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Resistance alloys

DIN 17 471

Widerstandslegierungen; Eigenschaften

Supersedes January 1966 edition.

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

1 Scope and field of application

This standard specifies technical delivery conditions for copper and nickel resistance alloys which, due to their electrical resistance and temperature characteristics, are suitable for the manufacture of resistors of all kinds as well as heating conductors.

This standard does not cover materials for resistance thermometers (cf. DIN 43 760), thermocouples (cf. DIN 43 710) or compensating cables (cf. DIN 43 713).

2 Designation

The standard designation shall include the name of the material (alloy), the DIN number (DIN 17 471), and the material designation or number (cf. table 1).

Example:

Designation of a resistance alloy complying with this standard, made of a material identified by material designation CuNi2 (material number 2.0802):

Alloy DIN 17 471 – CuNi2

or Alloy DIN 17 471 – 2.0802

3 Order details

The material, the product form and the as delivered condition shall be specified by the purchaser at the time of ordering. The manufacturing process shall be at the manufacturer's discretion.

The intended use and any subsequent treatment of the material may be specified at the time of ordering.

The material designations or numbers specified in table 1 shall be used for ordering purposes.

4 Chemical composition

Table 1 only specifies mean values of the content of elements, since the resistivity is the most relevant parameter of the alloys covered here.

5 Properties

5.1 Physical properties

Values of the resistivity and the coefficient of linear thermal expansion are given in table 2 for materials in the softened condition. Note that the resistivity values at a temperature of 100 °C and higher are guideline values only. Table 3 gives guideline values for other physical properties.

5.2 Mechanical properties

Table 4 specifies mechanical properties of alloys in the softened condition, at 20 °C. The three nickel alloys covered here are normally supplied as continuously annealed wire, in diameters of less than 1 mm. It should be noted that their tensile strength is much higher than the values specified.

5.3 Corrosion resistance

Information on the corrosion resistance of resistance alloy elements is given in table 5.

5.4 Service temperature

Table 6 specifies guideline values for maximum service temperature.

5.5 Jointing methods

Due to the variety of applications and materials, no general requirements can be specified for joints or jointing methods.

6 Product forms and as delivered condition

Unless otherwise specified, resistance alloys shall be supplied in the softened condition, in the form of strip or of bare or covered round or flat wire.

The condition in which the products are to be delivered (e.g. on spools in compliance with DIN 46 399 Part 2 or coiled) shall be specified at the time of ordering.

7 Testing

7.1 Tensile strength

Tensile testing shall be carried out as described in DIN 50 114, DIN 50 145 or DIN 51 210 Parts 1 and 2.

7.2 Resistivity

Resistivity testing shall normally be carried out at the manufacturer's works, using a routine method. In cases of dispute, the reference method described in IEC 468 shall be used, unless otherwise specified.

Continued on pages 2 to 6

Table 1. **Chemical composition, properties and applications**

Material designation	Material number	Al	Cr	Cu	Fe	Mn	Ni	Si	Information 1) regarding properties	Information 1) regarding usage
		Chemical composition (mean values, as a percentage by mass)								
CuNi2	**2.0802**	–	–	*)	–	–	2	–	Very low resistivity, solderable.	Terminals, low-resistive resistors, heating wires and cables with a low heating conductor temperature.
CuNi6	**2.0807**	–	–	*)	–	–	6	–	Low resistivity, solderable.	
CuMn3	**2.1356**	–	–	*)	–	3	–	–	Very low resistivity and relatively low coefficient of linear thermal expansion, solderable.	Low-resistive resistors subject to low loading.
CuNi10	**2.0811**	–	–	*)	–	–	10	–	Low resistivity, resistant to corrosion and scaling, solderable.	As for CuNi2 and CuNi6.
CuNi23Mn	**2.0881**	–	–	*)	–	1,5	23	–	Resistant to corrosion and scaling, solderable.	Electrical resistors, heating wires and cables.
CuNi30Mn	**2.0890**	–	–	*)	–	3	30	–	Highly resistant to corrosion and scaling, solderable.	Electrical resistors, starters and indicating pins.
CuMn12Ni	**2.1362**	–	–	*)	–	12	2	–	Particularly low coefficient of linear thermal expansion, low thermovoltage when used with copper, resistivity very stable over time, solderable.	Precision, measurement, standard and series resistors.
CuNi44	**2.0842**	–	–	*)	–	1	44	–	Low coefficient of linear thermal expansion, highly resistant to scaling, high thermovoltage when used with copper, solderable.	Electrical resistors of all kinds, measuring resistors, heating wires and cables.
CuMn12NiAl	**2.1365**	1,2	–	*)	–	12	5	–	Low coefficient of linear thermal expansion, solderable.	Electrical resistors.
NiCr8020 2)	**2.4869** 2)	–	20	–	–	–	*)	–	High resistivity, highly resistant to corrosion and scaling, not ferromagnetic.	High-resistive resistors, heating conductors (cf. DIN 17 470).
NiCr6015 2)	**2.4867** 2)	–	15	–	20	–	*)	–	As for NiCr8020, but higher coefficient of linear thermal expansion.	
NiCr20AlSi 2)	**2.4872** 2)	3,5	20	–	0,5	0,5	*)	1	High resistivity, particularly low coefficient of linear thermal expansion where required, low thermovoltage when used with copper, very strong, not ferromagnetic.	Particularly good for high-resistive measuring and precision resistors.

1) The information given is intended for guidance purposes only and may not be complete.
2) Cf. DIN 17 742.
*) Remainder.

Table 2. **Electrical resistance**

Material designation	Coefficient of linear thermal expansion, between 20 and 105 °C, in 10^{-6}/K	Guideline values of resistivity, in Ω mm²/m, at a temperature of: 20 °C Nominal value	20 °C Limit dev., in %	100 °C	200 °C	300 °C	400 °C	500 °C
CuNi2	+ 1000 to + 1600	0,05	±10	0,057	0,064	–	–	–
CuNi6	+ 500 to + 900	0,10	±10	0,107	0,114	0,123	–	–
CuMn3	+ 280 to + 380	0,125	±10	0,129	0,133	–	–	–
CuNi10	+ 350 to + 450	0,15	±10	0,156	0,162	0,169	0,175	–
CuNi23Mn	+ 220 to + 280	0,30	± 5	0,308	0,315	0,323	0,331	0,339
CuNi30Mn	+ 80 to + 130	0,40	± 5	0,404	0,410	0,417	0,424	0,432
CuMn12Ni	− 10 to + 10 [1)]	0,43	± 5	0,43	–	–	–	–
CuNi44	− 80 to + 40	0,49	± 5	0,49	0,49	0,49	0,49	0,49
CuMn12NiAl	− 50 to + 50	0,50	± 5	0,50	0,50	0,50	0,50	0,50
NiCr8020 [2)]	+ 50 to + 150	1,08	± 5	1,09	1,10	1,12	1,14	1,16
NiCr6015 [2)]	+ 100 to + 200	1,11	± 5	1,12	1,14	1,16	1,18	1,22
NiCr20AlSi	− 50 to + 50 [3)]	1,32	± 5	1,32	1,32	–	–	–

1) For this material, the coefficient only applies to temperatures between 20 and 50 °C. The resistivity/temperature curve is parabolic, with a maximum between +20 and +40 °C.

2) The values apply to the condition as obtained by rapid cooling.

3) Subject to agreement, where the material is intended to be used for precision resistors, the coefficient may be designed to be between $-10 \cdot 10^{-6}$/K and $+10 \cdot 10^{-6}$/K.

Table 3. **Physical properties** (guideline values)

Material designation	Density at 20 °C, in g/cm³	Melting temperature, in °C	Specific heat capacity at 20 °C, in J/gK	Thermal conductance at 20 °C, in W/mK	Mean coefficient of linear thermal expansion, in 10^{-6}/K, at a temperature between 20 °C and 100 °C	400 °C	Thermovoltage to copper at 20 °C, in µV/K
CuNi2	8,9	1090	0,38	130	16,5	17,5	− 15
CuNi6	8,9	1095	0,38	92	16	17,5	− 20
CuMn3	8,8	1050	0,39	84	15,5	18	+ 1
CuNi10	8,9	1100	0,38	59	16	17,5	− 25
CuNi23Mn	8,9	1150	0,37	33	16	17,5	− 30
CuNi30Mn	8,8	1180	0,40	25	14,5	16	− 25
CMn12Ni	8,4	960	0,41	22	18	19,5	− 0,6
CuNi44	8,9	1280	0,41	23	13,5	15	− 40
CuMn12NiAl	8,2	1000	0,41	22	17,5	19	− 2
NiCr8020	8,3	1400	0,42	15	13	15	+ 4
NiCr6015	8,2	1390	0,46	13	13,5	15	+ 1
NiCr20AlSi	8,0	1400	0,46	14	14	15	+ 1

Table 4. **Mechanical properties, at 20 °C**

Material designation	Minimum tensile strength 1), in N/mm²	Elongation at fracture 2) (L_0 = 100 mm) as a percentage, for a nominal diameter, in mm, of				
		0,02 to 0,063 (approx.)	over 0,063 up to 0,125 (approx.)	over 0,125 up to 0,5 (approx.)	over 0,5 up to 1 min.	over 1 3) min.
CuNi2	220	–	15	18	18	25
CuNi6	250	–	15	18	18	25
CuMn3	290	–	15	20	20	25
CuNi10	290	–	15	20	20	25
CuNi23Mn	350	12	18	20	20	25
CuNi30Mn	400	12	18	20	20	25
CuMn12Ni	390	12	18	20	20	25
CuNi44	420	12	18	20	20	25
CuMn12NiAl	400	–	–	18	18	25
NiCr8020	650	8	14	18	18	25
NiCr6015	600	8	14	18	18	25
NiCr20AlSi	1000	8	15	20	20	25

1) The values apply to wire with a diameter of over 2 mm. For smaller diameters, the minimum values are considerably higher, depending on the particular alloy and the other dimensions. The values also apply to flat wire and strip whose thickness corresponds to the wire diameter.

2) In accordance with DIN 51 210 Parts 1 and 2, the values specified for wire diameters under 0,5 mm shall be regarded as guideline values only.

3) For wire diameters greater than 3 mm, it may be agreed that L_0 be equal to 10 d_0.

Table 5. **Degree of corrosion resistance**

Material designation	Degree of corrosion resistance, up to the maximum service temperature 1), against					
	atmospheric corrosion (at 20 °C)	air and other oxygenous gases	nitrogenous, low-oxygen gases	oxidizing sulfuric gases	reducing sulfuric gases	carburization
CuNi2	High	Low	Low	Low	Low	High
CuNi6	High	Low	Low	Low	Low	High
CuMn3	High	Low	Low	Low	Low	High
CuNi10	High	Medium	Medium	Medium	Low	High
CuNi23Mn	High	Medium	Medium	Medium	Low	High
CuNi30Mn	High	High	High	High	Low	High
CuMn12Ni	High	Medium	Medium	Medium	Low	High
CuNi44	High	High	High	High	Low	High
CuMn12NiAl	High	Medium	Medium	Medium	Low	High
NiCr8020	High	High	High	Medium	Medium	High
NiCr6015	High	High	High	Medium	Medium	High
NiCr20AlSi	High	High	High	High	High	High

1) Cf. table 6.

Table 6. **Guideline values for maximum service temperature**

Material designation	Maximum temperature of the surrounding air in service, in °C
CuNi2	300
CuNi6	300
CuMn3	200
CuNi10	400
CuNi23Mn	500
CuNi30Mn	500
CuMn12Ni	140 [1)]
CuNi44	600
CuMn12NiAl	500
NiCr8020	600 [2)]
NiCr6015	600 [2)]
NiCr20AlSi	200 [3)]

1) Where the material is used for precision resistors, this shall be 60 °C.

2) Where the material is used as a resistance alloy, 600 °C is recommended as the maximum service temperature; where it is used as a heating conductor alloy, the higher temperatures specified in DIN 17 470 shall apply.

3) When used at higher temperatures, the coefficient of linear thermal expansion may change irreversibly.

Standards referred to

DIN 17 470	Heating conductor alloys; properties and requirements
DIN 17 742	Wrought nickel-chromium alloys; chemical composition
DIN 43 710	Electrical temperature sensors; thermocouples; thermovoltage and materials
DIN 43 713	Electrical temperature sensors; wire and wire strands for compensating cables
DIN 43 760	Electrical temperature sensors; reference tables for nickel resistors for resistance thermometers
DIN 46 399 Part 2	Spools for the delivery of bare and insulated wire; dimensions
DIN 50 114	Tensile testing of metallic sheet or strip less than 3 mm thick without using an extensometer
DIN 50 145	Tensile testing of metallic materials
DIN 51 210 Part 1	Tensile testing of wire without using an extensometer
DIN 51 210 Part 2	Tensile testing of wire using an extensometer
IEC 468	Method of measuring the specific electrical resistance of metallic materials

Other relevant standards

DIN 46 460 Part 1	Bare winding wire and round wire made from resistance alloys; technical delivery conditions
DIN 46 460 Part 2	Type V self-fluxing enamel-insulated winding wire and round wire made from resistance alloys; technical delivery conditions
DIN 46 460 Part 3	Type W 180 enamel-insulated winding wire and round wire made from resistance alloys; technical delivery conditions
DIN 46 460 Part 4	Cotton-covered winding wire and round wire made from resistance alloys; technical delivery conditions
DIN 46 461	Bare winding wire and round wire made from copper resistance alloys; dimensions, resistivity and mass
DIN 46 462 Part 1	Insulated, enamel-insulated winding wire and round wire made from resistance alloys; dimensions
DIN 46 462 Part 2	Cotton-covered, insulated winding wire and round wire made from resistance alloys; dimensions
DIN 46 462 Part 3	Cotton-covered, insulated, enamel-insulated winding wire and round wire made from resistance alloys; dimensions
DIN 46 463	Bare winding wire and round wire made from nickel resistance alloys; dimensions, resistivity and mass
DIN 46 464	Oxide-coated winding wire and round wire made from resistance alloys; dimensions and resistivity
DIN 46 465	Oxide-coated winding wire and flat wire made from resistance alloys; dimensions and resistivity
DIN 59 470	Heating conductors; round wire and strip; dimensions, mass and resistivity

Previous editions

DIN VDE 6460 = DIN 46 460: 02.32; DIN 17 471: 01.66.

Amendments

The following amendments have been made to the January 1966 edition.

a) Alloys NiCr8020, NiCr6015 and NiCr20AlSi have been included.

b) In keeping with the specifications made in ASTM B 267-1968, alloys CuNi2, CuNi6, CuNi10 and CuNi23Mn have been included.

c) Alloy CuNi20Mn10 has been deleted, and alloy CuMn2Al replaced by CuMn3.

d) The values specified and the units used have been changed to comply with the International System of Units.

e) The standard has been editorially revised.

International Patent Classification

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