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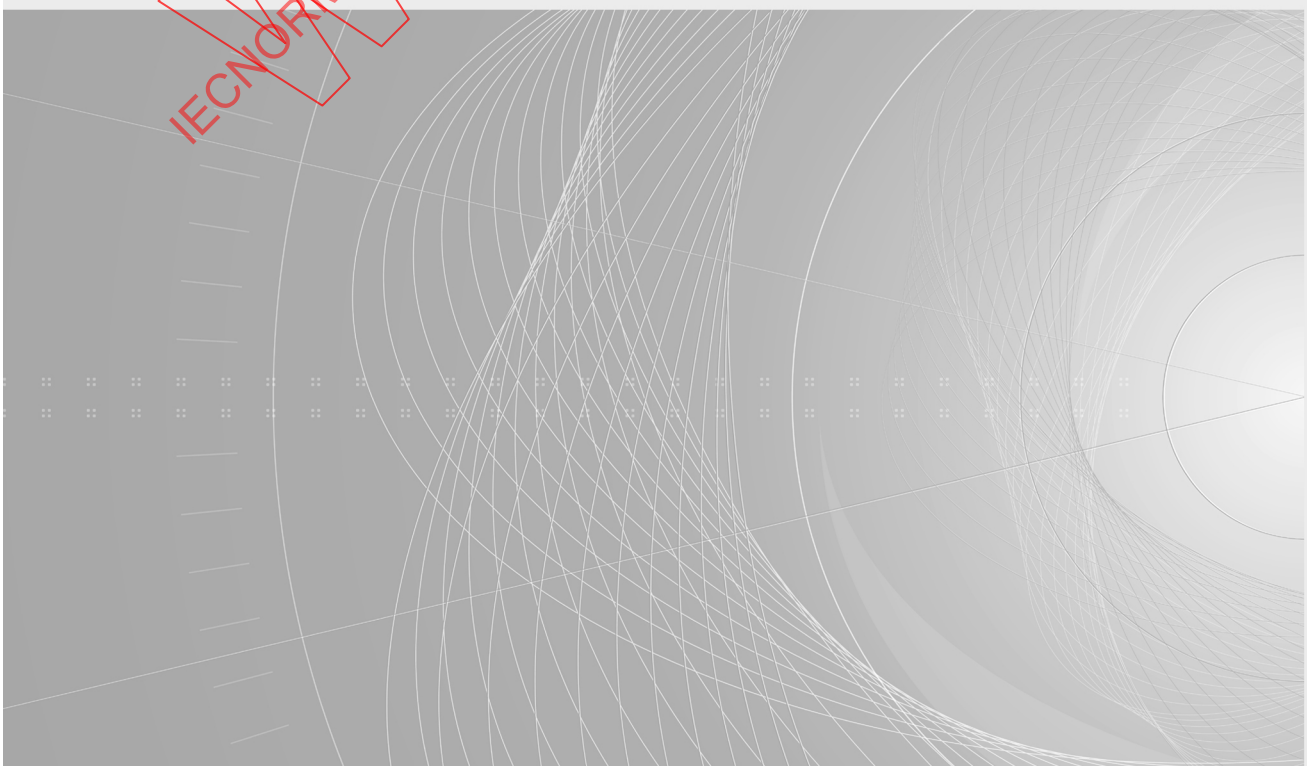
INTERNATIONAL STANDARD

QC 430 000

Directly heated negative temperature coefficient thermistors – Part 1: Generic specification



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

DIRECTLY HEATED NEGATIVE TEMPERATURE COEFFICIENT THERMISTORS –

Part 1: Generic specification

FOREWORD

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International Standard IEC 60539-1 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This second edition cancels and replaces the first edition published in 2002 and constitutes a minor revision related to tables, figures and references.

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

FDIS	Report on voting
40/1878A/FDIS	40/1895/RVD

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

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

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

IEC 60539 consists of the following parts, under the general title *Directly heated negative temperature coefficient thermistors:*

Part 1: Generic specification

Part 2: Sectional specification: Surface mount negative temperature coefficient thermistors

The committee has decided that the contents of this publication 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- withdrawn,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 publication may be issued at a later date.

DIRECTLY HEATED NEGATIVE TEMPERATURE COEFFICIENT THERMISTORS –

Part 1: Generic specification

1 General

1.1 Scope

This part of IEC 60539 is applicable to directly heated negative temperature coefficient thermistors, typically made from transition metal oxide materials with semiconducting properties.

It establishes standard terms, inspection procedures and methods of test for use in sectional and detail specifications of electronic components for quality assessment or any other purpose.

1.2 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 60027-1, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60050, *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 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Tests A: Cold*

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Tests B: Dry heat*

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

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

IEC 60068-2-14:1984, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

Amendment 1 (1986)

IEC 60068-2-17:1994, *Environmental testing – Part 2-17: Tests – Test Q: Sealing*

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

IEC 60068-2-21:2006, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

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

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

IEC 60068-2-32:1975, *Environmental testing – Part 2-32: Tests – Test Ed: Free fall*
Amendment 2 (1990)

IEC 60068-2-38:1974, *Environmental testing – Part 2-38: Tests – Test Z/AD: Composite temperature/humidity cyclic test*

IEC 60068-2-45:1980, *Environmental testing – Part 2-45: Tests – Test XA and guidance: Immersion in cleaning solvents*
Amendment 1 (1993)

IEC 60068-2-52:1996, *Environmental testing – Part 2-52: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60068-2-54:2006, *Environmental testing – Part 2-54: Tests – Test Ta: Solderability testing of electronic components by the wetting balance method*

IEC 60068-2-58:2004, *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 60068-2-69:2007, *Environmental testing – Part 2-69: Tests – Test Te: Solderability testing of electronic components for surface mounting devices (SMD) by the wetting balance method*

IEC 60068-2-78:2001, *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, *Graphical symbols for diagrams*

IEC 60717, *Method for the 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*

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

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

2 Technical data

2.1 Units, symbols and terminology

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

– IEC 60027-1
– IEC 60050
– IEC 60617
– ISO 1000

When further items are required, they should be derived in accordance with the principles of the publications listed above.

2.2 Terms and definitions

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

2.2.1
type
products having similar design features manufactured by the same techniques and falling within the manufacturer's usual range of ratings for these products

NOTE 1 Mounting accessories are ignored, provided they have no significant effect on the test results.

NOTE 2 Ratings cover the combination of
– electrical ratings;
– sizes;
– climatic category.

NOTE 3 The limits of the range of ratings should be given in the detail specification.

2.2.2
style
variation within a type having specific nominal dimensions and characteristics

2.2.3
thermistor
thermally sensitive semiconducting resistor whose primary function is to exhibit an important change in electrical resistance with a change in body temperature

2.2.4
negative temperature coefficient thermistor (NTC)
thermistor in which the resistance decreases with increasing temperature

2.2.5
directly heated negative temperature coefficient thermistor
thermistor which obtains its resistance variation by the changes of physical conditions such as current through it, ambient temperature, humidity, wind velocity, gas, etc.

2.2.6
indirectly heated negative temperature coefficient thermistor
thermistor which obtains its resistance variation primarily by the change of temperature of the thermistor, due to the change of a current through a separate heater which is in close contact with, but electrically insulated from, the thermistor element

NOTE The temperature of the thermistor can also be changed by the changes of physical conditions such as current through the thermistor element itself, ambient temperature, humidity, wind velocity, gas, etc.

2.2.7
positive temperature coefficient (PTC) thermistor (for information only)
thermistor in which the resistance increases with increasing temperature

2.2.8
thermistor with wire terminations
thermistor provided with wire terminations

2.2.9
thermistor without wire terminations
thermistor provided only with two metallized faces, to be used as electrical contacts

2.2.10
insulated thermistor
thermistor coated with materials such as resin, glass or ceramic, capable of meeting the requirements of the insulation resistance and voltage proof tests when specified in the test schedule

2.2.11
non-insulated thermistor
thermistor with or without coating materials for surfacing of elements but not intended to meet the requirements of the insulation resistance and voltage proof tests when specified in the test schedule

2.2.12
surface mount thermistor
thermistor whose small dimensions and nature or shape of terminations make them suitable for use in hybrid circuits and on printed board

2.2.13
assembled thermistor (probe)
thermistor encapsulated in different materials such as tubes, plastic and metal housing and/or assembled with cables and/or connectors

2.2.14
thermistor for sensing
thermistor which responds to temperature changes and therefore is used for temperature sensing and control

2.2.15
inrush current limiting thermistor
thermistor which limits the inrush current just after switching on the power

2.2.16
residual resistance (only for inrush current-limiting thermistors)
value of the d.c. resistance of a thermistor when its thermal stability is reached with the maximum current passing

2.2.17
maximum permissible capacitance (only for inrush current-limiting thermistors)
maximum permissible capacitance value of a capacitor which can be connected to a thermistor under loading

2.2.18
zero-power resistance, R_T
value of the d.c. resistance of a thermistor, when measured at a specified temperature, under such conditions that the change in resistance due to the internal generation of heat is negligible with respect to the total error of measurement

2.2.19
rated zero-power resistance
nominal value at the standard reference temperature of 25 °C, unless otherwise specified

2.2.20
resistance-temperature characteristic
relationship between the zero-power resistance and the body temperature of a thermistor

The resistance law follows approximately the formula:

$$R = R_a \times e^{B\left(\frac{1}{T} - \frac{1}{T_a}\right)}$$

where

R is the zero-power resistance in ohms (Ω) at absolute temperature T in kelvins (K);

R_a is the zero-power resistance in ohms (Ω) at absolute temperature T_a in kelvins (K);

B is the thermal sensitivity index (see 2.2.22).

NOTE This formula is only applicable for representing the resistance variation over a restricted temperature range. For more precise representation of the R/T-curve, a resistance/temperature relation should be specified in tabulated form in the detail specification.

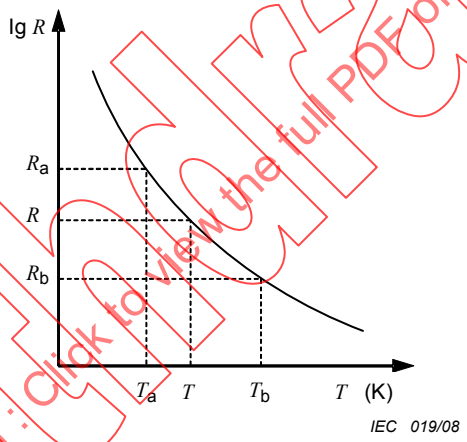

Figure 1 – Typical resistance-temperature characteristic for NTC thermistors

2.2.21
resistance ratio
ratio of the zero-power resistance of a thermistor measured at the reference temperature of 25 °C to that measured at 85 °C, or at such other pairs of temperatures as may be prescribed in the detail specification

2.2.22
***B*-value**
index of the thermal sensitivity expressed by the formula:

$$B = [(T_a \times T_b)/(T_b - T_a)] \times \ln(R_a/R_b)$$

or

$$B = 2{,}303 \times [(T_a \times T_b)/(T_b - T_a)] \times \log(R_a/R_b)$$

where

B is a constant in kelvins (K);

R_a is the zero-power resistance in ohms (Ω) at temperature T_a in kelvins (K);

R_b is the zero-power resistance in ohms (Ω) at temperature T_b in kelvins (K);

T_a = 298,15 K *;

T_b = 358,15 K *.

* The values given above for T_a and T_b are the preferred values and are equivalent to +25 °C and +85 °C respectively.

NOTE Where the detail specification prescribes that the B-value should be measured at other temperatures, the specified values (in kelvins) shall be used for T_a and T_b in the calculation in place of the preferred values and the B-value may be expressed by "$B_{a/b}$".

2.2.23
zero-power temperature coefficient of resistance, α_T
ratio at a specified temperature (T) of the rate of change of zero-power resistance with temperature to the zero-power resistance of the thermistor, expressed by the formula:

$$\alpha_T = (1/R_T) \times (dR_T/dT) \times 100$$

The value α_T can be approximately calculated by the formula:

$$\alpha_T = (-B/T^2) \times 100$$

where

α_T is the zero-power temperature coefficient of resistance in %/K;

R_T is the zero-power resistance in ohms at temperature T in kelvins (K);

B is the index of the thermal sensitivity in kelvins (K).

2.2.24
category temperature range
range of ambient temperatures for which the thermistor has been designed to operate continuously at zero-power, defined by the temperature limits of the appropriate category

2.2.25
upper category temperature, θ_{max}
maximum ambient temperature for which a thermistor has been designed to operate continuously at zero-power

2.2.26
lower category temperature, θ_{min}
minimum ambient temperature for which a thermistor has been designed to operate continuously at zero-power

2.2.27
storage temperature range
range of ambient temperatures for which a thermistor can be stored continuously under no-load condition

2.2.28
decreased power dissipation curve (not for inrush current-limiting thermistors)
relation between the ambient temperature and the maximum power dissipation $P_{max\theta}$, which is usually expressed as curve a or, alternatively, as curve b in Figure 2

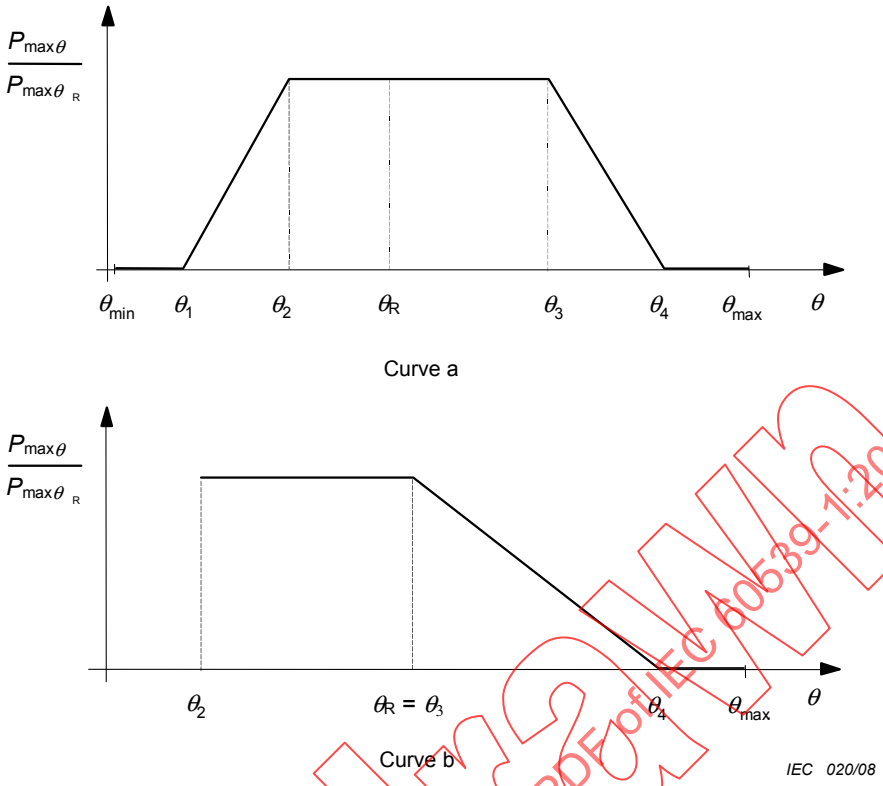

Figure 2 – Decreased power dissipation curve

2.2.29

maximum power dissipation at rated ambient temperature θ_R ($P_{max\theta_R}$)

maximum value of the power dissipation which can be continuously applied to the thermistor at the rated ambient temperature θ_R.

NOTE See curve a, $\theta 2 \leq \theta R \leq \theta 3$ or curve b, $\theta 2 \leq \theta R = \theta 3$ in Figure 2.

The rated ambient temperature θ_R is the ambient temperature specified in the detail specification and is usually 25 °C.

2.2.30

maximum power dissipation at ambient temperature θ ($P_{max\theta}$)

maximum value of the power dissipation which can be continuously applied to the thermistor at an ambient temperature θ

Curve a

The maximum power dissipation rises at a temperature θ_1 linearly to a temperature θ_2. Between temperature θ_2 and θ_3 the power dissipation is constant. When the temperature exceeds θ_3, the power dissipation must be decreased linearly to zero at a temperature θ_4

The maximum power dissipation at ambient temperature θ in general is calculated as follows:

$$P_{max\theta} = I_{max\theta} \times U$$

where U is the voltage across the thermistor (for $I_{max\theta}$, see 2.2.32).

The maximum power dissipation can be expressed by the following formula:

$\theta_1 \leq \theta \leq \theta_2$: $P_{\text{max}.\theta} = P_{\text{max}.\theta_R} \times \dfrac{\theta - \theta_1}{\theta_2 - \theta_1}$

$\theta_3 \leq \theta \leq \theta_4$: $P_{\text{max}.\theta} = P_{\text{max}.\theta_R} \times \dfrac{\theta_4 - \theta}{\theta_4 - \theta_3}$

where

θ_R is the rated ambient temperature in Celsius (°C);

θ_1 is the temperature in Celsius (°C) specified in the detail specification below which zero-power shall be applied. θ_1 is equal to the lower category temperature $\theta_{\text{min.}}$(°C) or higher;

θ_2 is the lowest temperature at which $P_{\text{max}.\theta}$ can be applied. θ_2 = 0 °C, unless otherwise specified in the detail specification;

θ_3 is the maximum temperature at which $P_{\text{max}.\theta}$ can be applied. θ_3 = 55 °C, unless otherwise specified in the detail specification;

θ_4 is the temperature in Celsius (°C) specified in the detail specification, above which zero-power shall be applied. θ_4 is equal to, or lower than, the upper category temperature θ_{max} (°C).

Curve b

The maximum power dissipation is constant between temperature θ_2 and θ_R. θ_2 = 0 °C, unless otherwise specified in the detail specification. When the temperature exceeds θ_R, the power dissipation must be decreased linearly to zero at a temperature θ_4.

The maximum power dissipation at ambient temperature θ in general is calculated as follows:

$$P_{\text{max}\theta} = I_{\text{max}\theta} \times U$$

where U is the voltage across the thermistor (for $I_{\text{max}.\theta}$, see 2.2.32).

The maximum power dissipation can be expressed by the following formula:

$\theta_R \leq \theta \leq \theta_4$: $P_{\text{max}\theta} = P_{\text{max}\theta_R} \times \dfrac{\theta_4 - \theta}{\theta_4 - \theta_R}$

where

θ_R is the rated ambient temperature in Celsius (°C). θ_R = 25 °C, unless otherwise specified in the detail specification;

θ_4 is the temperature in Celsius (°C) specified in the detail specification, above which zero-power shall be applied. θ_4 is equal to, or lower than the upper category temperature θ_{max} (°C).

2.2.31

maximum current at ambient temperature of 25 °C (I_{max25}) (for inrush current-limiting thermistors)

maximum value of current (d.c. or r.m.s. values for sine-shaped a.c.) which can be continuously applied to the thermistor at an ambient temperature of 25 °C.

NOTE 1 See curve c, $\theta_2 \leq 25\ °C \leq \theta_3$ or curve d, $\theta_2 \leq \theta_R = \theta_3$ in Figure 3.

NOTE 2 The maximum power dissipation at ambient temperature of 25 °C (P_{max25}) is calculated by $P_{\text{max25}} = I_{\text{max25}} \times U$, where U is the voltage drop across the thermistor.

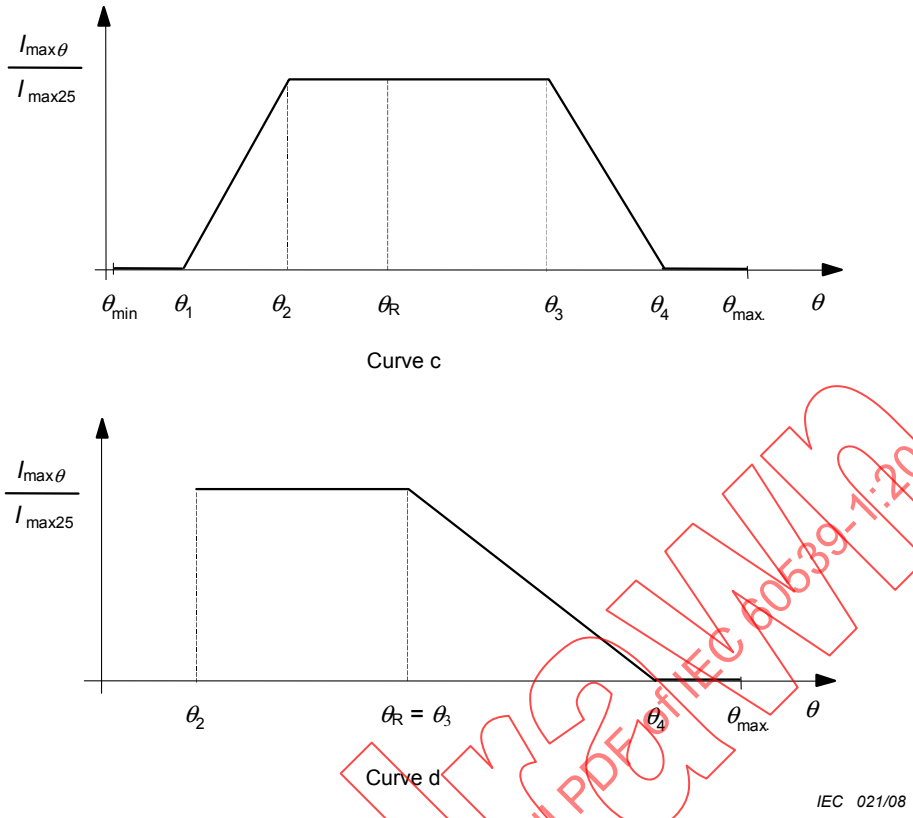

Figure 3 – Maximum current derating

2.2.32
maximum current at ambient temperature θ ($I_{max\theta}$)
maximum value of the current which can pass continuously through the thermistor at an ambient temperature θ

Curve c

The maximum current rises at a temperature θ_1 linearly to a temperature θ_2. Between temperature θ_2 and θ_3 the current is constant. When the temperature exceeds θ_3, the current must be decreased linearly to zero at a temperature θ_4.

The maximum current can be expressed by the following formulae:

$\theta_1 \leq \theta \leq \theta_2$: $\quad I_{max\theta} = I_{max25} \times \dfrac{\theta - \theta_1}{\theta_2 - \theta_1}$

$\theta_3 \leq \theta \leq \theta_4$:

where

θ is the ambient temperature in Celsius (°C);

θ_1 is the temperature in Celsius (°C) specified in the detail specification, which is equal to the lower category temperature θ_{min}(°C) or higher;

θ_2 is the ambient temperature at 0 °C, unless otherwise specified in the relevant detail specification;

θ_3 is the ambient temperature at 55 °C, unless otherwise specified in the relevant detail specification;

θ_4 is the temperature in Celsius (°C) specified in the detail specification, which is equal to the upper category temperature θ_{max} (°C) or lower.

Curve d

The maximum current is constant between temperature θ_2 and θ_R. θ_2 = 0 °C, unless otherwise specified in the detail specification. When the temperature exceeds θ_R, the current must be decreased linearly to zero at a temperature θ_4.

The maximum current can be expressed by the following formulae:

$\theta_R \leq \theta \leq \theta_4$: $\quad I_{max\theta} = I_{max25} \times \dfrac{\theta_4 - \theta}{\theta_4 - \theta_R}$

where

θ_R is the rated ambient temperature specified in the detail specification. θ_R = 25 °C, unless otherwise specified in the detail specification;

θ_4 is the temperature in Celsius (°C) specified in the detail specification, which is equal to the upper category temperature θ_{max} (°C) or lower.

2.2.33
dissipation factor, δ
power dissipation required for a thermistor to raise its temperature by 1 K and which is generally the ratio of the power dissipation change to the resulting thermistor body temperature change at a specified ambient temperature

2.2.34
response time
time (in s) required for a thermistor to change its temperature between two defined conditions when subjected to a change in ambient temperature, power or a combination of temperature and power

NOTE Because of the impracticability to measure response time direct, two methods are defined to measure the thermal time constant direct.

2.2.34.1
thermal time constant by ambient temperature change, τ_a
time (in s) required for a thermistor to respond to 63,2 % of an external step change in ambient temperature in a defined medium

NOTE Step change and medium are specified in the detail specification.

2.2.34.2
thermal time constant by cooling after self-heating, τ_c
time (in s) required for a thermistor to cool by 63,2 % of its temperature excess induced by self-heating, in a defined medium

NOTE The medium is specified in the detail specification.

2.2.35
heat capacity, C_{th}
energy (in joules) the thermistor needs to raise 1 K in temperature. It is completely determined by the component design

NOTE The heat capacity is calculated by the following formula: $C_{th} = \delta \times \tau_c$ or $C_{th} = \delta \times \tau_a$.

2.2.36
voltage-current characteristic
relationship between the voltage (d.c., a.c. r.m.s.) across the thermistor and the applied steady-state current when the thermistor reaches a thermal equilibrium condition in still air or in the still medium specified in the detail specification, at 25 °C or at the temperature specified in the detail specification

2.2.37
maximum operating power for limited self-heating, $P_{\Delta T}$ (only for thermistors for sensing)
maximum value of the power dissipation ($I_{\Delta T} \times U_{\Delta T}$) based on the consideration of the sensing error due to the internal generation of heat (self-heating) of the thermistor, which can be continuously applied to the thermistor in its practical use.

Unless otherwise specified in the detail specification, ΔT is equal to 1 K. The relationship among $P_{\Delta T}$, $I_{\Delta T}$ and $U_{\Delta T}$ is expressed by the following formulae:

$$P_{\Delta T} = \delta \times \Delta T$$

$$I_{\Delta T} = \sqrt{\frac{\delta \times \Delta T}{R_T}}$$

$$U_{\Delta T} = \sqrt{R_T \times (\delta \times \Delta T)}$$

where,

$P_{\Delta T}$ is the maximum operating power for limited self-heating;

δ is the dissipation factor;

ΔT is the temperature rise of the thermistor due to its internal generation of heat;

$I_{\Delta T}$ is the permissible operating current;

$U_{\Delta T}$ is the permissible operating voltage;

R_T is the value of resistance at temperature T in kelvins (K).

2.3 Preferred values

Each sectional specification shall prescribe the preferred values appropriate to the subfamily.

2.3.1 Climatic categories

The thermistors covered by this standard are classified into climatic categories according to the general rules given in Appendix A of IEC 60068-1.

The upper and lower category temperatures and the duration of the damp-heat, steady-state test shall be selected from Table 1.

Table 1 – Upper and lower category temperatures and duration of the damp-heat test

Lower category temperature °C	-90, -80, -65, -55, -40, -25, -10, -5, +5
Upper category temperature °C	30, 40, 55, 70, 85, 100, 105, 125, 150, 155, 175, 200, 250, 315, 400, 500, 630, 800, 1000
Damp heat, steady state days	4, 21, 42, 56

The detail specification shall prescribe the appropriate category.

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) rated zero-power resistance;

b) manufacturer's name and/or trade mark;

c) date of manufacture;

d) tolerance on rated zero-power resistance;

e) the number of the detail specification and style.

The package containing the thermistor(s) 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 Small size types such as surface mount thermistors are generally not marked on the body. If some marking can be applied, they shall be clearly marked with as many as possible of the above items as is considered useful. Any duplication of information in the marking on the thermistor should be avoided.

2.4.3 Coding

Where coding for resistance value, tolerance or date is used, the method shall be one selected from those given in IEC 60062.

3 Quality assessment procedures

3.1 General

When this standard and any related standards are used for the purpose of a full quality assessment system such as the IEC Quality Assessment System for Electronic Components (IECQ), compliance with 3.4 and 3.5 is required.

When such standards are used outside such quality assessment systems as the IECQ system for purposes such as design proving or type testing, the procedures and requirements of 3.4.1 and 3.4.2b) may be used, but the tests and parts of tests shall be applied in the order given in the test schedules.

3.2 Primary stage of manufacture

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

3.3 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.

3.3.1 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.

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

3.3.3 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.

3.3.4 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.

3.4 Qualification approval procedures

3.4.1 The manufacturer shall comply with

a) the general requirements of Clause 3 of IECQ 001002-3 governing qualification approval; and

b) the requirements for the primary stage of manufacture (see 3.2).

3.4.2 In addition to the requirements of 3.4.1, the procedures a) or b) below shall apply.

a) The manufacturer shall produce test evidence of conformance to the specification requirements on three lots taken in as short a time as possible for lot-by-lot inspection and on one lot for periodic inspection.

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

b) The manufacturer may, as an alternative to the procedure specified in 3.4.2a), produce test evidence to show conformance to the specification requirements on one of the fixed sample size test schedules given in the sectional specification.

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

For the two procedures the sample sizes and the permissible number of nonconformances shall be of comparative order. The test conditions and requirements shall be the same.

3.4.3 Qualification approval obtained as part of a quality assessment system, shall be maintained by regular demonstration of compliance with the requirements for quality conformance (see 3.5). Otherwise, this qualification approval must be verified by the rules for the maintenance of qualification approval given in 3.1.7 of IECQ 001002-3.

3.5 Quality conformance inspection

Blank detail specifications associated with the sectional specifications 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.

Inspection levels and sampling plans shall be selected from those given in IEC 60410.

If required, more then one test schedule may be specified.

3.6 Certified test records of released lots

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

3.7 Delayed delivery

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

The re-examination procedure adopted by the manufacturer's Designated Management Representative shall be approved by the National Supervising Inspectorate.

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

3.8 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.

3.9 Alternative test methods

See 3.2.3.7 of IECQ 001002-3 with the following details.

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

3.10 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 sectional and/or blank detail specifications shall contain tables showing 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 carried out. 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 documents, they shall be fully described.

The issue and amendment status of any IEC 60068 test in this clause is given in 1.2.

4.2 Standard atmospheric conditions for testing

Unless otherwise specified, all tests and measurements shall be made 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.

Before the measurements are made, the thermistor shall be stored at the measuring temperature for a time sufficient to allow the entire thermistor to reach this temperature. The same period as is prescribed for recovery at the end of a test is normally sufficient for this purpose.

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

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

When tests are conducted in a sequence, the final measurements of one test may be taken as the initial measurements for the succeeding test.

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

Procedure II

For 96 h ± 4 h in an oven at 100 °C ± 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

Unless otherwise specified, recovery shall take place under the standard atmospheric conditions for testing (4.2). If recovery has to be made under closely controlled conditions, the controlled recovery conditions of 5.4.1 of IEC 60068-1 shall be used.

4.4 **Mounting** (for surface mount thermistors only)

4.4.1 An example of a mounting for surface mount thermistors is shown in Figure C.4.

4.4.2 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) 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.

4.4.3 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).

4.4.4 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 the construction of which 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 shall 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 should 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.

4.5 Visual examination and check of dimensions

4.5.1 Visual examination

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

4.5.2 Marking

Marking shall be legible as determined by visual examination.

4.5.3 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.

Where applicable, measurements shall be made in accordance with IEC 60294 or IEC 60717.

4.5.4 Dimensions (detail)

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

4.6 Zero-power resistance

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

4.6.2 The thermistors shall be mounted by their normal means in corrosion-resistant clips on a mounting plate made of an appropriate insulating material.

The thermistors shall then be deeply inserted into a measurement bath containing a non-corrosive and non-reducing medium, close to the thermometer and during a time needed to reach a stable reading of the zero-power resistance.

All measurements shall be made without self-heating of the devices (zero-power condition).

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

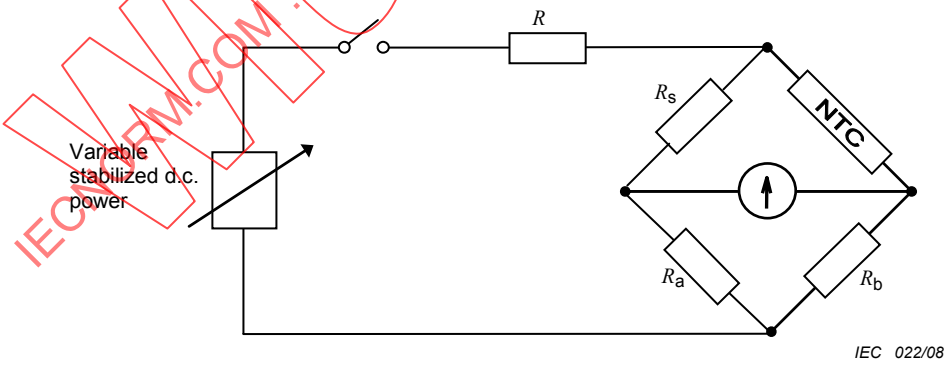

Figure 4 – Zero-power resistance measuring basic circuit

4.6.3 The zero-power resistance shall be within the limits specified in the detail specification, taking into account the tolerance.

4.7 *B*-value or resistance ratio

4.7.1 Calculate the *B*-value (see 2.2.22) or the resistance ratio (see 2.2.21) using zero-power resistance values measured at 25 °C and 85 °C (or at such other pairs of temperatures as may be prescribed in the detail specification) using the method specified in 4.5.

4.7.2 The B-value or the resistance ratio shall be within the specified tolerance.

4.8 Insulation resistance (for insulated types only)

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

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

Method 1

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 mm ± 0,2 mm diameter or 1,0 mm ± 0,2 mm diameter, so that only the metallized 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.

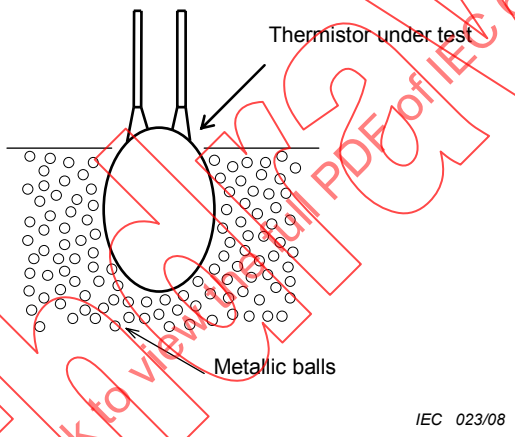

Figure 5 – Test method 1

Method 2

The thermistor shall be placed in water (≤100 Ω × m), 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.

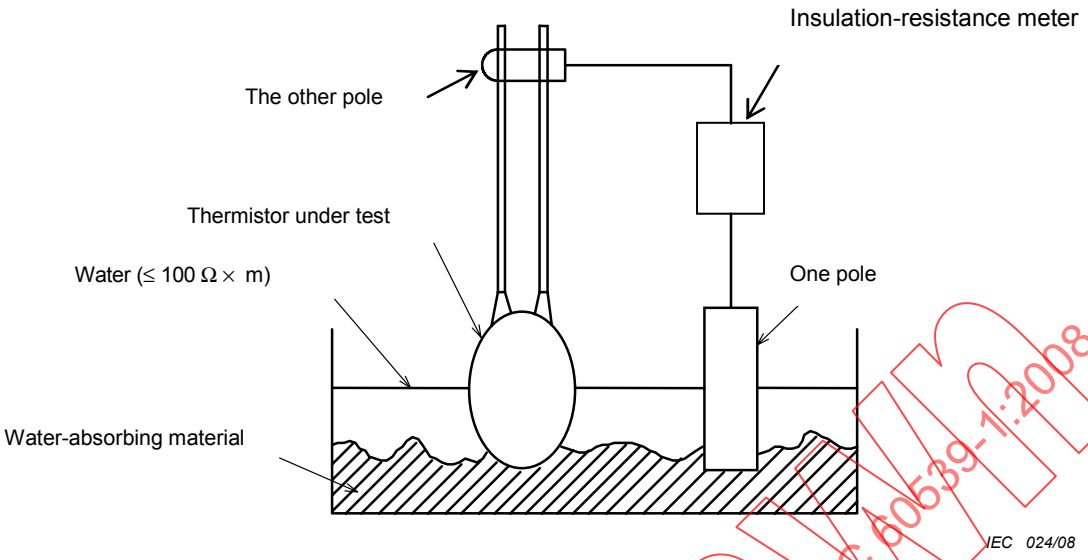

Figure 6 – Test method 2

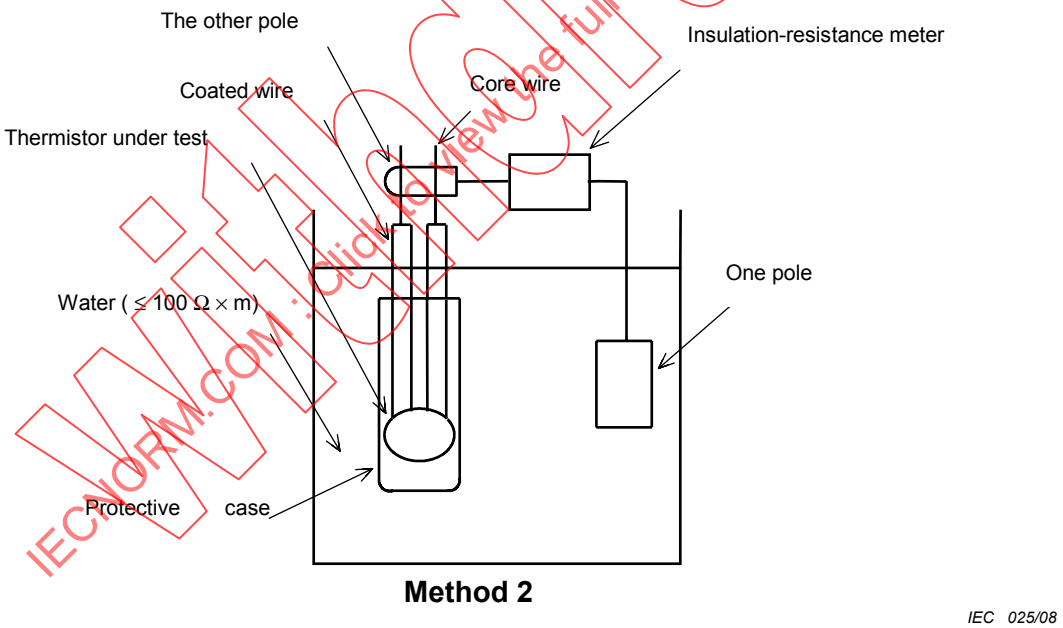

Figure 7 – Test method 2

Method 3

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.

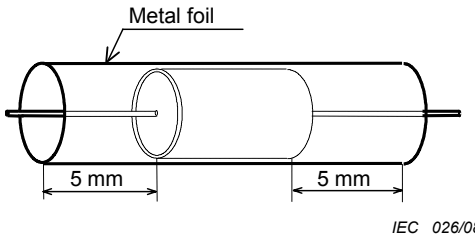

Figure 8 – Test method 3

Method 4

The thermistor shall be clamped in the trough of a 90° metallic V-block of such a 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.

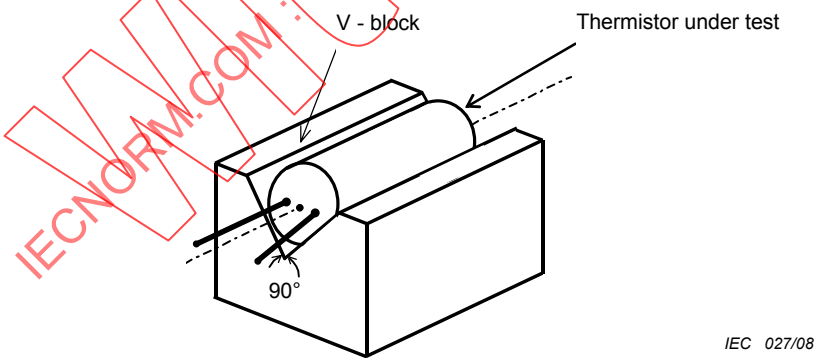

Figure 9 – Test method 4

Method 5

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

Method 6

The thermistor is insulated from the accessory (mounting bracket, flange, and other) which is one pole.

4.8.5 Unless otherwise specified in the detail specification, the insulation resistance shall be measured with a direct voltage of 500 V ± 15 V between both terminations of the thermistor connected together as one pole and the metallic balls, the water (≤ 100 Ω × m), metal foil, V-block, metal plates or accessory 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.

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

4.9 Voltage proof (for insulated types only)

4.9.1 The thermistors are tested as specified below.

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

4.9.3 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, the V-block, the metal plates, the accessory or the clean water 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 20 %.

4.9.4 There shall be no breakdown or flashover.

4.10 Resistance/temperature characteristic

4.10.1 The measuring temperature shall be selected from those given in Table 1 and the resistance/temperature characteristic shall be measured using the method described in 4.5.2.

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

4.11 Dissipation factor (δ)

4.11.1 The zero-power resistance shall be measured at the temperature T_b, which is equivalent to 85 °C ± 0,1 °C, unless otherwise prescribed in the detail specification, and shall be recorded.

4.11.2 Unless otherwise prescribed by the detail specification, the thermistors with wire terminations shall be gripped by clips 25 mm ± 1,5 mm from the body of the thermistor.

Thermistors with other than wire terminations shall be supported by clips, if practicable, according to Annex C. Any exceptions to this shall be fully 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.

Dimensions in millimetres

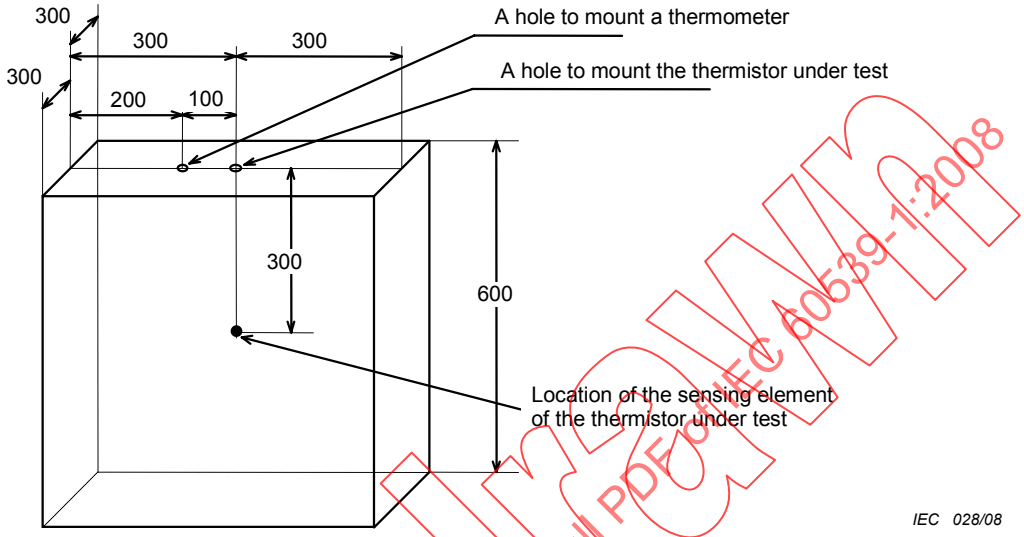

Figure 10 – Example of test chamber

The air in the chamber shall be stationary and shall be at a temperature of 25 °C ± 5 °C. The thermistors shall be connected in the circuit as shown in Figure 11.

The high impedance voltmeter and the ammeter shall have an accuracy better than 1 %.

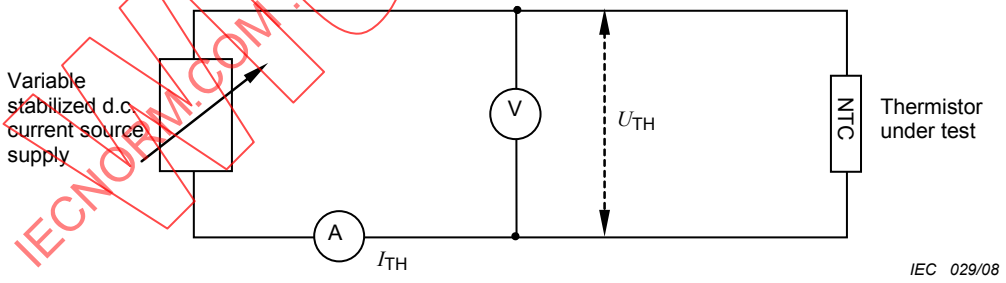

Figure 11 – Dissipation factor measuring circuit

4.11.3 The current I_{TH} shall be adjusted until the ratio U_{TH}/I_{TH} is within 5 % of the zero-power resistance value at T_b. When stable readings have been achieved, the values of U_{TH} and I_{TH} shall be recorded.

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

$$\delta = (U_{TH} \times I_{TH})/(T_b - 25) \quad \text{W/°C}$$

where

T_b is 85 °C, unless otherwise specified in the detail specification;

U_{TH} is measured in volts;

I_{TH} is measured in amperes.

4.11.5 The dissipation factor shall be within the limits prescribed in the detail specification.

4.12 Thermal time constant by ambient temperature change (τ_a)

4.12.1 The zero-power resistance shall be measured as prescribed in 4.5 at the temperature T_i followed by the same measurement at T_a. The temperature T_i is calculated as follows:

$$T_i = T_b - (T_b - T_a) \times 0{,}632$$

where

T_b is (273,15 + 85) K, unless otherwise specified in the detail specification;

T_a is (273,15 + 25) K, unless otherwise specified in the detail specification.

Measurements shall be recorded.

4.12.2 The thermistor shall be immersed in a medium with a temperature T_a and allowed to reach the medium temperature.

4.12.3 The thermistor shall be transferred rapidly to a medium with a temperature T_b. The time it takes for the thermistor to reach the zero-power resistance at T_i shall be measured.

The resulting time is the thermal time constant by ambient temperature change.

4.12.4 The thermal time constant by ambient temperature change shall be within the limits specified in the detail specification.

The medium used in 4.11.2 and 4.11.3, the temperature tolerance on T_a and T_b, air (flow rate) or liquid (flow rate and viscosity) shall be defined in the detail specification.

NOTE This method is not suitable for miniature thermistors because the change of temperature during transfer from the first to the second medium can lead to a considerable measuring error.

4.13 Thermal time constant by cooling after self-heating (τ_c)

4.13.1 The zero-power resistance shall be measured as prescribed in 4.5 at the temperatures T_b = (358,15 ± 2) K, T_a = (298,15 ± 2) K and T_i which is calculated as follows:

$$T_i = T_b - (T_b - T_a) \times 0{,}632$$

Measurements shall be recorded.

NOTE Other values for T_a and T_b may be specified in the detail specification.

4.13.2 Unless otherwise prescribed in the detail specification, the thermistor shall be mounted and enclosed in a chamber as described in 4.10.2. Before insertion in the chamber, the thermistor shall be connected in the circuit shown in Figure 12.

The high-impedance voltmeter and the ammeter shall have an accuracy better than 1 %. The resistance measuring equipment shall have an accuracy of 0,1 % or better.

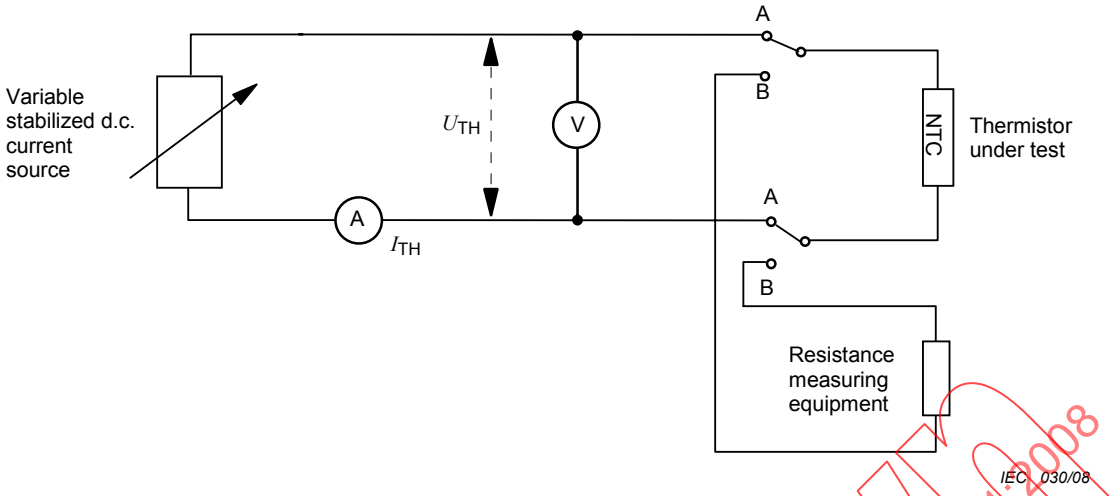

Figure 12 – Thermal time constant measuring circuit

4.13.3 The method of measurement shall be as described below.

With contacts AA closed, the current I_{TH} shall be adjusted until the ratio U_{TH}/I_{TH} is within 60 % to 80 % of the zero-power resistance at T_b and stable readings have been achieved.

Throw switch to close contacts BB and start the timing when the zero-power resistance meets the conditions as described above. Stop timing when the zero-power resistance at T_i is reached.

The elapsed time between start and stop is the thermal time constant.

4.13.4 The thermal time constant shall be within the limits prescribed in the detail specification.

4.14 Robustness of terminations (not applicable to surface mount thermistors)

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_1, 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.

4.14.1 Test Ua_1 – Tensile

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

– for all types of terminations except wire terminations: 20 N;

– for wire terminations: see Table 2.

Table 2 – 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
$0,1 < S \leq 0,2$	$0,35 < d \leq 0,5$	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.

4.14.2 Test Ub – Bending (half the number of terminations)

Two consecutive bends shall be applied (method 1).

4.14.3 Test Uc – Torsion (remaining terminations)

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

4.14.4 Visual examination

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

4.14.5 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.

4.15 Resistance to soldering heat

4.15.1 Preconditioning

When prescribed by the relevant specification the thermistors shall be dried using the method of 4.3.

The thermistors shall be measured as prescribed in the relevant specification.

4.15.2 Test procedure

Unless otherwise stated in the relevant specification, one of the following tests as set out in the same specification shall be applied.

The test conditions shall be defined in the relevant specification.

a) For all thermistors except those of item b) and c) below:

   IEC 60068-2-20, Test Tb, method 1 (solder bath).

b) For thermistors not designed for use in printed boards, but with connections intended for soldering as indicated by the detail specification:

   1) IEC 60068-2-20, Test Tb, method 1 (solder bath)

2) IEC 60068-2-20, Test Tb, method 2 (soldering iron).

c) For surface mounting thermistors

IEC 60068-2-58, reflow or solder bath method

4.15.3 Recovery

The period of recovery shall, unless otherwise specified by the detail specification, be not less than 1 h nor more than 2 h, except for surface mount thermistors, for which the period of recovery shall be 24 h ± 2 h.

4.15.4 Final inspection, measurement and requirements

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.

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

4.16 Solderability

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

The relevant specification should prescribe whether ageing is to be applied. If accelerated ageing is required, one of the ageing procedures given in IEC 60068-2-20 should be applied.

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

4.16.1 Test procedure

Unless otherwise stated in the relevant specification, one of the following tests as set out in the same specification shall be applied.

The test conditions shall be defined in the relevant specification.

a) For all thermistors except those of item b) and c) below:

1) IEC 60068-2-20, Test Ta, method 1 (solder bath)

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

2,0.mm, using a thermal insulating screen of 1,5 mm ± 0,5 mm thickness;

2) IEC 60068-2-20, Test Ta, method 2 (soldering iron).

3) IEC 60068-2-54

b) For thermistors not designed for use in printed boards, but with connections intended for soldering as indicated by the detail specification:

1) IEC 60068-2-20, Test Ta, method 1 (solder bath)

Depth of immersion (from the seating plane or component body): 3,5mm.

2) IEC 60068-2-20, Test Ta, method 2 (soldering iron).

c) For surface mounting thermistors

1) IEC 60068-2-58, reflow or solder bath method

2) IEC 60068-2-69, solder bath or solder globule method

4.16.2 Final inspection, measurements and requirements

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

The thermistors shall meet the requirements as prescribed in the relevant specification.

4.17 Rapid change of temperature

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

4.17.2 The thermistors shall be subjected to the procedure of test Na of IEC 60068-2-14 as follows.

– The lower temperature T_A shall be the lower category temperature.
– The higher temperature T_B shall be the upper category temperature.
– The number of cycles shall be selected from: 5, 10, 25, 50, 100, 500 and 1 000.
– The medium of the test chamber, if different from air, shall be specified in the detail specification.

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

4.17.4 The appropriate parameter(s) given in the detail specification shall be measured using the method specified. The change in value compared with that measured in 4.16.1 shall not exceed the limit specified in the detail specification.

4.17.5 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.

4.18 Vibration

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

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

4.18.3 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.

4.18.4 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.

4.18.5 During the last hour of vibration in each direction of movement, an electrical measurement shall be made to determine intermittent contact or open or short-circuits as defined in the detail specification. Detecting equipment shall be sufficiently sensitive to detect an interruption.

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

4.18.7 The appropriate parameters given in the relevant detail specification shall be measured using the method specified. The change in value compared to the initially measured value shall not exceed the limit specified in the detail specification.

4.19 Bump

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

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

4.19.3 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.

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

4.19.5 The appropriate parameters given in the relevant detail specification shall be measured using the method specified. The change in value compared to the initially measured value shall not exceed the limit specified in the detail specification.

4.20 Shock

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

4.20.2 Mounting shall be as specified in 4.17.2.

4.20.3 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.

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

4.20.5 The appropriate parameters given in the relevant detail specification shall be measured using the method specified. The change in value compared to the initially measured value shall not exceed the limit specified in the detail specification.

The change between the measured value and the initially measured value shall not exceed the limit specified in the detail specification.

4.21 **Free fall** (if specified in the detail specification)

4.21.1 The appropriate parameters given in the relevant detail specification shall be measured using the method specified and recorded.

4.21.2 The thermistors shall be subjected to the procedure 1 of test Ed of IEC 60068-2-32.

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

4.21.4 The appropriate parameters given in the relevant detail specification shall be measured using the method specified. The change in value compared to the initially measured value shall not exceed the limit specified in the detail specification.

4.22 Thermal shock (if specified in the detail specification)

4.22.1 The appropriate parameters given in the relevant detail specification shall be measured using the method specified and recorded.

4.22.2 The thermistors shall be subjected to the procedure of test Nc of IEC 60068-2-14 as follows.

– The lower temperature T_A shall be the lower category temperature.
– The higher temperature T_B shall be the upper category temperature.
– The duration of immersion t_1 and transition time t_2 shall be specified in the detail specification.
– The number of cycles shall be selected from: 5, 10, 25, 50 and 100.
– The medium of the test bath, if different from water or oil, shall be specified in the detail specification.

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

4.22.4 The appropriate parameters given in the relevant detail specification shall be measured using the method specified. The change in value compared to the initially measured value shall not exceed the limit specified in the detail specification.

4.23 Cold (if required by the sectional specification)

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

4.23.2 The thermistors for sensing application shall be subjected to the procedure of test Aa of IEC 60068-2-1 using the degree of severity of the lower category temperature as prescribed in the detail specification. This lower category temperature shall be selected from Table 1 and the duration of the test shall be selected from 2 h, 16 h, 72 h, 96 h, 168 h, 250 h, 500 h and 1 000 h.

4.23.3 The thermistors for other applications shall be subjected to the procedure of test Ad of IEC 60068-2-1 using the degree of severity of the lower category temperature as prescribed in the detail specification. This lower category temperature shall be selected from Table 1 and the duration of the test shall be selected from 2 h, 16 h, 72 h, 96 h, 168 h, 250 h, 500 h and 1 000 h.

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

4.23.5 The appropriate parameter(s) given in the detail specification shall be measured using the method specified. The change in value compared with that measured in 4.23.1 shall not exceed the limit specified in the detail specification.

4.23.6 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.

4.24 Dry heat (if required by the sectional specification)

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

4.24.2 The thermistors for sensing application shall be subjected to the procedure of test Ba of IEC 60068-2-2 using the degree of severity of the upper category temperature as

prescribed in the detail specification. This upper category temperature shall be selected from Table 1 and the duration of the test shall be selected from: 2 h, 16 h, 72 h, 96 h, 168 h, 250 h, 500 h and 1 000 h.

4.24.3 The thermistors for other applications shall be subjected to the procedure of test Bc of IEC 60068-2-2 using the degree of severity of the upper category temperature as prescribed in the detail specification. This upper category temperature shall be selected from Table 1 and the duration of the test shall be selected from: 2 h, 16 h, 72 h, 96 h, 168 h, 250 h, 500 h and 1 000 h.

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

4.24.5 The appropriate parameter(s) given in the detail specification shall be measured using the method specified. The change in value compared with that measured in 4.24.1 shall not exceed the limit specified in the detail specification.

4.24.6 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.

4.25 Damp heat, steady state

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

4.25.2 Non-insulated thermistors shall be subjected to the procedure of test Cab of IEC 60068-2-78 using the severity corresponding to the climatic category of the thermistor as given in the detail specification.

4.25.3 For insulated types the same procedure shall be applied and the test voltage specified in the detail specification, which is based on the consideration of its practical use situation, should be applied.

4.25.4 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.

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

4.25.6 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.

4.25.7 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.

4.26 Endurance

4.26.1 **Endurance at room temperature with applied continuous maximum current (I_{max25})** (for inrush current-limiting thermistors only)

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

4.26.1.2 The thermistors shall be subjected to an endurance test of 42 days (1 000 h) at ambient temperature of between 15 °C and 35 °C. The temperature shall remain within ± 5 °C of that at the beginning of the test.

4.26.1.3 The thermistors shall be connected so that their terminations have an effective length of 20 mm to 25 mm, unless otherwise specified in the relevant 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 thermistors.

4.26.1.4 The thermistors shall be connected in the circuit shown in Figure 13.

4.26.1.5 The current I_{max25} shall be adjusted.

4.26.1.6 After 168 h, 500 h and 1 000 h, the load shall be removed and the thermistors allowed to recover according to 4.3.2.

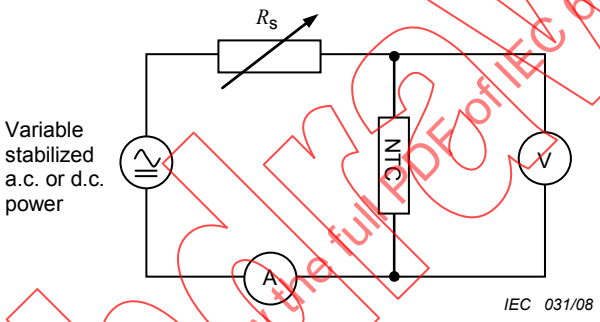

Figure 13 – Endurance at room temperature with I_{max25} evaluating circuit

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.

4.26.1.7 The thermistors shall then 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 compared with the value(s) measured in 4.26.1.1 shall not exceed the limit specified in the relevant detail specification.

4.26.2 Endurance at room temperature with applied cyclic maximum current (I_{max25}) (for inrush current-limiting thermistors only)

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

4.26.2.2 The thermistors shall be subjected to an endurance test of 1 000 cycles at an ambient temperature of between 15 °C and 35 °C. The temperature shall remain within ± 5 °C of that at the beginning of the test.

4.26.2.3 The thermistors shall be connected so that their terminations have an effective length of 20 mm to 25 mm, unless otherwise specified in the relevant 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 thermistors.

4.26.2.4 The thermistors shall be connected in the circuit shown in Figure 11.

4.26.2.5 The current I_{max25} shall be adjusted.

4.26.2.6 The power shall be applied intermittently 1 min on and 5 min off, for 1 000 cycles, unless otherwise specified in the relevant detail specification.

The cycles shall start with the thermistors cooled down to room temperature and shall end with the thermistors dissipating electrical power (P_{max25}).

NOTE This means that each cycle should cover the portion of the R/T-curve between room temperature and electrical power dissipation (P_{max25}).

4.26.2.7 After approximately 500 cycles and 1 000 cycles, the load shall be removed and the thermistors allowed to recover according to 4.3.2.

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.

4.26.2.8 The thermistors shall then 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 then be measured using the method specified. The change compared with the value(s) measured in 4.26.2.1 shall not exceed the limit specified in the relevant detail specification.

4.26.3 Endurance at θ_3 and P_{max}

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

4.26.3.2 The thermistors shall be placed in a test chamber and subjected to the temperature θ_3 ± 2 °C (see Figure 2) for 42 days (1 000 h) and at dissipation P_{max}. 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.

4.26.3.3 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.

4.26.3.4 The appropriate parameter(s) given in the detail specification shall then be measured using the method specified. The change compared with the value(s) measured in 4.26.3.1 shall not exceed the limit specified in the relevant detail specification.

4.26.3.5 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.

4.26.3.6 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.

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

4.26.3.8 The appropriate parameter(s) given in the detail specification shall then be measured using the method specified. The change compared with the value(s) measured in 4.26.3.1 shall not exceed the limit specified in the relevant detail specification.

4.26.4 Endurance at upper category temperature

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

4.26.4.2 The thermistors 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.

4.26.4.3 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.

4.26.4.4 The appropriate parameter(s) given in the detail specification shall then be measured using the method specified. The change compared with the value(s) measured in 4.26.4.1 shall not exceed the limit specified in the relevant detail specification.

4.26.4.5 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.

4.26.4.6 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.

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

4.26.4.8 The appropriate parameter(s) given in the detail specification shall then be measured using the method specified. The change compared with the value(s) measured in 4.26.4.1 shall not exceed the limit specified in the relevant detail specification.

4.26.5 **Maximum permissible capacitance** (for inrush current-limiting thermistors only)

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

4.26.5.2 According to the instructions given in the detail specification, one of the following test methods shall be used.

Method 1

The capacitor C_T (see test circuit, Figure 14) specified in the detail specification, shall be discharged across a series fixed resistor and the thermistor. The charge voltage is chosen so that the voltage applied to the thermistor at the beginning of discharge is 180/375 V, corresponding to (110/230 V + ΔU) × $\sqrt{2}$.

The capacitor shall be discharged 1 000 times at an ambient temperature of between 15 °C and 35 °C. The temperature shall remain within ± 2 °C of that at the beginning of the test.