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Standard Specification for Iron-Nickel-Cobalt Alloys for Metal-to-Ceramic Sealing Applications¹

This standard is issued under the fixed designation F1466; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers two iron-nickel-cobalt alloys, the former, (UNS No. K94630), containing nominally 29 % nickel, 17 % cobalt, and 53 % iron, the latter, (UNS No. K94620), nominally 27 % nickel, 25 % cobalt and 48 % iron, in the forms of wire, rod, bar, strip, sheet, and tubing, intended primarily for brazed metal-to-ceramic seals with alumina ceramics, for vacuum electronic applications. Unless otherwise indicated, all articles apply to both alloys.

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.

1.3 The following hazard caveat pertains only to the test method portion, Sections 14 and 16 of this specification. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

- D1971 Practices for Digestion of Water Samples for Determination of Metals by Flame Atomic Absorption, Graphite Furnace Atomic Absorption, Plasma Emission Spectroscopy, or Plasma Mass Spectrometry
- E3 Guide for Preparation of Metallographic Specimens
- E8 Test Methods for Tension Testing of Metallic Materials
- E18 Test Methods for Rockwell Hardness of Metallic Materials
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E45 Test Methods for Determining the Inclusion Content of Steel
- E92 Test Method for Vickers Hardness of Metallic Materials (Withdrawn 2010)³
- E112 Test Methods for Determining Average Grain Size
- E140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness
- E228 Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer
- E354 Test Methods for Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys
- E1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques
- E1060 Practice for Interlaboratory Testing of Spectrochemical Methods of Analysis (Withdrawn 1997)³

3. Ordering Information

3.1 Orders for material under this specification shall include the following information:

- 3.1.1 Alloy, as indicated with UNS number,
- 3.1.2 Size,

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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 Document Summary page on the ASTM website.

³ The last approved version of this historical standard is referenced on www.astm.org.

- 3.1.3 Temper designation (Section 6),
- 3.1.4 Surface finish (Section 10),
- 3.1.5 Marking and packaging (Section 19), and
- 3.1.6 Certification, if required. Please note that certification should include traceability of the heat to the original manufacturer.

4. Chemical Requirements

4.1 Each alloy shall conform to the requirements as to chemical composition prescribed in Table 1.

5. Surface Lubricants

5.1 All lubricants used during cold-working operations, such as drawing, rolling, or spinning, shall be capable of being removed readily by any of the common organic degreasing solvents.

6. Temper

6.1 The desired temper of the material shall be specified in the purchase order.

6.2 *Tube*—Unless otherwise agreed upon between the supplier or the manufacturer and the purchaser, these forms shall be given a final bright anneal by the manufacturer and supplied in the annealed temper.

6.3 *Strip and Sheet*—These forms shall be supplied in one of the tempers given in Table 2 or in deep-drawing temper, as specified.

6.4 *Wire and Rod*—These forms shall be supplied in one of the tempers given in Table 3 as specified. Unless otherwise specified, the material shall be bright annealed and supplied in Temper A (annealed).

NOTE 1—For rod forms, air anneal, followed by centerless grinding to remove scale, is an acceptable alternate.

7. Grain Size

7.1 Strip and sheet for deep drawing shall have an average grain size not larger than ASTM No. 5 (Note 2), and no more than 10 % of the grains shall be larger than No. 5 when measured in accordance with Test Methods E112.

NOTE 2—This corresponds to a grain size of 0.065 mm, or 16 grains/in.² of image at 100×.

7.2 Finer grain sizes for deep drawing quality shall be negotiated between user and supplier.

8. Hardness

8.1 *Deep-Drawing Temper*—For deep drawing, the hardness shall not exceed 82 HRB for material 0.100 in. (2.54 mm) and less in thickness, and 85 HRB for material over 0.100 in. in thickness when determined in accordance with Test Methods E18. See also Test Method E92 for Vickers Hardness Testing and tables in E140.

TABLE 1 Chemical Requirements

NOTE 1—Round observed or calculated values to the nearest unit in the last right-hand place of figures used in expressing the limiting value, in accordance with the rounding-off method of Practice E29.

Element	UNS No. K94630	UNS No. K94620
Iron, nominal	remainder ^A	remainder ^A
Nickel, nominal	29 ^A	27 ^A
Cobalt, nominal	17 ^A	25 ^A
Manganese, max	0.35	0.35
Silicon, max	0.15	0.15
Carbon, max	0.02	0.02
Aluminum, max	0.01 ^B	0.01 ^B
Magnesium, max	0.01 ^B	0.01 ^B
Zirconium, max	0.01 ^B	0.01 ^B
Titanium, max	0.01 ^B	0.01 ^B
Copper, max	0.20	0.20
Chromium, max	0.03	0.03
Molybdenum, max	0.06	0.06
Phosphorus, max	0.006 ^C	0.006 ^C
Sulfur, max	0.006 ^C	0.006 ^C

^A The iron, nickel, and cobalt requirements are nominal and may be adjusted by the manufacturer to meet the requirements for the coefficient of thermal expansion as specified in 12.1.

^B The total of aluminum, magnesium, titanium, and zirconium shall not exceed 0.04 %.

^C The total of phosphorus and sulfur shall not exceed 0.010. %.

TABLE 2 Tensile Strength Requirements for Strip and Sheet

Temper Designation	Temper Name	Tensile Strength, ksi (MPa)	
		UNS No. K94630	UNS No. K94620 (Nominal Values)
A	annealed	82 max (565 max)	85 max (586 max)
B	¼ hard	75 to 90 (517 to 621)	85 to 100 (586 to 689)
C	half hard	85 to 100 (586 to 689)	95 to 110 (655 to 758)
D	¾ hard	95 to 110 (655 to 758)	105 to 120 (724 to 827)
E	hard	100 min (689 min)	120 min (827 min)

TABLE 3 Tensile Strength Requirements for Wire and Rod

Temper Designation	Tensile Strength, ksi (MPa)	
	UNS No. K94630	UNS No. K94620 (Nominal Values)
A	85 (586) max	85 (586) max
B	85 to 105 (586 to 724)	85 to 100 (586 to 689)
C	95 to 115 (655 to 793)	95 to 110 (655 to 758)
D	105 to 125 (724 to 862)	105 to 120 (724 to 827)
E	125 (862) min	120 (827) min

8.2 *Rolled and Annealed Tempers*—Hardness tests when properly applied can be indicative of tensile strength. Hardness scales and ranges for these tempers, if desirable, shall be negotiated between supplier and purchaser.

9. Tensile Strength

9.1 *Strip and Sheet*:

9.1.1 Tensile strength shall be the basis for acceptance or rejection for the tempers given in **Table 2** and shall conform with the requirements prescribed.

9.1.2 Tension test specimens shall be taken so the longitudinal axis is parallel to the direction of rolling and the test shall be performed in accordance with Test Methods **E8**.

9.2 *Wire and Rod*:

9.2.1 Tensile strength shall be the basis for acceptance or rejection for the tempers given in **Table 3** and shall conform to the requirements prescribed.

9.2.2 The test shall be performed in accordance with Test Methods **E8**.

10. Surface Finish

10.1 The standard surface finishes available shall be those resulting from the following operations:

- 10.1.1 Hot rolling,
- 10.1.2 Forging,
- 10.1.3 Centerless grinding (rod),
- 10.1.4 Belt polishing,
- 10.1.5 Cold rolling, and
- 10.1.6 Wire and rod drawing.

11. Inclusion Content

11.1 *Wire, Rod, Bar, Strip and Sheet*—These product forms shall be free of inclusions, cracks, blow holes and other defects that are detrimental to the quality of subsequent product. The maximum inclusion rating number shall be 2 for Inclusion Types, A, B, C and D in both the thin and heavy series shown in Plate I using Practice **E45**, Method A, Worst-Field Technique.

NOTE 3—The test for inclusions may be performed on billet sections. In such cases, the sample section must include regions that correspond to the top of the ingot.

NOTE 4—Product section size information at which the inclusion ratings were taken should be included.

12. Thermal Expansion Characteristics

12.1 The average linear coefficients of thermal expansion shall be within the limits specified in **Table 4**.

13. Test for Thermal Expansion

13.1 Heat the specimen in a non-oxidizing atmosphere for 1 h at 1000°C. Cool at a rate not to exceed 300°C per hour.

13.2 Determine the thermal expansion characteristics in accordance with Test Method **E228**.