

Thermistors — Directly heated positive temperature coefficient —

Part 1: Generic specification

ICS 31.040.30

National foreword

This British Standard is the UK implementation of EN 60738-1:2006+A1:2009. It is identical with IEC 60738-1:2006, incorporating amendment 1:2009. It supersedes BS EN 60738-1:2006 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by **A1** **A1**.

The UK participation in its preparation was entrusted to Technical Committee EPL/40X, Capacitors and resistors for electronic equipment.

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

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Amendments/corrigenda issued since publication

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**Thermistors -
Directly heated positive temperature coefficient
Part 1: Generic specification
(IEC 60738-1:2006)**

Thermistances à coefficient
de température positif
à chauffage direct
Partie 1: Spécification générique
(CEI 60738-1:2006)

Direkt geheizte temperaturabhängige
Widerstände mit positivem
Temperaturkoeffizienten
Teil 1: Fachgrundspezifikation
(IEC 60738-1:2006)

This European Standard was approved by CENELEC on 2006-05-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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CENELEC

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

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Foreword

The text of document 40/1651/FDIS, future edition 3 of IEC 60738-1, prepared by IEC TC 40, Capacitors and resistors for electronic equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60738-1 on 2006-05-01.

This European Standard supersedes EN 60738-1:1999.

The changes with respect to EN 60738-1:1999 refer to the tables, figures and references.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2007-02-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2009-05-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60738-1:2006 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 40/1940/CDV, future amendment 1 to IEC 60738-1:2006, prepared by IEC TC 40, Capacitors and resistors for electronic equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60738-1:2006 on 2009-09-01.

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implemented at national level by publication of
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- latest date by which the national standards conflicting
with the amendment have to be withdrawn (dow) 2012-09-01

Endorsement notice

The text of amendment 1:2009 to the International Standard IEC 60738-1:2006 was approved by CENELEC as an amendment to the European Standard without any modification.

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THERMISTORS – DIRECTLY HEATED POSITIVE TEMPERATURE COEFFICIENT –

Part 1: Generic specification

1 Scope

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

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

2 Normative references

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

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

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

IEC 60062, *Marking codes for resistors and capacitors*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3 Terms and definitions

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

3.1

type

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

They are generally covered by a single detail specification

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

¹ “DB” refers to the IEC on-line database.

3.2 style

variation within a type having specific nominal dimensions and characteristics

3.3 thermistor

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

3.4 positive temperature coefficient thermistor

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

3.5 positive step-function temperature coefficient thermistor PTC

thermistor which shows a step-like increase in its resistance when the increasing temperature reaches a specific value

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

3.6 zero-power resistance

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

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

3.7 nominal zero-power resistance

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

3.8 voltage dependency

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

3.9 frequency dependency

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

3.10 resistance/temperature characteristics

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

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

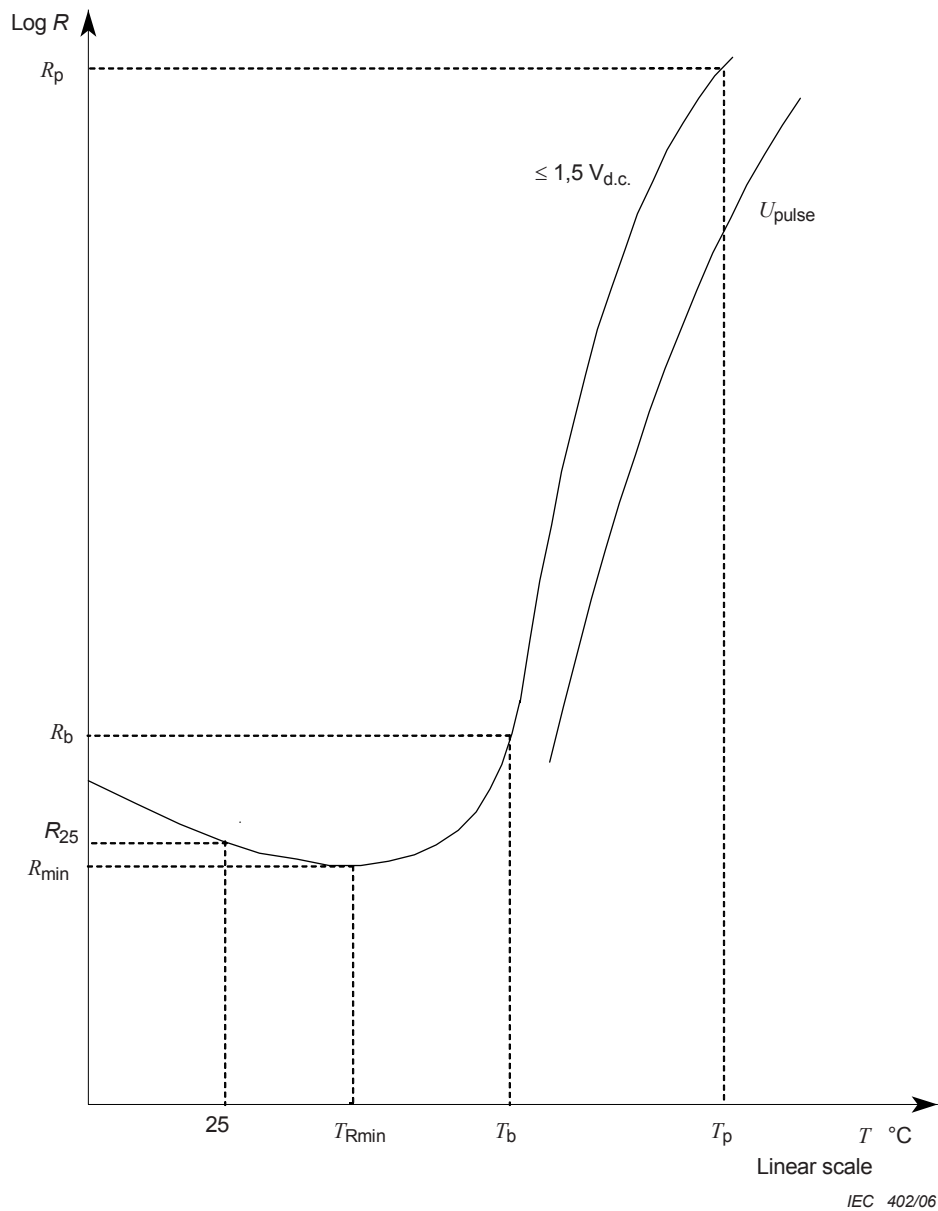


Figure 1 – Typical resistance-temperature characteristic and definitions for PTC thermistors (at zero power)

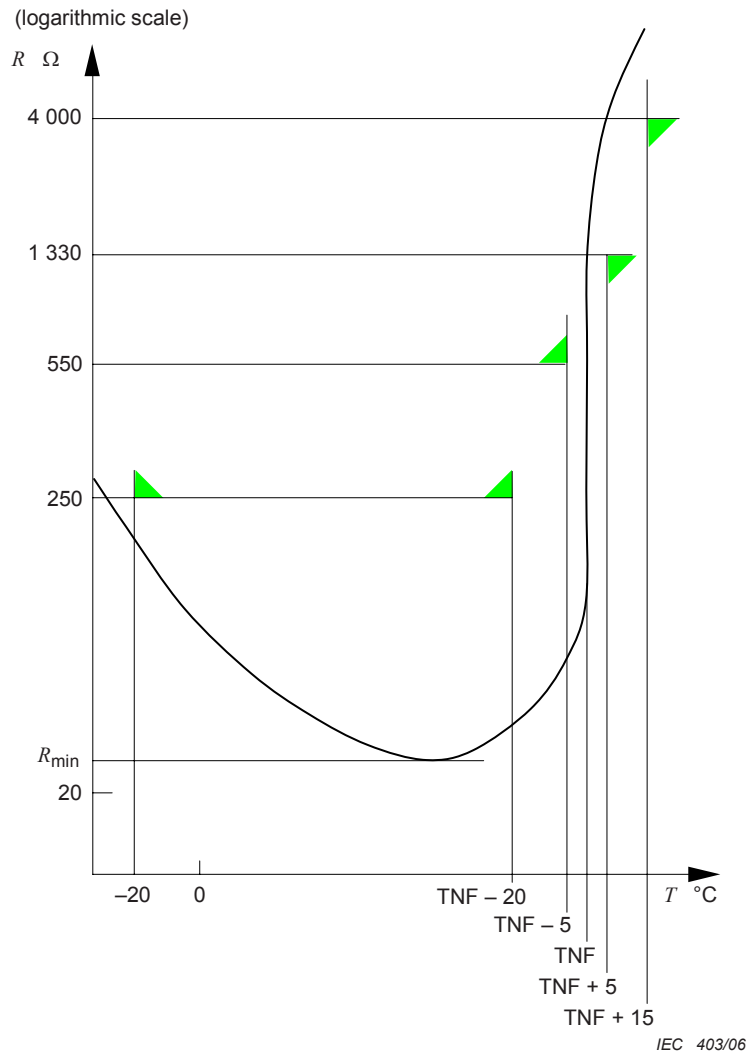
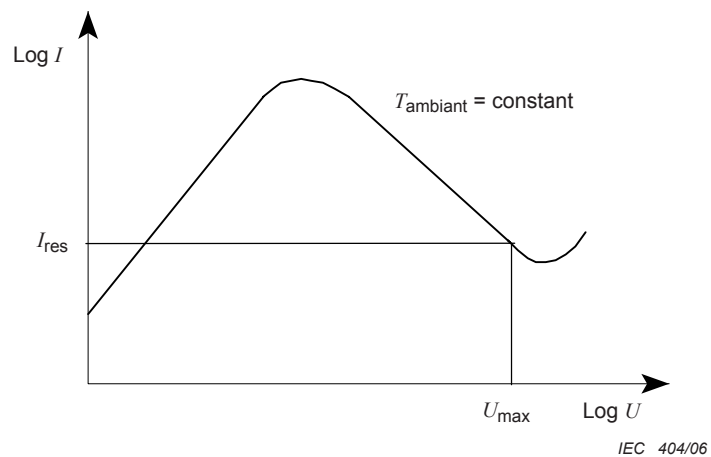


Figure 2 – Typical R-TNF characteristic for PTC thermistors in sensor applications

3.11

current/voltage characteristic

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



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

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

Figure 3 – Typical current/voltage characteristic for PTC thermistors

3.12 nominal functioning temperature

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

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

3.13 switching temperature

T_b
temperature at which the step-like function commences

3.14 minimum resistance

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

3.15 resistance at switching temperature

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

3.16 temperature for minimum resistance

T_{Rmin}
temperature at which R_{min} occurs

3.17 temperature

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

3.18 resistance

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

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

3.19 average temperature coefficient of resistance at a stated voltage

α_R
rate of change of resistance with temperature expressed as %/K

It is calculated from the formula:

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

where T_p exceeds T_b by a minimum of 10 K.

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

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

3.20

upper category temperature

UCT

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

3.21

lower category temperature

LCT

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

3.22

maximum voltage

$U_{\max}$

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

3.23

operating temperature range at maximum voltage

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

3.24

isolation voltage (applicable only to insulated thermistors)

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

3.25

maximum overload current

I_{mo}

value of current for the operating temperature range, which shall not be exceeded

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

3.26

residual current

I_{res}

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

3.27

tripping current

I_t

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

3.28

maximum non-tripping current

$I_{\max nt}$

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

3.29 inrush current

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

3.30 peak inrush current

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

3.31 minimum peak inrush current

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

3.32 maximum peak inrush current

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

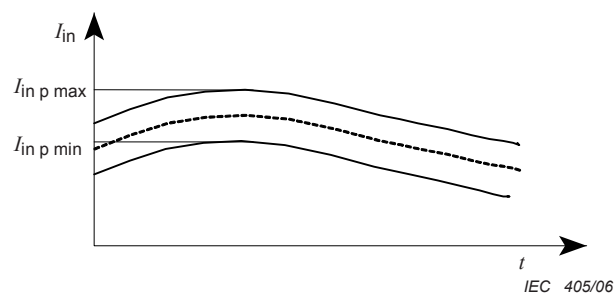


Figure 4 – I_{in} against t at U_{dc}

3.33 peak-to-peak inrush current (for a.c. conditions only)

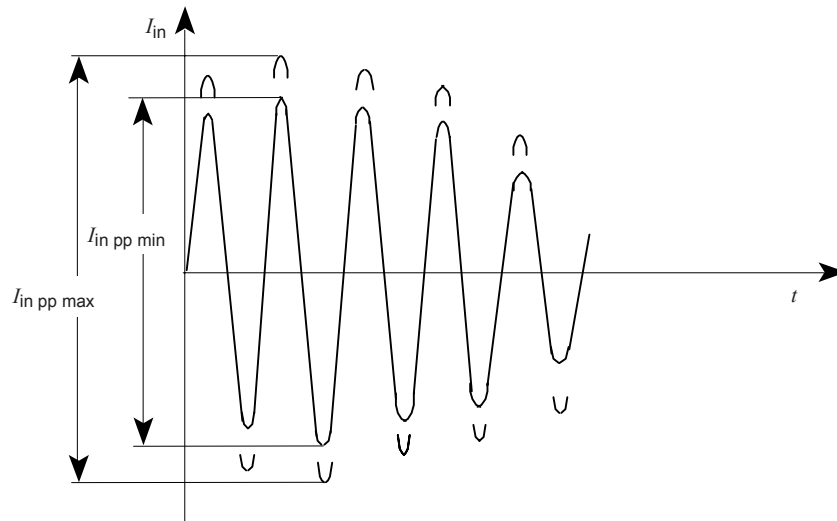
$I_{in pp}$
value of the inrush current measured between adjacent positive and negative peaks (see Figure 5)

3.34 minimum peak-to-peak inrush current

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

3.35 maximum peak to peak inrush current

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



IEC 406/06

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

3.36 peak inrush power

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

3.37 maximum peak inrush power

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

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

3.38 maximum power

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

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

3.39 dissipation factor

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

3.40 thermal resistance

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

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

3.41
heat capacity

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

3.42
response time

- a) response time by ambient temperature change (t_a)
time (in s) required by a thermistor to change its temperature between two defined conditions when subjected to a change in ambient temperature
- b) response time by power change (t_p)
time (in s) required by a thermistor to change its temperature between two defined conditions of power input

3.43
thermal time constant

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

- a) thermal time constant by ambient temperature change (τ_a)
time required for a thermistor to respond to 63,2 % of an external step change in ambient temperature
- b) thermal time constant by cooling (τ_c)
time required for a thermistor to cool by 63,2 % of its temperature excess, due to electrical heating, in still air

3.44
insulated thermistors

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

3.45
surface temperature

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

3.46
final surface temperature

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

4 Units and symbols

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

IEC 60027
IEC 60050
IEC 60617
ISO 1000

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

5 Preferred values

5.1 Climatic categories

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

5.1.1 Bump test severities

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

Test Eb (IEC 60068-2-29)

Acceleration: 400 m/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.

5.1.2 Shock test severities

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

Test Ea (IEC 60068-2-27)

Pulse shape: Half-sine

Acceleration: 500 m/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.

5.1.3 Vibration severities

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

Test Fc (IEC 60068-2-6)

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

5.2 Marking

5.2.1 General

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

- 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.
- Manufacturer's name and/or trade mark.