



Standard Specification for Drawn or Rolled Nickel-Chromium and Nickel-Chromium- Iron Alloys for Electrical Heating Elements¹

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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.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 ASTM Standards:

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products²

B 63 Test Method for Resistivity of Metallically Conducting Resistance and Contact Materials³

B 70 Test Method for Change of Resistance with Temperature of Metallic Materials for Electrical Heating³

B 76 Test Method of Accelerated Life Test of Nickel-Chromium and Nickel-Chromium-Iron Alloys for Electrical Heating³

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. Chemical 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 A 751, 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:

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 B 63.

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

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² *Annual Book of ASTM Standards*, Vol 01.03.

³ *Annual Book of ASTM Standards*, Vol 03.04.

TABLE 1 Chemical Requirements

Element	Composition, %		
	80 Nickel-20 Chromium Alloy	60 Nickel-16 Chromium Alloy	35 Nickel-20 Chromium Alloy
Nickel ^A	remainder	57 min	34 to 37
Chromium	19 to 21	14 to 18	18 to 21
Manganese	1.0 max	1.0 max	1.0 max
Carbon	0.15 max	0.15 max	0.15 max
Silicon	0.75 to 1.75	0.75 to 1.75	1.0 to 3.0
Sulfur	0.01 max	0.01 max	0.01 max
Iron	1.0 max	remainder	remainder

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

TABLE 2 Specific Resistance

Alloy	Specific Resistance	
80 Nickel-20 Chromium	650 $\Omega \cdot \text{cm/ft}$	1.081 $\mu\Omega \cdot \text{M}$
	510 $\Omega \cdot \text{mil}^2/\text{ft}$	1.081 $\mu\Omega \cdot \text{M}$
60 Nickel-16 Chromium	675 $\Omega \cdot \text{cm/ft}$	1.122 $\mu\Omega \cdot \text{M}$
	530 $\Omega \cdot \text{mil}^2/\text{ft}$	1.122 $\mu\Omega \cdot \text{M}$
35 Nickel-20 Chromium	610 $\Omega \cdot \text{cm/ft}$	1.014 $\mu\Omega \cdot \text{M}$
	479 $\Omega \cdot \text{mil}^2/\text{ft}$	1.014 $\mu\Omega \cdot \text{M}$

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.

10. Resistance Change with Temperature

10.1 Nominal values for resistance change with temperature are contained in Appendix X1.

TABLE 3 Electrical Resistance Tolerance

	Tolerance, %
Round Wire:	
0.005-in. (0.127-mm) diameter and larger	±5
Finer than 0.005 in. to 0.002-in. (0.014-mm) diameter, incl	±8
Finer than 0.002-in. diameter	±10
Strip:	
Cold rolled	±5
Hot rolled	±8

10.2 The change in resistance with change in temperature shall be measured in accordance with Test Method B 70.

11. Durability

11.1 When it is desired to determine the durability of the material at high temperatures, life tests shall be made in accordance with Test Method B 76. Test results may be reported either in hours or in percentage of an accepted standard. The temperature of the life tests for the three alloys shall be as follows:

80 Nickel-20 Chromium Alloy	2175°F (1190°C)
60 Nickel-16 Chromium Alloy	2100°F (1150°C)
35 Nickel-20 Chromium Alloy	2025°F (1105°C)

11.2 The life or durability value shall be the average of at least three simultaneous determinations each, on wire specimens of the material and on the reference standard. If any test result varies more than 10 % from the average of the three determinations, that group shall be discarded and the test repeated.

11.3 Determination is not required for routine acceptance.

12. Finish

12.1 The material shall be as uniform and free from surface defects such as splits, kinks, laminations, scale, and other irregularities as the best commercial practice will permit. The finish shall be either bright annealed or oxidized, as specified.

13. Packaging and Marking

13.1 Packaging shall be subject to agreement between the manufacturer and the purchaser.

13.2 The material as furnished under this specification shall be identified by the name or symbol and color code of the manufacturer and by melt number.

14. Precision and Bias

14.1 Precision and bias on chemistry, electrical resistance, and resistance change with temperature are contained in Test Methods A 751, B 63, and B 70. The precision and bias on the test method for durability is contained in Test Method B 76.

(Nonmandatory Information)

X1. BASIS FOR ESTABLISHMENT OF PERCENT CHANGE IN RESISTANCE WITH TEMPERATURE

X1.1 The conditions of test, wire or strip size, chemistry of heats, and the environment are so varied it is not possible to accurately specify the resistance change versus temperature for nickel-chromium and nickel-chromium-iron alloys.

X1.2 Since this information is of general value to those designing appliances, furnaces, or other apparatus, the data in Table X1.1 is included for general guidance only. See also Fig. X1.1. The change in resistance values in this table were obtained using free coils of wire tested in accordance with Test Method B 70.

X1.3 The electrical properties of 80 nickel-20 chromium alloys can be changed by heat treatment in the temperature range from 500 to 1450°F (260 to 788°C). The wire as supplied by the manufacturer will normally have been strand annealed at

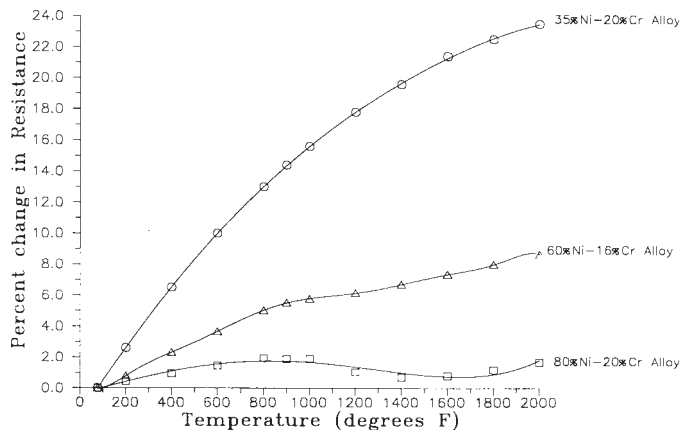


FIG. X1.1 Nominal Percent Change in Resistance with Temperature

temperatures higher than 1450°F. This results in rapid cooling of the alloy. It will therefore have a resistivity near the minimum for the alloy. After heating or slow cooling in the range from 500 to 1450°F the resistivity may increase as much as 6 %. The resistivity above 1450°F is reproducible regardless of previous treatment below this temperature. (The 60 nickel-16 chromium alloy may change up to 2 % under similar treatment while the change for 35 nickel-20 chromium will be insignificant.)

X1.4 The minimum resistance change with temperature will be obtained for heavy sizes while the maximum change will occur for small sizes. Therefore, for extreme accuracy it is advisable to run tests on a prototype to determine the resistance change with temperature.

TABLE X1.1 Nominal Percent Change in Resistance with Temperature

Temperature	80 Nickel-20 Chromium Alloy	60 Nickel-16 Chromium Alloy	35 Nickel-20 Chromium Alloy
2000°F	1.66	8.66	23.5
1800°F	1.18	8.00	22.5
1600°F	0.79	7.35	21.4
1400°F	0.71	6.70	19.6
1200°F	1.04	6.15	17.8
1000°F	1.90	5.77	15.6
900°F	1.88	5.52	14.4
800°F	1.94	5.03	13.0
600°F	1.46	3.67	10.0
400°F	0.93	2.32	6.5
200°F	0.43	0.78	2.6
77°F	0.0	0.0	0.0

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