BRITISH STANDARD

BS EN
60477 : 1999

Incorporating Amendment No. 1 to BS 5457 : 1977 (renumbers the BS as BS EN 60477 : 1999)

Laboratory d.c. resistors

The European Standard EN 60477 : 1997, with the incorporation of its amendment A1 : 1997, has the status of a British Standard

ICS 17.220.20; 31.040.99

BSi
British Standards

National foreword

This British Standard is the English language version of EN 60477 : 1997, including its amendment A1 : 1997. It is identical to IEC 60477 : 1974 and its Amendment 1 : 1997.

The UK participation in its preparation was entrusted to Technical Committee PEL/85, Measuring equipment for electrical and electromagnetic quantities, (formerly PEL/13/5), which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

Textual note No abbreviation is specified in IEC 61010-1, amendment 2, for pollution degree. In Figure 2 of this standard, the suggested abbreviation "PD" has been used.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

This British Standard, having been prepared under the direction of the Power Electrical Engineering Standards Committee, was published under the authority of the Executive Board and comes into effect on 29 April 1977

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Amendments issued since publication

Amd. No.	Date	Text affected
10233	May 1999	Renumbers BS 5457 : 1977 as BS EN 60477 : 1999; other changes indicated by a sideline

Summary of pages

The following table identifies the current issue of each page. Issue 1 indicates that a page has been introduced for the first time by amendment. Subsequent issue numbers indicate an updated page. Vertical sidelining on replacement pages indicates the most recent changes (amendment, addition, deletion).

Page	Issue	Page	Issue
Front cover	2	8	2
Inside front cover	2	9	2
a	1	10	original
b	blank	11	2
EN title page	1	12	original
EN foreword page	1	13	2
1 to 7	original	Back cover	2

Change of identifier

Wherever BS 5457 : 1977 appears in the page headings of this standard, it should be read as EN 60477 : 1999.

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 60477

October 1997

+ A1

October 1997

ICS 17.220.20

Supersedes HD 249 S1 : 1978

Descriptors: laboratory, direct current, resistors

English version

Laboratory d.c. resistors

(includes amendment A1 : 1997)
(IEC 60477 : 1974 + A1 : 1997)

Résistance de laboratoire à courant continu
(inclut l'amendement A1 : 1997)
(CEI 60477 : 1974 + A1 : 1997)

Gleichstrom-Meßwiderstände
(enthält Änderung A1 : 1997)
(IEC 60477 : 1974 + A1 : 1997)

This European Standard and its amendment A1 were approved by CENELEC on 1997-10-01. 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.

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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

Ref. No. EN 60477 : 1997 + A1 : 1997 E

Foreword

The text of the International Standard IEC 60477 : 1974, prepared by IEC TC 85, Measuring equipment for electromagnetic quantities, was approved by CENELEC as HD 249 S1 on 1975-10-08.

This Harmonization Document was submitted to the formal vote for conversion into a European Standard and was approved by CENELEC as EN 60477 on 1997-10-01.

The following date was 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) 1998-09-01

Foreword to amendment A1 : 1997

The text of document 85/171/FDIS, future amendment 1 to IEC 60477 : 1974, prepared by IEC TC 85, Measuring equipment for electromagnetic quantities, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60477 : 1997 on 1997-10-01.

The following dates were fixed:

— latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1998-09-01

— latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1998-09-01

CONTENTS

LABORATORY D.C. RESISTORS

1. Scope

1.1 This recommendation applies to resistors intended for use as laboratory d.c. resistors (hereinafter referred to as "resistors") comprising single or multiple resistors of accuracy Classes 0.0005 ... 0.2 (5 ppM ... 2000 ppM) and single or multi-decade resistors of accuracy Classes 0.0005 ... 5 (5 ppM ... 50 000 ppM).

1.2 This recommendation does not apply to:

— resistors which are intended for use solely as permanent mounted circuit components,

— resistors used on alternating current or on pulsed currents,

— series resistors and shunts which are considered as accessories of electrical measuring instruments in the relevant IEC publications.

Note. — Examples are the following publications:
Publication 51: Recommendations for Direct Acting Indicating Electrical Measuring Instruments and Their Accessories.
Publication 258: Direct Recording Electrical Measuring Instruments and Their Accessories.

2. Definitions

2.1 *General terms*

2.1.1 *Point of connection*

A single terminal for both current and potential or a pair of terminals, one each for current and for potential.

2.1.2 *Single resistor*

A device which provides a single definite resistance value between certain points of connection.

2.1.3 *Multiple resistor*

An assembly comprising a number of resistors which are accessible either singly or in combination and which provides definite resistance values between certain points of connection.

2.1.4 *Measurement standard resistor*

A single or multiple resistor intended for reference measurement purposes.

2.1.5 *Resistance decade*

A multiple resistor which, by means of a switching device, generally allows the selection of a combination of resistance values rising in equal steps, each step corresponding to an increment of a decadic resistance value (e.g. 0.1 Ω or 1 Ω or 10 Ω ...).

Note. — A resistance decade generally allows a selection of 10, 11 or 12 resistance values (including zero).

2.1.6 *Multi-decade resistor*

A multiple resistor comprising a number of resistance decades which are generally connected in series.

2.1.7 *Leakage current screen*

A path which conducts leakage currents to earth or to a fixed point so that they do not pass through the resistor or other parts of the measuring circuit.

2.1.8 *Electrostatic screen*

A covering in the form of metal foil, fine mesh wire netting or conductive coating intended to protect the enclosed space from external electrostatic effects.

2.2 *Characteristic values*

2.2.1 *Nominal value*

A value which designates a single resistor or a selected combination of a multiple resistor.

2.2.2 *Actual value*

A value obtained under specified test conditions and at a specified time. For a multiple resistor with switching devices having a zero position, the actual value for a given setting is the value obtained for that setting minus the actual residual resistance (see Sub-clause 2.2.5.2).

Note. — Since the true value cannot be determined by measurement, a value traceable to national measurement standards, or a measurement standard agreed upon by manufacturer and user, and having a stated uncertainty, is used in place of the true value. This value, known as the actual value, may be found by applying small corrections according to the known variations with influence quantities, if necessary.

2.2.3 *Certified value*

The actual value, with its associated uncertainty, at the date when it is reported in the accompanying document.

2.2.4 *Fiducial value*

A value to which the errors of a resistor are referred in order to specify its accuracy. The fiducial value corresponds to:

— the selected value for a resistance decade,

— the certified value for a single or a multiple resistor of Classes 0.0005 ... 0.01 (5 ppM ... 100 ppM),

— the nominal value for a single or a multiple resistor of Classes 0.02 ... 5 (200 ppM ... 50 000 ppM).

2.2.5 *Residual resistance*

The resistance value between the points of connection of a multiple resistor having switching devices with a zero position, when all switching elements are set to the zero position.

2.2.5.1 *Nominal residual resistance*

A rounded off value which designates the value of the residual resistance.

2.2.5.2 *Actual residual resistance*

A value of residual resistance obtained under specified conditions and at a specified time.

2.3 *Influence quantities, reference conditions, nominal range of use*

2.3.1 *Influence quantity*

A quantity which is liable to cause unwanted variation in the value of a resistor.

Note. — Generally, it covers such quantities as ambient temperature and humidity, position and power dissipation. These quantities will have reference ranges and nominal ranges of use, which are given in the appropriate tables.

2.3.2 *Limiting values of an influence quantity*

Extreme values which an influence quantity may assume without the resistor being damaged or permanently altered in such a way that it no longer satisfies the requirements of its accuracy class, e.g. the limiting power dissipation (see Sub-clause 6.3.2).

2.3.3 *Reference conditions*

The specified conditions under which the resistor meets the requirements concerning intrinsic errors. For each influence quantity, these conditions may be either a fixed value or a range of values.

2.3.3.1 *Reference value*

A single value of an influence quantity at which (within the tolerance stated in Clause 5) the resistor complies with the requirements concerning intrinsic errors.

2.3.3.2 *Reference range*

A range of values of an influence quantity within which the resistor complies with the requirements concerning intrinsic errors.

2.3.4 *Nominal range of use*

A range of values which each influence quantity can assume without causing a variation exceeding the limits specified in Clause 6.

2.4 *Errors and variations*

2.4.1 *Error*

The value of the deviation of the actual value from the fiducial value. It is expressed in per cent or in parts per million of the fiducial value.

Note. — It is recommended that the following convention be adopted:
error = actual value − fiducial value.

2.4.2 *Intrinsic error*

An error determined under reference conditions.

2.4.3 *Variation*

The difference between the actual values, expressed in per cent or in parts per million of the fiducial value, determined when an influence quantity assumes successively two specified values, all other influence quantities remaining within their reference conditions.

2.5 *Accuracy, accuracy class, class index*

2.5.1 *Accuracy*

The accuracy of a resistor is defined by the limits of intrinsic error and the limits of variations due to influence quantities.

2.5.2 *Accuracy class*

A class of resistors the accuracy of all of which can be designated by the same number if they comply with all the requirements of this recommendation.

2.5.3 *Class index*

The number which designates the accuracy class.

3. Classification

3.1 Resistors satisfying this recommendation are classified according to their accuracy class (as defined in Sub-clause 2.5.2) in the classes designated by the class indices given in Table I.

There are two permissible methods of expressing the class index of a resistor. They are both related to the fiducial value. One is expressed as a percentage of the fiducial value, the other is expressed in parts per million (ppM) of it.

The class index of a resistor can be given using either method or both methods.

TABLE I

Class indices for resistors

Expressed in %	0.0005	0.001	0.002	0.005	0.01	0.02	0.05	0.1	0.2
Expressed in ppM	5	10	20	50	100	200	500	1 000	2 000

3.2 For multi-decade resistors, each decade may have a different class index (see example in Appendix A4). Some of the decades may have a class index taken from Table II.

TABLE II

Class indices for some resistance decades of multi-decade resistors only

Expressed in %	0.5	1	2	5
Expressed in ppM	5 000	10 000	20 000	50 000

4. Limits of intrinsic error

4.1 Resistors shall comply with the limits of intrinsic error specified for their respective accuracy class in Table III for the duration of one year from the date of certification associated with delivery or another date (such as the date of initial certification) agreed upon by manufacturer and user.

This requirement applies only if the working and storage conditions specified by the manufacturer are complied with.

Note. — For resistors, constancy with regard to time is a characteristic of decisive importance. Here, it is specified only for the duration of one year, but experience has shown that the rate of change due to ageing effects decreases with time.

4.1.1 The difference at initial certification between the actual value and the nominal value for resistors of Classes 0.0005 ... 0.01 (5 ppM ... 100 ppM) shall not exceed ± 0.01% (± 100 ppM) of the nominal value.

4.1.2 The actual value at initial certification and the nominal value for resistors of Classes 0.02 ... 5 (200 ppM ... 50 000 ppM) shall not differ by more than an amount corresponding to the class index.

4.2 In a multiple resistor, the actual value relates to each resistor, singly or in combination, the value of which is stated and which is intended for measurement and is directly accessible by terminals or other connection means.

TABLE III

Limits of intrinsic error expressed as a proportion of the fiducial value and limits for initial certification

Class index		Limits of intrinsic error		Limits for initial certification *	
%	ppM	%	ppM	%	ppM
0.0005	5	± 0.0005	± 5		
0.001	10	± 0.001	± 10	± 0.01	± 100
0.002	20	± 0.002	± 20		
0.005	50	± 0.005	± 50		
0.01	100	± 0.01	± 100		
0.02	200	± 0.02	± 200	± 0.02	± 200
0.05	500	± 0.05	± 500	± 0.05	± 500
0.1	1 000	± 0.1	± 1 000	± 0.1	± 1 000
0.2	2 000	± 0.2	± 2 000	± 0.2	± 2 000
0.5	5 000	± 0.5	± 5 000	± 0.5	± 5 000
1	10 000	± 1	± 10 000	± 1	± 10 000
2	20 000	± 2	± 20 000	± 2	± 20 000
5	50 000	± 5	± 50 000	± 5	± 50 000

* See Sub-clauses 4.1.1 and 4.1.2.

4.3 For a multiple resistor with switching devices each having a zero position, the manufacturer shall state the nominal value of the residual resistance with its tolerances if it is higher than 50% of a value corresponding to the class index of the smallest resistance step.

5. Conditions for the determination of intrinsic errors

5.1 The reference conditions relative to each of the influence quantities are shown in Table IV.

TABLE IV

Reference conditions and tolerances of the influence quantities

Influence quantity	Reference conditions, unless marked	Tolerance permitted for testing purposes applicable for a single reference value [1]
Ambient temperature (atmosphere, oil bath, etc.)	20 °C	$^1/_{10}$ of the nominal range of use, but not less than ± 0.1 °C [2]
Relative humidity	50%	40% ... 60% [3]
Dissipated power	Shall be specified in all cases	—
Cooling	None	—
Position	Any	—
External connections	Any	—

[1] For a reference range, no tolerance is allowed.

[2] For resistors of Class 0.0005 (5 ppM), as an exception the tolerance is ± 0.1 °C and not $^1/_{10}$ of the nominal ranges of use (see Table V).

[3] Considerable care may have to be taken in order to ensure that this permitted tolerance is not exceeded.

5.2 The reference values are for stable conditions. Any change in conditions shall be followed by a sufficient time under reference conditions to allow equilibrium to be established before measurements are made.

5.3 The measurement of resistance values shall be made with a substantially constant value of direct current which shall have been applied for a time that is sufficient for a constant resistance value to have been attained unless a shorter time or range of time is specified by the manufacturer. These requirements shall also apply to current that is interrupted or reversed.

Notes 1. — The value of resistance is taken as the average (mean) of the values determined using the two directions of the current.

2. — Resistance may vary or appear to vary with time because of:

a) transient effects due to reactance either inductive or capacitive;

b) dielectric absorption;

c) polarization voltage;

d) thermo-electric Seebeck, Peltier and Thompson effects (see Appendix A1).

Due to the complexity of these causes of change, it is not generally reliable to obtain a direct current value of resistance by extrapolation from measurements of resistance using alternating current over a range of low frequencies.

6. Permissible variations

6.1 *Limits of variation*

When the resistor is under the conditions given in Table V and a single influence quantity is varied in accordance with Sub-clause 6.2, the variation expressed as a percentage (or ppM) of the fiducial value shall not exceed:

— a value corresponding to the class index for the influence quantities listed in Table V,

— the limits stated in Sub-clauses 6.3 and 6.4 for other influence quantities.

TABLE V

Limits of the nominal range of use
(applicable unless marked)

Influence quantity *	Nominal range of use for resistors of classes
Ambient temperature (atmosphere, oil bath, etc.)	0.0005 (5 ppM) Reference temperature ± 0.5 °C
	0.001 (10 ppM) Reference temperature ± 1 °C
	0.002 (20 ppM) Reference temperature ± 2 °C
	0.005 ... 0.02 (50 ppM ... 200 ppM) Reference temperature ± 5 °C
	0.05 ... 5 (500 ppM ... 50 000 ppM) Reference temperature ± 10 °C
Relative humidity	25% ... 75%

* Those influence quantities not listed in Table V and Clause 6 are considered not to have a nominal range of use.

6.2 *Conditions for the determination of the variations*

6.2.1 The variations shall be determined for each influence quantity. During each test, all other influence quantities shall be maintained at their reference conditions.

6.2.2 The degree of variation is assessed as follows:

6.2.2.1 When a reference value is assigned to the resistor, the influence quantity shall be varied between that value and any value within the limits of the nominal range of use as given in Table V, unless otherwise marked.

6.2.2.2 When a reference range is assigned to the resistor, the nominal range of use shall include the whole of the reference range and shall extend beyond it at least at one of the limits of the reference range. The influence quantity shall be varied between each of the limits of the reference range and any value in that part of the nominal range of use adjacent to the chosen limit of the reference range.

6.3 *Influence of self-heating (power dissipation)*

6.3.1 Variation due to self-heating, unless otherwise specified, at any power between the reference value or the upper limit of the reference range and the upper limit of the nominal range of use shall not exceed a value corresponding to the class index, stable conditions being assumed.

6.3.2 The manufacturer may indicate that the upper limit of the nominal range of use for power dissipation may be exceeded, by marking the value of the limiting power dissipation. When so marked, the difference between the value of the resistor before and after the application of this limiting power dissipation shall not exceed 10% of a value corresponding to the class index when the resistor is again under reference conditions. Unless otherwise specified by the manufacturer, the length of time for which the nominal range of use may be exceeded shall be unlimited. When testing the resistor, the limiting power dissipation shall be applied for at least 2 h unless a shorter time has been specified by the manufacturer.

6.3.3 If the value of the limiting power dissipation depends on additional cooling (such as a temperature controlled oil bath or forced ventilation), the value of the limiting power dissipation shall be stated both with and without the extra cooling.

6.4 *Influence of position*

When a reference position is marked (see Table VII) on the resistor, then the nominal range of use for position shall be the reference position ± 20°, unless otherwise stated by the manufacturer.

The permissible variation is 10% of a value corresponding to the class index.

7. Further electrical and mechanical requirements

7.1 *Voltage tests and other safety requirements*

The requirements for the voltage test and other safety requirements are included in IEC 61010-1 *Safety requirements for electrical equipment for measurement, control and laboratory use — Part 1: General requirements* (1990), to which reference shall be made.

7.1.1 *Circuit insulation voltage (nominal circuit voltage)*

Unless otherwise specified, the circuit insulation voltage (nominal circuit voltage) shall be 650 V unless a higher value results from the voltage implied by the limiting power dissipation.

Notes 1. — The circuit insulation voltage (nominal circuit voltage) is the highest voltage to earth at which the resistor may be operated.

2. — For a circuit insulation voltage (nominal circuit voltage) of 650 V, the corresponding test voltage is 2 kV.

7.2 *Insulation resistance*

The value of d.c. insulation resistance measured at 500 V ± 20% between any two points which are not intended to have any connection between them shall be:

— not less than 100 MΩ for Classes 0.01 ... 5 (100 ppM ... 50 000 ppM),

— one million times the nominal value of the resistor, but not less than 100 MΩ for all other classes.

For this test, the nominal value of a multiple resistor shall be the maximum selectable value.

7.3 *Conditions of transport, storage and use*

Unless otherwise stated by the manufacturer, resistors shall be capable of withstanding, without damage, exposure to ambient temperatures within the range −10 °C to + 50 °C. After returning to reference conditions, the resistors shall meet the requirements of Clause 4.

Note. — Resistors shall be transported in accordance with the manufacturer's instructions using a method which avoids both shock and continued vibration so as to prevent a change in value due to strain or work hardening of the resistance material. If a resistor is installed in a rack or test deck, care should be taken to ensure that the ventilation required for its operation is in no way impeded.

7.4 *Point of connection*

Each point of connection shall be so designed that the actual value of resistance between the points of connection shall not vary by more than the specified amount.

After 100 connections and disconnections of each point of connection, the actual value of resistance shall not vary by more than:

— 10% of a value corresponding to the class index for single resistors,

— 10% of a value corresponding to the class index of the chosen selectable value for multiple resistors.

This test shall be carried out under reference conditions.

Unless otherwise specified by the manufacturer, the selectable value to be used for a multiple resistor shall be the lowest selectable value other than zero.

Note. — Care shall be taken that the connections are properly made.

7.5 *Provision of temperature measuring facilities*

Provision for the measurement of the temperature of the resistor shall be provided when the measurement of the temperature of the surrounding medium does not sufficiently define the temperature of the resistor itself.

8. Markings and symbols

Resistors shall bear on the nameplate, or on one of the external surfaces of the case, or in a separate document, the markings listed below.

The majority of these markings are made as given in Sub-clauses 8.2, 8.3 and 8.4, using the symbols listed in Table VII.

8.1 The following information shall be given by the manufacturer:

a) the manufacturer's name or mark;

b) type reference, if any, given by the manufacturer;

c) serial number of the resistor;

d) nominal resistance value(s) (symbol J-1 or according to Sub-clause 8.4);

e) class index or class indices (symbols E-1 or E-6). If a multi-decade resistor has resistance decades which have different limits of intrinsic error, the class index for each resistance decade shall be marked;

f) nominal residual resistance with its tolerance, if necessary (symbol J-2);

g) position symbol, if necessary (symbols D-1 to D-6);

h) reference value or reference range and nominal range of use, if any, for temperature (see Sub-clause 8.4);

j) type of cooling, if necessary (see Table IV);

k) reference value or reference range for power dissipation (see Sub-clause 8.4);

l) nominal range of use for power dissipation, if applicable (see Sub-clause 8.4);

m) limiting power dissipation, if necessary (symbol J-3);

n) any other reference value or reference range and nominal range of use, if relevant;

p) temperature limits and other instructions for transport, storage and use, if necessary;

q) certified value(s) with the associated uncertainty(ies);

r) date of certification;

s) certifying authority;

t) *text deleted*

u) where relevant, the symbol showing that some other essential information is given in a separate document (for example: common mode voltage, symbol F-33);

v) overvoltage category;

w) pollution degree.

8.2 *Locations of markings and symbols*

8.2.1 The following information (see Sub-clause 8.1) shall be given on a nameplate or on the enclosure, if any:

— *a), b), c), d), e), f), g), u), v), w).*

In addition, the following marking shall be made:

— "Laboratory d.c. resistor".

This term can be marked in any other language.

8.2.2 The following information shall be given on the nameplate or on the enclosure, if any, or in a separate document:

— *h), j), k), l), m)* and *a), b), c),* if relevant (see Sub-clause 8.2.4).

8.2.3 The following information shall be given in separate documents:

— *n), p), q), r), s), u) and a), b), c)* (see Sub-clause 8.2.4).

8.2.4 For linking the resistor with the relevant separate document, the information *a), b)* and *c)* which is given on a nameplate or on the enclosure shall be repeated in the document (see Sub-clauses 8.2.2 and 8.2.3).

8.3 All markings shall be legible and indelible.

8.4 *Marking relating to the reference conditions and nominal ranges of use*

8.4.1 Reference values or reference ranges corresponding to each influence quantity shall be marked, if different from those given in Table IV.

8.4.2 The nominal ranges of use shall be marked if different from Table V.

8.4.3 If the reference value or reference range is marked, it shall be identified by underlining.

The influence quantity shall be identified by the symbol of the unit in which it is measured (see Table VII).

The following examples (Table VI) show the significance of the various markings for temperature:

TABLE VI

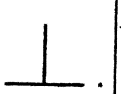
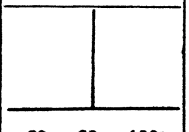
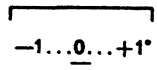
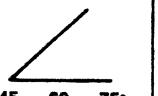
Examples of markings for temperature

Indication	Example	Meaning *
No marking		Reference value: 20 °C (see Table IV) Nominal range of use: 18 °C to 22 °C (see Table V)
One number	25 °C	Reference value: 25 °C Nominal range of use: 23 °C to 27 °C (see Table V)
Three numbers	20 ... 25 ... 30 °C	Reference value: 25 °C Nominal range of use: 20 °C to 30 °C (both limits of the nominal range of use are different from those specified in Table V)
Three numbers	15 ... 20 ... 25 °C	Reference range: 20 °C to 25 °C Nominal range of use: 15 °C to 27 °C (the lower limit of the nominal range of use is different from that specified in Table V; for the upper limit of the same, see Table V)
Four numbers	15 ... 20 ... 25 ... 30 °C	Reference range: 20 °C to 25 °C Nominal range of use: 15 °C to 30 °C (permissible variations between 15 °C to 20 °C and 25 °C to 30 °C)
Four numbers	15 ... 15 ... 20 ... 25 °C	Reference range: 15 °C to 20 °C Nominal range of use: 15 °C to 25 °C (permissible variations between 20 °C to 25 °C)

* The nominal ranges of use for these examples are taken from Table V for a resistor of Class 0.002 (20 ppM).

TABLE VII

Symbols for marking resistors

No.	Item	Symbol
A	Principal units and their principal multiples and sub-multiples *	
A-5	kilovolt	kV
A-6	volt	V
A-11	watt	W
A-18	megohm	MΩ
A-19	kilohm	kΩ
A-20	ohm	Ω
A-21	milliohm	mΩ
A-24	degree Celsius	°C
C	Safety (see IEC 61010-1)	
D	Position of use	
D-1	Resistor to be used with marked surface in vertical plane	
D-2	Resistor to be used with marked surface in horizontal plane	
D-3	Resistor to be used with marked surface inclined (e.g. 60°) from the horizontal plane	
D-4	Example for resistor to be used as D-1 Nominal range of use 80° ... 100°	
D-5	Example for resistor to be used as D-2 Nominal range of use −1° ... +1°	
D-6	Example for resistor to be used as D-3 Nominal range of use 45° ... 75°	
E	Accuracy classes	
E-1	Class index expressed in % (e.g. 0.02%)	0.02
E-6	Class index expressed in ppM (e.g. 200 ppM)	200 ppM
F	General symbols	
F-31	Earth terminal	
F-33	Refer to a separate document	
J	Characteristic values	
J-1	Nominal resistance value (e.g. 1 Ω)	1 Ω
J-2	Nominal residual resistance and its tolerance (e.g. 5 ± 0.5 mΩ)	$R_0 = (5 \pm 0.5)$ mΩ
J-3	Limiting power (e.g. 2 W)	(2) W

* If other units and prefixes are needed, see IEC Publication 27: Letter Symbols to be used in Electrical Technology.

APPENDIX

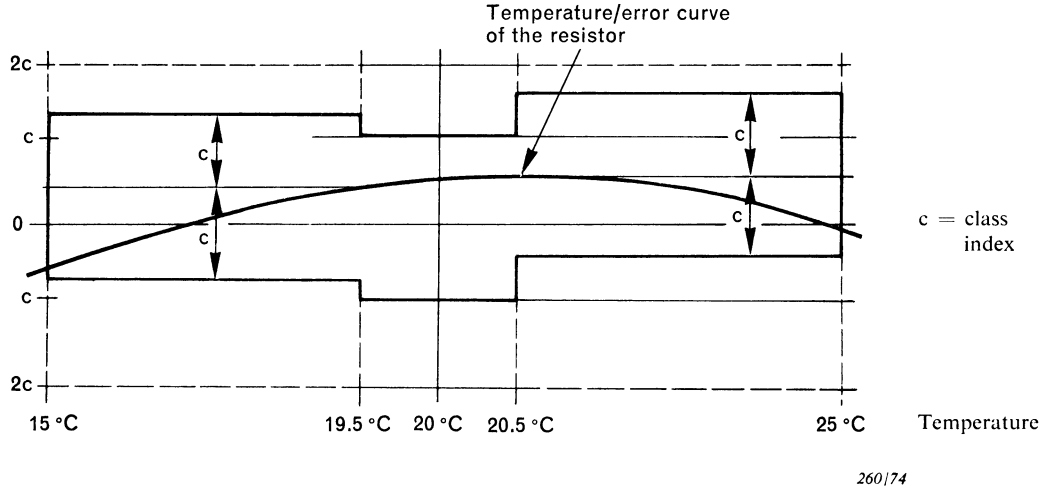
A1 **Thermoelectric effects** (see Sub-clause 5.3, Note 2)

It is recommended that in relation to copper, the Seebeck coefficients of the resistance material, the connections and the terminals should not exceed 2 μV/°C. This is important especially for resistors of low resistance value.

Note. — Commercial copper is sometimes impure and has an appreciable Seebeck coefficient with respect to pure copper.

A2 **Reference range and nominal range of use**

The concept of the fiducial value, reference value or reference range and nominal range of use is fully described in the appendix of IEC Publication 51, Direct Acting Indicating Electrical Measuring Instruments and Their Accessories. Figure 1 below is an example of a resistor of class index 0.005 (50 ppM) without markings relating to temperature.



Not to scale

Reference value 20 °C

FIG. 1. — Effect of temperature.

Figure 1 shows the effect of temperature on the actual value of resistance.

If the resistor had been of any other accuracy class, the reference temperature and the nominal range of use for temperature would have to be marked. The effect of temperature from 19.5 °C to 20.5 °C is negligible, from 15 °C to 19.5 °C and from 20.5 °C to 25 °C, a variation of the resistance is permitted, the maximum value of which is equivalent to a value corresponding to the class index.

The broken boundary lines represent the greatest allowable extent of the variation if the error under reference conditions is at its allowable limits.

A3 Example of marking for a single resistor

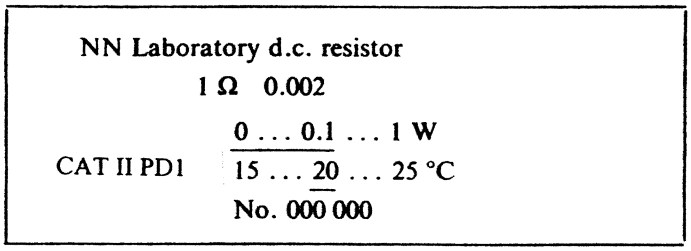


FIG. 2. — Example of marking for a single resistor.

The marking denotes that if the resistor is subjected to a load up to 0.1 W, the limits of intrinsic error of a resistor of accuracy Class 0.002 comply with Table III and that for loads of more than 0.1 W up to 1 W, the variation will not exceed ± 0.002% of the nominal value, all other influence quantities being maintained under stable reference conditions.

The resistor, No. 000 000, was manufactured by NN. The overvoltage category is II and the pollution degree is 1. The reference value for temperature is 20 °C and the nominal range of use for temperature is 15 °C to 25 °C. The reference value or reference range and nominal range of use for all other influence quantities are as specified in this recommendation.

Note. — The resistor may be marked "Class 20 ppM" instead of "Class 0.002", i.e. the class index being given in ppM instead of %.

A4 Example of marking for a five-decade resistor

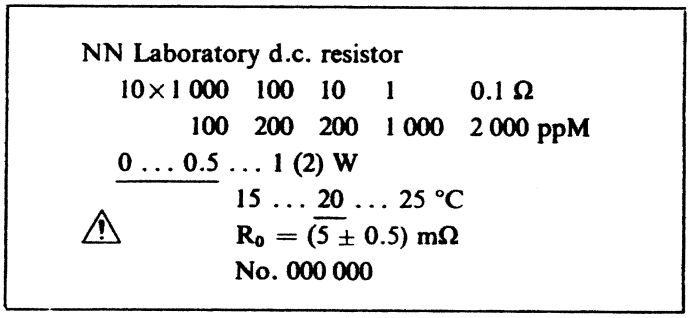


FIG. 3. — Example of marking for a five-decade resistor.

The marking denotes that if the resistor remains within the reference range of power of 0 W to 0.5 W for each step, the limits of intrinsic error for the marked accuracy class of each are complied with for the ten increasing values of each resistance decade. For loads of more than 0.5 W up to 1 W for each step, the variation due to self-heating does not exceed the limits according to the accuracy class of each resistance decade. It may be subjected to a loading of 2 W for each step without causing permanent damage. The residual resistance (with all dials set to zero) is 5 ± 0.5 mΩ.

The resistor, No. 000 000, was manufactured by NN. The reference value for temperature is 20 °C and the nominal range of use for temperature is 15 °C to 25 °C. The reference value or reference range and nominal range of use for all other influence quantities are as specified in this recommendation. The common mode voltage is given in a separate document.

Note. — The resistor may be marked Classes 0.01 - 0.02 - 0.02 - 0.1 - 0.2 instead of Classes 100 - 200 - 200 - 1 000 - 2 000 ppM, i.e. the class index being given in % instead of in ppM.

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