for each condition.

6 Classification

6 effective September 26, 2005

6.1 Electrical conditions

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

a) Voltage

1) A.C.

2) D.C.

b) Current

1) Resistive

2) Inductive

– Motor

– PILOT DUTY

– Electric discharge lamp

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 120 to 174;

b) Proof tracking index from 175 to 249;

c) 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 effective September 26, 2005

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.

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

The RATED FUNCTIONING TEMPERATURE, T_f, may be omitted if a different type or catalogue reference is employed for each different functioning temperature.

Where size permits, additional markings such as RATED VOLTAGE followed by V, RATED CURRENT followed by A, and other optional markings as needed may be placed on the THERMAL-LINK.

Marking shall be indelible and legible.

Indelibility is checked by trying to remove the marking by rubbing lightly for 15 seconds with a piece of cloth soaked with water. Legibility is checked by inspection. After the ageing tests of 11.4, compliance is checked by inspection.

NOTE – Instead of ″rubbing lightly″ the apparatus shown in Figure G.1 may be used.

The marking in accordance with (a), (b), (c) and (d) above shall be printed on the packaging, together with a reference to this standard.

Compliance is checked by inspection.

8 Documentation

8 effective September 26, 2005

The manufacturer shall provide in his 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 V_r;

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

NOTE 1 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.

d) information for mounting the THERMAL-LINK in the equipment.

NOTE 2 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.

NOTE 3 Catalogue or reference numbers shall define those parameters such as temperature, current and voltage which together classify a THERMAL-LINK.

9 Mechanical requirements

9 effective September 26, 2005

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.

Tab terminals shall be constructed in accordance with IEC 61210.

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 IEC 60730-1.

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 spacings to less than those required elsewhere in this standard. The security of contact assemblies shall be such that alignment of contacts is maintained.

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.

Exception: 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

b) formed test samples shall be subjected to the bending/twist lead secureness test of 9.4 and the RATED FUNCTIONING TEMPERATURE test of 11.2.

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.

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

When applicable, provision shall be made for securely mounting a THERMAL-LINK in position.

Exception: Types intended to be embedded in windings and the like need not have provision for mounting.

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.

Compliance is checked by the lead secureness tests of 9.1. Mounting and securement instructions shall be provided with THERMAL-LINKS for the manufacturer of the end-product in accordance with Annex A.

9.1 Lead secureness tests

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, 9.3 and 9.4 shall be conducted. There shall be no displacement of parts that would tend to reclose a THERMAL-LINK or reduce CREEPAGES or CLEARANCES as a result of the tests specified in 9.2 and 9.3. There shall be no displacement of parts other than the wire leads as a result of the test specified in 9.4.

The tests shall be conducted with the samples at an ambient temperature of (25 ±5)°C.

9.2 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 10 minutes.

9.3 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 10 minutes at a distance of 2 mm from the THERMAL-LINK.

9.4 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

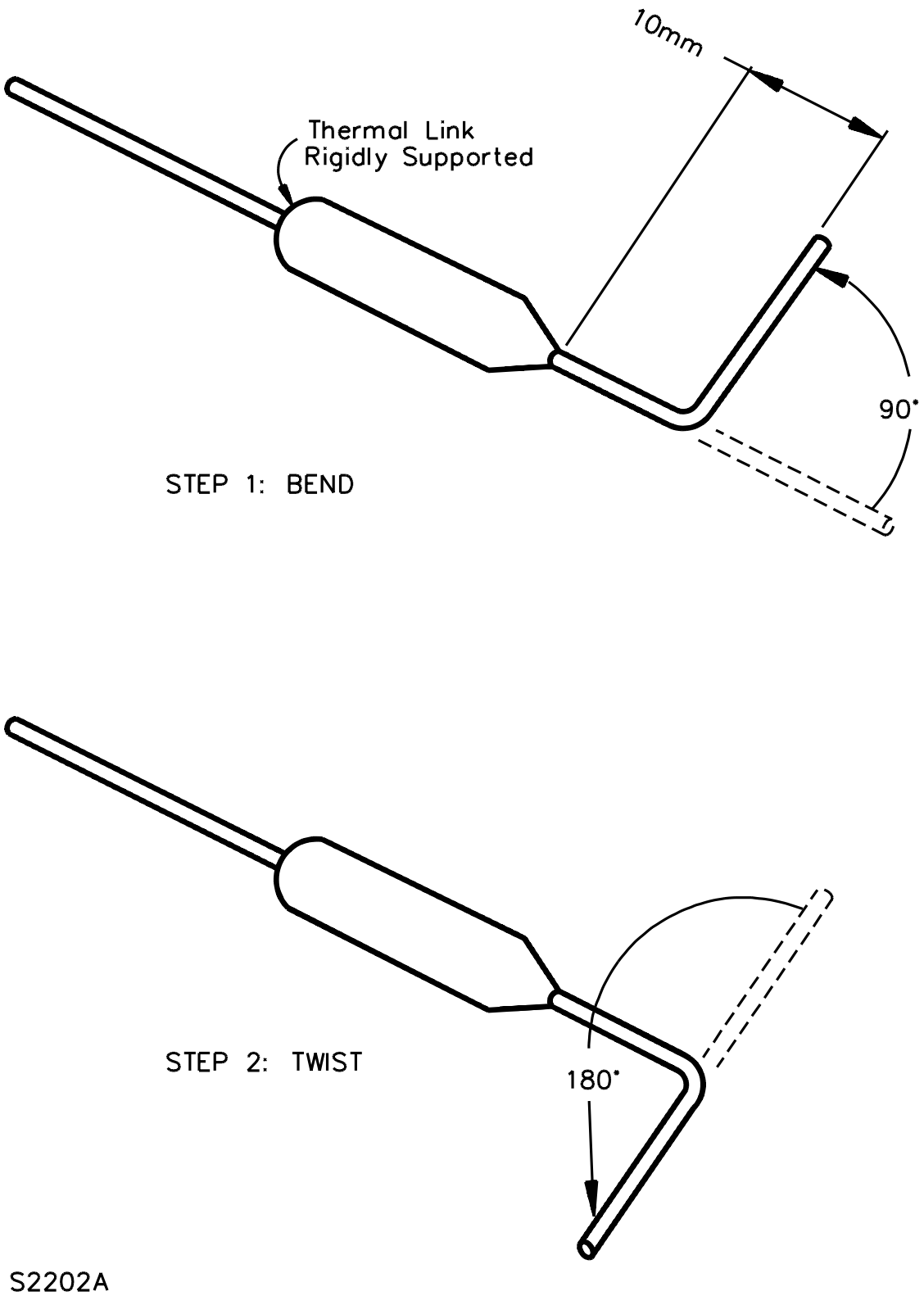


Table 2
Strength of terminals
Minimum required tensile and thrust test forces

Nominal cross-sectional area of the terminal, *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.		

10 Electrical requirements

10 effective September 26, 2005

THERMAL-LINKS shall comply with the relevant requirements in this clause with regard to test voltages, currents, insulation resistances, CREEPAGE DISTANCES and CLEARANCES in air.

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.

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.

NOTE 1 The RATED VOLTAGE, V_r, as stated by the manufacturer is used for deriving the relevant values for test voltages.

NOTE 2 The voltage rating of a THERMAL-LINK should be based on the source voltage in the circuit. The voltage rating for the insulation between current-carrying parts of such devices and the enclosure may be increased by additional insulation; for example, by wrapping the THERMAL-LINK in insulating foil.

10.1 CREEPAGE DISTANCES and CLEARANCES

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.

These distances do not apply between the open contacts of a THERMAL-LINK.

Compliance is checked by measuring the distances concerned.

An insulating barrier or liner that is used to provide spacings, including spacings in conjunction with the required over surface spacings, shall be at least 0,7 mm thick.

However, there are two exceptions:

Exception No. 1: A barrier or liner providing spacing in air or oil and used in conjunction with at least one-half the required spacing shall be at least 0,3 mm thick provided the barrier or liner

a) is an acceptable insulating material,

b) is resistant to moisture,

c) has mechanical strength for the application if exposed, or otherwise subjected to mechanical damage,

d) is held in place,

e) is located so that it will not be adversely affected by the operation of the equipment in service, including the effects of arcing.

Exception No. 2:

• Insulating material having a thickness less than 0,7 mm may be used if investigated and found to be acceptable for the particular application, and equivalent in all respects to materials of the specified thickness.

• Mica shall be at least 0,4 mm thick if used in place of the CLEARANCE required in Table 3, provided the mica is fixed in position by the parts between which the CLEARANCE is to be maintained.

Table 3
CREEPAGE DISTANCES and CLEARANCES
(absolute minimum values)

RATED VOLTAGE, V_r V	CLEARANCE mm	CREEPAGE DISTANCES mm
0 – 32	0,2	0,53
33 – 50	0,2	1,2
51 – 125	0,5	1,5
126 – 250	1,5	2,5
251 – 400	3,0	4,0
401 – 690	4,0	6,9

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) altitude of 2000 m;

c) basic insulation;

d) inhomogeneous field;

e) overvoltage category II;

f) pollution degree 2;

g) material group IIIa.

NOTE 3 If conditions are different from those specified in note 2, adjustments in CLEARANCES/CREEPAGES will be necessary as per IEC 60664-1.

10.2 Humidity conditioning

THERMAL-LINKS shall not be adversely influenced by humidity present in the ambient conditions for which they are intended. Compliance is checked by subjecting the specimens to the temperature and humidity conditioning tests of 10.2.1 and 10.2.2 below, followed immediately by the tests for dielectric strength (see 10.3) and insulation resistance (see 10.4).

10.2.1 **Humidity test**

The humidity test is carried out in a humidity chamber containing air with a relative humidity between 90% and 95%. The temperature, *t*, of the air at all places where the THERMAL-LINKS can be located, is maintained at 30°C, +0°C, -2°C. Before being placed in the chamber, the specimens are brought to a temperature between 30°C and 40°C, and kept at that temperature for about 1 hour. The specimens are kept in the humidity chamber for seven days.

After this test, the samples shall show no damage in the sense of this standard.

The air in the chamber should be moving and the chamber so designed that mist or condensed water cannot precipitate on specimens.

10.2.2 **Temperature and humidity cycle conditioning**

THERMAL-LINK samples shall be subjected to three complete conditioning cycles. Each cycle shall consist of 24 hours at RATED FUNCTIONING TEMPERATURE, T_f, minus 15 K but not less than 60°C, followed immediately by at least 96 hours at (35 ±2)°C and (90 ±5)% relative humidity, followed by 8 hours at (0 ±2)°C.

After the conditioning test, the samples shall be brought to a room ambient temperature of (25 ±5)°C before being subjected to the test sequence specified in Table 1.

10.3 Dielectric strength

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 10.2.

Compliance is checked by applying the following voltage test immediately after the tests of 10.2, if applicable, and also after the temperature tests of Clause 11.

Test voltages shall comply with the values indicated in Table 4.

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

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.

Immediately after the humidity test, the enclosure shall be wrapped in metal foil and the test voltage shall be applied for 1 minute across the disconnection and between the live parts and the metal foil.

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

NOTE – A power transformer with an output of not less than 100 VA is recommended for this test.

Table 4
Test voltages for dielectric strength

Between	Test voltage
Live parts and enclosure	2 V_r + 1000 V
Disconnection (between open contacts)	2 V_r

10.4 Insulation resistance

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 10.2.

Compliance is checked by measuring the insulation resistance after the humidity test, 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 V_r between the current path and the enclosure, wrapped in metal foil, if applicable, and between the terminals.

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

The specimens are deemed to comply with the requirements if the insulation resistance measured between the current path and the enclosures is not less than 2 MΩ, and across the disconnection is not less than 0,2 MΩ.

10.5 Resistance to tracking

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.

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 PTI values shall be declared by the manufacturer.

In order to determine acceptability of an insulating material, consideration shall be given to such properties as:

a) mechanical strength;

b) resistance to combustion and ignition;

c) dielectric strength;

d) insulation resistance;

e) thermal ageing;

f) the degree that a material is enclosed or protected;

g) resistance to arcing;

h) resistance to distortion and creep under conditions of normal and abnormal use; and

i) any other properties in conjunction with conditions of service.

Insulating materials, such as mica, cold-molded compound, or refractory material, are usually acceptable for use as direct supports of live parts without further evaluation.

If it is necessary to investigate an insulating material, the following standards shall be used for evaluation of the properties itemized in points (a) to (i) above: IEC 60085, IEC 60216-1, IEC 60695-2-11, IEC 60695-10-2, IEC 60695-10-3, IEC 60695-11-10 and IEC 60695-11-20.

Exception: Seals and potting compounds not relied upon for contact alignment or securement of leads may be subjected to the seal ageing test specified in Annex E.

10.6 INTERRUPTING CURRENT

10.6.1 General

A THERMAL-LINK shall interrupt the applicable test current specified in Table 5 at 1,1 times RATED VOLTAGE, V_r, under the conditions specified in items (a) to (i) of 10.6.2. There shall be no damage to the integral leads of a THERMAL-LINK. The case of an enclosed element shall remain intact. The 3 A fuses specified in items (a) and (b) of 10.6.2 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.

10.6.2 Specific conditions

a) 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 3 A fuse to earth.

Table 5
Test current for interrupting test

Type of rating	Rated in	Test current	Power factor
Motor	A.C. locked rotor amperes (LRA) D.C. amperes	6 times full-load current [a] 10 times full-load current [c]	0,40 – 0,50 [b]
Electric discharge lamp	A.C. amperes	4 times RATED CURRENT [c]	0,40 – 0,50
Ampere	A.C. amperes D.C. amperes	1,5 times RATED CURRENT 1,5 times RATED CURRENT	0,75 – 0,80 [d, b]
PILOT DUTY	Volt-amperes	[e]	[e]

[a] Or the specified value, such as horsepower, if locked rotor ampere rating is omitted.
[b] Non-inductive resistive load.
[c] For 120 V supply use at least 20 A test current.
[d] Power factor may be 1,0 if rated resistive only.
[e] See point (f) [below].

b) 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 3 A fuse. The distance is measured between the screen and the nearest point of the element when the element is in the open position.

Exception: 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.

c) The test circuit shall have an open circuit voltage within a range of 100% to 105% of the specified test voltage, unless a higher voltage is acceptable to both the manufacturer and the end user. The closed circuit voltage of the test circuit with the device's RATED CURRENT flowing shall be within 2,5% of the specified test voltage.

d) 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.

e) 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.

f) 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.

g) Compliance is checked by the following test. Each sample shall be placed in a test oven stabilized at a temperature 10 K below the RATED FUNCTIONING TEMPERATURE, T_f, of the sample and then the temperature of the oven shall restabilize. The THERMAL-LINK shall then be energized and the oven temperature increased at a 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.

h) 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.

i) 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.

After these tests, the insulation resistance shall comply with the requirements of 10.4.

10.7 TRANSIENT OVERLOAD CURRENT

THERMAL-LINKS shall withstand repeated current surges, considered as being normal in most applications.

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

D.C. 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.

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

10.8 Limited short-circuit test

10.8.1 General

When declared by a manufacturer, a THERMAL-LINK is tested as described in 10.8.2 and 10.8.3, and there shall be no ignition of the cotton mentioned in 10.8.2 or other evidence of a risk of fire or electric shock during or after the test.

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.

10.8.2 Method

Three samples of the THERMAL-LINK shall be subjected to a limited short-circuit test. The test shall be conducted at a voltage within ±5% tolerance of the RATED VOLTAGE, V_r. The THERMAL-LINK shall be connected in series with a non-renewable fuse properly selected for the application in accordance with 10.8.3. The circuit shall limit the current to the applicable value specified in Table 6, measured without the THERMAL-LINK in the circuit. The power factor of the circuit shall be 0,9 – 1,0, unless a lower power factor is acceptable to both the manufacturer and the end user. The THERMAL-LINK shall be connected in the circuit by two 915 mm lengths of copper wire of the appropriate size. Cotton shall surround the THERMAL-LINK, or a metal screen located 50 mm away – or less if agreeable to both the manufacturer and the end user – from all parts of the THERMAL-LINK during the test. Each THERMAL-LINK shall be subjected to one test.

Table 6
Limited short-circuit test capacity

Combined rating of THERMAL-LINK					Short-circuit capacity (amperes)[a]	
Volt-amperes, single-phase	Volt-amperes, three-phase	Volt-amperes, direct current	Horsepower	kW	0 V to 250 V	251 V to 690 V
0 – 1176	0 – 832	0 – 648	0 to 0,5	0 to 0,375	200	1000
1177 – 1920	833 – 1496	649 – 1140	Over 0,5 to 1	Over 0,375 to 0,750	1000	1000
1921 – 4080	1497 – 3990	1141 – 3000	Over 1 to 3	Over 0,750 to 2,250	2000	5000
4081 – 9600	3991 – 9145	3001 – 6960	Over 3 to 7,5	Over 2,250 to 5,600	3500	5000
9601 or more	9146 or more	6961 or more	Over 7,5	Over 5,600	5000	5000

[a] For the fluorescent lamp ballast test, the limited short-circuit test capacity shall be 200 A.

10.8.3 **Fuse size (rating)**

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

a) Twenty amperes 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) through (f).

b) Twenty amperes 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 seconds 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) through (f).

11 Temperature tests

11 effective September 26, 2005

The characteristic temperatures of THERMAL-LINKS shall comply with the values and tolerances as declared by the manufacturer and with the requirements of this clause.

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

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

Operation of THERMAL-LINKS shall be signaled by suitable means, for example, light emitting diodes with series resistors limiting the signal current to maximum of 10 mA.

Operation of THERMAL-LINKS shall be checked after each test step.

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.

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.

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

11.1 HOLDING TEMPERATURE, T_h

If requested by the manufacturer, the specimen(s) is (are) subjected to the specified time under conditions as declared by the manufacturer.

11.2 RATED FUNCTIONING TEMPERATURE, T_f

THERMAL-LINKS shall be exposed, in the test oven or oil bath, to T_f – 20 K for devices rated less than T_f 250°C or to T_f – 30 K for devices rated T_f 250°C or greater until temperature has stabilized, shown when two consecutive readings taken 5 minutes apart, are the same. 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. The individual functioning temperatures shall be recorded and they shall be not less than T_f – 10 K and not greater than T_f for devices rated less than T_f 250°C. For devices rated T_f 250°C or greater, the functioning temperature shall be not less than T_f – 20 K and not greater than T_f.

NOTE – The equipment recommended for the tests of 11.2 is shown in Clause C.6.

11.3 MAXIMUM TEMPERATURE LIMIT, T_m

The specimens shall be subjected to T_m, +0°C, –5°C for a period of 10 minutes, and, during a further period of 2 minutes, a test voltage of 2 V_r shall be applied between current-carrying parts and any insulated exposed metal parts, or between terminals of an opened THERMAL-LINK.

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

NOTE – If it is deemed necessary 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, it is recommended, where possible, that the specimens be inserted into a sand box maintained at T_m.

11.4 Ageing

In order to verify whether ageing at high temperature has a deleterious effect, THERMAL-LINKS shall be subjected to the following series of test steps. The temperature shall be maintained constant within ±1 K. Any specimen 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:

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.

The following tests are mandatory:

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.

Step 3 T_f – 10 K for two weeks.

Step 4 T_f – 5 K for one week.

Step 5 T_f – 3 K for one week.

Step 6 T_f + 3 K for 24 hours.

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

The test is considered successful if all specimens have functioned.

12 Resistance to rusting

12 effective September 26, 2005

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

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

THERMAL-LINKS provided with one or more ferrous parts shall not be adversely affected by possible rusting of such parts.

Compliance is checked by subjecting three specimens during 14 days to the humidity conditioning test described in 10.2.

After the test, 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.

Annex A
(normative)
Application guide

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.

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 mains-operated electronic and related apparatus for household and similar general use, see IEC 60065.

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.

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.

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.

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

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

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.

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.

The mounted THERMAL-LINK shall be adequately protected from harmful effects produced by possible spillage of liquids from the equipment, for example by covers.

Annex B
(normative)
Alternative ageing test for THERMAL-LINKS with T_h greater than 250°C for use in electric irons

THERMAL-LINKS used to protect electric irons where the normal HOLDING TEMPERATURE is 250°C or greater and which, in the event of failure, rise rapidly to a functioning temperature of 300°C or higher, are not required to follow the usual ageing test described in 11.4.

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

Additionally, the tolerance of T_f in 11.2 is allowed to be -20 K instead of -10 K.

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

Annex C
(normative)
CONDUCTIVE HEAT AGEING TEST

In the USA, this annex is required to be declared. For all other countries, this annex 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.

Exception: The CONDUCTIVE HEAT AGEING TEST may be omitted if the THERMAL-LINK is of eutectic type and is constructed without contacts.

C.2 Method

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.2.1 through 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 aluminum test box section and the ceramic oven liner section, shown in Figure C.2, shall be removed from the test oven.

C.2.1 Typical test fixture assembly

A typical test fixture assembly as shown in Figure C.1 consists of an aluminum 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 aluminum 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.2.2 **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 aluminum plate. The test oven shall apply heat to the aluminum plate and, by thermal conduction, conduct heat from the aluminum plate to the body of the THERMAL-LINK. The test oven shall be rated 10 A, 120 V a.c.

C.2.3 **Temperature behavior**

The temperature on the aluminum 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.2.4 **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 hours 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

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 plus 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 K to -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 seconds but not longer than 10 seconds 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 through Step G allowing the +0 K to -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.3.1 **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 hours 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.3.2 **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.

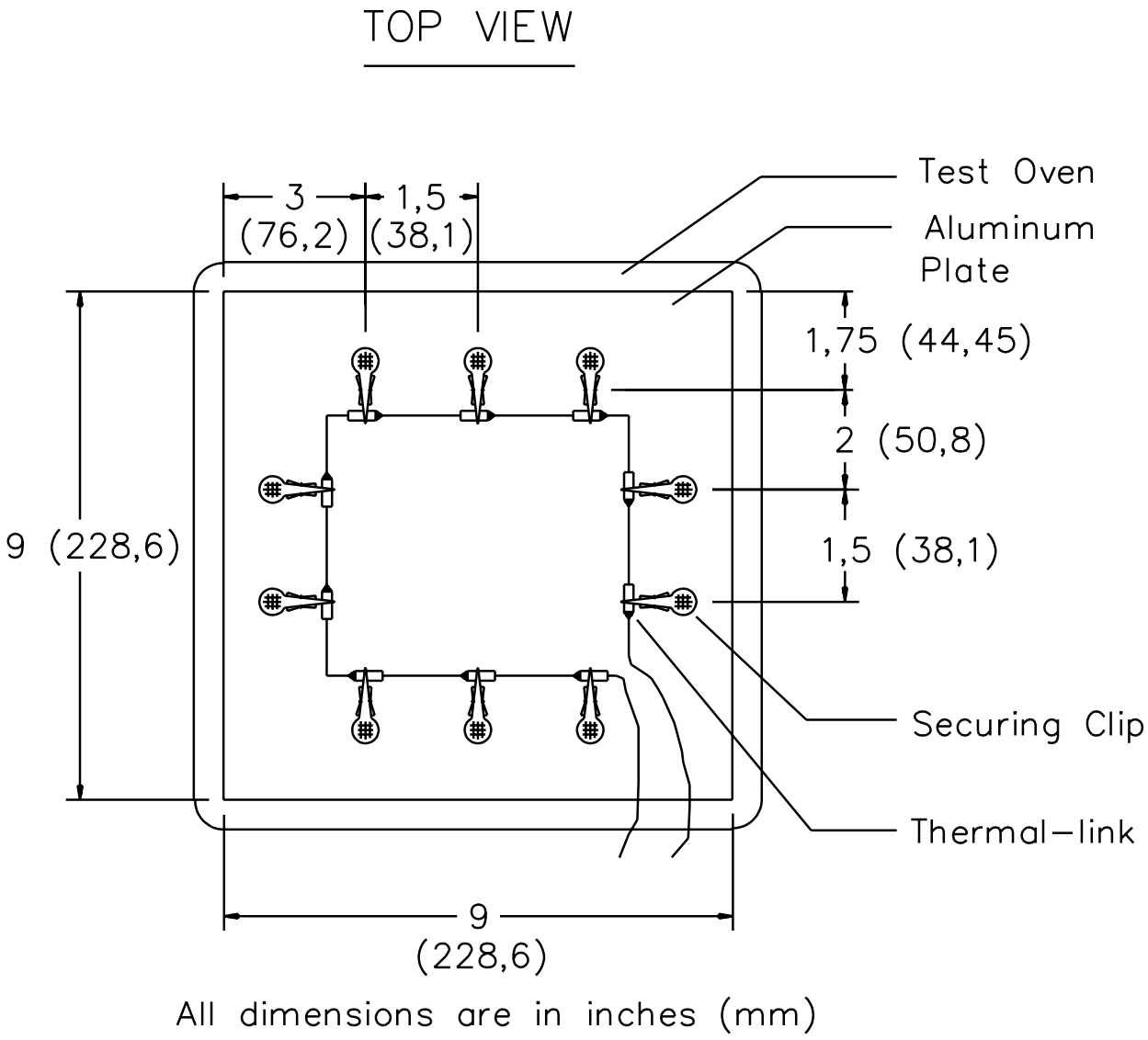
C.4 Results

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 10.3, applied between the leads or terminals of the opened THERMAL-LINK after the test samples have been brought to room temperature.

Figure C.1
Typical test fixture assembly



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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 drafts and the ambient temperature shall be maintained reasonably constant during the test.

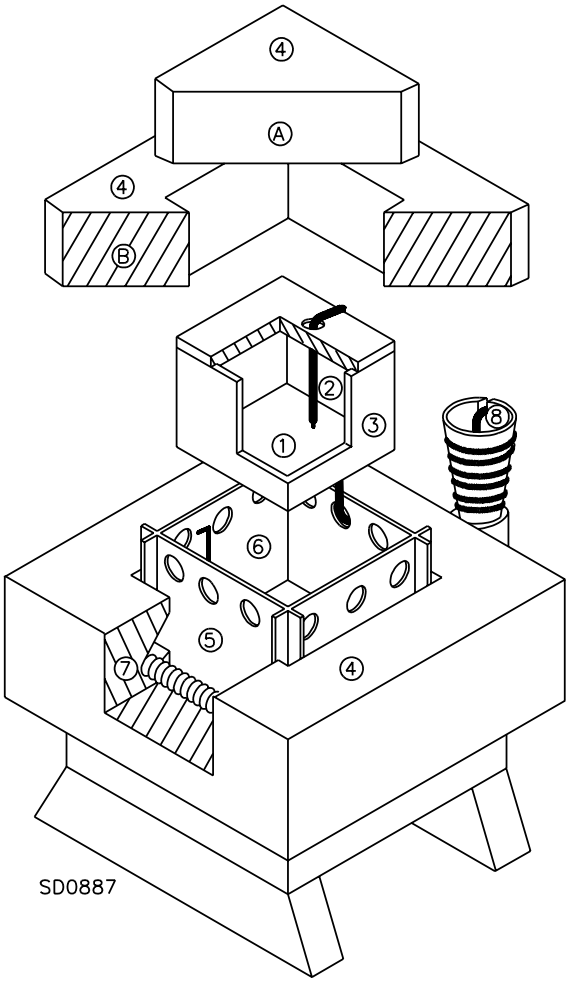
The oven described in Figure C.2 has a two-section core consisting of a non-metallic oven liner and a metal test box.

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.

Figure C.2
Typical THERMAL-LINK test oven



Key

1 Test sample chamber

2 Temperature monitoring and recording thermocouples

3 Aluminum 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: 6,35 cm × 6,35 cm × 11,45 cm

B 6,35 cm × 22,85 cm × 22,85 cm with a hole 8,25 cm × 8,25 cm

Annex D
(informative)
EXTENDED HOLDING TEMPERATURE evaluation

This annex is applicable when declared by the manufacturer.

D.1 EXTENDED HOLDING TEMPERATURE conditioning test

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.

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 $T_{h\text{-}100}$ value. A thermocouple shall be attached to each THERMAL-LINK to monitor the body temperature.

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

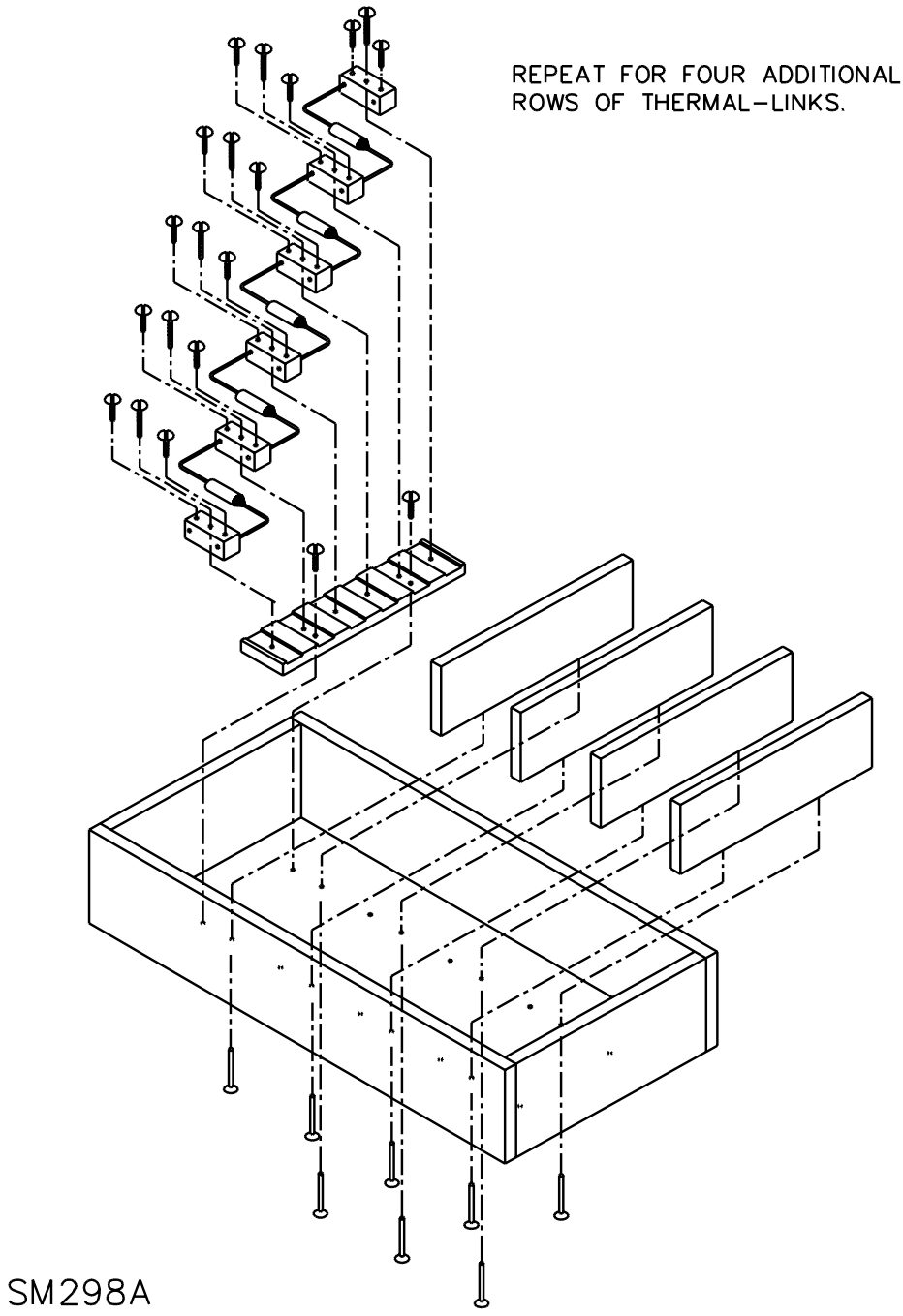
All samples that do not exceed +10% of the $T_{h\text{-}100}$ rating shall not be open at the conclusion of the conditioning. After the conditioning period, all but two of the samples shall be subjected to the load current interrupt test of Clause D.2. The remaining two samples shall be subjected to the RATED FUNCTIONING TEMPERATURE test of 11.2.

D.2 Load current interrupt test

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.

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.

Figure D.1
Typical terminal block support test fixture



NOTE 1 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.

NOTE 2 Secure thermocouple leads to THERMAL-LINK body. Exit box through nearest hole in the lid.

Annex E
(normative)
Seal ageing test

In the USA, this annex is required to be declared. For all other countries, this annex is applicable when declared by the manufacturer.

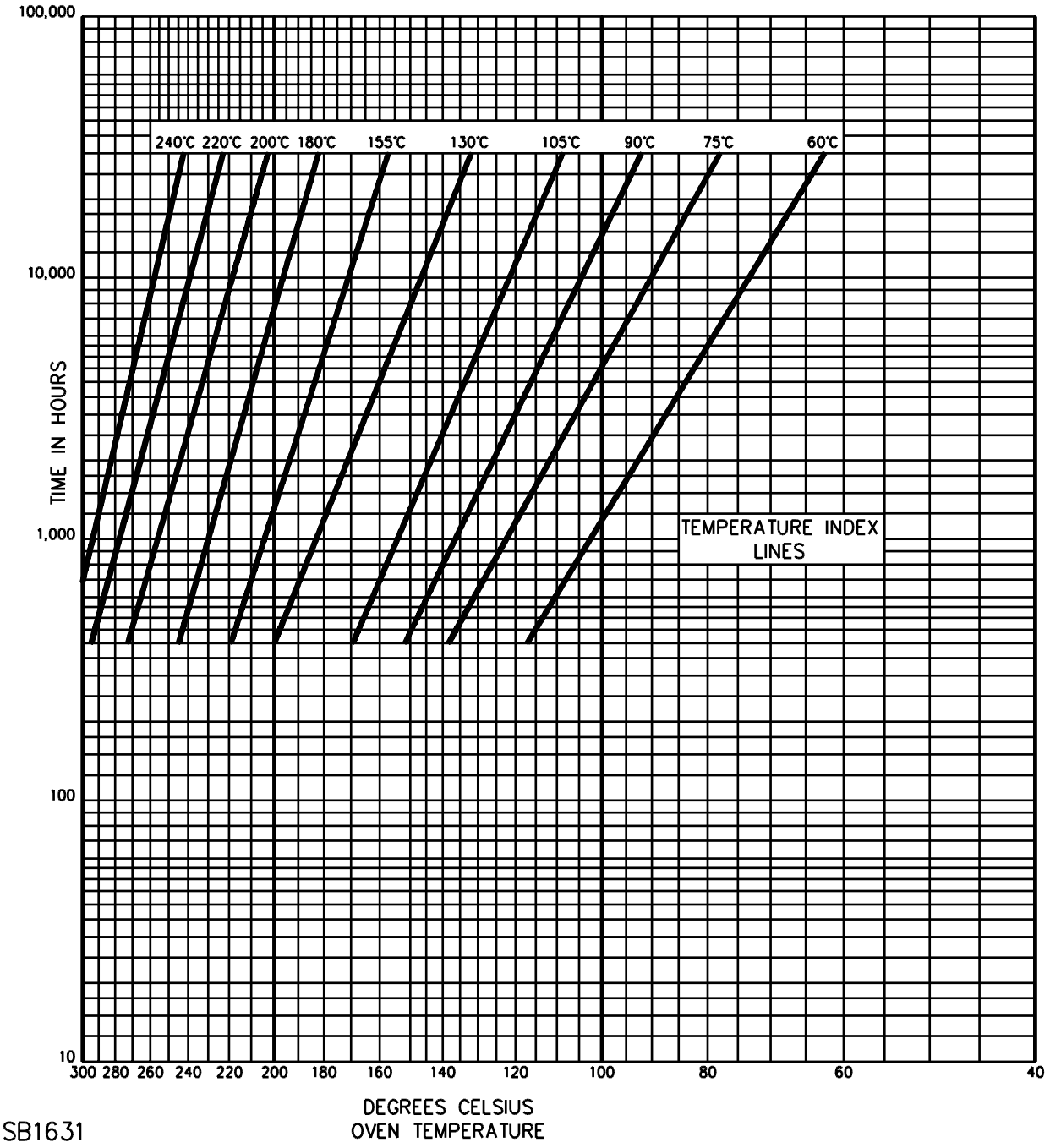
This test applies to seals and potting compounds. After the conditioning, as specified below, the samples shall be tested to determine critical electrical and mechanical property values. The average value for each property on the conditioned samples shall be at least 50% of the average value determined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

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

For each property to be evaluated, ten samples shall be conditioned for 1000 hours 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.

Exception: 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 hours shall be used.

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



Annex F
(normative)
Identification requirements

In the USA, this annex is required to be declared. For all other countries, this annex is applicable when declared by the manufacturer.

The procedure described below shall be conducted on a number of samples of THERMAL-LINKS employing eutectic-type elements for identification purposes.

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.

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.

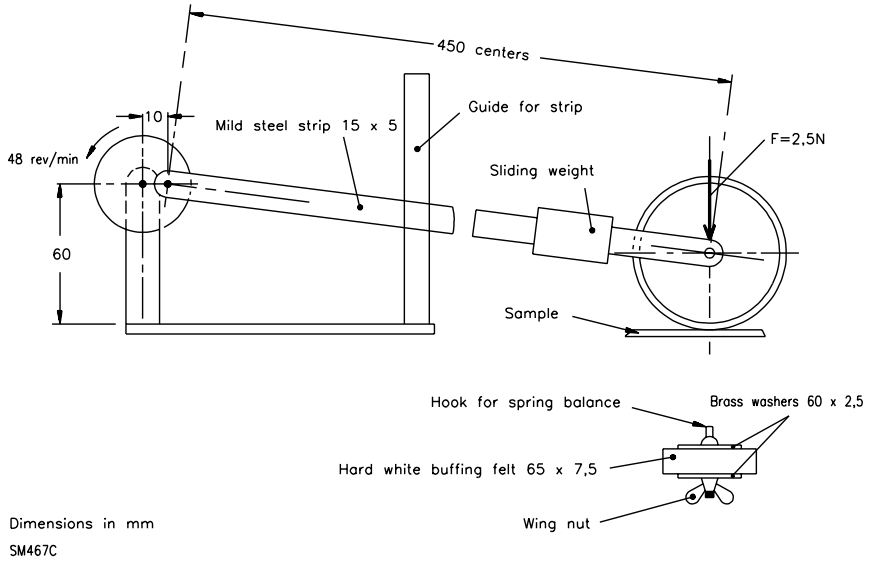
To confirm adequate sealing, 25 samples shall be submerged 25,4 mm below the surface in hot mineral oil, maintained at 125°C for 1 minute. There shall be no air-bubbles escaping, indicating that the THERMAL-LINK is sealed. This procedure shall be conducted on THERMAL-LINKS identified as sealed.

Annex G
(informative)
Indelibility of markings[1]

Compliance with the marking indelibility testing requirements of Clause 7 may be checked with the apparatus shown below as an alternative to the phrase ″rubbing lightly.″ 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 seconds.

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

Figure G.1
Apparatus for testing durability of markings



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

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