British Standard

BRITISH STANDARD

BS 115:1995

Incorporating Amendment No. 1

Specification for

Metallic resistance materials for electrical purposes

UDC 621.316.84

Committees responsible for this British Standard

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Covered Conductors Association

Electrical and Electronic Insulation Association (BEAMA Ltd.)

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Contents

Foreword

This British Standard has been prepared under the direction of the Cables and Insulation Standards Policy Committee. It is a revision of BS 115:1954 which is withdrawn.

Unlike the previous edition, in this standard metallic resistance materials are divided into four classes with no reference to the maximum working temperature of the materials. The inclusion of maximum working temperatures was considered to be too subjective, as the question of devising a suitable life test to prove these has been impractical, because of the numerous factors which affect high-temperature performance. Classification is therefore effected by typical values of temperature coefficient of resistance and resistivity. The materials are coded for class, alloy, condition and grade.

New tolerances have been introduced for resistance and uniformity of resistance of wire (including a new grade), out-of-roundness, straightness, the width of strip and tape, and the width and thickness of sheet.

New sections have been included on temperature coefficient of resistance, spiralling test, product marking, documentation, packaging and health and safety.

The section on physical and mechanical properties has been modified.

Formulae for the calculation of resistance per unit length of wire, strip and tape together with density/mass formulae for determining the cross-section of small dimensional material are given.

It has not been possible to specify definitive requirements for wire and strip supplied in cut and straightened lengths as the cutting and straightening processes can cause variations in electrical properties. Recommendations on dimensional tolerances have, however, been included.

Product certification. Users of this British Standard are advised to consider the desirability of third party certification of product conformity with this British Standard based on testing and continuing product surveillance which may be coupled with assessment of a supplier's quality systems against the appropriate Standard in the BS EN ISO 9000 series.

Enquiries as to the availability of third party certification schemes are forwarded by BSI to the Association of British Certification Bodies. If a third party certification scheme does not already exist, users should consider approaching an appropriate body from the list of Association members.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 20, an inside back cover and a back cover.

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Introduction

Maximum working temperatures are not definitive for an alloy. They are affected by the following:

a) alloy type;

b) temperature;

c) diameter or thickness;

d) temperature cycling;

e) whether the elements are open to the atmosphere or surrounded by refractory, as in mineral filled elements;

f) the general conditions of use.

For these reasons, classifying materials by maximum operating temperatures was not considered to be satisfactory. It was preferable to classify these materials by temperature coefficient of resistance and resistivity, subdividing these classes into alloys which could be coded by reference to typical composition.

Due to order-disorder reactions, the resistivity and temperature coefficient of resistance of some of the materials in this standard are affected by the rate at which they are cooled from the annealing temperature. These values can also be altered by the amount of cold work, so that materials supplied in the tempered condition may be affected.

Section 1. General

1.1 Scope

This British Standard specifies requirements for the dimensions, electrical and mechanical properties of metallic resistance materials in the form of wire, strip, tape and sheet.

It also provides a classification of these materials based on the typical temperature coefficient of resistance and resistivity, then subdivided into alloys. Codes are assigned to each known alloy within the class. Other alloys, not specifically listed, may also be classified and coded. A grading of materials, based on tolerances on resistance, is also introduced.

Requirements for product marking, documentation and packaging are also specified.

In addition to the definitive requirements, this standard also requires the items detailed in **1.4** to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

Material conditions, limits of uncertainty, details of the sizes of wire in general use and conversion factors to foot-pound units are given in Annex A to Annex D and recommendations are also made relating to health and safety (Annex E).

This standard does not specify requirements for wire and strip supplied in cut and straightened lengths but recommendations on tolerances are given in Annex F.

NOTE 1 For nickel and nickel alloys supplied in cut and straightened lengths for structural use see BS 3073 and BS 3075.
NOTE 2 For fine resistance wires for special purposes, e.g. telecommunication, reference should be made to BS 1117.

1.2 References

1.2.1 Normative references

This British Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on the inside back cover. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this British Standard only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

1.2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

1.3 Definitions

For the purposes of this British Standard the following definitions apply.

1.3.1
typical

the average value derived from published data by all suppliers

1.3.2
nominal

the average value declared by the supplier

1.3.3
actual

the measured value

1.3.4
nominal resistance

the resistance calculated from the nominal dimensions and nominal resistivity for the condition of the material declared by the supplier (see **3.2**)

1.3.5
strip

cold rolled material, slit with square edges, in widths over 3 mm up to 152 mm

1.3.6
tape

strip with rounded edges normally in the size ranges of width, 0.3 mm to 6.35 mm and thickness 0.05 mm to 2.0 mm

NOTE Reference should be made to the suppliers' data to ascertain the combinations of width and thickness which are available.

1.3.7
round edged strip

strip with rolled or ground round edges

1.3.8
sheet

material in widths from 152 mm to 610 mm

1.3.9
concession

a deviation in the physical, mechanical or dimensional properties of the metallic resistance material from that specified, that has been accepted by the purchaser

1.4 Information and requirements to be agreed and to be documented

1.4.1 Information to be supplied by the purchaser

The following information to be supplied by the purchaser shall be fully documented. Both the definitive requirements specified throughout this British Standard and the following documented items shall be satisfied before a claim of compliance with the standard can be made and verified.

a) The supply condition required if other than that specified in **6.1** (see also **2.2**).

b) The alloy, class and grade required.

c) The tolerance on nominal resistance if other than that given in Table 6 or Table 7 (see **3.3**).

1.4.2 Items to be agreed

The following items to be agreed between the contracting parties, which are specified in the clauses referred to, shall be fully documented. Both the definitive requirements specified in this British Standard and the following documented items shall be satisfied before a claim of compliance with the standard can be made and verified.

a) The form of declaration of the properties listed in **1.4.3** if other than as published literature.

b) If the temperature coefficient of resistance in the range 20 °C to 200 °C is to be determined (see **4.3.2**) on material in the as-despatched condition for classes C and D.

c) If the values of any of the additional physical properties listed in **6.7** are to be determined.

d) Any additional information to be included in the certificate of conformity (see **7.2**).

1.4.3 Information to be declared by the supplier

The following information to be declared by the supplier shall be fully documented.

a) The nominal resistivity (in μΩ·cm) at 20 °C for the material in the condition as supplied (see **3.1** and **3.2**).

b) The calculated nominal resistance per unit length of tape, wire, strip and round-edged strip at 20 °C and, where applicable, the reduction factor used in the calculation of cross-sectional area (see **3.2**).

c) The nominal temperature coefficient of resistance (see **4.1**).

d) For materials in classes A and B only, the nominal thermoelectromotive force (in mV/K) between 0 °C and 100 °C and the polarity of the material against copper (see **6.2**).

e) When agreed [see **1.4.2** c)], the nominal values of the applicable physical properties listed in **6.7**.

NOTE These nominal values may be documented in published literature or another form agreed between purchaser and supplier [see **1.4.2** a)].

Section 2. Classification

2.1 Classification and codes

2.1.1 General

Metallic resistance materials shall be classified in accordance with **2.1.2** and individual alloys within the classes shall be coded in accordance with **2.1.3**.

2.1.2 Classification

Metallic resistance materials shall be classified, depending upon their typical temperature coefficient of resistance and resistivity as follows.

a) *Class A.* For applications where low values and tolerances of temperature coefficient of resistance are of primary importance (typically 0×10^{-6}/K).

b) *Class B.* For applications where low values and tolerances of temperature coefficient of resistance are important but may be larger than that permitted for class A.

c) *Class C.* For applications where the temperature coefficient of resistance may be larger than that permitted for class B and having a resistivity of 70 μΩ·cm or greater.

d) *Class D.* For applications where the temperature coefficient of resistance may be larger than that permitted for class B and having a resistivity up to, but not including, 70 μΩ·cm.

NOTE 1 Table 1 to Table 4 list metallic resistance materials which have been classified in classes A to D respectively.

NOTE 2 The typical resistivity figures listed in the tables are for bright material in the annealed and quenched condition (the majority of material is supplied in this condition) except for alloy Ni74Cr20Al3.5 of class A for which the resistivity is in the bright, annealed, quenched and heat-treated condition.

The typical temperature coefficient of resistance values for classes A and B, whose temperature ranges are quoted up to 200 °C, are for materials in the as-received condition. For classes C and D, the temperature coefficient of resistance values are for a sample which has been annealed and then slowly cooled from this annealing temperature to ambient.

2.1.3 Alloy code

The individual alloys within each class shall be coded as follows:

PpQqRr:ST

where

P, Q, R are the atomic symbols for elements that are present at levels of 2 % or above;

p, q, r are the typical percentages of elements P, Q, R, quoted to the nearest 0.1 % where this is significant;

S, T are the atomic symbols for elements that are present at levels below 2 % but contribute substantially to the performance of the material.

The elements shall be listed in decreasing order of percentage composition.

Codes for alloys other than those listed in Table 1 to Table 4 shall not be allocated unless they differ sufficiently in composition such that the code is not duplicated in the same class for alloys with different electrical properties.

NOTE 1 In Table 1 to Table 4 the typical composition for the alloy codes has been derived from average analysis from manufacturers. The percentages may vary slightly between manufacturers and are only used for the purpose of classification and coding.

NOTE 2 Identical codes may occur in different classes due to minor variations in composition with effects on the electrical properties of the material.

NOTE 3 Applications to include alloys not currently listed in Table 1 to Table 4 should be made to the Secretary of BSI Technical Committee CIL/55. Applications should state the following alloy particulars:

a) typical composition;

b) temperature coefficient of resistance and its temperature range;

c) resistivity;

together with a recommendation as to the class in which it should be placed. The allocation of a code will then be considered by the Technical Committee. If allocated, the new code and associated data will be included in any revision of this standard.

Table 1 — Class A

Alloy code	Typical composition %							Typical resistivity at 20 °C	Typical temperature coefficient of resistance	
	Ni	Cr	Al	Cu	Si	Mn	Fe	μΩ·cm	10^{-6}/K	Temperature range °C
Ni74Cr20Al3.5	74	20	3.5	—	+	—	—	133	0	20 to 150
Cu85Mn11Ni4	4	—	—	85	—	11	—	43	0	15 to 35
Cu86Mn10Ni4	4	—	—	86	—	10	—	38	0	40 to 60

NOTE 1 "+" indicates present at a level of up to, but not including, 2 %.
NOTE 2 These alloys have a low thermoelectromotive force against copper.
NOTE 3 See Table 9 for tolerances on the temperature coefficient of resistance.

Table 2 — Class B

Alloy code	Typical composition %							Typical resistivity at 20 °C	Typical temperature coefficient of resistance	
	Ni	Cr	Al	Cu	Si	Mn	Fe	μΩ·cm	10^{-6}/K	Temperature range °C
Cu55Ni44	44	—	—	55	—	+	—	49	25	20 to 100
Cu87Mn10Al2	—	—	2	87	—	10	—	41	– 40	20 to 200

NOTE 1 "+" indicates present at a level of up to, but not including, 2 %.
NOTE 2 See Table 9 for tolerances on the temperature coefficient of resistance.

Table 3 — Class C

Alloy code	Typical composition %							Typical resistivity at 20 °C	Typical temperature coefficient of resistance	
	Ni	Cr	Al	Mn	Si	Fe	Other	μΩ·cm	10^{-6}/K	Temperature range °C
Fe69Cr25Al5.5	—	25	5.5	—	—	69	—	144	35	20 to 1 000
Fe70Cr25Al5	—	25	5	—	—	70	—	139	60	20 to 1 000
Fe75Cr20Al5	—	20	5	—	—	75	—	137	70	20 to 1 000
Fe72Cr22Al5	—	22	5	—	—	72	—	135	40	20 to 1 000
Fe78Cr16Al5:Y	—	16	5	—	—	78	Y +	134	100	20 to 1 000
Fe80Cr15Al4	—	15	4	—	—	80	—	127	110	20 to 1 000
Ni74Cr20Al3Fe3	74	20	3	+	+	3	—	124	20	20 to 1 000
Ni69Cr30	69	30	—	—	+	—	—	118	90	20 to 500
Ni79Cr20	79	20	—	—	+	—	—	108	13	20 to 1 000
Ni77Cr20:Cb	77	20	—	—	+	+	Cb +	108	13	20 to 1 000
Ni84Cr14	84	14	—	—	+	—	—	100	90	20 to 100
Ni90Cr10	90	10	—	—	+	—	—	71	300	20 to 100
Ni60Fe23Cr15	60	15	—	+	+	23	—	112	107	20 to 1 000
Ni60Fe22Cr16	60	16	—	+	+	22	—	112	107	20 to 1 000
Ni50Fe30Cr18	50	18	—	+	+	30	—	111	170	20 to 1 000
Fe40Ni37Cr20Si2	37	20	—	+	2	40	—	105	240	20 to 1 000
Fe42Ni37Crl8Si2	37	18	—	+	2	42	—	106	240	20 to 1 000
Fe38Ni37Cr21Si2:Cb	37	21	—	+	2	38	Cb +	105	380	20 to 500
Fe47Ni30Cr20Si2	30	20	—	+	2	47	—	104	250	20 to 1 000
Fe42Ni35Cr20Si2	35	20	—	+	2	42	—	102	230	20 to 1 000
Fe42Ni35Cr20	35	20	—	+	+	42	—	102	230	20 to 1 000
Ni77Cr15Fe7	77	15	—	+	+	7	—	100	120	20 to 500
Fe53Cr25Ni20	20	25	—	+	+	53	—	95	330	20 to 1 000
Fe72Ni18Cr8	18	8	—	+	+	72	—	73	940	20 to 500

NOTE 1 "+" indicates present at a level of up to, but not including, 2 %.
NOTE 2 For the purpose of convenience, similar alloy types have been grouped together.
NOTE 3 See Table 9 for tolerances on the temperature coefficient of resistance.

Table 4 — Class D

Alloy code	Typical composition %							Typical resistivity at 20 °C	Typical temperature coefficient of resistance	
	Ni	Cr	Al	Mn	Si	Fe	Cu	μΩ·cm	10^{-6}/K	Temperature range °C
Cu53Ni43Mn2Fe2	43	—	—	2	—	2	53	52	100	20 to 100
Cu55Ni44	44	—	—	+	—	—	55	49	60	20 to 100
Cu70Ni30	30	—	—	—	—	—	70	38	150	20 to 150
Cu76Ni23	23	—	—	+	—	—	76	30	200	20 to 150
Cu80Ni20	20	—	—	—	—	—	80	28	230	20 to 150
Cu89Ni11	11	—	—	—	—	—	89	15	450	20 to 150
Cu95Ni3Mn2	3	—	—	2	—	—	95	12	1 500	20 to 100
Cu94Ni6	6	—	—	—	—	—	94	10	700	20 to 150
Cu98Ni2	2	—	—	—	—	—	98	5	1 300	20 to 150
Ni95Si4	95	—	—	—	4	—	—	36	680	20 to 100
Ni95:AlMnSi	95	—	+	+	+	—	—	29	1 900	20 to 100
Ni72Fe28	72	—	—	—	—	28	—	20	4 500	20 to 100
Ni95Mn5	95	—	—	5	—	—	—	18	3 600	20 to 100
Ni98Mn2	98	—	—	2	—	—	—	12	4 500	20 to 100
Ni99.2	99.2	—	—	—	—	—	—	9	5 000	20 to 100
Ni99.6	99.6	—	—	—	—	—	—	8	5 600	20 to 100

NOTE 1 "+" indicates present at a level of up to, but not including, 2 %.
NOTE 2 For the purpose of convenience, similar alloy types have been grouped together.
NOTE 3 See Table 9 for tolerances on the temperature coefficient of resistance.

2.2 Condition code

Electrical resistance material shall be coded as given in Table 5 according to the condition in which it is to be supplied [see **1.4.1** a)].

The code shall comprise the following elements in the order given:

a) a single surface condition;

b) an annealing or a tempered condition;

c) heat-treated condition, if appropriate (see Annex A).

Examples. The code for bright, annealed and quenched material which has subsequently been heat-treated is BQC.

The code for bright material reduced in cross-sectional area by 20 % after the final anneal to produce a tempered condition is B20H.

NOTE Guidance on the material conditions listed in Table 5 is given in Annex A.

2.3 Grade of wire

Wire shall be graded, depending upon its intended application, as follows:

a) *grade 1.* For special applications where close tolerances on resistance and uniformity of resistance are critical;

b) *grade 2.* For general applications.

NOTE See Table 6 and Table 8 for limiting values of tolerances and variation of actual resistance for grades 1 and 2.

Table 5 — Condition code

Condition		Code
Surface condition	Bright Oxidized Light oxide	B O LO
Annealing condition	Annealed and quenched Annealed and slowly cooled Temper annealed	Q S T
Tempered condition (by cold work)	Percentage reduction in cross-sectional area from annealed size to final size	*X*H where *X* is the nominal percentage reduction in cross-section
Heated-treated condition	Low temperature heat-treated	C

Section 3. Resistivity and resistance

NOTE Limits of uncertainty for resistivity and resistance and guidance on frequency of testing are given in Annex B.

3.1 Nominal and actual resistivity

The actual resistivity of the material, as supplied, when determined in accordance with BS 5714 shall not vary by more than ± 5 % from the declared nominal resistivity [see **1.4.3** a)].

3.2 Nominal resistance

3.2.1 General

The nominal resistance per metre at 20 °C [see **1.4.3** b)] shall be calculated in accordance with **3.2.2** with the following modifications, where appropriate:

a) for wire, strip and tape which do not have a simple cross-section, or where determination of the cross-sectional area has an uncertainty greater than 0.50 %, first determine the cross-sectional area A_{20} by density in accordance with **3.2.3**;

b) for tape and round-edged strip, make a reduction in cross-sectional area ($W_{20} \times T_{20}$) to take account of the reduction of area due to the rounded edge and the variation of thickness across the width (see note to **5.2**).

3.2.2 Calculation of nominal resistance

The nominal resistance per metre at 20 °C shall be calculated from the following formulae, as appropriate:

a) *General*[1)]

$$r_{20} = \frac{R_{20}}{100 \times A_{20}}$$

b) *Strip, round-edged strip and tape*[2)]

$$r_{20} = \frac{R_{20}}{100 \times W_{20} \times T_{20}}$$

c) *Wire*

$$r_{20} = \frac{R_{20}}{78.5398 \times D_{20}}$$

where

A_{20} is the nominal cross-sectional area of the wire or strip at 20 °C (in mm^2);

r_{20} is the nominal resistance per metre at 20 °C (in Ω);

R_{20} is the nominal resistivity at 20 °C (in μΩ·cm);

D_{20} is the nominal diameter of the wire at 20 °C (in mm);

W_{20} is the nominal width of the strip or tape at 20 °C (in mm);

T_{20} is the nominal thickness of the strip or tape at 20 °C (in mm).

3.2.3 Determination of cross-section by density

A suitable length of wire, strip or tape shall be weighed and the cross-sectional area A_{20} calculated from the following formula:

$$A_{20} = \frac{1000 \times m_{20}}{l_{20} \times P_{20}}$$

where

A_{20} is the cross-sectional area at 20 °C (in mm^2);

m_{20} is the mass at 20 °C (in g);

l_{20} is the total length at 20 °C (in mm);

P_{20} is the density of the test specimen at 20 °C (in g/cm^3).

3.3 Actual resistance

The actual resistance, in ohms per metre at 20 °C, determined in accordance with BS 5714, shall be determined for each reel, coil or drum. The actual resistance shall not vary from the calculated nominal value at 20 °C declared by the supplier [see **1.4.3** b) and **3.2**] for the class, grade and condition of material ordered [see **1.4.1** b)] by more than the following:

a) the tolerance specified in Table 6 and Table 7; or

b) any other tolerances stated at the time of enquiry or order [see **1.4.1** c)].

NOTE 1 It has not been found practical to specify tolerances on resistance for sheet (i.e. materials in widths greater than 152 mm). Better control is obtained by specifying tolerances on sheet width and thickness (see section 5).
NOTE 2 For grading of wire see **2.3**.

[1)] This equation is applicable to the wire, strip and tape covered under item a) of **3.2.1**.
[2)] For round-edged strip and tape, the modification given in item b) of **3.2.1** is applicable.

Table 6 — Tolerances on resistance of wire

Diameter of wire mm	Tolerance on resistance %	
	Grade 1	Grade 2
0.015 up to but excluding 0.05	± 8	± 10
0.05 up to but excluding 0.12	± 6	± 8
0.12 and upwards	± 3	± 5

Table 7 — Tolerance on resistance of tape and strip

Width of tape or strip mm	Tolerance on resistance %
0.3 up to and including 152	± 5

3.4 Uniformity of resistance

The actual resistance at 20 °C of any two equal portions of wire, strip, round-edged strip or tape, each between 300 mm and 1 500 mm long, taken from one unbroken length, shall be used to calculate the percentage difference of the actual resistance between the portions according to the following:

$$P_{20} = \frac{(r_2 - r_1) \times 100}{r_n}$$

where

P_{20} is the percentage difference of actual resistance, at 20 °C, of the two portions;

r_1 is the actual resistance, at 20 °C, of the first portion (in Ω);

r_2 is the actual resistance, at 20 °C, of the second and any subsequent portions of equal length (in Ω);

r_n is the nominal resistance at 20 °C of an identical length to these portions, calculated from the nominal resistivity and nominal cross-sectional area of the material (in Ω).

The calculated percentage difference (P_{20}) between the first and subsequent portions or the variations of these percentage differences of resistance from one another, shall not be greater than:

a) the values shown in Table 8 for wire;

b) 5 % for strip, round-edged strip and tape.

Table 8 — Uniformity of resistance of wire

Diameter of wire mm	Tolerance on resistance %	
	Grade 1	Grade 2
0.015 up to but excluding 0.0050	9	10
0.050 up to but excluding 0.120	7	8
0.120 and upwards	4	5

Section 4. Temperature coefficient of resistance

NOTE Uncertainties associated with measurements of the temperature coefficient of resistance are listed in Annex B.

4.1 General

The nominal temperature coefficient of resistance [see **1.4.3** c)] shall be determined in accordance with **4.3**.

4.2 Tolerances

The actual temperature coefficient of resistance, when tested in accordance with **4.3**, shall not vary from the declared nominal value [see **1.4.3** c)] for the class and grade of material ordered by more than the tolerances given in Table 9.

4.3 Methods for temperature coefficient of resistance

4.3.1 Classes A and B materials

The temperature coefficient of resistance for classes A and B materials shall be determined, on the as-despatched material, by the methods described in BS 3467.

4.3.2 Classes C and D materials

The temperature coefficient of resistance for classes C and D materials shall be determined on either:

a) a test sample which has been annealed and slowly cooled to 20 °C; or

b) if agreed between the purchaser and supplier [see **1.4.2** b)], for temperatures in the range 20 °C to 200 °C, material in the as-despatched condition.

The temperature coefficient of resistance shall be determined by one of the following methods as appropriate:

1) for temperature ranges from 20 °C to 200 °C, by the methods described in BS 3467;

2) for temperature ranges from 20 °C to greater than 200 °C, by the method described in ASTM B70.

NOTE Where necessary, the sample may be protected from excessive oxidation during the heating period by a suitable protective atmosphere.

Table 9 — Tolerances on temperature coefficient of resistance

Class	Alloy code	Tolerance	Temperature range °C
A	Ni74Cr20Al3.5	$\pm 10 \times 10^{-6}$/K	20 to 150
	Cu85Mn11Ni4	$\pm 15 \times 10^{-6}$/K	15 to 35
	Cu86Mn10Ni4	$\pm 15 \times 10^{-6}$/K	40 to 60
B	Cu55Ni44	$\pm 20 \times 10^{-6}$/K	20 to 100
	Cu87Mn10Al2	$\pm 20 \times 10^{-6}$/K	20 to 200
C and D	All alloy codes	$\pm 60 \times 10^{-6}$/K or ± 10 % whichever is the greatest	Ranges from 20 to 200
		$\pm 100 \times 10^{-6}$/K or ± 20 % whichever is the greatest	Ranges from 20 to over 200 to 600
		$\pm 80 \times 10^{-6}$/K or ± 10 % whichever is the greatest	Ranges from 20 to over 600 to 1 000

Section 5. Dimensions

NOTE Information on sizes of wire, strip and tape in general use is given in Annex C. Annex D gives conversion factors from metric to imperial units.

5.1 Out-of-roundness of wires

For each reel, coil or drum, the out-of-roundness of the wire, measured as the maximum difference in diameter as the wire is rotated 180°, shall not exceed 0.003 mm or 2.5 % of the nominal diameter, whichever is the greater.

5.2 Tolerances on tape, strip and sheet

For each reel, coil or drum, the width tolerances for tape and strip from 0.3 mm up to and including 152 mm wide, shall be as given in Table 10. For each sheet the width and thickness tolerances shall be as given in Table 11 and Table 12.

NOTE No dimensional tolerances are applicable to wire and no thickness tolerances to tape and strip. Tape and some sizes of strip with round edges are rolled from wire and usually have a thickness variation across the width.

Table 10 — Tolerances on width for tape and strip

Dimensions in millimetres

Width	Width tolerance
0.3 up to and including 5	± 0.05
Over 5 up to and including 10	± 0.10
Over 10 up to and including 30	± 0.15
Over 30 up to and including 152	± 0.20

Table 11 — Tolerances on sheet width

Dimensions in millimetres

Thickness	Width tolerance	
	Over 152 up to and including 450	Over 450 up to and including 610
0.25 up to and including 0.50	± 0.25	± 0.80
Over 0.50 up to and including 1.60	± 0.40	± 0.80
Over 1.60 up to and including 2.50	± 0.80	± 1.60

Table 12 — Tolerances on sheet thickness

Dimensions in millimetres

Thickness	Thickness tolerance	
	Over 152 up to and including 450 in width	Over 450 up to and including 610 in width
0.25 up to and including 0.65	± 0.025	± 0.038
Over 0.65 up to and including 1.00	± 0.033	± 0.050
Over 1.00 up to and including 1.50	± 0.038	± 0.058
Over 1.50 up to and including 2.50	± 0.064	± 0.064

Section 6. Physical, mechanical and other requirements

6.1 Condition as-delivered

Unless otherwise agreed at the time of placing the enquiry or order [see **1.4.1** a)], wire, strip, tape or sheet shall be supplied bright, annealed and quenched, except for alloy Ni74Cr20Al3.5 of class A which shall be supplied bright, annealed and quenched and low temperature heat-treated (condition code BQC).

6.2 Thermoelectromotive force

For materials of classes A and B, the nominal thermoelectromotive force, in volts per Kelvin between 0 °C and 100 °C, and the polarity of the material against copper, shall be determined by the methods given in ASTM B77.

6.3 Defects

6.3.1 General defects

The material shall be uniform and free from defects such as kinks, snarls, shivs, splits, laminations, scale, contamination and other irregularities.

6.3.2 Bright and oxidized material

Bright material shall be uniformly bright and free from discolouration or oxides. Oxidized material shall be uniformly oxidized with an adherent film of oxide.

6.4 Spiralling test for class C wire

6.4.1 General

Class C wire of diameter 0.20 mm to 2.00 mm shall, when tested in accordance with **6.4.2**, produce a spiral of uniform spacing between the turns. In addition, for wire of oxidized or light oxide surface conditions (O or LO), the oxide film shall not flake to such an extent that its insulation properties are reduced to the point where electrical breakdown of the oxide film occurs.

NOTE It is unlikely that oxidized wire that flakes substantially would fulfil this requirement.

6.4.2 Test

Wind the wire cold in a closed coil around a mandrel of the appropriate diameter given in Table 13 for at least the number of turns given in Table 13. Remove the coil from the mandrel and stretch to three times its original length and then allow the spiral so produced to relax. Check whether or not the spacing between turns is uniform and the condition of the oxidized film, if applicable.

Table 13 — Diameter of mandrel and number of turns

Dimensions in millimetres

Wire diameter	Mandrel diameter	Minimum number of turns
0.2 up to and including 0.4	2.0	100
Over 0.4 up to and including 0.8	4.0	70
Over 0.8 up to and including 1.6	8.0	50
Over 1.6 up to and including 2.0	16.0	40

6.5 Bend test for wire, strip and tape

When clamped squarely in the jaws of a vice, the edges of which are rounded off to the radius as given in Table 14, the wire, strip or tape, except that of condition code *X*H or T (see **2.2**), shall be capable of being bent close to the radii of the jaws through a preliminary bend of 90°, and subsequently bent through an angle of 180° four times, alternately backwards and forwards, without cracking or breaking.

Table 14 — Jaw radii for bend test

Dimensions in millimetres

Diameter or thickness of wire, strip or tape	Radii of jaws
0.2 up to and including 0.5	0.5
Over 0.5 up to and including 1.0	1.0
Over 1.0 up to and including 2.0	2.0
Over 2.0 up to and including 3.0	3.0
Over 3.0 up to and including 3.25	3.25

6.6 Straightness of strip and tape

For strip or tape whose widths are less than or equal to 13 mm, the deviation of a side edge from a straight line, measured as a chord height, shall not exceed 6 mm in a 1 m length. For strip of width greater than 13 mm, the chord height shall not exceed 4 mm in 1 m length.

6.7 Other physical requirements

When agreed between the supplier and purchaser [see **1.4.2** c)] other physical properties of the material shall be determined by one or more of the following tests:

a) ultimate tensile strength in accordance with BS EN 10002-1;

b) proof stress in accordance with BS EN 10002-1;

c) elongation in accordance with BS EN 10002-1;

d) Vickers hardness in accordance with BS 427;

e) springback in accordance with ASTM F113;

f) grain size in accordance with ASTM E112.

Section 7. Product marking and documentation

NOTE Annex E gives guidance on health and safety matters relating to the materials covered by this standard.

7.1 Label and information

Each reel or drum shall be identified by using an adhesive label. This shall be firmly fixed on the flange of the reel or on the side of the drum. For coils, a label shall be firmly tied or bound on the coil. The label shall contain the following information:

a) supplier's name;

b) the number of this British Standard, i.e. BS 115[3)];

c) class and grade;

d) alloy code;

e) condition code;

f) nominal size;

g) actual resistance per metre at 20 °C (where applicable);

h) melt or heat number;

i) nett weight;

j) date of inspection;

k) inspector's initials or stamp.

NOTE The alloy description may be written as BS 115:class and grade:alloy code:condition code, e.g. BS 115:C2:Ni79Cr20:BQ.

7.2 Certificates of conformity

7.2.1 General

When issued, certificates of conformity shall contain the following information:

a) supplier's name and address;

b) customer's name and address;

c) certificate number;

d) customer's order number;

e) supplier's order number;

f) date of issue;

g) specification BS 115:1995[3)];

h) class and grade;

i) alloy code;

j) condition code;

k) nominal size;

l) melt or heat number(s);

m) nett weight of the delivery;

n) any other information agreed between supplier and purchaser [see **1.4.2** d)].

Each certificate shall be signed and stamped by an authorized signatory on behalf of the supplier and shall include the information given in **7.2.2** or **7.2.3**, as appropriate.

7.2.2 Conformity

The certificate shall state that the supplies detailed have been inspected and conform in all respects to the specification and contract/order.

7.2.3 Concessions

The certificate shall state that the supplies detailed have been inspected and conform in all respects, except for the concessions detailed, to the specification and contract or order. Details of the concessions shall be given.

[3)] Marking BS 115 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

Section 8. Packaging

NOTE 1 Wire in the size range 0.015 mm to 0.32 mm is normally supplied on reels. Wire in the size range 0.32 mm to 2.0 mm may be supplied on reels or in drums.
Wire of approximately 0.9 mm and larger may also be supplied in coils of a suitable inside diameter.
Tape is normally supplied on reels.
Strip and sheet are normally supplied in coils of suitable dimensions with thinner material sometimes supported by a centre of wood or board.
NOTE 2 It is recommended that materials are packaged in accordance with appropriate packaging standards, e.g. BS 1489, BS 1133, BS 1596, BS 2565, BS 5561, BS 7584 and DIN 46399-2 [1].

8.1 Winding, tangling and ends

Wire and tape, when wound on to reels, shall be wound with a tight, flat, uniform lay with no gaps at the flanges such that the material will unwind freely and without snags. The ends of the material shall either be looped through a hole in the flange or looped securely around the wire or tape such that sharp ends of the material do not protrude. The wire or tape shall be protected from damage and contamination by suitable wrapping or boxes.

Wire, when supplied in drums, shall be capable of being removed without snags. The wire within the drums shall be held in situ such that during transit tangling does not occur.

Coils of wire, strip or sheet shall be firmly bound such that the material will not tangle and the sharp ends secured such that they do not protrude. They shall be wrapped in order that damage and contamination does not occur.

NOTE It is recommended that batches of reels or coils are packed in boxes and suitable packing inserted to prevent movement in transit. Additionally, boxes or drums should be strapped firmly to pallets to avoid damage in handling.

8.2 Lengths

Material supplied on coils or spools shall only be in single lengths without welds or joined in any way.

8.3 Filling of reels and drums

Reels or drums shall not be totally filled to the top of the flange or the top of the drum.

8.4 Removal of old identification

Old labels or other old identification marks shall be removed from reels and drums.

Annex A (informative) Material conditions

The material conditions listed in Table 5 have been obtained by either quenching the material from the annealing temperature, or by slowly cooling from the annealing temperature. Certain alloys have different electrical and physical properties due to different cooling rates.

Some of the alloys can additionally be given a low temperature heat-treatment which can alter the electrical and physical properties by a significant amount.

To obtain tempered material, the annealed items are cold worked by rolling strip, tape or sheet to the finished size by fixed percentage reductions in cross-sectional area. Similarly, cold work may be carried out on the annealed wire by drawing to a smaller diameter. Varying degrees of hardness may be obtained by different reductions in cross-sectional area. Cold working may alter the electrical and physical properties of the material. Temper annealing, at temperatures lower than the normal annealing temperature, may also be carried out on hard wire, strip and tape to obtain tempered material and this too may alter the electrical and physical properties.

It is not practical to temper oxidized material by temper annealing or by work hardening.

Material may be supplied with a surface condition which is bright or with an oxidized finish that may be lightly oxidized or with a substantial oxide coating.

Annex B (informative) Testing and limits of uncertainty

B.1 Testing

The actual resistance per metre (see **3.3**) and dimensional tolerances, where applicable, (see Section 5) are determined and checked for each reel, coil or drum as part of routine testing. The actual resistivity, temperature coefficient of resistance and all other mechanical and physical properties should be checked on a defined, planned percentage of the product.

B.2 Resistivity and resistance

Table B.1 lists the uncertainty of resistivity and resistance as detailed in BS 5714:1979 when determining these properties. It then summarizes the total error.

Table B.1 — Limits of uncertainty for resistivity and resistance

	Uncertainty %
Gauge length	± 0.10
Resistance	± 0.30
Cross-sectional area	± 0.50
Using known specimen density	
Mass in air	± 0.10
Specimen length	± 0.20
Specimen density	± 0.45
Total errors	
Volume resistivity	± 0.65
Resistance per unit length	± 0.40

NOTE These values indicate that if the gauge length and resistance are measured with the accuracies stipulated, then micrometers with a resolution of 0.002 mm (probable accuracy ± 0.004 mm) should not be used in resistivity determinations for dimensions below 1.6 mm. Similarly laser micrometers and comparators (using suitable slip gauges and anvils), with resolutions of 0.0003 mm and 0.0001 mm respectively (probable accuracies of ± 0.0006 mm and ± 0.0002 mm respectively) should not be used for this determination for sizes less than 0.24 mm for the laser type, and 0.08 mm for such comparators with suitable slip gauges. For dimensions below these sizes the mass/density method should be used.

B.3 Limits of uncertainty for dimensions

For the purposes of checking conformance to dimensional tolerances, micrometers having an uncertainty of ± 0.004 mm should not be used for measuring dimensions whose tolerances are below ± 0.020 mm.

B.4 Limits of uncertainty for out-of-roundness

Micrometers having an uncertainty of ± 0.004 mm should not be used for measuring out-of-roundness for diameters below 0.08 mm. Suitable measuring instruments, having an accuracy equal to or better than ± 0.0006 mm, may be used for the measurement of out-of-roundness for all sizes covered in this standard.

B.5 Temperature coefficient of resistance

Table B.2 lists the uncertainty of resistance and temperature using the method described in BS 3467. It then summarizes the total errors for class A and B materials.

Table B.3 lists the uncertainty of measurements using the methods described in ASTM B70.

Table B.4 lists the uncertainty of temperature coefficient of resistance for classes C and D materials using the methods described in BS 3467 and ASTM B70.

Table B.2 — Limits of uncertainty for temperature coefficient of resistance for classes A and B

		Uncertainty
Stirred liquid baths		
Temperature 0 °C to 40 °C		± 0.3 °C
Temperature 40 °C to 80 °C		± 0.4 °C
Temperature 80 °C to 200 °C		± 1.5 °C
Resistance		± 0.002 %
Total errors		
Temperature coefficient of resistance:		
Ni74Cr20Al3.5	20 °C to 150 °C	$\pm 0.6 \times 10^{-6}$/K
Cu85Mn11Ni4	15 °C to 35 °C	$\pm 2.4 \times 10^{-6}$/K
Cu86Mn10Ni4	40 °C to 60 °C	$\pm 2.4 \times 10^{-6}$/K
Cu55Ni44	20 °C to 100 °C	$\pm 0.9 \times 10^{-6}$/K
Cu87Mn10Al2	20 °C to 200 °C	$\pm 0.4 \times 10^{-6}$/K

Table B.3 — Limits of uncertainty of measurements when using the methods described in ASTM B70

	Uncertainty
Furnace	
Change in temperature	± 7 °C
Resistance measurements	± 0.2 %

Table B.4 — Limits of uncertainty of measurements for classes C and D

Temperature range °C	Uncertainty of temperature coefficient of resistance 10^{-6}/K						
	100	200	500	1 000	2 000	4 000	6 000
ASTM B70							
20 to 300	± 17	± 20	± 28	± 42	± 71	± 127	± 184
20 to 400	± 13	± 15	± 21	± 32	± 54	± 98	± 142
20 to 500	± 10	± 12	± 17	± 27	± 45	± 81	± 118
20 to 700	± 7	± 9	± 13	± 20	± 34	± 62	± 91
20 to 1 000	± 5	± 6	± 10	± 15	± 26	± 48	± 70
BS 3467							
20 to 100	± 2	± 5	± 12	± 23	± 42	± 88	± 133
20 to 200	± 1	± 2	± 5	± 10	± 19	± 38	± 57

Annex C (informative)
Sizes in general use

Table C.1 gives sizes in general use for wire and the thickness of strip and tape where applicable.

Table C.1 — Sizes in general use

Size mm	SWG	B & S	Size mm	SWG	B & S	Size mm	SWG	B & S	Size mm	SWG	B & S	Size mm	SWG	B & S
7.620	1	—	2.600	—	—	0.800	—	—	0.250	—	—	0.0700	—	—
7.341	—	1	2.591	—	10	0.750	—	—	0.234	34	—	0.0650	—	—
7.010	2	—	2.500	—	—	0.724	—	21	0.226	—	31	0.0632	—	42
7.000	—	—	2.400	—	—	0.711	22	—	0.255	—	—	0.0610	46	—
6.553	—	2	2.337	13	—	0.700	—	—	0.213	35	—	0.0600	—	—
6.401	3	—	2.311	—	11	0.650	—	—	0.203	—	32	0.0564	—	43
6.000	—	—	2.300	—	—	0.643	—	22	0.200	—	—	0.0560	—	—
5.893	4	—	2.200	—	—	0.610	23	—	0.193	36	—	0.0550	—	—
5.817	—	3	2.100	—	—	0.600	—	—	0.180	—	33	0.0508	47	—
5.500	—	—	2.057	—	12	0.574	—	23	0.173	37	—	0.0503	—	44
5.385	5	—	2.032	14	—	0.559	24	—	0.160	—	34	0.0500	—	—
5.182	—	4	2.000	—	—	0.550	—	—	0.152	38	—	0.0457	—	—
5.000	—	—	1.900	—	—	0.511	—	24	0.150	—	—	0.0450	—	—
4.877	6	—	1.829	15	13	0.508	25	—	0.142	—	35	0.0447	—	45
4.750	—	—	1.800	—	—	0.500	—	—	0.140	—	—	0.0406	48	46
4.623	—	5	1.700	—	—	0.457	26	—	0.132	39	—	0.0400	—	—
4.500	—	—	1.626	16	14	0.455	—	25	0.130	—	—	0.0356	—	47
4.470	7	—	1.600	—	—	0.450	—	—	0.127	—	36	0.0350	—	—
4.115	—	6	1.500	—	—	0.417	27	—	0.122	40	—	0.0325	—	—
4.064	8	—	1.448	—	15	0.404	—	26	0.120	—	—	0.0315	—	48
4.000	—	—	1.422	17	—	0.400	—	—	0.114	—	37	0.0305	49	—
3.750	—	—	1.400	—	—	0.376	28	—	0.112	41	—	0.0300	—	—
3.658	9	7	1.300	—	—	0.361	—	27	0.110	—	—	0.0280	—	—
3.500	—	—	1.295	—	16	0.350	—	—	0.102	42	38	0.0275	—	—
3.251	10	8	1.219	18	—	0.345	29	—	0.100	—	—	0.0259	—	49
3.250	—	—	1.200	—	—	0.320	—	28	0.0914	43	—	0.0254	50	—
3.000	—	—	1.143	—	17	0.315	30	—	0.0900	—	—	0.0251	—	50
2.946	11	—	1.100	—	—	0.300	—	—	0.0889	—	39	0.0250	—	—
2.900	—	—	1.016	19	18	0.295	31	—	0.0813	44	—	0.0225	—	—
2.896	—	9	1.000	—	—	0.287	—	29	0.0800	—	—	0.0200	—	—
2.800	—	—	0.914	20	19	0.275	—	—	0.0787	—	40	0.0175	—	—
2.700	—	—	0.900	—	—	0.274	32	—	0.0750	—	—	0.0150	—	—
2.642	12	—	0.813	21	20	0.254	33	30	0.0711	45	41	—	—	—

NOTE "SWG" is Standard Wire Gauge (a common British wire gauge system).
"B & S" is an American wire gauge system.

Annex D (informative) Conversion factors

Table D.1 lists a number of conversion factors which may be useful in the application of this standard.

Table D.1 — Conversion factors

To convert	To	Multiply by
millimetres	inches	0.03937
metres	inches	39.37008
metres	feet	3.28084
ohms per metre	ohms per foot	0.30480
ohms per metre	ohms per yard	0.91440
microhm — centimetres	ohms per circular mil foot	6.015306
microhm — centimetres	ohms per square mil foot	4.724409
density g/cm^3	lb/in^3	0.0361273
kilograms	pounds	2.20462
10^{-6}/K	10^{-6}/°F	0.555556

NOTE For other conversion factors consult BS 350.

Annex E (informative) Guidance on health and safety

NOTE Attention is drawn to section 6 of the Health and Safety at Work etc. Act 1974 [2].

E.1 Hazards

Electrical resistance materials can present the following physical hazards.

a) *Strip.* Can have sharp edges and corners.

b) *Wire.* Can have sharp edges.

E.2 Exposure limits

The electrical resistance materials listed in Table 1 to Table 4 are not considered hazardous in the form in which they are supplied. However grinding, melting, welding, cutting or any other similar processes may generate hazardous levels of dust or fumes. Table E.1 lists the exposure limits for elements contained in these materials.

Table E.1 — Exposure limits of elements

Element	Permissible exposure limit mg/m^3	Operator exposure limit mg/m^3
Nickel	1.0	1.0
Chromium	1.0	0.5
Iron	10.0	5.0
Manganese	5.0 (dust)	5.0 (dust)
Copper	1.0 (fume)	1.0 (fume)

E.3 Effects of elements as dust or fume

E.3.1 *Nickel*

Fumes are respiratory irritants and may cause respiratory disease. Skin contact can also cause an allergic skin rash. Nickel and its compounds have been reported to cause cancer of the lungs and sinuses.

E.3.2 *Chromium*

Chromium alloys have been associated with lung changes, such as in workers exposed to these alloys.

E.3.3 *Iron*

Repeated exposure to iron oxide fume over a period of years may cause changes of the lungs as seen by X-rays over this period but does not seem to cause the exposed person to become ill.

E.3.4 *Manganese*

Inhalation of manganese fume may cause "Metal fume fever" with symptoms such as chills, fever, nausea, cough, dry throat, weakness, muscle aches or a metallic taste in the mouth. Prolonged or repeated exposure may affect the nervous system, causing difficulty in walking and balancing, weakness or cramps in the legs, hoarseness of the voice, trouble with memory or judgement, unstable emotions or unusual irritability. The respiratory system may also be affected by a pneumonia-like illness with symptoms such as coughing, fever, chills, body ache, chest pain and other common signs of pneumonia.

E.3.5 *Copper*

Fume or dust causes irritation of the eyes, nose and throat and a flu-like illness called "Metal fume fever". Symptoms include fever, muscle aches, nausea, dry throat, cough, weakness and a sweet or metallic taste in the mouth.

E.3.6 *Aluminium*

Metal dust and oxide may cause irritation of the eyes, nose and throat in high concentrations.

E.4 Suspected carcinogens

Chromium and nickel have been identified by the International Agency for Research on Cancer and/or The National Toxicology Program (USA) as potential cancer causing agents.

E.5 Exposure routes

Exposure to steels containing nickel and related alloys occurs primarily from inhalation of dust or fumes. However, constituents of these alloys may cause effects directly upon the skin or eyes.

E.6 Protection

E.6.1 *Ventilation*

If the process causes a release of dust or fumes then local and general exhaust ventilation should be used to keep airborne concentrations of dust or fumes below the operator exposure limit.

E.6.2 *Respiratory protection*

If the process causes release of dust or fumes in excess of the permissible exposure limit, then operators should use approved respirators for protection.

E.6.3 *Protective equipment*

It may be necessary to use gloves or barrier creams to prevent skin sensitization and dermatitis. If the process involves grinding and/or other actions that cause release of dust or fumes then approved safety glasses should be worn.

Suitable protection should be provided to avoid cuts when the material is handled.

Annex F (informative) Recommended tolerances for wire and strip supplied in cut and straightened lengths

F.1 General

For wire or strip supplied in cut and straightened lengths, the resistance per metre and other electrical properties and physical properties have to be agreed between the supplier and purchaser.

F.2 Length

Length tolerances for wire should be as given in Table F.1 and for strip as given in Table F.2.

Table F.1 — Tolerances for cut and straightened wire lengths

Dimensions in millimetres

Diameter	Length tolerance		
	Over 150 up to and including 1 000	Over 1 000 up to and including 2 000	Over 2 000 up to and including 3 500
Over 0.5 up to and including 1.6	± 1	—	—
Over 1.6 up to and including 2.5	± 1	± 2.0	± 2.5
Over 2.5 up to and including 7.6	± 2	± 2.5	± 3.0

Table F.2 — Tolerances for cut and straightened strip lengths

Dimensions in millimetres

Thickness	Length tolerance	
	Over 150 up to and including 1 200	Over 1 200 up to and including 3 500
Over 0.05 up to and including 1.6	± 2	± 3
Over 1.6 up to and including 3.2	± 3	± 3
Over 3.2 up to and including 4.0	± 5	± 7

F.3 Straightness

The deviation of one edge of the wire or strip from a straight line, when laid flat and measured as the chord height, should be as follows:

a) for wire: a maximum of 5 mm in a length of 1 m;

b) for strip up to and including 13 mm wide: a maximum of 5 mm in a length of 1 m;

c) for strip over 13 mm wide: a maximum of 3 mm in a length of 1 m.

F.4 Flatness of cut and straightened strip

NOTE The flatness of cut and straightened lengths of strip is measured as a chord height for a length of 100 mm.

The maximum chord height should be as determined by the following:

$$C = \frac{0.4}{t}$$

where

C is the maximum chord height for a length of strip of 100 mm (in mm);

t is the thickness of the strip (in mm).

At the cropped ends the cut should be square and free from burr.

blank

List of references (see clause 2)

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 427:1990, *Method for Vickers hardness test and for verification of Vickers hardness testing machines.*
BS 3467:1962, *Method of test for temperature coefficient of resistance of alloy wire for precision resistors.*
BS 3504:1962, *Specification for magnesium-activated nickel for cathodes of electronic tubes and valves.*
BS 5714:1979, *Method of measurement of resistivity of metallic materials.*
BS EN 10002, *Tensile testing of metallic materials.*
BS EN 10002-1:1990, *Method of test at ambient temperature.*

ASTM publications

AMERICAN SOCIETY FOR TESTING AND MATERIALS, USA (All publications are available from Customer Services, BSI)

ASTM B70:1990, *Method for change of resistance with temperature of metallic materials for electrical heating.*
ASTM B77:1981, *Method for thermoelectric power of electrical-resistance alloys.*
ASTM F112:1980, *Methods for determining average grain size.*
ASTM F113:1982, *Method for stiffness testing of wire for electron devices and lamps.*

Informative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 350, *Conversion factors and tables.*
BS 350-1:1974, *Basis of tables. Conversion factors.*
BS 1117, *Specification for bare fine resistance wire for precision electrical equipment.*
BS 1117-1:1964, *Inch units.*
BS 1117-2:1964, *Metric units.*
BS 1133, *Packaging code.*
BS 1133-22:1989, *Packaging in plastics containers.*
BS 1489:1972, *Specification for the packaging of covered winding wires for electrical purposes.*
BS 1596:1992, *Specification for fibreboard drums.*
BS 2565:1972, *Specification for drums for covered winding wires and strips for electrical purposes.*
BS 3073:1977, *Specification for nickel and nickel alloys: strip.*
BS 3075:1976, *Specification for nickel and nickel alloys: wire.*
BS 5561:1979, *Specification for spools for copper wire.*
BS 7584, *Packaging of winding wires.*
BS EN ISO 9000, *Quality management and quality assurance standards.*

Other references

[1] DIN 46399-2:1986, *Delivery spools for bare and insulated wires; technical terms of delivery for spools of plastic.*
[2] GREAT BRITAIN. Health and Safety at Work etc. Act 1974. London: HMSO.

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