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QC 440000

Thermistors – Directly heated positive temperature coefficient – Part 1: Generic specification

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THERMISTORS – DIRECTLY HEATED POSITIVE TEMPERATURE COEFFICIENT –

Part 1: Generic specification

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60738-1 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This consolidated version of IEC 60738-1 consists of the third edition (2006) [documents 40/1651/FDIS and 40/1730/RVD] and its amendment 1 (2009) [documents 40/1940/CDV and 40/1999/RVC].

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience.

It bears the edition number 3.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

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

The QC number that appears on the front cover of this publication is the specification number in the IEC Quality Assessment System for Electronic Components (IECQ).

IEC 60738 consists of the following parts, under the general title *Thermistors – Directly heated positive step-function coefficient*:

Part 1: Generic specification

Part 1-1: Blank detail specification – Current limiting application – Assessment level EZ

Part 1-2: Blank detail specification – Heating element application – Assessment level EZ

Part 1-3: Blank detail specification – Inrush current application – Assessment level EZ

Part 1-4: Blank detail specification – Sensing application – Assessment level EZ

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the maintenance result date indicated on the IEC web site 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.

A bilingual version of this standard may be issued at a later date.

THERMISTORS – DIRECTLY HEATED POSITIVE TEMPERATURE COEFFICIENT –

Part 1: Generic specification

1 Scope

This part of IEC 60738 describes terms and methods of test for positive step-function temperature coefficient thermistors, insulated and non-insulated types typically made from ferro-electric semi-conductor materials.

It establishes standard terms, inspection procedures and methods of test for use in detail specifications for Qualification Approval and for Quality Assessment Systems for electronic components.

2 Normative references

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 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)*

IEC 60062, *Marking codes for resistors and capacitors*

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*
Amendment 1 (1992)

IEC 60068-2-1:1990, *Environmental testing – Part 2: Tests – Tests A: Cold*
Amendment 1 (1993)
Amendment 2 (1994)

IEC 60068-2-2:1974, *Environmental testing – Part 2: Tests – Tests B: Dry heat*
Amendment 1 (1993)

IEC 60068-2-6, *Environmental testing – Part 2: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-11, *Environmental testing – Part 2: Tests – Test Ka: Salt mist*

IEC 60068-2-13, *Environmental testing – Part 2: Tests – Test M: Low air pressure*

IEC 60068-2-14:1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*
Amendment 1 (1986)

IEC 60068-2-20:1979, *Environmental testing – Part 2: Tests – Test T: Soldering*
Amendment 2 (1987)

IEC 60068-2-21, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-27, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*

IEC 60068-2-29, *Environmental testing – Part 2: Tests – Test Eb and guidance: Bump*

IEC 60068-2-30:2005, *Environmental testing – Part 2: Tests – Test Db: Damp heat, cyclic (12 h + 12-hour cycle)*

IEC 60068-2-45:1980, *Environmental testing – Part 2: Tests – Test XA and guidance – Immersion in cleaning solvents*

IEC 60068-2-58, *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60294, *Measurement of the dimensions of a cylindrical component having two axial terminations*

IEC 60410, *Sampling plans and procedures for inspection by attributes*

IEC 60617 (all parts) [DB][1]: *Graphical symbols for diagrams*

IEC 60717*, Method for determination of the space required by capacitors and resistors with unidirectional terminations*

IEC 61249-2-7, *Materials for printed boards and other interconnecting structures – Part 2-7: Reinforced base materials clad and unclad – Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test), copper-clad*

IEC 61760-1*, Surface mounting technology – Part 1: Standard method for the specification of surface mounting components (SMDs)*

IEC QC 001002-3, *Rules of Procedure of the IEC Quality Assessment System for Electronic Components (IECQ) – Part 3: Approval procedures*

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units*

3 Terms and definitions

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

3.1

type
group of components having similar design features and the similarity of whose manufacturing techniques enables them to be grouped together either for qualification approval or for quality conformance inspection

They are generally covered by a single detail specification

NOTE Components described in several detail specifications, may, in some cases, be considered as belonging to the same type but they are generally covered by a single detail specification.

[1] "DB" refers to the IEC on-line database.

3.2
style
variation within a type having specific nominal dimensions and characteristics

3.3
thermistor
thermally sensitive semiconducting resistor which exhibits a significant change in electrical resistance with a change in body temperature

3.4
positive temperature coefficient thermistor
thermistor, the resistance of which increases with its increasing temperature throughout the useful part of its characteristic

3.5
positive step-function temperature coefficient thermistor
PTC
thermistor which shows a step-like increase in its resistance when the increasing temperature reaches a specific value

A PTC thermistor will show secondary effects which are to be taken into account

3.6
zero-power resistance
R_T
value of the resistance of a PTC thermistor, at a given temperature, under conditions such that the change in resistance due to the internal generation of heat is negligible with respect to the total error of measurement

NOTE Any resistance value of a PTC thermistor is dependent on the value and the mode of the applied voltage (a.c. or d.c.) and, when an a.c. source is used, on the frequency (see 3.8 and 3.9).

3.7
nominal zero-power resistance
R_n
d.c. resistance value of a thermistor measured at a specified temperature, preferably at 25 °C, with a power dissipation low enough that any further decrease in power will result only in a negligible change in resistance. Zero-power resistance may also be measured using a.c. if required by the detail specification

3.8
voltage dependency
secondary effect, exhibiting a decreasing resistance with increasing voltage across the thermistor when measured at a constant body temperature

3.9
frequency dependency
secondary effect exhibiting a substantial decrease of the positive temperature coefficient of the thermistor with increasing frequency

3.10
resistance/temperature characteristics
relationship between the zero-power resistance of a thermistor and the temperature of the thermo-sensitive element when measured under specified reference conditions (see Figure 1)

NOTE PTC thermistors may have more than one resistance/temperature characteristic specified. The zero-power resistance of the resistance/temperature characteristics can be measured using a pulse voltage (U_{pulse}) higher than 1,5 V, which is specified in the detail specification. The right curve in Figure 1 shows the typical resistance/temperature characteristic when using the pulse voltage (U_{pulse}).

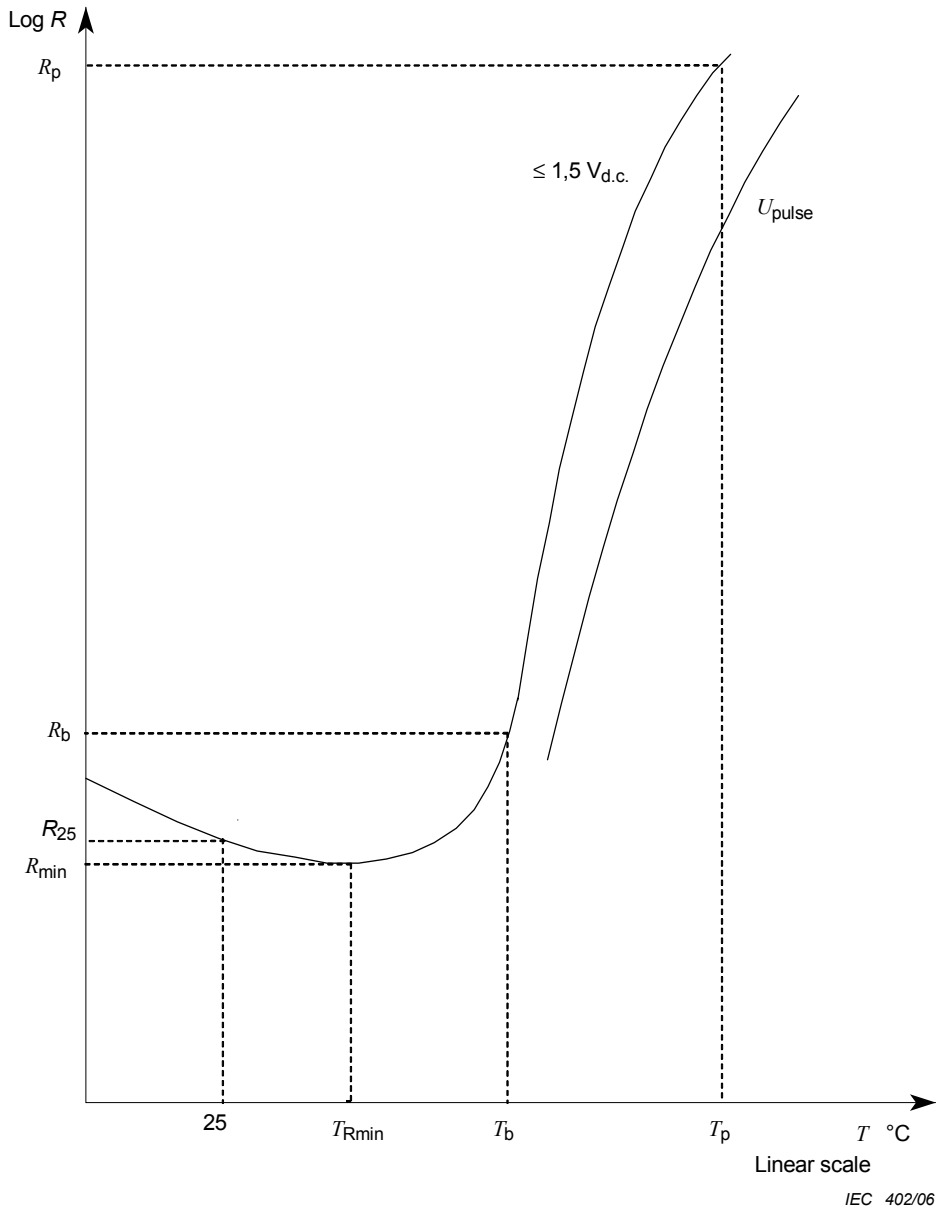


Figure 1 – Typical resistance-temperature characteristic and definitions for PTC thermistors (at zero power)

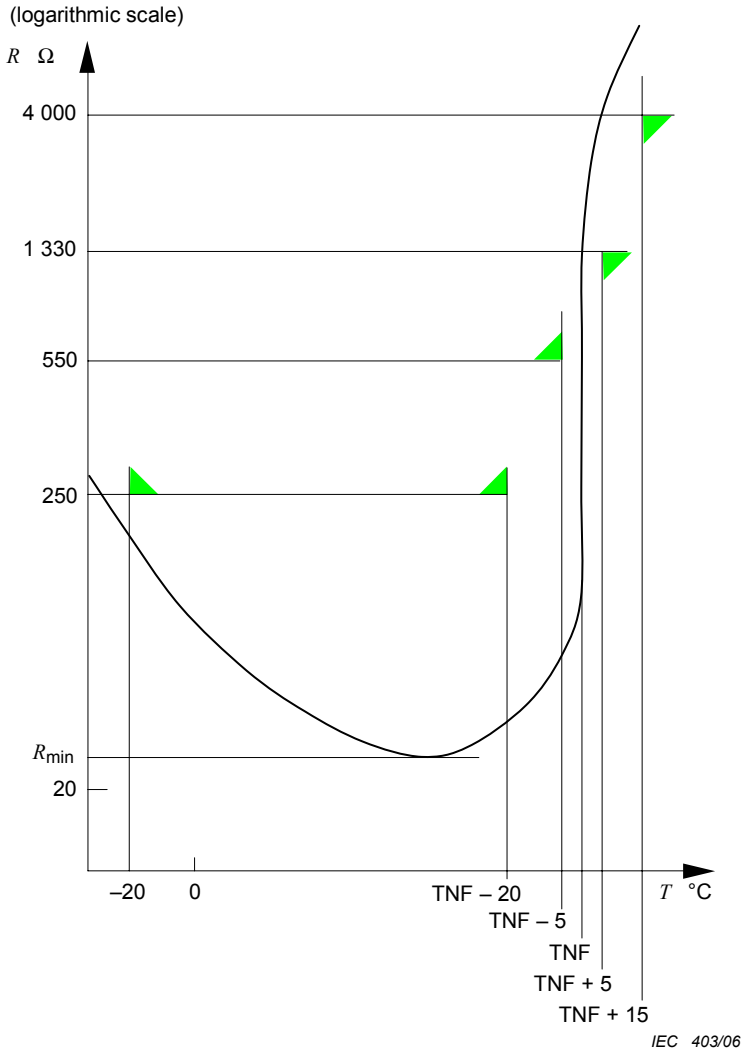
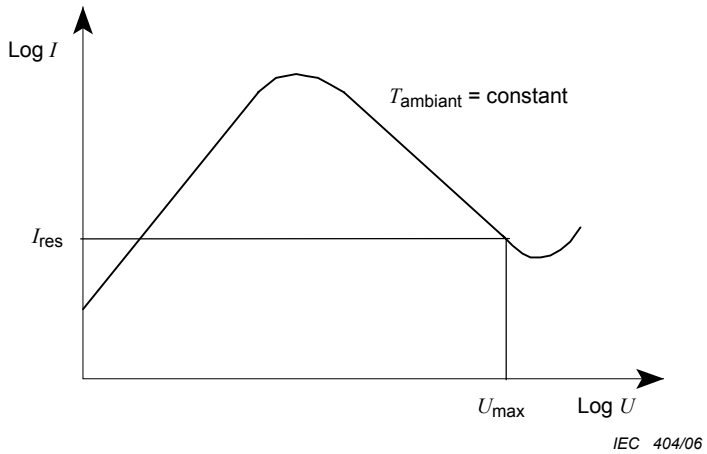


Figure 2 – Typical R-TNF characteristic for PTC thermistors in sensor applications

3.11
current/voltage characteristic
relationship in still air at 25 °C (unless otherwise stated) between the applied voltage (d.c. and/or a.c.) at the thermistor terminations and the current under steady-state conditions (see Figure 3)



NOTE 1 U_{max} will be specified by the manufacturer.

NOTE 2 The breakdown voltage is the value beyond which the voltage-handling capability of the thermistor no longer exhibits its characteristic property

Figure 3 – Typical current/voltage characteristic for PTC thermistors

3.12
nominal functioning temperature
T_{NF}
nominal temperature at the steep part of the resistance temperature characteristic at which the system controlled by the thermistor is designed to operate

NOTE T_{NF} is exclusively defined for PTC resistors in sensor applications.

3.13
switching temperature
T_b
temperature at which the step-like function commences

3.14
minimum resistance
R_{min}
minimum value of the zero-power resistance/temperature characteristic (see Figures 1 and 2)

3.15
resistance at switching temperature
R_b
value of the zero-power resistance corresponding to the switching temperature defined as $R_b = 2 \times R_{min}$. As an alternative definition $R_b = 2 \times R_{25}$ can be used. If this definition is used, this shall be explicitly stated in the detail specification

3.16
temperature for minimum resistance
T_{Rmin}
temperature at which R_{min} occurs

3.17
temperature
T_p
temperature, higher than T_b, in the PTC part of the resistance/temperature characteristic for which a minimum value R_p of the zero-power resistance is specified

3.18
resistance
R_p
zero-power resistance at temperature T_p measured at maximum voltage or a voltage specified in the detail specification and given as a minimum value

NOTE The measurement should be made under such conditions that a change in resistance due to internal generation of heat is negligible with respect to the total error of measurement. The applied voltage and the characteristics of any pulse used should be given in the detail specification; when applying the maximum voltage, the maximum overload current may not be exceeded.

3.19
average temperature coefficient of resistance at a stated voltage
α_R
rate of change of resistance with temperature expressed as %/K

It is calculated from the formula:

$$\alpha_R = \frac{100}{(T_p - T_b)} \times \ln \frac{R_p}{R_b}$$

where T_p exceeds T_b by a minimum of 10 K.

The temperatures T_p and T_b are to be given if applicable and the measurement conditions for R_b and R_p should be the same, unless otherwise specified in the detail specification

NOTE The detail specification may specify the measurement of the temperature coefficient of resistance in a narrow temperature range where its value is a maximum, together with a suitable test method.

3.20
upper category temperature
UCT
maximum ambient temperature for which a thermistor has been designed to operate continuously at zero power

3.21
lower category temperature
LCT
minimum ambient temperature for which a thermistor has been designed to operate continuously at zero power

3.22
maximum voltage
U_{max}
maximum a.c. or d.c. voltage which may be continuously applied to the thermistor without exceeding the maximum overload current

3.23
operating temperature range at maximum voltage
range of ambient temperatures at which the thermistor can operate continuously at the maximum voltage without exceeding the maximum overload current

3.24
isolation voltage (applicable only to insulated thermistors)
maximum peak voltage which may be applied under continuous operating conditions between any of the thermistor terminations and any conducting surface

3.25
maximum overload current
I_{mo}
value of current for the operating temperature range, which shall not be exceeded

NOTE It may be necessary to limit the current through the thermistor by the use of a series resistor R_s.

3.26
residual current
I_{res}
value of current in the thermistor at a specified ambient temperature (preferably 25 °C) under steady-state conditions. The applied voltage is the maximum voltage unless otherwise specified (see Figure 3)

3.27
tripping current
I_t
lowest current which will cause the thermistor to trip to a high resistance condition at a specified temperature (preferably 25 °C) and within a time to be specified in the detail specification

3.28
maximum non-tripping current
$I_{max\ nt}$
maximum current at a specified ambient temperature (preferably 25 °C), which the thermistor will conduct indefinitely in its low-resistance condition

3.29
inrush current
I_{in}
current occurring during the transient period from the moment of switching to the steady-state condition

3.30
peak inrush current
$I_{in\ p}$
peak inrush current is the maximum value of current during the transient period (see Figure 4)

3.31
minimum peak inrush current
$I_{in\ p\ min}$
lowest specified value of the peak of the inrush current

3.32
maximum peak inrush current
$I_{in\ p\ max}$
maximum specified value of the peak inrush current

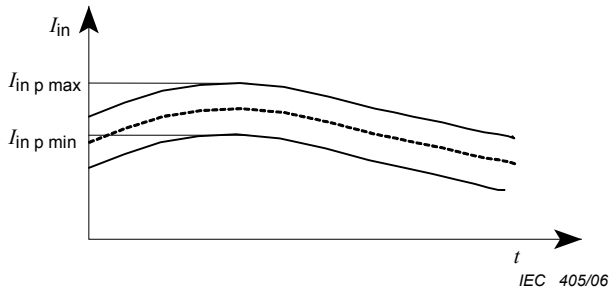


Figure 4 – I_{in} against t at U_{dc}

3.33
peak-to-peak inrush current (for a.c. conditions only)
$I_{in\ pp}$
value of the inrush current measured between adjacent positive and negative peaks (see Figure 5)

3.34
minimum peak-to-peak inrush current
$I_{in\ pp\ min}$
lowest specified value of the peak to peak inrush current

3.35
maximum peak to peak inrush current
$I_{in\ pp\ max}$
maximum specified value of the peak to peak inrush current

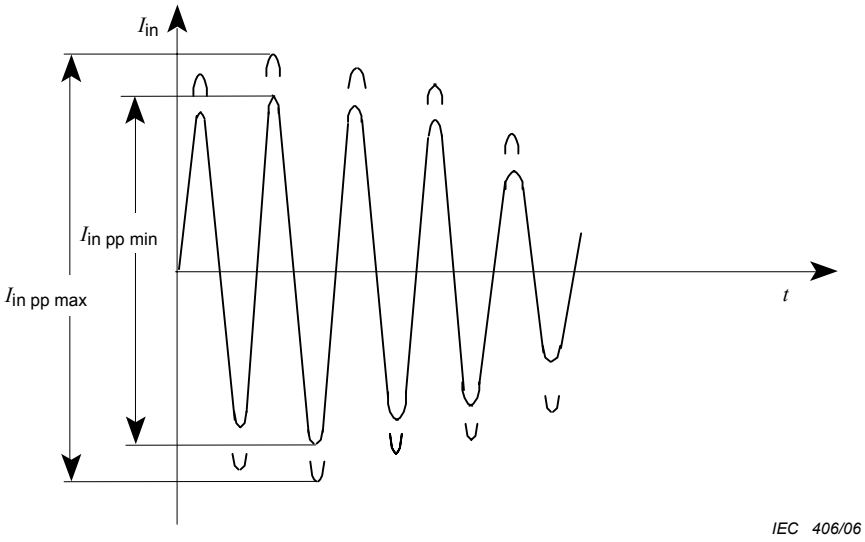


Figure 5 – I_{in} against t at U_{rms}

3.36
peak inrush power
$P_{in\ p}$
peak power ($U \times I_{in\ p}$) measured at the maximum peak value of the current occurring during the transient period from the moment of switching to the steady-state operating condition measured under specified conditions of ambient temperature, voltage and circuit

3.37
maximum peak inrush power
$P_{in\ p\ max.}$
maximum peak power which can occur during the transient period before the thermistor reaches its steady-state operating condition

NOTE In the detail specification it should be specified whether the "0-peak value" or the "r.m.s. value" of the voltage should be taken.

3.38
maximum power
$P_{max.}$
maximum power is the power ($U_{max.} \times I_{res}$) which can be dissipated continuously by the thermistor when the maximum voltage is applied under specified conditions of ambient temperature, circuit and thermal dissipation when thermal equilibrium is obtained

NOTE If the power is supplied by an a.c. source then the voltage and current should be measured with true r.m.s. meters.

3.39
dissipation factor
δ
quotient (in W/K) of the change in power dissipation in the thermistor and the resultant change of the body temperature under specified ambient conditions (temperature, medium)

3.40
thermal resistance
R_{th}
quotient (in K/W) of the temperature difference between the thermistor and its ambient and the power dissipated by the thermistor under specified ambient conditions (temperature, medium)

NOTE "Dissipation factor" and "thermal resistance" are mutually reciprocal.

3.41
heat capacity
C_{th}
energy (in J) the thermistor needs to increase its body temperature by 1 K

3.42
response time

a) response time by ambient temperature change (t_a)

time (in s) required by a thermistor to change its temperature between two defined conditions when subjected to a change in ambient temperature

b) response time by power change (t_p)

time (in s) required by a thermistor to change its temperature between two defined conditions of power input

3.43
thermal time constant
thermal time constant (ideal) for a thermistor is the product of its heat capacity and its thermal resistance

a) thermal time constant by ambient temperature change (τ_a)

time required for a thermistor to respond to 63,2 % of an external step change in ambient temperature

b) thermal time constant by cooling (τ_c)

time required for a thermistor to cool by 63,2 % of its temperature excess, due to electrical heating, in still air

3.44
insulated thermistors
thermistors capable of meeting the requirements of the insulation-resistance and voltage-proof tests when specified in the test schedule

3.45
surface temperature
T_s
temperature under defined conditions at the boundary layer between two media

3.46
final surface temperature
T_{sf}
temperature reached under defined conditions when thermal equilibrium is established

4 Units and symbols

Units, graphical symbols, letter symbols and terminology shall, whenever possible, be taken from the following publications:

IEC 60027

IEC 60050

IEC 60617

ISO 1000

When further items are required they shall be derived in accordance with the principles of the documents listed above.

5 Preferred values

5.1 Climatic categories

The thermistors are classified into climatic categories according to the general rules given in the annex to IEC 60068-1. The detail specification shall prescribe the appropriate category.

5.1.1 Bump test severities

The test severity given in the detail specification shall preferably be the following:

Test Eb (IEC 60068-2-29)

Acceleration: 400 m/s^2
Number of bumps: 4 000 total

Thermistors shall be mounted by their normal means, in such a manner that there shall be no parasitic vibration.

5.1.2 Shock test severities

Test severities given in detail specifications shall preferably be the following:

Test Ea (IEC 60068-2-27)

Pulse shape: Half-sine
Acceleration: 500 m/s^2
Pulse duration: 11 ms
Severity: Three successive shocks in each axis direction per specimen
Separate specimens to be used for each axis (six shocks total per specimen)

NOTE The shock and bump tests are normally specified as alternatives.

5.1.3 Vibration severities

Test severities given in the detail specifications shall preferably be selected from the following:

Test Fc (IEC 60068-2-6)

Frequency Hz	**Total number of sweep cycles**
10 to 55	3 × 24
10 to 500	3 × 10
10 to 2 000	3 × 8

5.2 Marking

5.2.1 General

The following shall be clearly marked on the thermistor in the following order of precedence as space permits.

a) Values of the primary characteristics appropriate to the application of the thermistor to be specified in the detail specification. When these values are coded (including colour coding), details shall be given in the detail specification or type designation.

b) Manufacturer's name and/or trade mark.

c) Date of manufacture.

d) The number of the detail specification and style.

The package containing the thermistors shall be clearly marked with all the information listed above.

Any additional marking shall be so applied that no confusion can arise.

5.2.2 Coding

Where coding for the date is used, the method shall be selected from those given in IEC 60062.

5.3 Spacings

5.3.1 The spacings between parts of opposite polarity of a thermistor shall be not less than the applicable values specified in Table 1.

Table 1 – Creepage distances and clearances

Environment	Operating voltage DCV or Vrms			
	≤ 32	> 32 and ≤ 50	> 50 and ≤ 300	> 300 and ≤ 600
Sealed or encapsulated	Exception 1	0,4 mm	0,8 mm	0,8 mm
Clean	Exception 1	1,0 mm	1,0 mm	1,0 mm
Normal and dirty	Exception 1	1,0 mm	1,5 mm	1,5 mm

This applies to both creepage distances and clearances.

Exception 1: as to the creepage distances and clearances for PTC thermistors with a rated operating voltage of less than 32 V, this value meets the intention of these requirements when the thermistor is confirmed to have the maximum voltage specified in the detail specification.

5.3.2 An insulating barrier or liner that is used to provide spacings shall be not less than 0,71 mm.

Exception 2: a barrier or liner that is used in conjunction with at least 50 % of required through-air spacing shall be not less than 0,33 mm thickness.

Exception 3: a barrier or liner having a thickness of less than that specified above complies with the requirements when it is investigated and found to be rated for the intended conditions of use, and found to be mechanically and electrically equivalent to the barrier or liner specified above.

6 Quality assessment procedures

6.1 General

When these documents are being used for the purposes of a full quality assessment system such as the IEC Quality Assessment System for Electronic Components (IECQ), compliance with 6.5 is required.

When these documents are used outside such quality assessment systems for purposes such as design proving or type testing, the procedures and requirements of 6.5.1 and 6.5.3b) may be used, but, if used, the tests and parts of tests shall be applied in the order given in the test schedules.

Before thermistors can be qualified according to the procedures of this subclause, the manufacturer shall obtain the approval of his organization in accordance with the provisions of IEC QC 001002-3.

The method for the approval of thermistors of assessed quality given in 6.5 is qualification approval according to the provisions of Clause 3 of IEC QC 001002-3.

6.1.1 Applicability of qualification approval

Qualification approval is appropriate for a standard range of thermistors manufactured to similar design and production processes and conforming to a published detail specification.

The programme of tests defined in the detail specification for the appropriate assessment and performance levels applies directly to the subfamily of thermistors to be qualified, as prescribed in 6.5 and the relevant blank detail specification.

6.2 Primary stage of manufacture

The primary stage of manufacture is defined as the initial mixing process of the ingredients.

6.3 Subcontracting

If subcontracting of the primary stage of manufacture and/or subsequent stages is employed it shall be in accordance with 4.2.2 of IEC QC 001002-3.

The blank detail specification may restrict subcontracting in accordance with 4.2.2.2 of IEC QC 001002-3.

6.4 Structurally similar components

Thermistors may be grouped as structurally similar for the purpose of forming inspection lots provided that the following requirements are met.

– They shall be produced by one manufacturer on one site using essentially the same design, materials, processes and methods.
– The sample taken shall be determined from the total lot size of the grouped devices.
– Structurally similar devices should preferably be included in one detail specification but the details of all claims to structural similarity shall be declared in the qualification approval test reports.

6.4.1 For electrical tests, devices having the same electrical characteristics may be grouped provided that the element determining the characteristics is similar for all the devices concerned.

6.4.2 For environmental tests, devices having the same encapsulation, basic internal structure and finishing processes may be grouped.

6.4.3 For visual inspection (except marking), devices may be grouped if they have been made on the same production line, have the same dimensions, encapsulation and external finish.

This grouping may also be used for robustness of terminations and soldering tests where it is convenient to group devices with different internal structures.

6.4.4 For endurance tests, thermistors may be grouped if they have been made on the same production line using the same design and differing only in electrical characteristics. If it can be shown that one type from the group is more heavily stressed than the others then tests on this type may be accepted for the remaining members of the group.

6.5 Qualification approval procedures

6.5.1 Eligibility for qualification approval

The manufacturer shall comply with 3.1.1 of IEC QC 001002-3.

6.5.2 Application for qualification approval

The manufacturer shall comply with 3.1.3 of IEC QC 001002-3.

6.5.3 Test procedure for qualification approval

One of the two following procedures shall be followed.

a) The manufacturer shall produce test evidence of conformance to the specification requirements on three inspection lots for lot-by-lot inspection taken in as short a time as possible and one lot for periodic inspection. No major changes in the manufacturing process shall be made in the period during which the inspection lots are taken.

   Samples shall be taken from the lots in accordance with IEC 60410 (see Annex A). Normal inspection shall be used, but when the sample size would give acceptance on zero non-conformances, additional specimens shall be taken to meet the sample size requirements to give acceptance on one non-conforming item.

b) The manufacturer shall produce test evidence to show conformance to the specification requirements on one of the fixed sample size test schedules given in 6.5.4.

   The specimens taken to form the sample shall be selected at random from current production or as agreed with the National Supervising Inspectorate (NSI).

For the two procedures the sample sizes shall be of comparable order. The test conditions and requirements shall be the same.

6.5.4 Qualification approval on the basis of the fixed sample size procedure

The fixed sample size test schedules for qualification approval given hereafter are appropriate to the intended application of the thermistor which is to be approved. The schedules provide information on the test grouping and sampling and acceptance criteria. The conditions of test and the end-of-test requirements shall be identical to those specified in the related blank detail specification for the lot-by-lot and periodic tests.

The complete series of tests specified in the relevant table are required for the approval of thermistors covered by one detail specification. The tests of each group shall be carried out in the order given.

The whole sample shall be subjected to the tests of group 0 and then divided for the other groups.

Non-conforming specimens during the tests of group 0 shall not be used for the other groups.

"One non-conforming item" is counted when a thermistor has not satisfied the whole or a part of the tests of a group.

The approval is granted when the number of non-conformances does not exceed the specified number of permissible non-conforming items for each group or subgroup and the total number of permissible non-conformances.

The following list applies to each test schedule developed in Tables 2 to 5.

1 Clause number references are to clauses in this specification.

2 a) Where the test schedule of a blank detail specification omits a test, that test may be omitted from the corresponding fixed sample size schedule in this specification.

b) Where additional tests are specified in a detail specification, that test shall be included in the corresponding fixed sample size schedule, either by its addition to an existing group or by the addition of another group. In the former case there shall be no change in the number of specimens to be tested or in the acceptance criteria. In the latter case, the number of specimens to be tested and the acceptance criteria shall be comparable to those already specified.

3 In these tables,

n is the sample size;

c is the acceptance criterion (permitted number of non-conforming items);

D indicates a destructive test;

ND indicates a non-destructive test.

4 The temperature at which the zero-power resistance shall be measured is the temperature specified in the detail specification. This temperature shall be stated, where required, in the test schedule.

5 Data for conditions of test are defined in the detail specification.

6 The additional specimens are to permit substitution for incidents not attributable to the manufacturer. The specimens may be used to replace non-conforming specimens which occur as a result of a test in a group which is identified as being “destructive”. Where a specimen is used for this purpose, it shall be subjected to those tests in the group to which the non-conforming item had already been subjected, before proceeding with the remaining tests in the group.

7 The specimens used for this group may, at the discretion of the manufacturer, be used for any subsequent group which is identified as being "destructive".

8 Ten samples from group 0 tests samples shall be chosen; 5, having the lowest zero-power resistance of the sample, shall be used for group 1A; 5, having the highest zero-power resistance of the sample for group 1B.

9 The soldering – solderability and soldering – resistance to soldering heat tests shall only be applied where the thermistor has terminations which are appropriate for soldering.

10 Where the terminations are stated to be suitable for printed wiring applications, the appropriate test conditions in IEC 60068 shall apply.

11 The thermistors shall be mounted by their normal means.

12 The bump test and the shock test are to be alternatives. The test selected in the detail specification shall be used.

13 The detail specification shall specify which of the endurance tests in groups 5, 6 and 7 for Table 2 or Table 5, in groups 5 and 6 for Table 3 or groups 4 and 5 for Table 4, respectively, are appropriate to the construction and application of the thermistor.

Table 2 – Fixed sample size test schedule for qualification approval of thermistors for current limitation – Assessment level EZ

Group No.	Test (see list item 5)	Subclause of this standard	D or ND	Number of specimens *n*	Permissible number of non-conforming items *c*
0	Visual examination Marking Dimensions (gauging) Nominal zero-power resistance R_n Voltage proof	7.4.1 7.4.2 7.4.3 7.5 7.8	ND	100 + 5 (see list item 6)	0
1	Temperature coefficient of resistance (if specified)	7.6	D	10 (see list items 7 and 8)	0
1A	Tripping current and tripping time Residual current	7.25 7.27		5 (list item 8)	
1B	Non-tripping current	7.26		5 (list item 8)	
	Solderability (see list items 9 and 10)	7.16			
2A	Resistance to soldering heat (see list items 9 and 10) Robustness of terminations	7.17 7.15		5	
2B	Rapid change of temperature Vibration Bump or shock (see list item 12)	7.18 7.19 7.20 or 7.21		5	
2	Climatic sequence	7.22	D	10	0
3	Thermal time constant by cooling (if specified)	7.14	ND	10	0
4	Dimensions (detail) Dissipation factor at U_{max} (if specified)	7.4.4 7.10	ND	10	0
5	Endurance at room temperature (cycling)(see list item 13)	7.24.1	D	10	0
6	Endurance at upper category temperature (see list item 13)	7.25.2 7.22.2	D	10	0
7	Endurance at max. operating temperature and max. voltage (see list item 13)	7.24.3	D	10	0
8	Cold environmental electrical cycling	7.24.4	D	10	0
9	Thermal runaway	7.24.5	D	10	0
10	Damp heat, steady state	7.23	D	10	0

Table 3 – Fixed sample size test schedule for qualification approval of thermistors for use as heating elements – Assessment level EZ

Group No.	Test (see list item 5)	Subclause of this standard	D or ND	Number of specimens *n*	Permissible number of non-conforming items *c*
0	Visual examination Marking Dimensions (gauging) Nominal zero-power resistance R_n Voltage proof	7.4.1 7.4.2 7.4.3 7.5 7.8	ND	90 + 5 (see list item 6)	0
1	Temperature coefficient of resistance (if specified) Surface temperature (if specified) Maximum inrush power (if specified) Residual current (if specified) Solderability (see list item 9 and 10)	7.6 7.28 7.29 7.27 7.16	D	10 (see list item 7)	0
2A	Resistance to soldering heat (see list item 9 and 10) Robustness of terminations	7.17 7.15		5	
2B	Rapid change of temperature Vibration (if specified, not for non-insulated types) Bump or shock (see list item 12)	7.18 7.19 7.20 or 7.21		5	
2	Climatic sequence	7.22	D	10	0
3	Thermal time constant by cooling (if specified)	7.14	ND	10	0
4	Dimensions (detail) Dissipation factor at U_{max} (if specified)	7.4.4 7.10	ND	10	0
5	Endurance at room temperature (cycling)(see list item 13)	7.24.1	D	10	0
6	Endurance at max. operating temperature and max. voltage (see list item 13)	7.24.3	D	10	0
7	Cold environmental electrical cycling	7.24.4	D	10	0
8	Thermal runaway	7.24.5	D	10	0
9	Damp heat, steady state	7.23	D	10	0

Table 4 – Fixed sample size test schedule for qualification approval of thermistors for inrush current application – Assessment level EZ

Group No.	Test (see list item 5)	Subclause of this standard	D or ND	Number of specimens *n*	Permissible number of non-conforming items *c*
0	Visual examination Marking Dimensions (gauging) Nominal zero-power resistance R_n Voltage proof	7.4.1 7.4.2 7.4.3 7.5 7.8	ND	80 + 5 (see list item 6)	0
1	Inrush current Residual current Solderability (see list items 9 and 10)	7.29 7.27 7.16	D	10 (see list item 7)	0
2A	Resistance to soldering heat (see list items 9 and 10) Robustness of terminations	7.17 7.15		5	
2B	Rapid change of temperature Vibration Bump or shock (see list item 12)	7.18 7.19 7.20 or 7.21		5	
2	Climatic sequence	7.22	D	10	0
3	Dimensions (detail) (see list item 7)	7.4.4	ND	10	0
4	Endurance at room temperature (cycling) (see list item 13)	7.24.1	D	10	0
5	Endurance at max. operating temperature and max. voltage (see list item 13)	7.24.3	D	10	0
6	Cold environmental electrical cycling	7.24.4	D	10	0
7	Thermal runaway	7.24.5	D	10	0
8	Damp heat, steady state	7.23	D	10	0

Table 5 – Fixed sample size test schedule for qualification approval of thermistors for use as temperature sensing elements – Assessment level EZ

Group No.	Test (see list item 5)	Subclause of this publication	D or ND	Number of specimens *n*	Permissible number of non-conforming items *c*
0	Visual examination Marking Dimensions (gauging) Nominal zero-power resistance R_n Voltage proof	7.4.1 7.4.2 7.4.3 7.5 7.8	ND	90 + 5 (see list item 6)	0
1	Temperature coefficient of resistance (if specified) Zero-power resistance R_T (if specified) Nominal functioning temperature T_{NF} Residual current (if specified) Solderability (see list items 9 and 10)	7.6 7.5 7.9 7.27 7.16	D	10 (see list item7)	0
2A	Resistance to soldering heat (see list items 9 and 10) Robustness of terminations	7.17 7.15		5	
2B	Rapid change of temperature Vibration (if specified, not for non-insulated types) Bump or shock (see list item 12)	7.18 7.19 7.20 or 7.21		5	
2	Climatic sequence	7.22	D	10	0
3	Response time (if specified) by ambient temperature change t_a or Response time by power change t_p	7.11 or 7.12	ND	10	0
4	Dimensions (detail) Dissipation factor at U_{max} (if specified)	7.4.4 7.10	ND	10	0
5	Endurance at room temperature (cycling) (see list item 13)	7.24.1	D	10	0
6	Endurance at upper category temperature (see list item 13)	7.24.2	D	10	0
7	Endurance at max. operating temperature and max. voltage (see list item 13)	7.24.3	D	10	0
8	Cold environmental thermal cycling	7.24.4	D	10	0
9	Damp heat, steady state	7.23	D	10	0

6.5.5 Granting of qualification approval

Qualification approval shall be granted when the procedures in accordance with 3.1.4 of IEC QC 001002-3 have been completed satisfactorily.

6.5.6 Maintenance of qualification approval

Qualification approval shall be maintained by regular demonstration of compliance with the requirements for Quality Conformance (see 6.5.7).

6.5.7 Quality conformance inspection

6.5.7.1 The blank detail specifications associated with this specification shall prescribe the test schedule for quality conformance inspection. This schedule shall also specify the grouping, sampling and periodicity for the lot-by-lot and periodic inspection (see Tables 6 and 7).

Sampling plans and inspection levels shall be selected from those given in IEC 60410.

If required, more than one schedule may be specified.

An inspection lot shall consist of thermistors of the same style. It should be representative of those extremes of the resistance and switching temperature range produced during the inspection period.

Styles having the same nominal dimensions but different temperature characteristics of resistance produced during the period may be aggregated, except for the purposes of sub-groups which contain a test for temperature coefficients of resistance. The extremes, or any critical value of the ranges of resistance and temperature characteristics of resistance for which qualification approval has been granted, shall be inspected during a period which is approved by the National Supervising Inspectorate (NSI).

The sample for Groups C and D shall be collected over the last 13 weeks of the inspection period.

6.5.7.2 Assessment level

The assessment level given in the blank detail specification shall be in accordance with Tables 6 and 7.

Table 6 – Quality conformance inspection for lot-by-lot inspection

Inspection subgroup[d]	Assessment level				
	EZ				
	IL[a]	*n*[a]	*c*[a]		
A0	100 %[b]				
A1	S-4	[c]	0		
A2	S-3	[c]	0		
B1	S-2	[c]	0		
B2	S-2	[c]	0		

[a] *IL* is the inspection level;
n is the sample size;
c is the permissible number of non-conforming items.

[b] 100 % testing shall be followed by re-inspection by sampling in order to monitor outgoing quality level by non-conforming items per million (ppm). The sampling level shall be established by the manufacturer. For the calculation of ppm values, any parametric failure shall be counted as a non-conforming item. If one or more non-conforming items occur in a sample, this lot shall be rejected.

[c] Number to be tested: Sample size as directly allotted to the code letter for IL in Table 2A of IEC 60410.

[d] The content of the inspection subgroups is described in Clause 2 of the relevant blank detail specification.

Table 7 – Quality conformance inspection for periodic testing

Inspection subgroup[b]	Assessment level				
	EZ				
	p[a]	*n*[a]	*c*[a]		
C1A	6	5	0		
C1B	6	5	0		
C1	6	10	0		
C2	6	10	0		
C3	6	10	0		
C4	6	10	0		
C5	6	10	0		
D1	12	10	0		
D2	12	10	0		
D3	12	10	0		

[a] *p* is the periodicity in months;
n is the sample size;
c is the permissible number of non-conforming items.

[b] The content of the inspection subgroups is described in Clause 2 of the relevant blank detail specification.

6.6 Rework and repair

6.6.1 Rework

Rework, as defined in 4.1.4 of IEC QC 001002-3, shall not be carried out if prohibited by the relevant specification. The relevant specification shall state if there is a restriction on the number of occasions that rework may take place on a specific component.

All rework shall be carried out prior to the formation of the inspection lot offered for inspection to the requirements of the detail specification.

Such rework procedures shall be fully described in the relevant documentation produced by the manufacturer and shall be carried out under the direct control of the designated management representative (DMR). Rework shall not be subcontracted.

6.6.2 Repair

Thermistors which have been repaired as defined in IEC QC 001002-3 shall not be released under the IECQ system.

6.7 Release for delivery

Thermistors shall be released for delivery according to 3.2.6 and 4.3.2 of IEC QC 001002-3, after the Quality Conformance Inspection prescribed in the detail specification has been carried out.

6.7.1 Release for delivery under qualification approval before the completion of group B tests

When the conditions of IEC 60410 for changing to reduced inspection have been satisfied for all group B tests, the manufacturer is permitted to release components before the completion of such tests.

6.8 Certified test records of released lots

When certified test records are requested by a purchaser, they shall be specified in the detail specification.

6.9 Delayed delivery

Thermistors held for a period exceeding three years (unless otherwise specified in the relevant specification), following the release of the lot shall, before delivery, be re-examined as specified in the relevant specification.

The re-examination procedure adopted by the manufacturer's DMR shall be approved by the NSI.

Once a lot has been satisfactorily re-inspected, its quality is re-assured for the specified period.

6.10 Alternative test methods

See 3.2.3.7 of IEC QC 001002-3 with the following details.

In case of dispute, for referee and reference purposes only the specified methods shall be used.

6.11 Manufacture outside the geographical limits of IECQ NSIs

A manufacturer may have his approval extended to cover part or complete manufacture of thermistors in a factory of his company located in a country which does not have a NSI for the technical area concerned, whether this country is an IECQ member country or not, provided that the requirements of 2.5.1.3 of IEC QC 001002-3 are met.

6.12 Unchecked parameters

Only those parameters of a component which have been specified in a detail specification and which were subject to testing shall be assumed to be within the specified limits.

It cannot be assumed that any unspecified parameter will remain unchanged from one component to another. Should for any reason it be necessary for further parameters to be controlled, then a new, more extensive specification shall be used.

The additional test method(s) shall be fully described and appropriate limits, sampling plans and inspection levels specified.

7 Test and measurement procedures

7.1 General

The blank detail specification shall indicate the tests to be made, which measurements are to be made before and after each test or subgroup of tests, and the sequence in which they shall be made. The stages of each test shall be carried out in the order written. The measuring conditions shall be the same for initial and final measurements.

If national specifications within any quality assessment system include methods other than those specified in the above specifications, they shall be fully described.

The limits given in all specifications are absolute limits. The principle to take measurement uncertainty into account shall be applied (see IEC QC 001002-3, Annex C).

7.2 Standard conditions for testing

7.2.1 Standard atmospheric conditions for testing

Unless otherwise specified, all tests shall be carried out under standard atmospheric conditions for testing as given in 5.3 of IEC 60068-1:

– temperature 15 °C to 35 °C;
– relative humidity 25 % to 75 %;
– air pressure 86 kPa to 106 kPa.

All tests requiring a close control of temperature shall be made with the thermistor immersed in a well-stirred non-conducting, non-corrosive, non-reducing medium maintained at the test temperature. The thermistors shall attain thermal equilibrium before results are recorded.

When measurements are made at a temperature other than the specified temperature the results shall, where necessary, be corrected to the specified temperature. The ambient temperature during the measurements shall be stated in the test report.

During measurements the thermistor shall not be exposed to draughts, direct sun rays or other influences likely to cause error.

The tests shall be carried out in the prescribed order.

7.2.2 Error of measurement

The total error of measurement of power dissipation, temperature tolerance and the tolerance of the measuring equipment shall not exceed 10 % of the tolerance in the detail specification.

7.3 Drying and recovery

7.3.1 Drying

Where drying is called for in the specification, the thermistor shall be conditioned before measurement is made, using Procedure I or Procedure II as called for in the detail specification.

Procedure I

For (24 ± 4) h in an oven at a temperature of (55 ± 2) °C and relative humidity not exceeding 20 %.

Procedure II

For (36 ± 4) h in an oven at (100 ± 5) °C.

The thermistor shall then be allowed to cool in a desiccator using a suitable desiccant, such as activated alumina or silica gel, and shall be kept therein from the time of removal from the oven to the beginning of the specified tests.

7.3.2 Recovery

Where recovery is required, the thermistor shall be stored at standard atmospheric conditions for testing for 1 h to 2 h.

7.4 Visual examination and check of dimensions

7.4.1 Visual examination

The condition, workmanship and finish shall be satisfactory as determined by visual examination.

7.4.2 Marking

Marking shall be legible as determined by visual examination.

7.4.3 Dimensions (gauging)

The dimensions indicated in the detail specification as being suitable for gauging shall be checked and shall comply with the values prescribed in the detail specification.

When applicable, measurements shall be made in accordance with IEC 60294 and IEC 60717.

7.4.4 Dimensions (detail)

All dimensions prescribed in the detail specification shall be checked and shall comply with the values prescribed.

Also the spacings according to 5.3 shall be checked, except for lot-by-lot inspection and/or periodic testing.

7.5 Zero-power resistance

7.5.1 The zero-power resistance shall be measured at the temperature given in the detail specification.

7.5.2 The thermistors shall be mounted by their normal means in corrosion-resistant clips on a mounting plate made of polytetrafluoroethylene (PTFE) or equivalent insulating material.

The thermistors shall then be immersed in a non-corrosive and non-reducing medium the temperature of which shall be controlled in accordance with the relevant test method.

All measurements shall be made without self-heating of the devices (zero-power condition). If the voltage produces self-heating of the device, a pulsating voltage shall be applied. The value and the characteristics of the pulsating voltage shall be specified in the detail specification.

The measuring method shall be such that

a) for temperatures lower than, or equal to, T_{Rmin}
   1) for absolute resistance measurement, the error does not exceed 10 % of the resistance tolerance;
   2) for measurements of variation of resistance, the error does not exceed 10 % of the specified maximum change of resistance.
b) For temperatures higher than T_{Rmin}
   1) for absolute resistance measurements,
      i) when tolerances are specified on the resistance value, the error shall not exceed 10 % of the specified tolerance;
      ii) when a minimum resistance value is specified, the error shall not exceed 0,5 α_{R} (%) of the specified minimum value;

2) for measurements of variation of resistance,

   i) when tolerances are specified on the resistance value, the error shall not exceed 10 % of the specified tolerance;

   ii) when a minimum resistance value is specified, the error shall not exceed 0,5 α_R (%) of the value measured.

Where a pulse voltage is used, the characteristics of the pulse shall be given in the detail specification.

NOTE α_R is the average temperature coefficient.

7.5.3 The zero-power resistance shall be within the limits given in the detail specification.

7.6 Temperature coefficient of resistance

7.6.1 Calculate the temperature coefficient at a specified voltage using resistance values R_p and R_b measured at any pair of temperatures to be specified in the detail specification and using the formula specified in 3.19.

7.6.2 The temperature coefficient of resistance shall be within the specified tolerance.

7.7 Insulation resistance (for insulated types only)

7.7.1 The insulation resistance of the protective coating shall be measured.

7.7.2 According to the instructions given in the detail specification one of the following test methods is used.

Method 1

a) The non-insulated parts of the thermistor shall be wrapped in a good insulating material.

   The thermistor is placed in a vessel containing metallic balls having a diameter of (1,6 ± 0,2) mm, so that only the insulated part is immersed. (The metal of the balls shall be such that it does not develop a resistive surface.)

   An electrode is placed in the metallic balls.

b) The thermistor shall be placed in a saline solution, so that only the insulated part is immersed.

   The solution shall be of the same concentration as for the salt mist test (IEC 60068-2-11).

   An electrode is immersed in the solution.

Method 2

A metal foil shall be wrapped closely around the body of the thermistor.

For those types not having axial terminations, a space of 1 mm to 1,5 mm shall be left between the edge of the foil and each termination. For those types having axial terminations, the foil shall be wrapped round the whole body of the thermistor protruding by at least 5 mm from each end, provided that the minimum space of 1 mm between the foil and the termination can be maintained. The ends of the foil shall not be folded over the ends of the thermistor.

Method 3

The thermistor shall be clamped in the trough of a 90° metallic V-block of such size that the thermistor body does not extend beyond the extremities of the block.

The clamping force shall be such as to maintain adequate contact between the thermistor and the block.

The thermistor shall be positioned in the V-block in accordance with the following:

– for cylindrical thermistors: the thermistor shall be positioned in the block so that the termination furthest from the axis of the thermistor is nearest to one of the faces of the block;
– for rectangular thermistors: the thermistor shall be positioned in the block so that the termination nearest to the edge of the thermistor is nearest to one of the faces of the block;

for cylindrical and rectangular thermistors with axial leads: any out-of-centre positioning of the point of emergence of the terminations from the body shall be ignored.

7.7.3 The insulation resistance shall be measured with a direct voltage of 100 V ± 15 V between both terminations of the thermistor connected together as one pole and the metallic balls, metal foil or V-block as the other pole.

The voltage shall be applied for 1 min, or for such shorter time as is necessary to obtain a stable reading, the insulation resistance being read at the end of that period.

7.7.4 When thermistors are measured as specified, the insulation resistance shall not be less than the appropriate figure specified in the detail specification.

7.8 Voltage proof (for insulated types only)

7.8.1 The thermistors shall be tested as specified below.

7.8.2 As required by the detail specification, one of the test methods given in 7.7.2 shall be used.

7.8.3 The applied voltage shall be that specified in the applicable safety document. In the absence of a safety document the applied voltage shall be as follows.

An alternating voltage with a frequency of 40 Hz to 60 Hz and with a peak value of 1,4 times the isolation voltage specified in the detail specification, shall be applied for 60 s ± 5 s between all terminations of the thermistor connected together as one pole and the metallic balls, the metal foil or the V-block as the other pole.

The voltage shall be applied gradually at a rate of approximately 100 V/s. The test time may be reduced to 1 s provided the test voltage is increased by 10 %.

7.8.4 There shall be no breakdown or flashover.

7.9 Resistance/temperature characteristic

7.9.1 The resistance/temperature characteristic shall be measured in the manner described below.

7.9.2 Resistance measurements shall be made in accordance with the method specified in 7.5 but at the temperatures and voltages indicated in the detail specification.

7.9.3 The resistance/temperature characteristic shall be within the limits specified in the detail specification.

7.10 Dissipation factor at U_{max} (δ)

7.10.1 The dissipation factor of the PTC thermistor shall be determined at maximum voltage unless otherwise specified in the detail specification.

7.10.2 Thermistors with wire terminations shall be gripped and connected by clips at the distance from the body given in the detail specification.

If possible, preferential lengths shall be chosen in the series 1 mm, 2 mm, 5 mm and decimal multiples.

Thermistors with other than wire terminations shall be mounted and connected as described in the detail specification.

The clips carrying the thermistors shall then be enclosed in a chamber having a volume at least 1 000 times as great as that of the thermistors under test. The wires shall be so positioned that no thermistor is within 75 mm of any other thermistor or the walls of the chamber.

The air in the chamber shall be stationary and shall be at a temperature of (25 ± 0,5) °C. The thermistors shall be connected in the circuit shown below.

7.10.3 U_{max} as specified in the detail specification shall be applied gradually ensuring that I_{mo} is not exceeded (see Figure 6).

After stabilization at maximum voltage ($U_{max.}$), the current through the thermistor shall be measured and noted. For a.c. current both the peak value and the r.m.s. value of the current shall be noted.

7.10.4 The thermistors shall be immersed in the medium as defined in 7.2 and the maximum d.c. or a.c. peak voltage shall be applied under zero-power conditions (pulses).

The temperature of the medium shall be increased until the d.c. current or the a.c. peak current reaches the same value as registered under the previous conditions.

The temperature (°C) reached shall be noted (T_3).

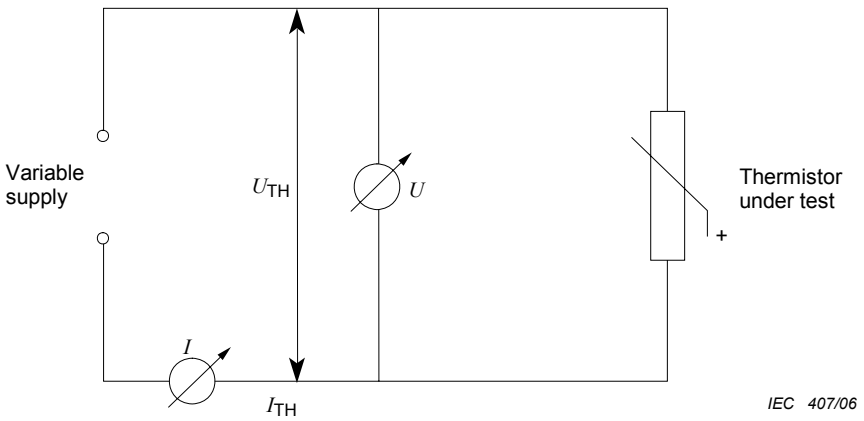


Figure 6 – Dissipation factor test circuit

7.10.5 The dissipation factor (δ) shall be calculated using the following formula:

$$\delta = \frac{U_{\mathrm{TH}} \times I_{\mathrm{TH}}}{T_3 - 25}$$

For d.c. $$\delta = \frac{U_{\mathrm{dc}} \times I_{\mathrm{dc}}}{T_3 - 25}$$

For a.c. $$\delta = \frac{U_{\mathrm{rms}} \times I_{\mathrm{rms}}}{T_3 - 25}$$

7.11 Response time by ambient temperature change (t_a)

7.11.1 The resistances R_1 and R_2 of the thermistor at temperatures T_1 and T_2 shall be recorded using the method specified in the detail specification.

7.11.2 The thermistor shall be immersed in the medium as defined in 7.2 and as specified in the detail specification, with a temperature T_1, until it has reached thermal equilibrium.

7.11.3 The thermistor shall then be immersed in the medium as defined in 7.2, as specified in the detail specification, with a temperature T_3 ($T_3 > T_2$, T_3 shall be specified in the detail specification). The transfer time from state 1 to state 2 shall not exceed 2 s.

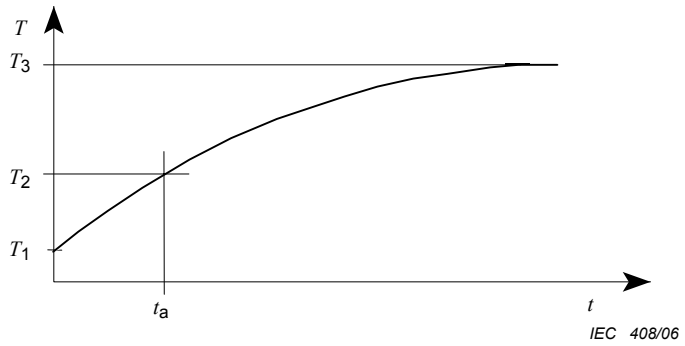


Figure 7 – Temperature gradient

7.11.4 The time elapsing between the moment of immersion as described in 7.11.3 and the moment when the resistance value of the thermistor reaches R_2 is the response time t_a (see Figure 7).

7.11.5 The response time shall be within the limits given in the detail specification.

7.12 Response time by power change (t_p)

7.12.1 Mounting

Thermistors with wire terminations shall be gripped and connected by clips at the distance from the body given in the detail specification.

If possible, preferential lengths shall be chosen in the series 1 mm, 2 mm, 5 mm and decimal multiples.

Thermistors with other than wire terminations shall be mounted and connected as described in the detail specification.

When the terminations are insulated, measurements are carried out at their end points, irrespective of their lengths.

7.12.2 Test

The thermistors shall be enclosed in a chamber in such a way that the temperature of other thermistors and the proximity of the walls will not materially affect the results of the test.

The temperature of the chamber is adjusted to the value given for this test in the detail specification and the air allowed to become stationary.

The thermistors are each connected to separate constant current supplies preset to the value given for this test in the detail specification and with voltage limiting at 50 % of U_{max}.

The response time shall be measured when the current reaches half of its preset value or at the moment stated in the detail specification.

The response time shall be within the limits given in the detail specification.

7.13 Thermal time constant by ambient temperature change (τ_a)

The method described in 7.11 shall be applied. The thermal time constant by ambient temperature change is by definition equal to 63,2 % of the response time by ambient temperature change (t_a) measured in 7.11.

7.14 Thermal time constant by cooling (τ_c)

7.14.1 Mounting

Thermistors with wire terminations shall be gripped and connected by clips at the distance from the body given in the detail specification.

If possible, preferential lengths shall be chosen in the series 1 mm, 2 mm, 5 mm and decimal multiples.

Thermistors with other than wire terminations shall be mounted and connected as described in the detail specification.

When the terminations are insulated, measurements are carried out at their end points, irrespective of their lengths.

7.14.2 Test

The thermistors are introduced in still air at temperature T_0 (T_0 = 25 °C ± 0,5 °C) in a test chamber the volume of which is at least 1 000 times that of the thermistors under test, in such a way that no thermistor is less than 75 mm from other thermistors or from the wall of the enclosure.

Before introduction in the test chamber, the thermistors are inserted in the circuit shown in Figure 8.

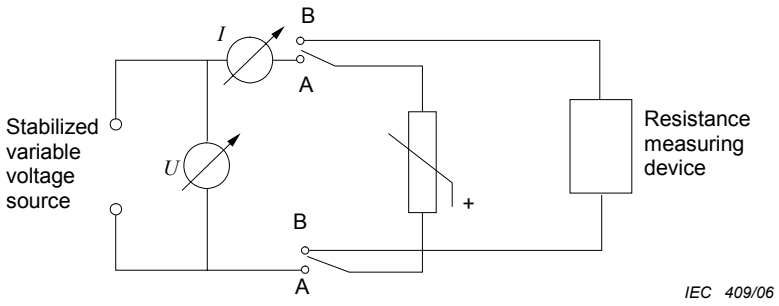


Figure 8 – Circuit for measurement of thermal time constant by cooling

The high impedance voltmeter and the ammeter shall measure to an accuracy of 1 %. The resistance measuring equipment shall measure to an accuracy of 0,1 % or less.

Depending on the cases determined below, Method A or Method B shall be used.

Method A

Applicable when $(T_3 - T_b) > 0{,}632\ (T_3 - T_0)$

Initial measurements: – R_{T_3} and R_{T_2} with $T_2 = T_3 - 0{,}632\ (T_3 - T_0)$.

With the contacts AA closed, the voltage is so adjusted that the power dissipated in the thermistor raises its temperature to a value slightly above T_3 (calculated as in 7.10), and the indications of the instruments are stable.

The applied power may then, for example, be calculated as follows:

$$P = U \times I = 1{,}1\ (T_3 - T_0) \times \delta$$

where δ is the value calculated according to 7.10.

The thermistor is then switched to contact position BB, and measurement of the time is started as soon as the resistance value has returned to R_{T_3} and the resistance measuring equipment is in balance.

Time measurement shall be stopped when the resistance measuring equipment indicates a value of R_{T_2} .

The elapsed time is noted. In this case, it represents the thermal time constant.

Method B

Applicable when $T_3 - T_b \leq 0{,}632\ (T_3 - T_0)$.

Initial measurements: – R_{T_3} and R_b.

With the contacts AA made, the voltage is so adjusted that the power dissipated in the thermistor raises its temperature to a value slightly above T_3 and the indications of the instruments are stable.

The applied power may then, for example, be calculated as follows:

$$P = U \times I = 1{,}1\ (T_3 - T_0) \times \delta$$

where δ is the value calculated according to 7.10.

The thermistor is then switched to contact position BB, and measurement of the time is started as soon as the resistance value has returned to R_{T_3} and the resistance measuring equipment is in balance.

Time measurement is stopped when the resistance measuring equipment indicates a value of R_b. The elapsed time (t) is noted, and the thermal time constant is then calculated as follows:

$$\tau_c = t/\ln[(T_3 - T_0)/(T_b - T_0)]$$

For thermistors with low time constants, automatic switching should be provided between both resistance measurements, as well as for measuring the time interval between both equilibria.

The power applied to the thermistor via the resistance measuring equipment shall be sufficiently low to enable the zero-power resistance of the thermistor to be measured.

7.14.3 The thermal time constant shall correspond to the value given in the detail specification, taking into account the tolerance.

7.15 Robustness of terminations

a) The appropriate parameter(s) given in the detail specification shall be measured and shall be recorded.
b) The thermistors shall be subjected to the procedure of Tests Ua, Ub and Uc of IEC 60068-2-21 as appropriate.
c) Tests Ub and Uc shall not be applied if the detail specification describes the terminations as rigid.

7.15.1 Test Ua_1 – Tensile

Unless otherwise prescribed in the detail specification, the force applied for 10 s shall be:

– for all types of terminations except wire terminations: 20 N;
– for wire terminations: see Table 8.

Table 8 – Tensile force

Nominal cross-sectional area (S) (see note) mm²	Corresponding diameter (d) for circular-section wires mm	Force with tolerance of ± 10 % N
$S \leq 0{,}05$	$d \leq 0{,}25$	1
$0{,}05 < S \leq 0{,}1$	$0{,}25 < d \leq 0{,}35$	2,5
$0{,}07 < S \leq 0{,}2$	$0{,}35 < d \leq 0{,}5$	5
$0{,}2 < S \leq 0{,}5$	$0{,}5 < d \leq 0{,}8$	10
$0{,}5 < S \leq 1{,}2$	$0{,}8 < d \leq 1{,}25$	20
$1{,}2 < S$	$1{,}25 < d$	40

NOTE For circular-section wires, strips or pins: the nominal cross-sectional area is equal to the value calculated from the nominal dimension(s) given in the relevant specification. For stranded wires, the nominal cross-sectional area is obtained by taking the sum of the cross-sectional areas of the individual strands of the conductor specified in the relevant specification.

7.15.2 Test Ub – Bending (half of the samples) (not applicable to thermistors encapsulated in glass or in envelopes)

Two consecutive bends shall be applied (Method 1).

7.15.3 Test Uc – Torsion (remaining samples)

Two rotations of 180° shall be applied (Severity 2).

7.15.4 Visual examination

After each of these tests the thermistors shall be visually examined. There shall be no visible damage.

7.15.5 Final measurements and requirements

After the test the appropriate parameter(s) given in the detail specification shall be measured and shall comply with the requirements prescribed in the detail specification.

7.16 Solderability

NOTE Not applicable to those terminations which the detail specification describes as not designed for soldering.

The relevant specification shall prescribe whether ageing is to be applied. If accelerated ageing is required, one of the ageing procedures given in IEC 60068-2-20 or 4 h dry heat test at 155 °C (other test conditions as in test Ba of IEC 60068-2-20) shall be applied.

Unless otherwise stated in the relevant specification, the test shall be carried out with non-activated flux.

7.16.1 Thermistors with leads

All thermistors except surface mount thermistors shall be subject to Test Ta of IEC 60068-2-20 either using the solder bath method (method 1) or the soldering iron method (method 2) or the solder globule method (method 3) as prescribed by the detail specification.

When the solder bath method (method 1) is specified, the following requirements apply.

7.16.1.1 Test conditions

Bath temperature: 235 °C± 5 °C for Sn-Pb solder. For Sn-Ag-Cu solder, bath temperature shall be described in the relevant specification.

Immersion time: 2,0 s ± 0,5 s

Depth of immersion (from the seating plane or component body):

a) all thermistors except those of b) below $2{,}0\,^{0}_{-0{,}5}$ mm, using a thermal insulating screen 1,5 mm ± 0,5 mm thickness;
b) thermistors indicated by the detail specification as not being designed for use on printed boards: $3{,}5\,^{0}_{-0{,}5}$ mm.

7.16.1.2 The terminations shall be examined for good tinning as evidenced by free flowing of the solder with wetting of the terminations.

7.16.1.3 When the solder bath method is not applicable, the relevant specification shall define both the method, test conditions and the requirement.

NOTE When the solder globule method is used, the requirement should include the soldering time.

7.16.1.4 Surface mount thermistors shall be tested in accordance with IEC 60068-2-58. The relevant specification shall be prescribe the test method and test conditions to be used for wetting, dewetting or resistance to dissolution of metallization consistent with the surface mounting classification (see IEC 61760-1)

7.16.1.5 Final inspection, measurements and requirements: the surface mount thermistors shall meet the requirements prescribed in the relevant specification.

7.17 Resistance to soldering heat

7.17.1 When prescribed by the relevant specification the thermistors shall be dried using the method of 7.3.1.

The thermistors shall be measured prescribed in the relevant specification.

7.17.2 Unless otherwise stated in the relevant specification, one of the following tests shall be applied, as prescribed by the relevant specification:

a) Method 1A of test Tb of IEC 60068-2-20 with
   - temperature of the solder bath: 260 °C ± 5 °C;
   - depth of immersion from the seating plane $2{,}0\,^{0}_{-0{,}5}$ mm, using a thermal insulating screen of 1,5 mm ± 0,5 mm thickness;
   - immersion time: 5 s or 10 s, as specified in the detail specification.

b) Method 1B of test Tb of IEC 60068-2-20 with
   - temperature of the solder bath: 350 °C ± 10 °C;
   - depth of immersion from the component body: $3{,}5\,^{0}_{-0{,}5}$ mm;
   - immersion time: 3,5 s ± 0,5 s.

c) Method 2: soldering iron of test Tb of IEC 60068-2-20 with
   - temperature of the soldering iron: 350 °C ± 10 °C;
   - soldering time: 10 s ± 1 s.

   The size of the soldering iron and the point of application shall be specified in the detail specification.

d) For surface mount thermistors, test Td of IEC 60068-2-58 shall be applied. The relevant specification shall prescribe the test method and test conditions to be used consistent with the surface mounting classification (see IEC 61760-1).

7.17.3 The period of recovery shall, unless otherwise specified by the detail specification, be not less than 1 h nor more than 2 h.

7.17.4 For all thermistors, except surface mount thermistors, the following shall apply.

- When the test has been carried out, the thermistors shall be visually examined.
- There shall be no visible damage and the marking shall be legible.
- The thermistors shall then be measured as prescribed in the relevant specification.

7.17.5 Surface mount thermistors shall be visually examined and measured and shall meet the requirements as prescribed in the relevant specification.

7.18 Rapid change of temperature

This test is only applicable to thermistors having a difference between the upper and lower category temperatures exceeding 95 °C.

The appropriate parameter(s) given in the detail specification shall be measured using the method specified and shall be recorded.

The thermistors shall then be subjected to Test Na of IEC 60068-2-14 for five cycles. The time of exposure at each extreme temperature is 30 min.

The thermistors shall be visually examined. There shall be no visible damage.

After recovery according to 7.3.2 the appropriate parameter(s) given in the detail specification shall be measured using the method specified. The change in value compared with that measured initially shall not exceed the limit specified in the detail specification.

7.19 Vibration

The appropriate parameter(s) given in the detail specification shall be measured using the method specified and shall be recorded.

The thermistors shall be securely mounted by their terminations and/or by their normal mounting means, as defined in the detail specification.

The design of the thermistor may be such that special mounting fixtures are required in its use. In this case the detail specification shall describe the mounting fixtures and they shall be used in the performance of the vibration, bump and shock tests.

The thermistors shall be subjected to the procedure of Test FC of IEC 60068-2-6, using the degree of severity given in the detail specification.

When specified in the detail specification, during the last 30 min of the vibration test an electrical measurement shall be made in each direction of movement to check intermittent contacts or open or short circuits.

The method of measurement shall be prescribed in the detail specification.

The duration of the measurement shall be the time needed for one sweep of the frequency range from one frequency extreme to the other.

After the test the thermistors shall be visually examined. There shall be no visible damage.

The appropriate parameter(s) given in the detail specification shall be measured using the method specified. The change in value compared with that measured initially shall not exceed the limit specified in the detail specification.

7.20 Bump

The appropriate parameter(s) given in the detail specification shall be measured using the method specified and shall be recorded.

Mounting shall be as specified in 7.12.1.

The thermistors shall be subjected to the procedure of Test Eb of IEC 60068-2-29 using the appropriate degree of severity as specified in the detail specification.

After the test the thermistors shall be visually examined. There shall be no visible damage.

The appropriate parameter(s) given in the detail specification shall be measured using the method specified. The change in value compared with that measured initially shall not exceed the limit specified in the detail specification.

7.21 Shock

The appropriate parameter(s) given in the detail specification shall be measured using the method specified and shall be recorded.

Mounting shall be as specified in 7.12.1.

The thermistors shall be subjected to the procedure of Test Ea of IEC 60068-2-27 using the appropriate degree of severity as specified in the detail specification.

After the test the thermistors shall be visually examined. There shall be no visible damage.

The appropriate parameter(s) given in the detail specification shall be measured using the method specified. The change in value compared with that measured initially shall not exceed the limit specified in the detail specification.

7.22 Climatic sequence

In the climatic sequence, an interval of not more than three days is permitted between any of these tests, except between damp heat, cyclic, first cycle and dry cold. In this case the cold test shall follow immediately after the recovery period specified for the damp heat test.

The test and measurements shall be performed in the following order.

7.22.1 Initial measurements

The thermistors shall be dried using Procedure I of 7.3.1.

The appropriate parameter(s) given in the detail specification shall be measured using the method specified and shall be recorded.

7.22.2 Dry heat

The thermistors shall be subjected to the procedure of Test Ba of IEC 60068-2-2 for a duration of 16 h, using the appropriate degree of severity.

7.22.3 Damp heat (cyclic), first cycle

The thermistors of categories -/-/56, -/-/21, -/-/10 and -/-/04 shall be subjected to Test Db of IEC 60068-2-30 for one cycle of 24 h.

After recovery the thermistors shall be subjected immediately to the cold test.

7.22.4 Cold

The thermistors shall be subjected to the procedure of Test Aa of IEC 60068-2-1 for a duration of 2 h, using the appropriate degree of severity.

7.22.5 Low air pressure

The thermistors shall be subjected to the procedure of Test M of IEC 60068-2-13 using the appropriate degree of severity.

The test shall be made at any temperature between 15 °C and 35 °C and the duration of the test shall be 1 h.

7.22.6 Damp heat (cyclic), remaining cycles

The thermistors shall be subjected to the procedure of Test Db of IEC 60068-2-30, for the following number of cycles.

Table 9 – Number of cycles per climatic category

Categories	Number of cycles
-/-/56	5
-/-/21	1
-/-/10	1
-/-/04	0

After the test the thermistors shall be subjected to recovery according to 7.3.2.

7.22.7 Final measurements

The thermistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The appropriate parameter(s) given in the detail specification shall be measured using the method specified. The change in value compared with that measured initially shall not exceed the limit specified in the detail specification.

For insulated types, the insulation resistance shall be measured according to 7.8 and shall be not less than that specified in the detail specification. The thermistors shall withstand the voltage-proof test as defined in 7.9 without breakdown or flashover.

7.23 Damp heat, steady state

The appropriate parameter(s) given in the detail specification shall be measured using the method specified and shall be recorded.

Non-insulated thermistors shall be subjected to the procedure of Test Ca of IEC 60068-2-78 using the appropriate severity.

For insulated types, the same procedure shall be applied but, if specified in the relevant detail specification, a d.c. voltage of 1/20 of the voltage (taken from the R5 series) corresponding to the maximum dissipation may be applied to the thermistor during the test.

At the end of this period the thermistors shall be removed from the chamber and shall then be subjected to recovery according to 7.3.2.

The thermistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The appropriate parameter(s) given in the detail specification shall be measured using the method specified.

The change in value compared with that measured initially shall not exceed that prescribed in the detail specification.

For insulated types, the insulation resistance shall be measured according to 7.7 and shall be not less than that specified in the detail specification. The thermistors shall withstand the voltage proof test as defined in 7.8 without breakdown or flashover.

7.24 Endurance

7.24.1 Endurance at room temperature (cycling)

The test is not required on thermistors for sensing application with exclusively passive warming.

The thermistors with exclusively passive warming shall be cycled thermally between the manufacturer's minimum specified ambient temperature and the maximum rated temperature under maximum rated electrical conditions.

Preconditioning, if required, shall be carried out by subjecting the thermistors to three successive applications of a voltage sufficient to heat them above the switching temperature. The value of the voltage and the durations of application and removal of the voltage shall be specified in the detail specification.

The appropriate parameter(s) as given in the blank detail specification shall be measured using the method specified and shall be recorded.

The thermistors shall be subjected to an endurance test under standard atmospheric conditions of testing (IEC 60068-1). The number of cycles shall be specified in the detail specification and shall preferably be selected from the following:

10 cycles
100 cycles
1 000 cycles
10 000 cycles
100 000 cycles

Thermistors with wire leads shall be connected so that their terminations have an effective length of 20 mm to 25 mm unless otherwise specified in the detail specification.

Thermistors suitable for use with printed wiring shall be connected at a point 1,5 mm to 2,0 mm from the seating plane.

Other thermistors shall be mounted by their normal means as prescribed in the detail specification.

The thermistors shall be so placed that the temperature of any one thermistor shall not appreciably influence the temperature of any other thermistor. There shall be no undue draught on the thermistor.

The thermistors shall be connected to a voltage supply of 95 % to 100 % of the maximum voltage. The tolerance on the voltage applied to the thermistor shall be calculated on the nominal value of the voltage source. Any series resistor shall take account of the impedance of the transformer controlling the supply and shall be such that the maximum overload current is obtained at the maximum voltage (U_{max}).

The rated voltage shall be applied to the thermistor for a heating time of not less than 10 % of the thermal time constant by cooling (see 7.14). At the end of the ON period the voltage shall be removed.

The thermistor shall be allowed to cool for a minimum of 1,2 times the thermal time constant by cooling (see 7.14). The cycling shall be repeated continuously (except for intermediate measurements, see hereafter) throughout the full period of the test.

After the specified number of cycles the thermistor shall be allowed to recover under standard atmospheric conditions of testing for not less than 1 h and not more than 2 h. The removal from test shall take place at the end of the OFF period. The interval between the removal from, and the return to, the conditions of test for any thermistor shall not exceed 12 h.

After cycling the thermistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The appropriate parameter(s) given in the detail specification shall be measured using the method specified. The change in value compared with that measured initially shall not exceed the limits specified in the detail specification.

7.24.2 Endurance at upper category temperature

The appropriate parameter(s) given in the detail specification shall be measured using the method specified and shall be recorded.

The thermistor shall be placed in a test chamber and subjected to the upper category temperature ± 2 °C for 42 days (1 000 h) and at zero dissipation. The thermistors shall be placed in the chamber in such a manner that their temperatures remain within the specified limits. The chamber shall meet the requirements of that specified for Test Ba of IEC 60068-2-2.

After 168 h and 500 h the thermistors shall be removed from the chamber and allowed to recover under standard atmospheric conditions of testing for not less than 1 h and not more than 2 h.

The appropriate parameter(s) as given in the detail specification shall be measured using the method specified. The change in value compared with that measured initially shall not exceed the limit specified in the detail specification.

After intermediate measurements the thermistors shall be returned to the conditions of test. The interval between the removal from, and the return to, the conditions of test for any thermistor shall not exceed 12 h.

After 1 000 h ± 48 h the thermistors shall be removed and allowed to recover under standard atmospheric conditions for a period of 1 h to 2 h.

The thermistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The appropriate parameter(s) as given in the detail specification shall be measured using the method specified. The change in value compared with that measured initially shall not exceed the limit specified in the detail specification.

7.24.3 Endurance at maximum operating temperature and maximum voltage

Preconditioning, if required, can be carried out by subjecting the thermistor to three successive applications of a voltage sufficient to heat them above the switching temperature. The value of the voltage and the durations of application and removal of the voltage shall be specified in the detail specification.

The appropriate parameter(s) given in the detail specification shall be measured using the methods specified and shall be recorded.

The thermistors shall be subjected to an endurance test of duration specified in the detail specification at maximum rated temperature. The temperature shall, unless otherwise specified, remain within +0/–2 °C of that at the commencement of the test.

Thermistors with wire leads shall be connected so that their terminations have an effective length of 20 mm to 25 mm unless otherwise specified in the detail specification.

Thermistors stated as being suitable for use on printed wiring boards shall be connected at a point 1,5 mm to 2,0 mm from the seating plane.

Other thermistors shall be mounted by their normal means as prescribed in the detail specification.

The thermistors shall be so placed that the temperature of any one thermistor shall not appreciably influence the temperature of any other thermistor. There shall be no undue draught on the thermistor.

The thermistor shall be connected in the circuit shown in Figure 9 (the series resistor R_S may be omitted if the voltage is applied slowly).

The voltage across the thermistor shall be the maximum voltage.

After approximately 168 h and 500 h the thermistor shall, if applicable, be allowed to recover under standard atmospheric conditions of testing for not less than 1 h and not more than 2 h.

The appropriate parameter(s) as given in the detail specification shall be measured using the method specified. The change in value compared with that measured initially shall not exceed the limit specified in the detail specification.

After the specified duration or at a specified time, the thermistors shall be removed from the chamber to recover under standard atmospheric conditions for a period of 1 h to 2 h.

The thermistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The appropriate parameter(s) given in the detail specification shall be measured using the method specified. The change in value compared with that measured initially shall not exceed the limit specified in the detail specification.

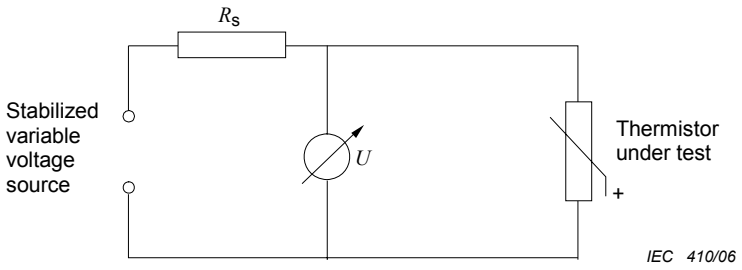


Figure 9 – Circuit for endurance at maximum operating temperature and maximum voltage

7.24.4 Cold environment electrical cycling

This test is not applicable to thermistors for type 1 controls, used as sensing devices, because self-heating is negligible.

The appropriate parameter(s) given in the blank detail specification shall be measured using the method specified and shall be recorded.

The thermistors shall be subjected to 1 000 cycles of operation at an ambient temperature of 0 °C or at the lowest specified operating temperature as mentioned in the detail specification, whichever is the lower.

The test conditions shall be as follows.

a) For current limitation application: U_{max} and I_t

b) For heater application: $P_{in\ p\ max}$

c) For inrush current application: U_{max} and $I_{in\ p\ max}$

d) For sensing application: Thermal cycling between 0 °C or the manufacturer's minimum specified ambient temperature and cover that portion of the R/T curve from the starting temperature to the maximum rated temperature.

For the above-mentioned test conditions a), b) and c), each cycle shall cover that portion of the R/T curve from the lower knee to the high resistance state. The thermistor temperature shall be returned to the starting temperature before each cycle.

The detail test condition shall be specified in the detail specification.

After the test the thermistor shall be visually examined. There shall be no visible damage and the marking shall be legible.

The appropriate parameter(s) as given in the blank detail specification shall be measured using the method specified. The change in value compared with that measured initially shall not exceed the limit specified in the detail specification.

7.24.5 Thermal runaway

Each of the thermistor samples shall be connected to a variable power source. The thermistors are to be energized and operated under maximum rated conditions until thermally stabilized. The maximum rated conditions mean the condition when the applicable maximum power (see 3.38) can be dissipated.

The voltage shall be gradually increased from 0 % to 200 % of maximum voltage (U_{max}) in increments of 10 % of U_{max} at 2 min intervals. The 200 % voltage shall be maintained for 2 min.

NOTE Examples of maximum rated conditions are considered as follows:

1) attach the heat sinks to thermistor;

2) add air flow to thermistor;

3) conditions equivalent to 1), 2) above.

In this test, the tested thermistor may be conditioned as mentioned above.

During the test, maximum overload current (I_{mo}) shall not be exceeded.

After the test the thermistors shall be visually examined. There shall be no visible damage and the marking shall be legible. There shall be no electrical or mechanical breakdown.

7.25 Tripping current and tripping time

Thermistors with wire terminations shall be gripped and connected by clips at the distance from the body given in the detail specification.

Thermistors with other than wire terminations shall be mounted and connected as described in the detail specification.

The thermistors shall be enclosed in a chamber such that the temperature of other thermistors and the proximity of the walls will not materially affect the results of the test.

The temperature of the chamber is adjusted to the value given for this test in the detail specification and the air allowed to become stationary.

The thermistors shall each be connected to a constant current supply preset to the I_t value specified in the detail specification. The voltage of the current supply shall be lower than 50 % of U_{max} or the voltage specified in the detail specification.

After a certain time the thermistors shall reduce the current to a lower level.

When specified in the detail specification the tripping time shall be measured. It is defined as the time between the start of the test and the moment at which the current is reduced to 50 % of the specified I_t.

7.26 Non-tripping current

The thermistors shall be connected and enclosed in a chamber as in 7.24.

The temperature of the chamber is adjusted to the value given for this test in the detail specification and the air allowed to become stationary.

The thermistors are connected to constant current or constant voltage supplies preset to the value given for this test in the detail specification and with voltage limiting at 90 % of U_{max}.

The voltage across each thermistor is measured after the time given in the detail specification and the value recorded.

The thermistor shall not pass into the tripped condition.

7.27 Residual current

Thermistors with wire terminations shall be gripped and connected by clips at the distance from the body given in the detail specification.

Thermistors with other than wire terminations shall be mounted and connected as described in the detail specification.

The thermistors shall be enclosed in a chamber such that the temperature of other thermistors and the proximity of the walls will not materially affect the results of the test.

The temperature of the chamber is adjusted to the value given for this test in the detail specification and the air allowed to become stationary.

The thermistors are tripped by increasing the voltage to the maximum voltage unless otherwise specified in the detail specification.

The thermistors are allowed to stabilize for a time given in the detail specification.

The current shall be within the limits given in the detail specification.

7.28 Surface temperature

The surface temperature of the thermistor shall be determined at the maximum voltage unless otherwise specified in the detail specification.

The insulated heating element shall be mounted as specified in the detail specification (see for example Annex C), and connected to a stabilized voltage source and to a time/temperature recorder via a double-pole switch as shown in Figure 10.

The accuracy of the recorder shall be better than 1,5 K.

The test set shall be enclosed in a chamber and positioned so that it is not within 75 mm of any other thermistor or the walls of the chamber.

The air in the chamber shall be still and shall be at a temperature of (25 ± 0,5) °C. The thermistor shall be connected to the circuit shown in Figure 10.

By operation of the double-pole switch the maximum voltage is applied to the thermistor and simultaneously the recorder is set into operation.

At times/temperatures to be specified in the detail specification, the time/temperature shall be noted and shall be within the limits specified in the detail specification.

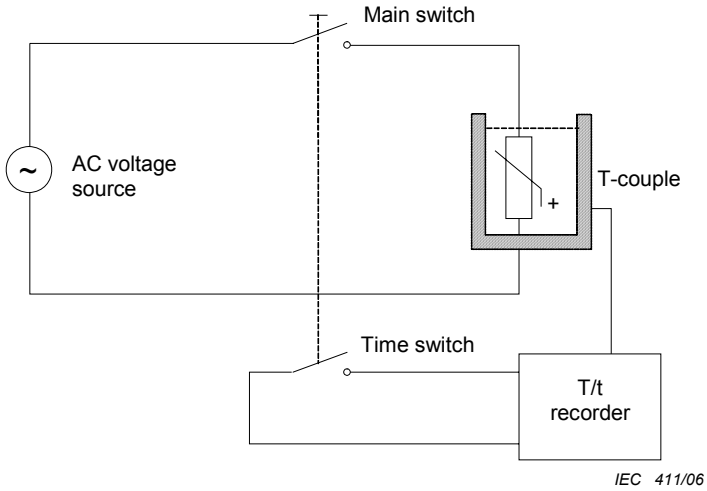
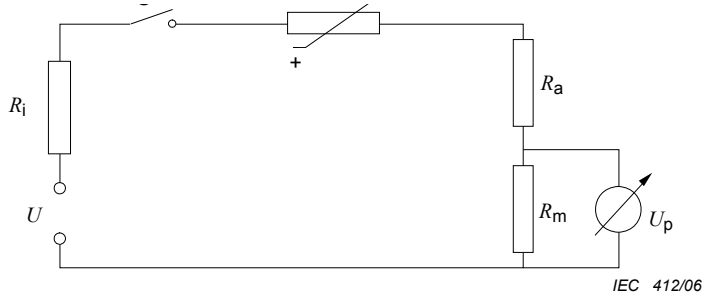


Figure 10 – Circuit for surface temperature measurement

7.29 Inrush current

7.29.1 Measuring circuit



Key

U stabilized variable voltage source
R_i internal resistance
S high current switch
R_a series resistance
R_m measuring resistance
U_p peak voltmeter (clamp and hold)

Figure 11 – Measuring circuit

7.29.2 Measuring method

The thermistor shall be mounted by its normal means with a series resistance as described in the detail specification.

The current measuring resistance shall be part of the total series resistance R_s so that $R_s = R_a + R_m + R_i$ is within the limits given in the detail specification.

The voltage and the ambient temperature shall be specified in the detail specification.

The stabilized voltage source shall maintain this output voltage with a maximum variation of 1 % during the measurement. (Account shall be taken of the source impedance.)

The inrush current shall be measured with a clamp and hold peak voltmeter or a memory oscilloscope to an accuracy better than 3 %.

7.30 Mounting (for surface mount thermistors only)

7.30.1 An example of a mounting for surface mount thermistors is shown in Figure B.3.

7.30.2 Surface mount thermistors shall be mounted on a suitable substrate, the method of mounting will depend on the thermistor construction. The substrate material shall normally be a 1,6 mm thick epoxide woven glass fabric laminated printed board (as defined in IEC 61249-2-7 IEC-EP-GC-CU) or an 0,635 mm alumina substrate and shall not affect the result of any test or measurement. The detail specification shall indicate which material is to be used for the electrical measurements.

The substrate shall have metallized land areas of proper spacing to permit mounting of surface mount thermistors and shall provide electrical connection to the surface mount thermistor terminals. The details shall be specified in the detail specification.

If another method of mounting applies, the method should be clearly described in the detail specification.

7.30.3 When the detail specification specifies wave soldering, a suitable glue, details of which may be specified in the detail specification, shall be used to fasten the component to the substrate before soldering is performed.

Small dots of the glue shall be applied between the conductors of the substrate by means of a suitable device securing repeatable results.

The surface mount thermistors shall be placed on the dots using tweezers. To ensure that no glue is applied to the conductors, the surface mount thermistors shall not be moved about.

The substrate with the surface mount thermistors shall be heat-treated in an oven at 100 °C for 15 min.

The substrate shall be soldered in a wave soldering apparatus. The apparatus shall be adjusted to have a pre-heating temperature of 80 °C to 130 °C, a solder bath at 260 °C ± 5 °C and a soldering time of 5 s ± 0,5 s.

The soldering operation shall be repeated once more (two cycles in total).

The substrate shall be cleaned for 3 min in a suitable solvent (see 3.1.2 of IEC 60068-2-45).

7.30.4 When the detail specification specifies reflow soldering, the following mounting procedure applies.

a) The solder used in preform or paste form shall be silver bearing (2 % minimum) eutectic Sn/Pb solder together with a non-activated flux as stated in IEC 60068-2-20. Alternative solders such as 60/40 or 63/37 may be used on surface mount thermistors whose construction includes solder leach barriers. The Pb-free solder used in preform or paste form shall be Sn96,5-Ag3,0-Cu0,5 or derivative solder together with a flux as stated in IEC 60068-2-58.

b) The surface mount thermistor shall then be placed across the metallized land areas of the test substrate so as to make contact between thermistor and substrate land areas.

c) The substrate shall then be placed in or on a suitable heating system (molten solder, hot plate, tunnel oven, etc.). The temperature of the unit shall be maintained between 215 °C and 260 °C, until the solder melts and reflows forming a homogeneous solder bond, but for not longer than 10 s.

NOTE 1 Flux should be removed by a suitable solvent (see 3.1.2 of IEC 60068-2-45). All subsequent handling shall be such as to avoid contamination. Care shall be taken to maintain cleanliness in test chambers and during post test measurements.

NOTE 2 The detail specification may require a more restricted temperature range.

NOTE 3 If vapour phase soldering is applied, the same method may be used with the temperatures adapted.

7.31 Shear (adhesion) test

7.31.1 Test conditions

The surface mount thermistors shall be mounted as described in IEC 60068-2-21, Test U.

7.31.2 The thermistors shall be subjected to Test Ue3 of IEC 60068-2-21 using the following conditions.

A force of 5 N shall be applied to the surface mount thermistor body progressively, without shock, and shall be maintained for a period of 10 s ± 1 s.

7.31.3 Requirements

The surface mount thermistors shall be visually examined in the mounted state. There shall be no visible damage.

7.32 Substrate bending test

7.32.1 The surface mount thermistor shall be mounted on an epoxide woven glass printed board as described in IEC 60068-2-21.

7.32.2 The zero-power resistance of the surface mount thermistor shall be measured as specified in 7.5 and the relevant specification.

7.32.3 The thermistor shall be subjected to Test Ue of IEC 60068-2-21 using the conditions as prescribed for in the relevant specification for the deflection D and the number of bends.

7.32.4 The zero-power resistance of the surface mount thermistor shall be measured as specified in 7.32.2 with the board in the bent position. The change of resistance shall not exceed the limits prescribed by the relevant specification.

7.32.5 The printed board shall be allowed to recover from the bent position and then removed from the test jig.

7.32.6 Final inspection and requirements

The surface mount thermistor shall be visually examined and there shall be no visible damage.

Annex A
(normative)

Interpretation of sampling plans and procedures as described in IEC 60410 for use within the IEC quality assessment system for electronic components (IECQ)

When using IEC 60410 for inspection by attributes, the interpretations of the clauses and subclauses of IEC 60410, as indicated below, apply for the purpose of this standard.

1 The responsible authority is the national authorized institution implementing the basic rules and rules of procedure.

1.5 The unit of product is the electronic component defined in a detail specification.

2 Only the following definitions from this clause are required:

- a “defect” is any non-conformance of the unit of product to specified requirements;
- a “defective” is a unit of product which contains one or more non-conformances.

3.1 The extent of non-conformance of a product shall be expressed in terms of per cent defective.

3.3 Not applicable.

4.5 The responsible authority is the IEC technical committee drafting the blank detail specification which forms part of the generic or sectional specification.

5.4 The responsible authority is the DMR, acting in accordance with the procedures prescribed in the document describing the inspection department of the approved manufacturer and approved by the national supervising inspectorate.

6.2 The responsible authority is the DMR.

6.3 Not applicable.

6.4 The responsible authority is the DMR.

8.1 Normal inspection shall always be used at the start of inspection.

8.3.3 d) The responsible authority is the DMR.

8.4 The responsible authority is the national supervising inspectorate.

9.2. The responsible authority is the IEC technical committee drafting the blank detail specification which forms part of the generic or sectional specification.

9.4 (Fourth sentence only) Not applicable.

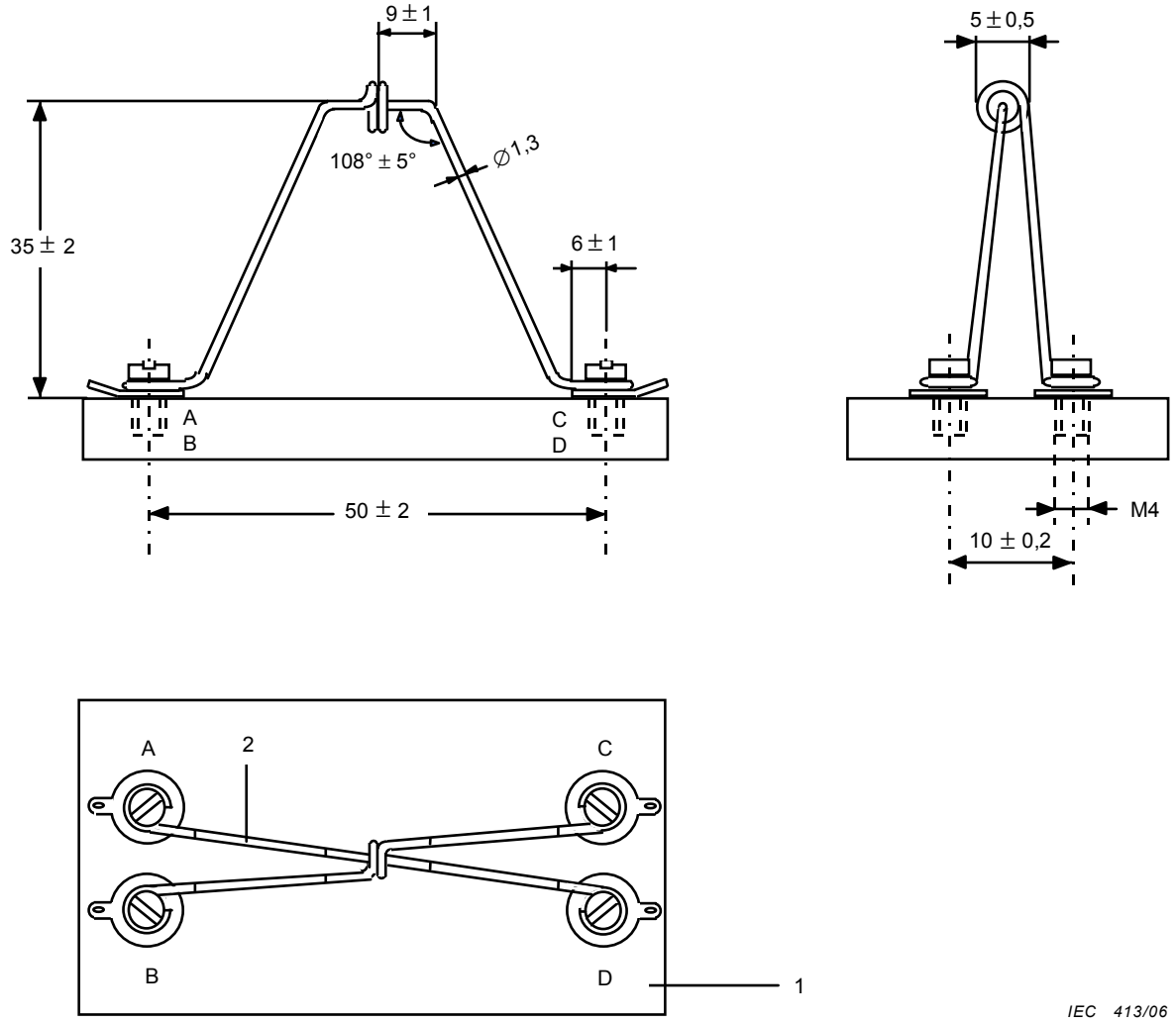
(Fifth sentence only) The responsible authority is the DMR.

10.2 Not applicable.

Annex B
(informative)

Mounting for electrical measurements (except surface mount types)

Dimensions in millimetres



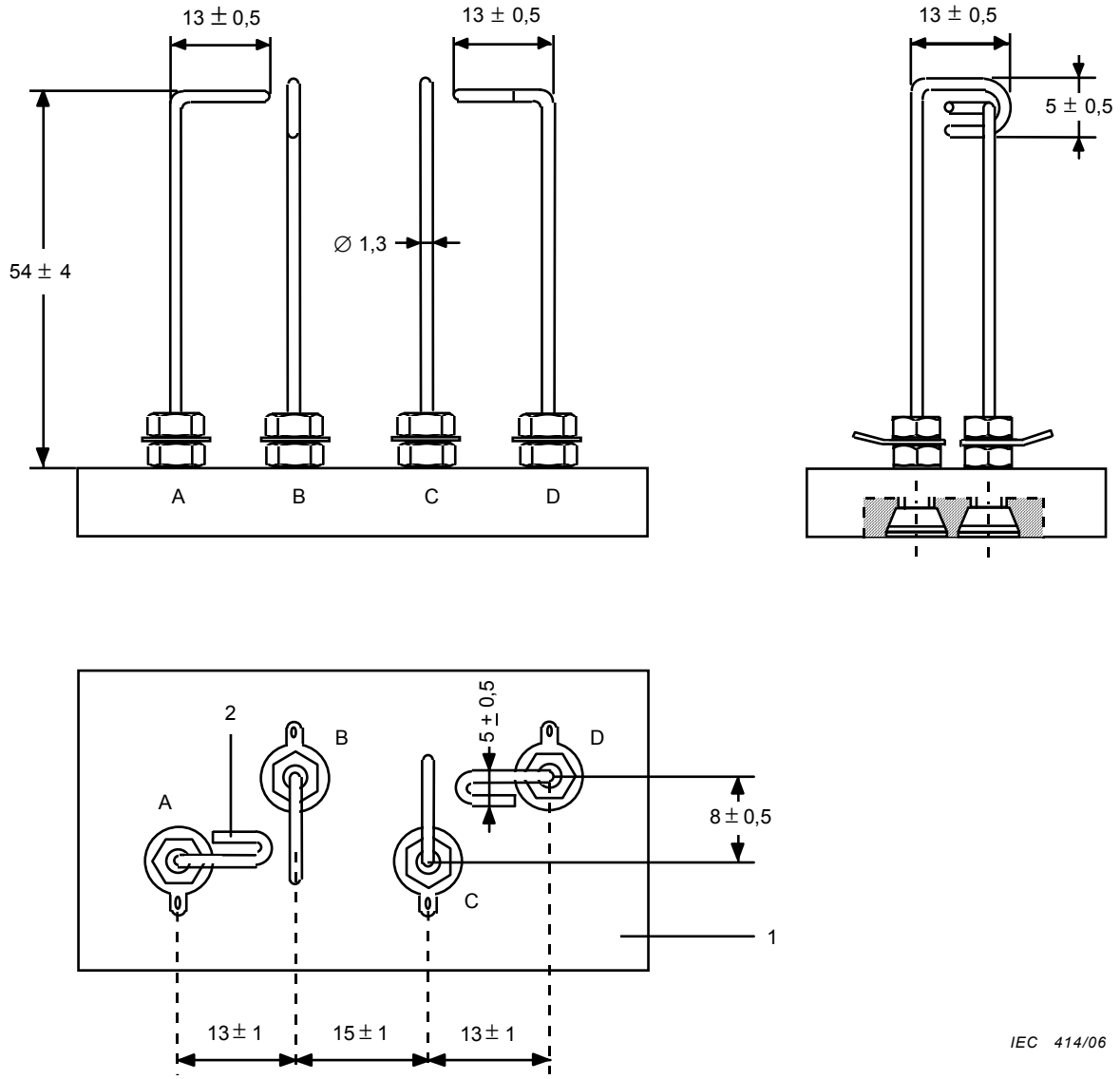
Key

1 base made of insulating material

2 contacts made of phosphor bronze wire

Figure B.1 – Example of a preferred mounting method for thermistors without wire terminations

Dimensions in millimetres



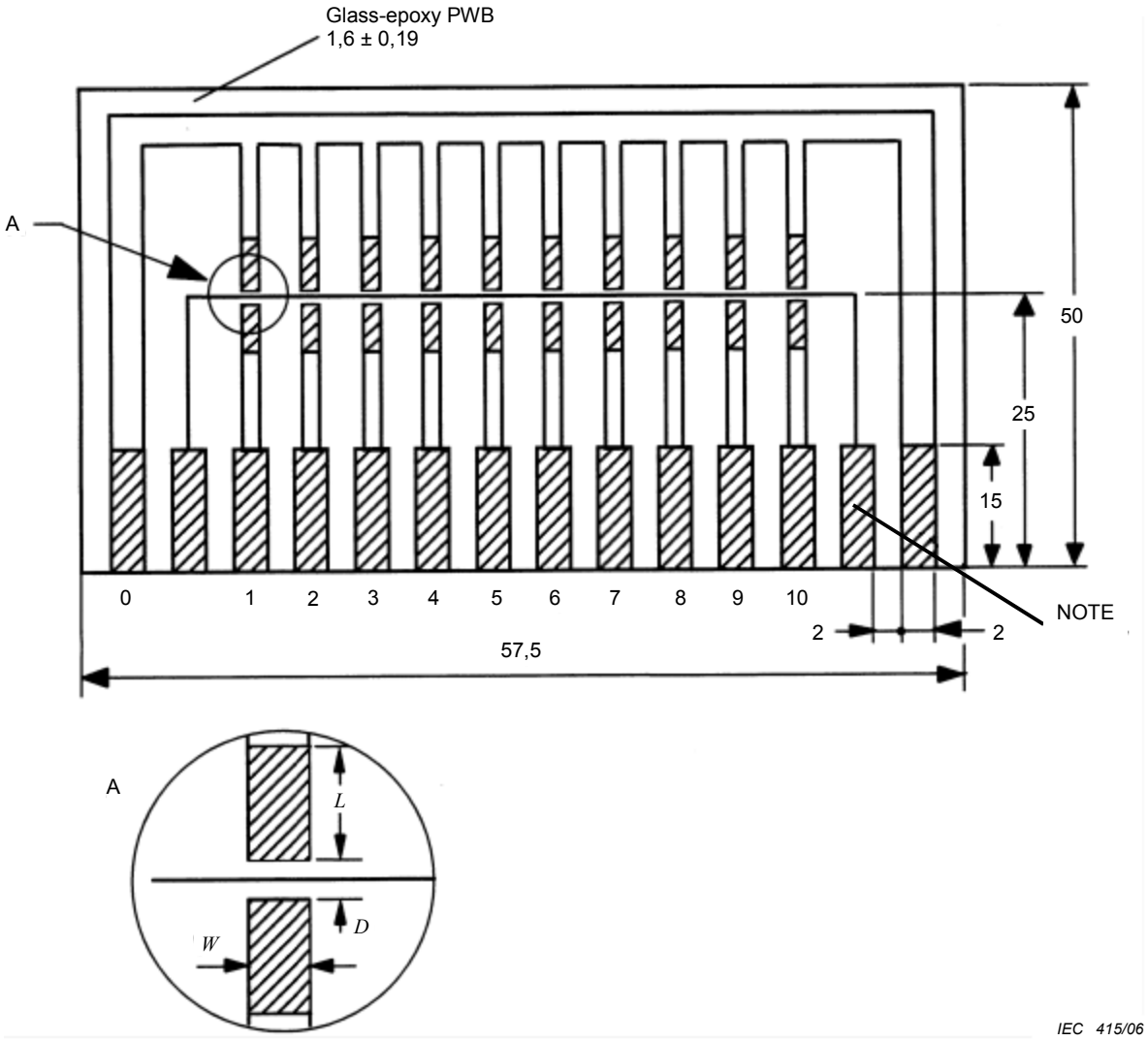
Key

1 Base made of insulating material

2 Contacts made of phosphor bronze wire

Figure B.2 – Example of a preferred mounting method for thermistors with wire terminations

Dimensions in millimetres



NOTE This conductor may be omitted or used as a guard electrode.

Figure B.3 – Example of a preferred mounting method for surface mount thermistors

Annex C
(informative)

Mounting for temperature measurements

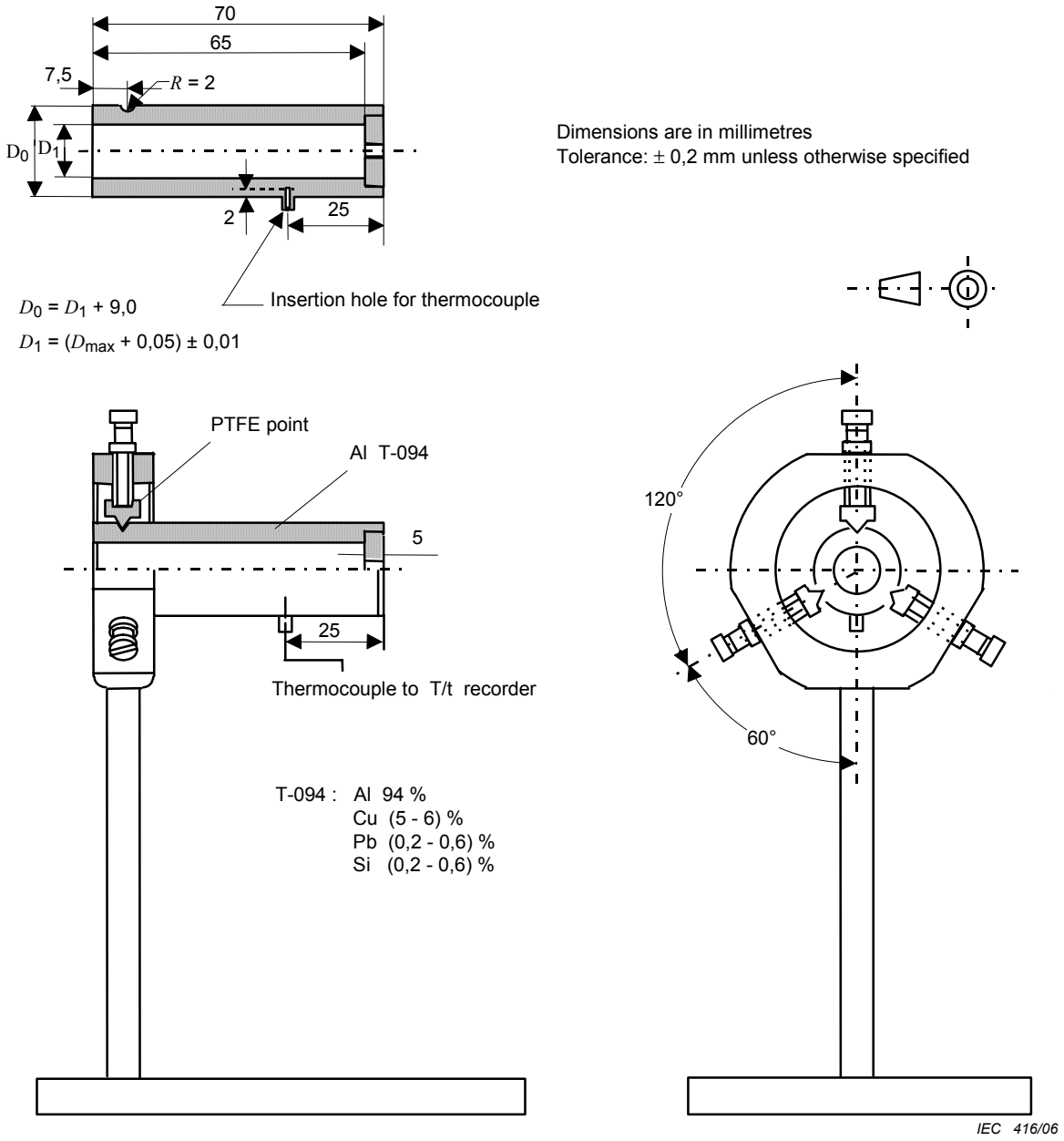


Figure C.1 – Example of a preferred mounting method for temperature measurement on cylindrical heating elements

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