

INTERNATIONAL STANDARD

IEC
60738-1

QC 440000

Second edition
1998-11

**Thermistors –
Directly heated positive step-function
temperature coefficient –**

**Part 1:
Generic specification**

*Thermistances à basculement à coefficient de température
positif à chauffage direct –*

*Partie 1:
Spécification générique*



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For general terminology, readers are referred to IEC 60050: *International Electrotechnical Vocabulary* (IEV).

For graphical symbols, and letter symbols and signs approved by the IEC for general use, readers are referred to publications IEC 60027: *Letter symbols to be used in electrical technology*, IEC 60417: *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets* and IEC 60617: *Graphical symbols for diagrams*.

* See web site address on title page.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

THERMISTORS –

DIRECTLY HEATED POSITIVE STEP-FUNCTION TEMPERATURE COEFFICIENT –

Part 1: Generic specification

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
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- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60738-1 has been prepared IEC technical committee 40: Capacitors and resistors for electronic equipment.

This second edition cancels and replaces the first edition published in 1982 and constitutes a technical revision.

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

FDIS	Report on voting
40/1080/FDIS	40/1096/RVD

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

Annex A forms an integral part of this standard.

Annexes B and C are for information only.

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).

THERMISTORS –

DIRECTLY HEATED POSITIVE STEP-FUNCTION TEMPERATURE COEFFICIENT –

Part 1: Generic specification

1 General

1.1 Scope

This International Standard prescribes 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.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

In the case of IEC 60068 publications, the referenced edition shall be used, regardless of any subsequent new edition(s) and amendment(s).

IEC 60027-1:1992, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60050: *International Electrotechnical Vocabulary*

IEC 60062:1992, *Marking codes for resistors and capacitors*

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-1:1990, *Environmental testing – Part 2: Tests – Tests A: Cold*

IEC 60068-2-2:1974, *Environmental testing – Part 2: Tests – Tests B: Dry heat*

IEC 60068-2-3:1969, *Environmental testing – Part 2: Tests – Test Ca: Damp heat, steady state*

IEC 60068-2-6:1995, *Environmental testing – Part 2: Tests – Test Fc and guidance: Vibration (sinusoidal)*

IEC 60068-2-11:1981, *Environmental testing – Part 2: Tests – Test Ka: Salt mist*

IEC 60068-2-13:1983, *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*

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

IEC 60068-2-21:1983, *Environmental testing – Part 2: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-27:1987, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*

IEC 60068-2-29:1987, *Environmental testing – Part 2: Tests – Test Eb and guidance: Bump*

IEC 60068-2-30:1980, *Environmental testing – Part 2: Tests – Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle)*

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

IEC 60249-2-4:1987, *Base materials for printed circuits – Part 2: Specifications – Specification No. 4: Epoxide woven glass fabric copper-clad laminated sheet, general purpose grade*

IEC 60294:1969, *Measurement of the dimensions of a cylindrical component having two axial terminations*

IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*

IEC 60617: *Graphical symbols for diagrams*

IEC QC 001002-3:1998, *Rules of procedure of the IEC Quality Assessment System for Electronic Components (IECQ) – Part 3: Approval procedures*

IEC QC 001003: *Guidance documents*

ISO 1000:1992, *SI units and recommendations for the use of their multiples and of certain other units*

2 Technical data

2.1 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

2.2 Definitions

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

2.2.1

type

a 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.

2.2.2**style**

variation within a type having specific nominal dimensions and characteristics

2.2.3**thermistor**

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

2.2.4**positive temperature coefficient thermistor**

a thermistor, the resistance of which increases with its increasing temperature throughout the useful part of its characteristic

2.2.5**positive step-function temperature coefficient thermistor (PTC)**

a 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 have to be taken into account.

2.2.6**zero-power resistance (R_T)**

the 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 2.2.8 and 2.2.9).

2.2.7**nominal zero-power resistance (R_N)**

the d.c. resistance value of a thermistor measured at a specified temperature, preferable 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.

2.2.8**voltage dependency**

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

2.2.9**frequency dependency**

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

2.2.10**resistance/temperature characteristics**

the relationship between the zero-power resistance of a thermistor and the temperature of the thermosensitive element when measured under specified reference conditions (see figure 1)

NOTE – PTC thermistors may have more than one resistance/temperature characteristic specified.

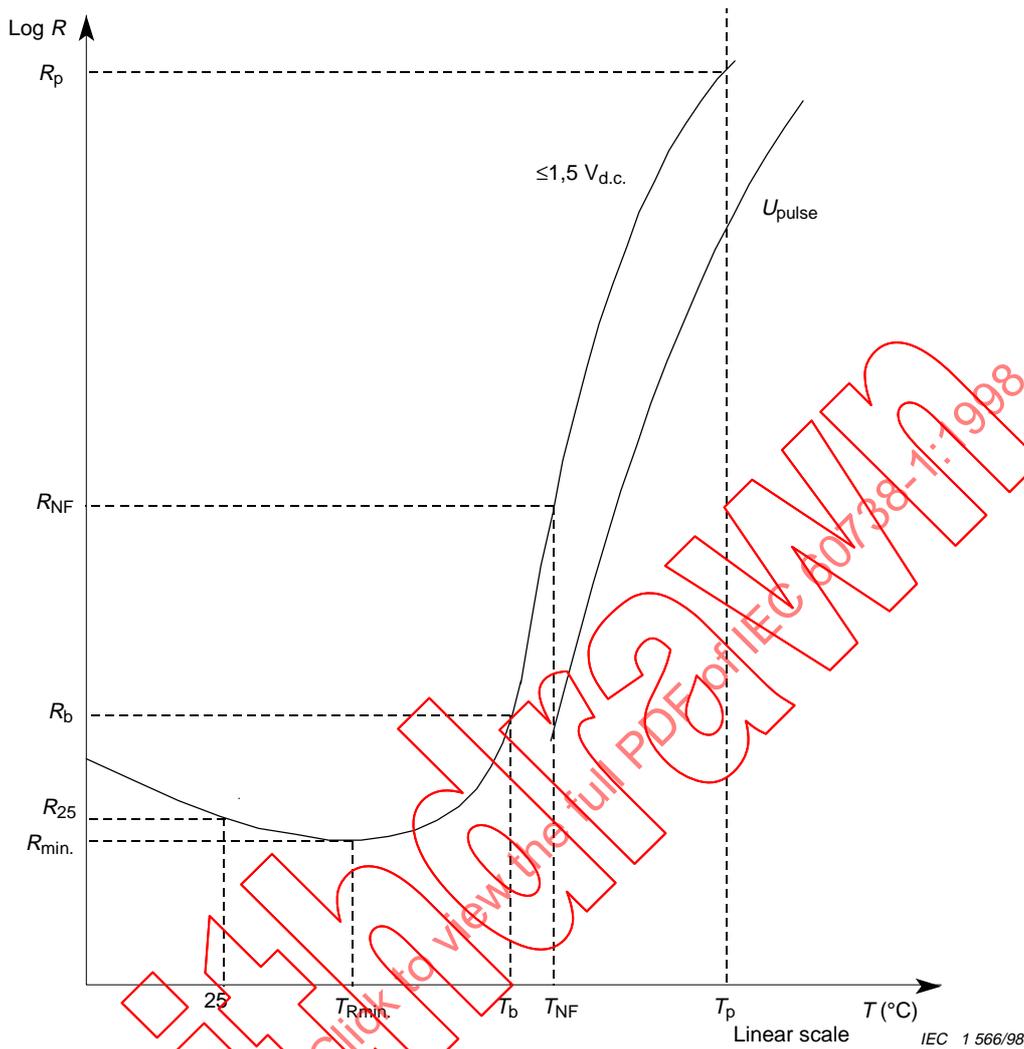
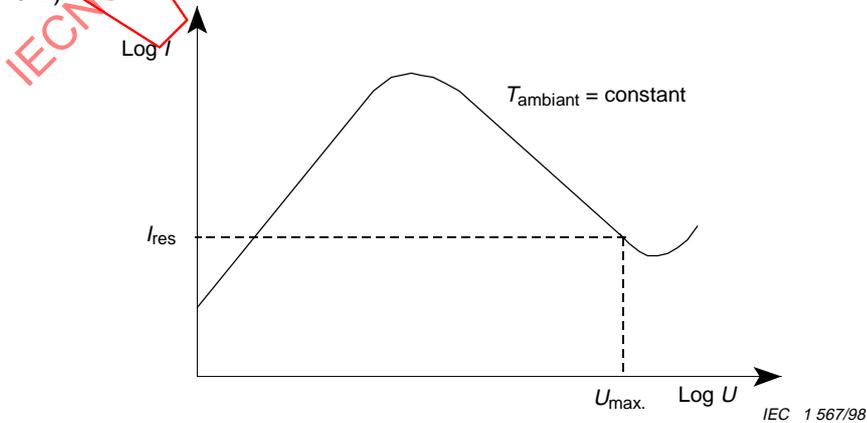


Figure 1 – Typical resistance-temperature characteristic and definitions for PTC thermistors (at zero-power)

2.2.11 current/voltage characteristic

the 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 2)



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

NOTE 2 – The breakdown voltage is the value beyond which the thermistor's voltage handling capability no longer exhibits its characteristic property.

Figure 2 – Typical current/voltage characteristic for PTC thermistors

2.2.12**nominal functioning temperature (T_{NF})**

the nominal temperature at the steep part of the resistance temperature characteristic at which the system controlled by the thermistor, is designed to operate

2.2.13**switching temperature (T_b)**

the temperature at which the step-like function commences

2.2.14**minimum resistance ($R_{min.}$)**

the minimum value of the zero-power resistance/temperature characteristic (see figure 1)

2.2.15**resistance at switching temperature (R_b)**

the value of the zero-power resistance corresponding to the switching temperature

It is 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.

2.2.16**temperature for minimum resistance ($T_{Rmin.}$)**

that temperature at which $R_{min.}$ occurs

2.2.17**temperature T_p**

that 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

2.2.18**resistance R_p**

the 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 any 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.

2.2.19**average temperature coefficient of resistance at a stated voltage (α_R)**

the 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.

2.2.20**upper category temperature (UCT)**

the maximum ambient temperature for which a thermistor has been designed to operate continuously at zero power

2.2.21**lower category temperature (LCT)**

the minimum ambient temperature for which a thermistor has been designed to operate continuously at zero power

2.2.22**maximum voltage ($U_{\max.}$)**

the maximum a.c. or d.c. voltage which may be continuously applied to the thermistor without exceeding the maximum overload current

2.2.23**operating temperature range at maximum voltage**

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

2.2.24**isolation voltage (applicable only to insulated thermistors)**

the maximum peak voltage which may be applied under continuous operating conditions between any of the thermistor terminations and any conducting surface

2.2.25**maximum overload current (I_{mo})**

the 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 .

2.2.26**residual current (I_{res})**

the 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 2)

2.2.27**tripping current (I_t)**

the 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

2.2.28**maximum non-tripping current ($I_{\max. nt}$)**

the maximum current at a specified ambient temperature (preferably 25 °C), which the thermistor will conduct indefinitely in its low resistance condition

2.2.29**inrush current (I_{in})**

the current occurring during the transient period from the moment of switching to the steady-state condition

2.2.30**peak inrush current ($I_{in p}$)**

the peak inrush current is the maximum value of current during the transient period (see figure 3)

2.2.31**minimum peak inrush current ($I_{in\ p\ min.}$)**

the lowest specified value of the peak of the inrush current

2.2.32**maximum peak inrush current ($I_{in\ p\ max.}$)**

the maximum specified value of the peak inrush current

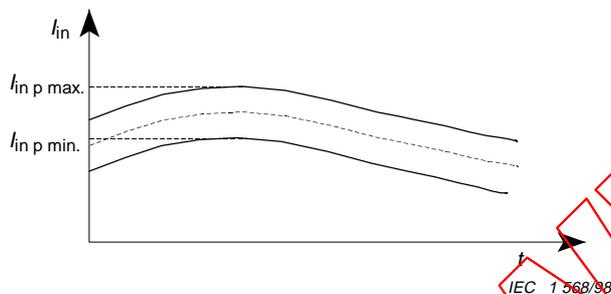


Figure 3 – I_{in} against t at U_{dc}

2.2.33**peak-to-peak inrush current ($I_{in\ pp}$) (for a.c. conditions only)**

the value of the inrush current measured between adjacent positive and negative peaks (see figure 4)

2.2.34**minimum peak-to-peak inrush current ($I_{in\ pp\ min.}$)**

the lowest specified value of the peak-to-peak inrush current

2.2.35**maximum peak to peak inrush current ($I_{in\ pp\ max.}$)**

the maximum specified value of the peak-to-peak inrush current

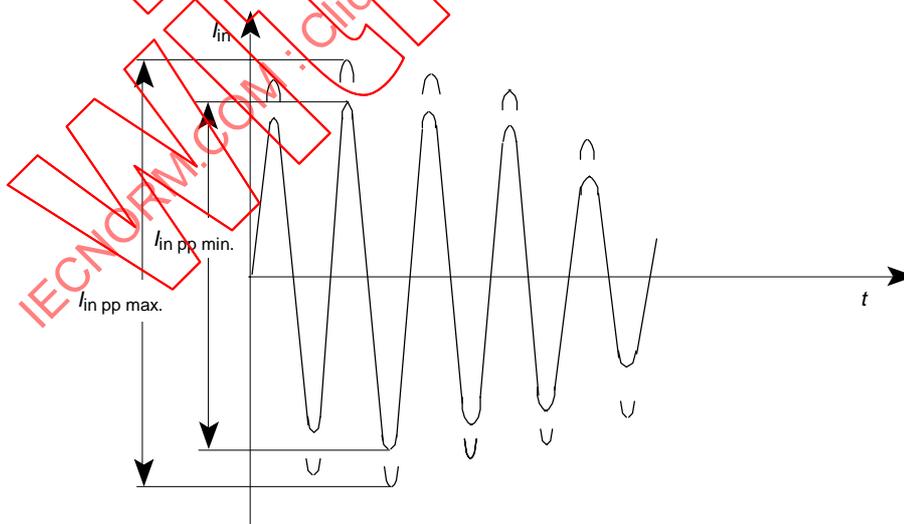


Figure 4 – I_{in} against t at U_{rms}

2.2.36**peak inrush power ($P_{in p}$)**

the 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

2.2.37**maximum peak inrush power ($P_{in p max.}$)**

the maximum peak power which can occur during the transient period before the thermistor reaches its steady-state operating condition

2.2.38**maximum power ($P_{max.}$)**

the 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.

2.2.39**dissipation factor (δ)**

the 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)

2.2.40**thermal resistance (R_{th})**

the 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.

2.2.41**heat capacity (C_{th})**

the energy (in J) the thermistor needs to increase its body temperature by 1 K

2.2.42**response time**a) Response time by ambient temperature change (t_a)

The time (in seconds) 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)

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

2.2.43**thermal time constant**

the 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)

The 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)

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

2.2.44**insulated thermistors**

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

2.2.45**surface temperature (T_s)**

the temperature under defined conditions at the boundary layer between two media

2.2.46**final surface temperature (T_{sf})**

the temperature reached under defined conditions when thermal equilibrium is established

2.3 Preferred values**2.3.1 Climatic categories**

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

2.3.2 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/s²

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.

2.3.3 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/s²

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.

2.3.4 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

2.4 Marking

2.4.1 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.

2.4.2 Coding

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

3 Quality assessment procedures

3.1 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 3.5 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 3.5.1 and 3.5.3 b) 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 section, the manufacturer shall obtain the approval of his organisation in accordance with the provisions of IEC QC 001002-3.

The method for the approval of thermistors of assessed quality given in 3.5 is qualification approval according to the provisions of clause 3 of IEC QC 001002-3.

3.1.1 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 3.5 and the relevant blank detail specification.

3.2 Primary stage of manufacture

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

3.3 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.

3.4 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.

3.4.1 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.

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

3.4.3 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.

3.4.4 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.

3.5 Qualification approval procedures

3.5.1 Eligibility for qualification approval

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

3.5.2 Application for qualification approval

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

3.5.3 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 3.5.4.

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.

3.5.4 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.

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 1 to 4:

- 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 10 samples from group 0 test samples have to 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 1 or table 4, in groups 5 and 6 for table 2 or groups 4 and 5 for table 3, respectively, are appropriate to the construction and application of the thermistor.

Table 1 – 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) Zero-power resistance R_n Voltage proof	4.4.1 4.4.2 4.4.3 4.5 4.8	ND	80 + 5 (see list item 6)	0
1	Temperature coefficient of resistance (if specified)	4.6	D	10 (see list item 7 and 8)	0
1A	Tripping current and tripping time Residual current	4.24 4.26		5 (list item 8)	
1B	Non-tripping current	4.25		5 (list item 8)	
	Soldering – Solderability (see list items 9 and 10)	4.16.1			
2A	Soldering – Resistance to soldering heat (see list items 9 and 10) Robustness of terminations	4.16.2 4.15		5	
2B	Rapid change of temperature Vibration Bump or shock (see list item 12)	4.17 4.18 4.19 or 4.20		5	
2	Climatic sequence	4.21	D	10	0
3	Thermal time constant by cooling (if specified)	4.14	ND	10	0
4	Dimensions (detail) Dissipation factor at t_{max} . (if specified)	4.4.4 4.10	ND	10	0
5	Endurance at room temperature (cycling)(see list item 13)	4.23.1	D	10	0
6	Endurance at upper category temperature (see list item 13)	4.23.2	D	10	0
7	Endurance at max. operating temperature and max. voltage (see list item 13)	4.23.3	D	10	0
8	Damp heat, steady state	4.22	D	10	0

Table 2 – 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) Zero-power resistance R_n Voltage proof	4.4.1 4.4.2 4.4.3 4.5 4.8	ND	70 + 5 (see list item 6)	0
1	Temperature coefficient of resistance (if specified) Final surface temperature (if specified) Maximum inrush power (if specified) Residual current (if specified) Soldering – Solderability (see list items 9 and 10)	4.6 4.27 4.28 4.26 4.16.1	D	10 (see list item 7)	0
2A	Soldering – Resistance to soldering heat (see list items 9 and 10) Robustness of terminations	4.16.2 4.15	D	5	0
2B	Rapid change of temperature Vibration (if specified, not for non-insulated types) Bump or shock (see list item 12)	4.17 4.18 4.19 or 4.20	D	5	0
2	Climatic sequence	4.21	D	10	0
3	Thermal time constant by cooling (if specified)	4.14	ND	10	0
4	Dimensions (detail) Dissipation factor at U_{max} (if specified)	4.4.4 4.10	ND	10	0
5	Endurance at room temperature (cycling) (see list item 13)	4.23.1	D	10	0
6	Endurance at max. operating temperature and max. voltage (see list item 13)	4.23.3	D	10	0
7	Damp heat, steady state	4.22	D	10	0

Table 3 – 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	Permissible number of non-conforming items
				n	c
0	Visual examination Marking Dimensions (gauging) Zero-power resistance R_n Voltage proof	4.4.1 4.4.2 4.4.3 4.5 4.8	ND	60 + 5 (see list item 6)	0
1	Inrush current Residual current Soldering – Solderability (see list items 9 and 10)	4.28 4.26 4.16.1	D	10 (see list item 7)	0
2A	Soldering – Resistance to soldering heat (see list items 9 and 10) Robustness of terminations	4.16.2 4.15	D	5	0
2B	Rapid change of temperature Vibration Bump or shock (see list item 12)	4.17 4.18 4.19 or 4.20		5	
2	Climatic sequence	4.21	D	10	0
3	Dimensions (detail) (see list item 7)	4.4.4	ND	10	0
4	Endurance at room temperature (cycling) (see list item 13)	4.23.1	D	10	0
5	Endurance at max. operating temperature and max. voltage (see list item 13)	4.23.3	D	10	0
6	Damp heat, steady state	4.22	D	10	0

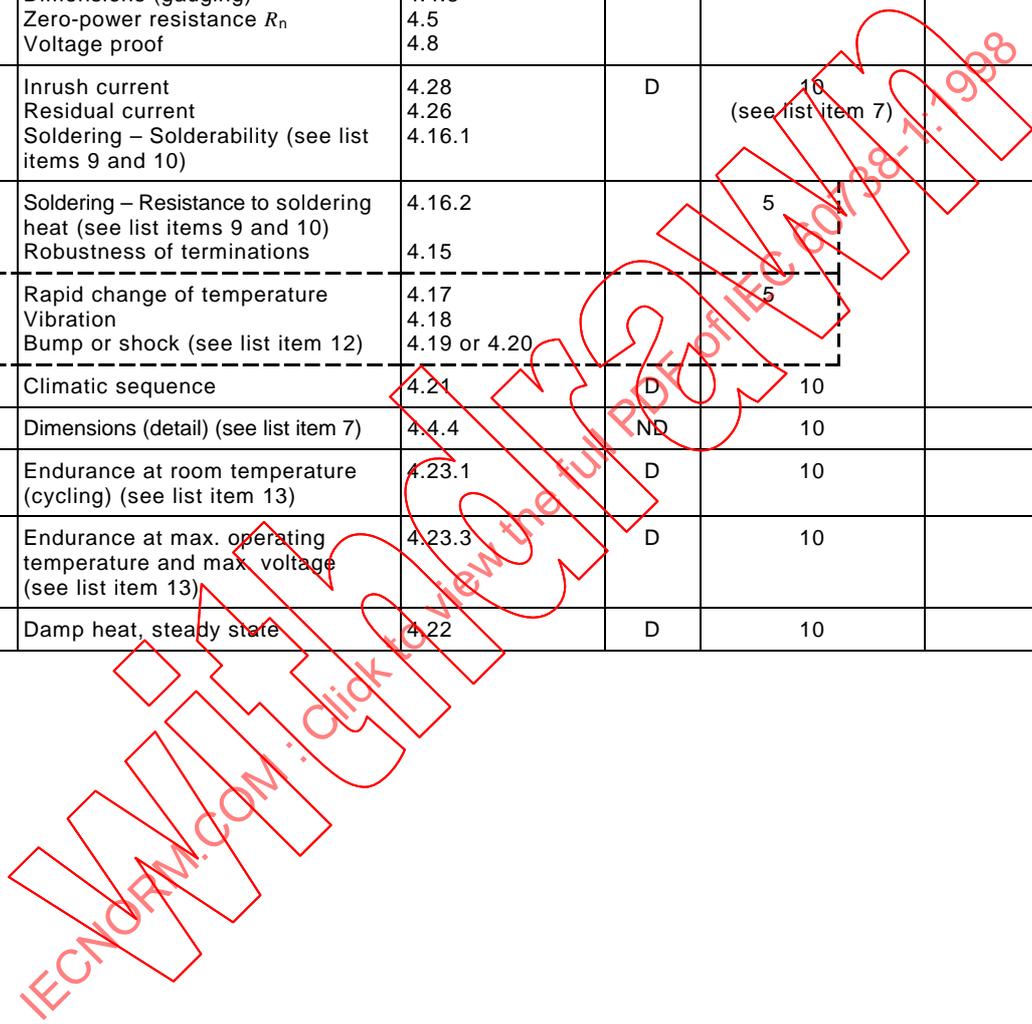


Table 4 – Fixed sample size test schedule for qualification approval of thermistors for sensing application, assessment level EZ

Group No.	Test (see list item 5)	Subclause of this standard	D or ND	Number of specimens	Permissible number of non-conforming items
				n	c
0	Visual examination Marking Dimensions (gauging) Zero-power resistance R_n Voltage proof	4.4.1 4.4.2 4.4.3 4.5 4.8	ND	80 + 5 (see list item 6)	0
1	Temperature coefficient of resistance (if specified) Zero-power resistance R_T (if specified) Functioning resistance R_{NF} and T_{NF} Residual current (if specified) Soldering – Solderability (see list items 9 and 10)	4.6 4.5 4.26 4.16.1	D	10 (see list item 7)	0
2A	Soldering – Resistance to soldering heat (see list items 9 and 10)	4.16.2	D	5	
	Robustness of terminations	4.15			
2B	Rapid change of temperature	4.17	D	5	
	Vibration (if specified, not for non-insulated types) Bump or shock (see list item 12)	4.18 4.19 or 4.20			
2	Climatic sequence	4.21	D	10	0
3	Response time (if specified), by ambient temperature change t_a or Response time by power change t_p	4.11 or 4.12	ND	10	0
4	Dimensions (detail) Dissipation factor at U_{max} (if specified)	4.4.4 4.10	ND	10	0
5	Endurance at room temperature (cycling) (see list item 13)	4.23.1	D	10	0
6	Endurance at upper category temperature (see list item 13)	4.23.2	D	10	0
7	Endurance at max. operating temperature and max. voltage (see list item 13)	4.23.3	D	10	0
8	Damp heat, steady state	4.22	D	10	0

3.5.5 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.

3.5.6 Maintenance of qualification approval

Qualification approval shall be maintained by regular demonstration of compliance with the requirements for Quality Conformance (see 3.5.7).

3.5.7 Quality conformance inspection

3.5.7.1 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 5 and 6).

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 subgroups 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.

3.5.7.2 Assessment level

The assessment level given in the blank detail specification shall be in accordance with tables 5 and 6:

Table 5 – Quality conformance inspection for lot-by-lot inspection

Inspection subgroup ⁴⁾	Assessment level			
	EZ			
	IL ¹⁾	n ¹⁾	c ¹⁾	
A0	100 % ²⁾			
A1	S-4	3)	0	
A2	S-3	3)	0	
B1	S-2	3)	0	
B2	S-2	3)	0	

NOTE 1 – IL is the inspection level
n is the sample size
c is the permissible number of non-conforming items

NOTE 2 – 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. In case one or more non-conforming items occur in a sample, this lot shall be rejected.

NOTE 3 – Number to be tested: Sample size as directly allotted to the code letter for IL in table IIA of IEC 60410 (Single sampling plan for normal inspection).

NOTE 4 – The content of the inspection subgroups is described in clause 2 of the relevant blank detail specification.

Table 6 – Quality conformance inspection for periodic testing

Inspection subgroup ²⁾	Assessment level			
	EZ			
	p ¹⁾	n ¹⁾	c ¹⁾	
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	

NOTE 1 – p is the periodicity in months
n is the sample size
c is the permissible number of non-conforming items

NOTE 2 – The content of the inspection subgroups is described in clause 2 of the relevant blank detail specification.

3.6 Rework and repair

3.6.1 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.

3.6.2 Repair

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

3.7 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.

3.7.1 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.

3.8 Certified test records of released lots

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

3.9 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.

3.10 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.

3.11 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 a IECQ member country or not, provided that the requirements of 2.5.1.3 of IEC QC 001002-3 are met.

3.12 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.

4 Test and measurement procedures

4.1 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).

4.2 Standard conditions for testing

4.2.1 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.

4.2.2 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.

4.3 Drying and recovery

4.3.1 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.

4.3.2 Recovery

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

4.4 Visual examination and check of dimensions

4.4.1 Visual examination

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

4.4.2 Marking

Marking shall be legible as determined by visual examination.

4.4.3 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.

4.4.4 Dimensions (detail)

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

4.5 Zero-power resistance

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

4.5.2 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:

- 1) For temperatures lower than or equal to T_{Rmin} ,
 - a) for absolute resistance measurement, the error does not exceed 10 % of the resistance tolerance;
 - b) for measurements of variation of resistance, the error does not exceed 10 % of the specified maximum change of resistance.
- 2) For temperatures higher than T_{Rmin} ,
 - a) 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;
 - b) 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.

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

4.6 Temperature coefficient of resistance

4.6.1 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 2.2.19.

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

4.7 Insulation resistance (for insulated types only)

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

4.7.2 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 of $(1,6 \pm 0,2)$ mm diameter, 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.

4.7.3 The insulation resistance shall be measured with a direct voltage of $100 \text{ V} \pm 15 \text{ V}$ 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.

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

4.8 Voltage proof (for insulated types only)

4.8.1 The thermistors shall be tested as specified below.

4.8.2 As required by the detail specification one of the test methods given in 4.7.2 shall be used.

4.8.3 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 $60 \text{ s} \pm 5 \text{ s}$ 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 %.

4.8.4 There shall be no breakdown or flashover.

4.9 Resistance/temperature characteristic

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

4.9.2 Resistance measurements shall be made in accordance with the method specified in 4.5 but at the temperatures and voltages indicated in the detail specification.

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

4.10 Dissipation factor at U_{max} . (8)

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

4.10.2 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 $(25 \pm 0,5) \text{ }^\circ\text{C}$. The thermistors shall be connected in the circuit shown below.

4.10.3 U_{max} , as specified in the detail specification shall be applied gradually ensuring that I_{mo} is not exceeded (see figure 5).

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.

4.10.4 The thermistors shall be immersed in the medium as defined in 4.2 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 ($^{\circ}\text{C}$) reached shall be noted (T_3)

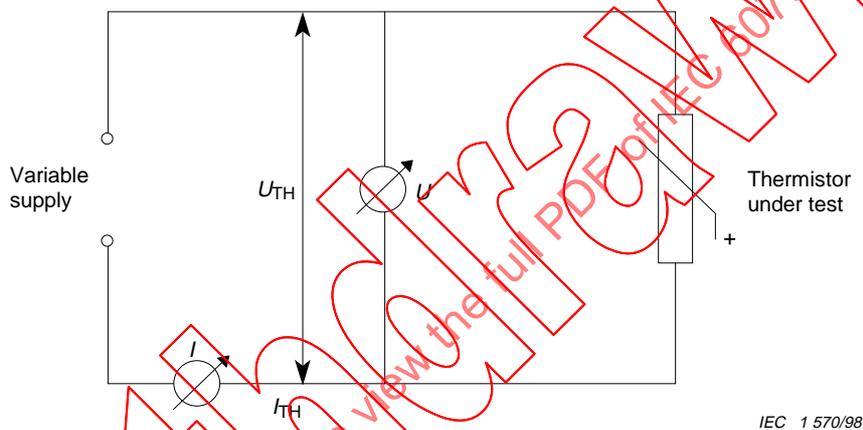


Figure 5 – Dissipation factor test circuit

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

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

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

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

4.11 Response time by ambient temperature change (t_a)

4.11.1 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.

4.11.2 The thermistor shall be immersed in the medium as defined in 4.2 and as specified in the detail specification, with a temperature T_1 , until it has reached thermal equilibrium.

4.11.3 The thermistor shall then be immersed in the medium as defined in 4.2, 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.

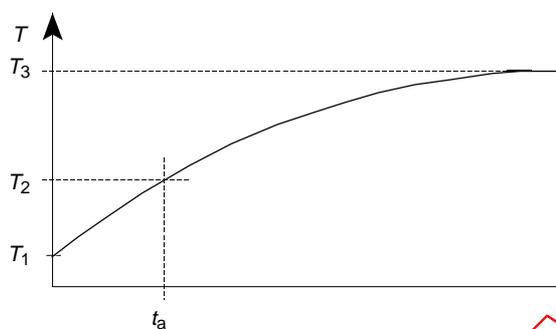


Figure 6 – Temperature gradient

4.11.4 The time elapsing between the moment of immersion as described in 4.11.3 and the moment when the resistance value of the thermistor reaches R_2 is the response time t_a (see figure 6).

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

4.12 Response time by power change (t_p)

4.12.1 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.

4.12.2

- 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 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 as stated in the detail specification.

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

4.13 Thermal time constant by ambient temperature change (τ_a)

The method described in 4.11 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 4.11.

4.14 Thermal time constant by cooling (τ_c)

4.14.1 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.

4.14.2 Test

The thermistors are introduced in still air at temperature T_0 ($T_0 = 25 \text{ }^\circ\text{C} \pm 0,5 \text{ }^\circ\text{C}$) 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 7.

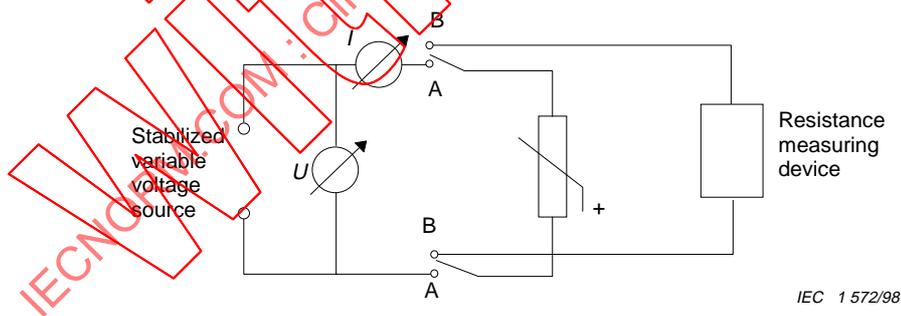


Figure 7 – Circuit for measurement of thermal time constant by cooling

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 4.10), 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 4.10.

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 4.10.

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.

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

4.15 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.

4.15.1 Test Ua₁ – 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 7.

Table 7 – Tensile force

Nominal cross-sectional area (S) (see note) mm ²	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
$0,1 < S \leq 0,2$	$0,35 < d \leq 0,5$	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.

4.15.2 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).

4.15.3 Test Uc – Torsion (remaining samples)

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

4.15.4 Visual examination

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

4.15.5 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.

4.16 Soldering

4.16.1 Solderability

The thermistors shall be subjected to one of the procedures for solderability of Test T of IEC 60068-2-20. The relevant detail specification shall prescribe which method is preferred and shall give the additional information as required in IEC 60068-2-20.

The thermistors shall be visually examined. Immersed parts shall be correctly tinned.

4.16.2 Resistance to soldering heat

The thermistors shall be dried according to 4.3.

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

The thermistors shall be subjected to the resistance to soldering heat test using method 1A of Test Tb of IEC 60068-2-20. All terminations of the thermistor shall be tested.

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

After recovery according to 4.3.2 the appropriate parameter(s) given in the detail specification shall be measured as specified. The change in value compared with that measured initially shall not exceed a value prescribed in the detail specification.

4.17 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 4.3.2 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.

4.18 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.

4.19 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 4.12.1.

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.

4.20 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 4.12.1.

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.

4.21 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:

4.21.1 Initial measurements

The thermistors shall be dried using procedure I of 4.3.1.

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

4.21.2 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.

4.21.3 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.

4.21.4 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.

4.21.5 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.

4.21.6 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 8 – 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 4.3.2.

4.21.7 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 4.7 and shall be not less than that specified in the detail specification. The thermistors shall withstand the voltage proof test as defined in 4.8 without breakdown or flashover.

4.22 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 60068-2-3 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 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 4.3.2.

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 4.7 and shall be not less than that specified in the detail specification. The thermistors shall withstand the voltage proof test as defined in 4.8 without breakdown or flashover.

4.23 Endurance

4.23.1 Endurance at room temperature (cycling)

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 4.14). 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 4.14). 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) 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 limits specified in the detail specification.

4.23.2 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 \pm 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.

4.23.3 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) as 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 $\pm \frac{0}{2}$ °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 8 (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 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) 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.

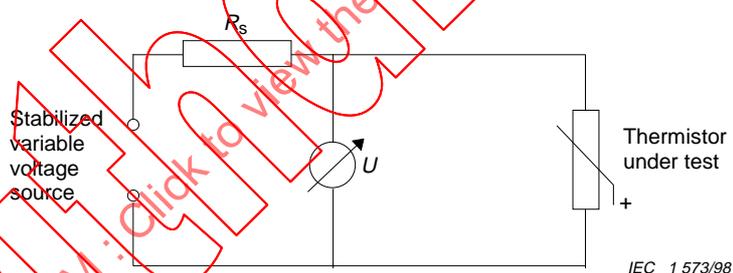


Figure 8 – Circuit for endurance at maximum operating temperature and maximum voltage

4.24 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 with the current preset to the value of I_t 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 .

4.25 Maximum non-tripping current

The thermistors shall be connected and enclosed in a chamber as in 4.23.

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 or a constant voltage supply with the current preset to the value of $I_{\max.nt}$ specified 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.

4.26 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.

4.27 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 9.

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