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Standard Specification for Drawn or Rolled Nickel-Chromium and Nickel-Chromium-Iron Alloys for Electrical Heating Elements[1]

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This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This specification covers annealed, drawn, or rolled shapes for electrical heating purposes, of alloys having the nominal compositions of 80 % nickel and 20 % chromium; 60 % nickel, 16 % chromium, and remainder iron; and 35 % nickel, 20 % chromium, and remainder iron; 38 % nickel, 21 % chromium, and remainder iron; and 35 % nickel, 20 % chromium remainder iron.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

B63 Test Method for Resistivity of Metallically Conducting Resistance and Contact Materials

B70 Test Method for Change of Resistance With Temperature of Metallic Materials for Electrical Heating

B76 Test Method for Accelerated Life of Nickel-Chromium and Nickel-Chromium-Iron Alloys for Electrical Heating

3. Significance and Use

3.1 This specification on nickel-chromium and nickel-chromium-iron alloys contains the requirements for chemistry, electrical resistance, mechanical properties, and packaging.

4. Requirements

4.1 The alloys shall conform to the requirements as to chemical composition prescribed in Table 1.

4.2 *Samples for Chemical Analysis*—Specimens for chemical analysis may be taken from either the melt or from a sample of finished wire that is representative of the lot.

4.2.1 The lot size for determining compliance with the requirements of this specification shall be one heat.

4.3 *Chemical Analysis*—The chemical analysis shall be made in accordance with Test Methods A751, or by other analytical methods approved by the purchaser.

4.4 Actual chemical analysis is not required for routine acceptance.

5. Physical Requirements

5.1 The material shall be thoroughly and uniformly annealed.

5.2 Wire shall conform to the following elongation requirements:

[1] This specification is under the jurisdiction of ASTM Committee B02 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.10 on Thermostat Metals and Electrical Resistance Heating Materials.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the ~~standard's~~standard's Document Summary page on the ASTM website.

TABLE 1 Chemical Requirements

Element	Composition, %			
	80 Nickel-20 Chromium Alloy	60 Nickel-16 Chromium Alloy	38 Nickel-21 Chromium Alloy	35 Nickel-20 Chromium Alloy
Nickel[A]	remainder	57 min	36 to 39	34 to 37
Chromium	19 to 21	14 to 18	20 to 23	18 to 21
Manganese	1.0 max	1.0 max	1.0 max	1.0 max
Carbon	0.15 max	0.15 max	0.12 max	0.15 max
Silicon	0.75 to 1.75	0.75 to 1.75	1.3 to 2.2	1.0 to 3.0
Sulfur	0.01 max	0.01 max	0.03 max	0.01 max
Iron	1.0 max	remainder	remainder	remainder
Phosphorus			0.03 max	
Copper			0.5 max	
Lanthanum			0.03 to 0.20	

[A] Quantities of less than 1 % cobalt included shall be reported as nickel.

Size	Elongation in 10 in., min, %
0.0035 in. (0.0889 mm) (No. 39 Awg) and larger	20
0.0031 in. (0.0787 mm) to 0.002 in. (0.0508 mm) (Nos. 40 to 44 Awg)	10

5.3 Determination is not required for routine acceptance.

6. Nominal Resistivity

6.1 The nominal resistivity (Note 1) shall be the resistivity of the wire as quenched from a temperature above 1450°F (788°C). The numerical value of the nominal resistivity shall be as shown in Table 2.

6.2 Determination is not required for routine acceptance.

NOTE 1—The characteristics of these alloys are such that the actual resistivity of annealed wire may be as much as 6 % higher than the nominal, depending on its method of manufacture.

7. Test for Resistivity

7.1 The resistivity shall be determined in accordance with Test Method B63.

7.2 Determination is not required for routine acceptance.

8. Nominal Electrical Resistance for Unit Length

8.1 The nominal resistance per unit length for round wire shall be calculated from the nominal resistivity and the nominal cross-sectional area.

NOTE 2—When ribbon or flat wire is produced by rolling from round wire, the cross section departs from that of a true rectangle by an amount depending on the width-to-thickness ratio and the specific manufacturing practice. The conventional formula for computing ohms per foot and feet per pound is to consider the cross section as 17 % less than a true rectangle when width is more than 15 times the thickness and 6 % less than a true rectangle in other cases. This is not valid in view of modern rolling equipment and practices, but still is widely used as a basis of description. Ribbon actually is made to a specified resistance per foot, and no tolerance is specified for thickness. An alternative and a closer approximation would be that for ribbon rolled from round wire, the electrical resistance would be calculated on a cross 6 % less than a true rectangle.

9. Tolerance on Electrical Resistance per Unit Length

9.1 The actual resistance per unit length shall not vary from the nominal resistance by more than the amounts shown in Table 3.

NOTE 3—*Dimensional Tolerances*—Tolerances on dimensions are not specified since the material is used for resistance purposes in which the resistivity and the electrical resistance per unit length rather than the dimensions are of prime importance. The electrical resistance per unit length can be determined more accurately than the dimensions of very small sizes of wire or strip.

TABLE 2 Specific Resistance

Alloy	Specific Resistance	
80 Nickel-20 Chromium	650Ω·cm/ft	1.081μΩ·M
	510 Ω·mil^2/ft	1.081 μΩ·M
60 Nickel-16 Chromium	675 Ω·cm/ft	1.122μΩ·M
	530 Ω·mil^2/ft	1.122 μΩ·M
38 Nickel-21 Chromium	638 Ω·cm^2/ft	1.06 μΩ·M
	500 Ω·mil^2/ft	1.06 μΩ·M
35 Nickel-20 Chromium	610 Ω·cm/ft	1.014μΩ·M
	479 Ω·mil^2/ft	1.014 μΩ·M