

Directly heated negative temperature coefficient thermistors —

Part 1: Generic specification

ICS 31.040.30

National foreword

This British Standard is the UK implementation of EN 60539-1:2008. It is identical to IEC 60539-1:2008. It supersedes BS EN 60539-1:2002 which is withdrawn.

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.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 June 2008

© BSI 2008

ISBN 978 0 580 57373 6

Amendments/corrigenda issued since publication

Date	Comments

**Directly heated negative temperature coefficient thermistors -
Part 1: Generic specification
(IEC 60539-1:2008)**

Thermistors à coefficient de température
négatif à chauffage direct -
Partie 1: Spécification générique
(CEI 60539-1:2008)

Direkt geheizte temperaturabhängige
Widerstände mit negativem
Temperaturkoeffizienten -
Teil 1: Fachgrundspezifikation
(IEC 60539-1:2008)

This European Standard was approved by CENELEC on 2008-03-01. 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.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

CENELEC

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 40/1878A/FDIS, future edition 2 of IEC 60539-1, 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 60539-1 on 2008-03-01.

This European Standard supersedes EN 60539-1:2002. It constitutes a minor revision related to 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) 2008-12-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2011-03-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60539-1:2008 was approved by CENELEC as a European Standard without any modification.

CONTENTS

1	General	5
1.1	Scope.....	5
1.2	Normative references	5
2	Technical data.....	7
2.1	Units, symbols and terminology	7
2.2	Terms and definitions	7
2.3	Preferred values	15
2.4	Marking	15
3	Quality assessment procedures	16
3.1	General	16
3.2	Primary stage of manufacture.....	16
3.3	Structurally similar components	16
3.4	Qualification approval procedures	17
3.5	Quality conformance inspection.....	17
3.6	Certified test records of released lots	17
3.7	Delayed delivery.....	18
3.8	Release for delivery under qualification approval before the completion of group B tests	18
3.9	Alternative test methods	18
3.10	Unchecked parameters.....	18
4	Test and measurement procedures.....	18
4.1	General	18
4.2	Standard atmospheric conditions for testing	18
4.3	Drying and recovery	19
4.4	Mounting (for surface mount thermistors only)	19
4.5	Visual examination and check of dimensions	20
4.6	Zero-power resistance.....	21
4.7	<i>B</i> -value or resistance ratio	21
4.8	Insulation resistance (for insulated types only)	22
4.9	Voltage proof (for insulated types only)	25
4.10	Resistance/temperature characteristic	25
4.11	Dissipation factor (δ)	25
4.12	Thermal time constant by ambient temperature change (τ_a)	27
4.13	Thermal time constant by cooling after self-heating (τ_c)	27
4.14	Robustness of terminations (not applicable to surface mount thermistors)	28
4.15	Resistance to soldering heat	29
4.16	Solderability	30
4.17	Rapid change of temperature	31
4.18	Vibration.....	31
4.19	Bump	32
4.20	Shock.....	32
4.21	Free fall (if specified in the detail specification)	32

4.22 Thermal shock (if specified in the detail specification)	33
4.23 Cold (if required by the sectional specification)	33
4.24 Dry heat (if required by the sectional specification)	33
4.25 Damp heat, steady state	34
4.26 Endurance	34
4.27 Shear (adhesion) test	39
4.28 Substrate bending test	39
4.29 Component solvent resistance	40
4.30 Solvent resistance of marking	40
4.31 Salt mist (if required by the sectional specification)	40
4.32 Sealing (if required by the sectional specification)	40
4.33 Composite temperature/humidity cycle (if required by the sectional specification)	40
 Annex A (normative) Interpretation of sampling plans and procedures as described in IEC 60410 for use within the IEC quality assessment system for electronic components (IECQ)	 42
Annex B (normative) Rules for the preparation of detail specifications for capacitors and resistors for electronic equipment	43
Annex C (informative) Typical examples of mountings for measurements of directly heated thermistors	44
Annex ZA (normative) Normative references to international publications with their corresponding European publications	45
 Figure 1 – Typical resistance-temperature characteristic for NTC thermistors	 9
Figure 2 – Decreased power dissipation curve	11
Figure 3 – Maximum current derating	13
Figure 4 – Zero-power resistance measuring basic circuit	21
Figure 5 – Test method 1	22
Figure 6 – Test method 2	23
Figure 7 – Test method 2	23
Figure 8 – Test method 3	24
Figure 9 – Test method 4	24
Figure 10 – Example of test chamber	26
Figure 11 – Dissipation factor measuring circuit	26
Figure 12 – Thermal time constant measuring circuit	28
Figure 13 – Endurance at room temperature with $I_{\max.25}$ evaluating circuit	35
Figure 14 – Maximum permissible capacitance test circuit (method 1)	38
Figure 15 – Maximum permissible capacitance test circuit (method 2)	38
Figure C.1 – Mounting for measurements of surface mount thermistors	44
 Table 1 – Upper and lower category temperatures and duration of the damp heat test	 15
Table 2 – Tensile force	29

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.

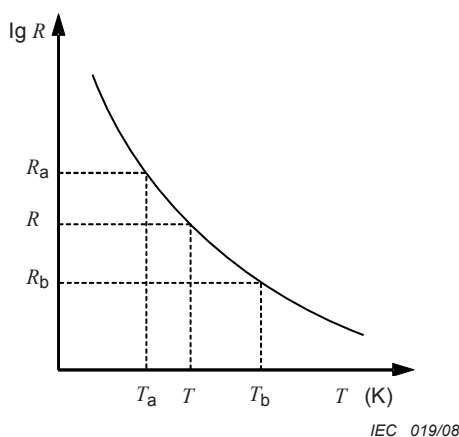


Figure 1 – Typical resistance-temperature characteristic for NTC thermistors

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);

$T_a = 298,15 \text{ K}^*$;

$T_b = 358,15 \text{ K}^*$.

* 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, $\theta_{\max}$

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

2.2.26

lower category temperature, $\theta_{\min}$

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

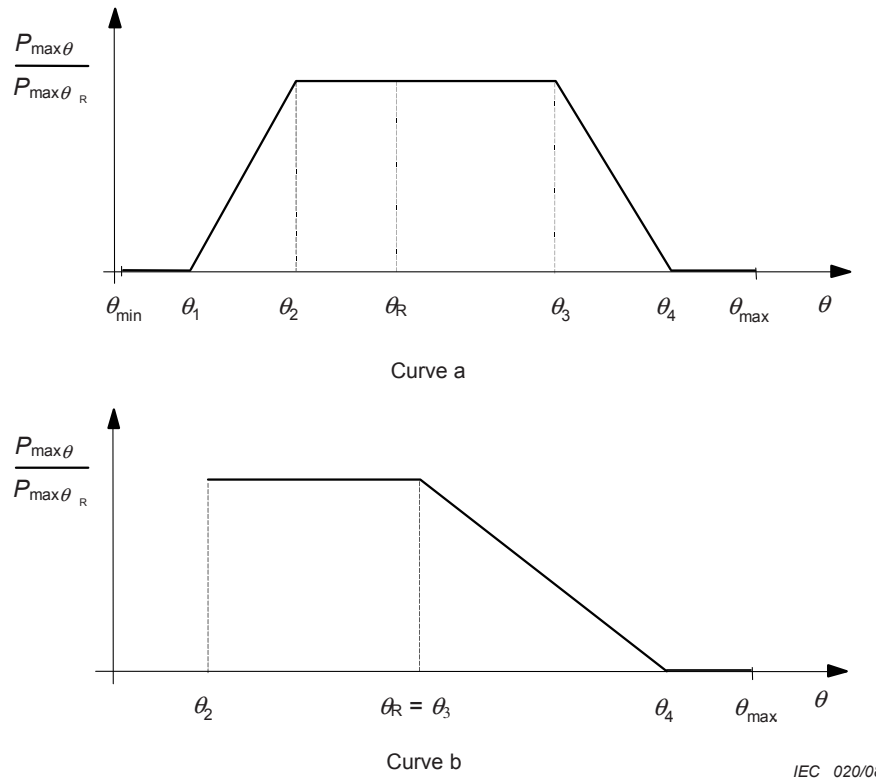


Figure 2 – Decreased power dissipation curve

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:

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

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

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 $\theta_{\min.}$ (°C) or higher;
- θ_2 is the lowest temperature at which $P_{\max.\theta}$ can be applied. $\theta_2 = 0$ °C, unless otherwise specified in the detail specification;
- θ_3 is the maximum temperature at which $P_{\max.\theta}$ can be applied. $\theta_3 = 55$ °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 $\theta_{\max}$ (°C).

Curve b

The maximum power dissipation is constant between temperature θ_2 and θ_R . $\theta_2 = 0$ °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:

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

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:

$$\theta_R \leq \theta \leq \theta_4: \quad P_{\max\theta} = P_{\max\theta_R} \times \frac{\theta_4 - \theta}{\theta_4 - \theta_R}$$

where

- θ_R is the rated ambient temperature in Celsius (°C). $\theta_R = 25$ °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 $\theta_{\max}$ (°C).

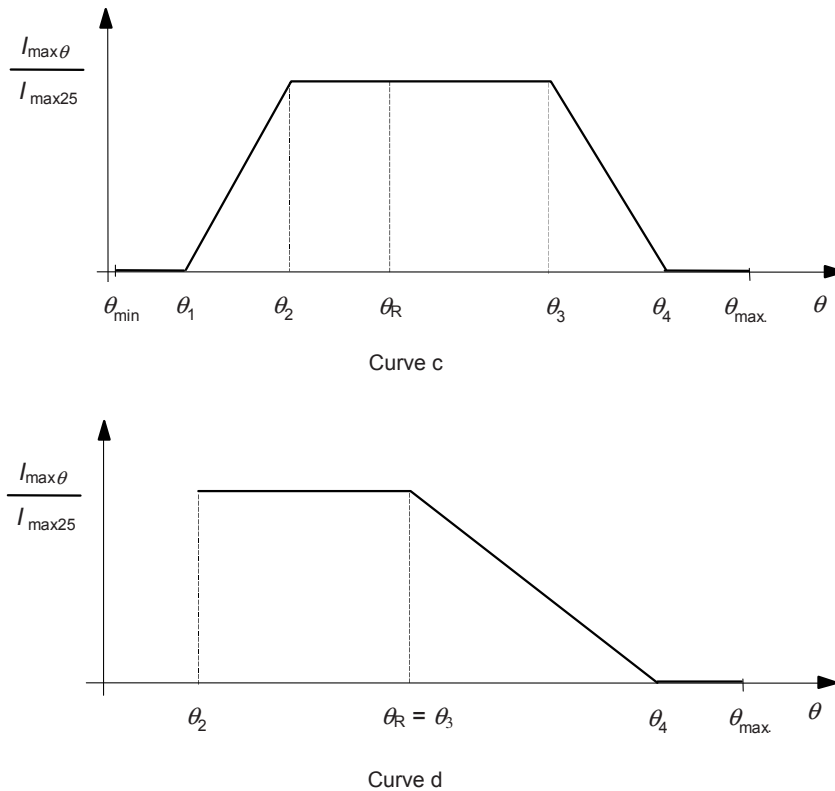
2.2.31

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 $P_{\max25} = I_{\max25} \times U$, where U is the voltage drop across the thermistor.



IEC 021/08

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:

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

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

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 $\theta_{\min}$ (°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 $\theta_{\max}$ (°C) or lower.