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Designation: ~~F15 – 04 (Reapproved 2013)~~ F15 – 04 (Reapproved 2017)

Standard Specification for Iron-Nickel-Cobalt Sealing Alloy[1]

This standard is issued under the fixed designation F15; 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 an iron-nickel-cobalt alloy, UNS K94610 containing nominally 29 % nickel, 17 % cobalt, and 53 % iron, in the forms of wire, rod, bar, strip, sheet, and tubing, intended primarily for sealing to glass in electronic applications.

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 13 and 14 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.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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
E92 Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials
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
F14 Practice for Making and Testing Reference Glass-Metal Bead-Seal
F140 Practice for Making Reference Glass-Metal Butt Seals and Testing for Expansion Characteristics by Polarimetric Methods
F144 Practice for Making Reference Glass-Metal Sandwich Seal and Testing for Expansion Characteristics by Polarimetric Methods

3. Ordering Information

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

3.1.1 Size,

3.1.2 Temper (Section 6),

3.1.3 Surface finish (Section 10),

3.1.4 Marking and packaging (Section 17), and

3.1.5 Certification if required.

4. Chemical Requirements

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

[1] This specification is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.03 on Metallic ~~Materials~~Materials, Wire Bonding, and Flip Chip.

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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.

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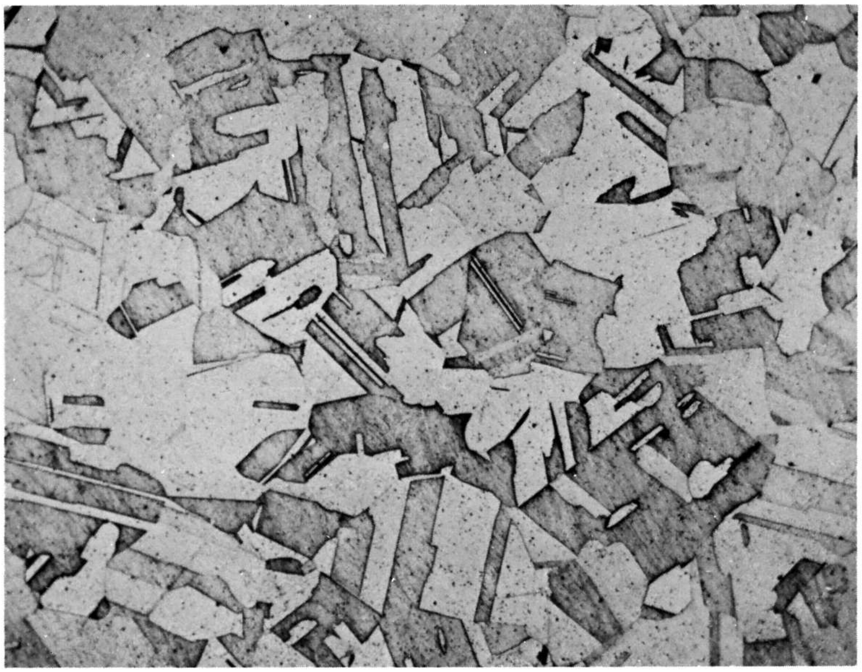

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FIG. 1 Normal Annealed Specimen Showing No Transformation

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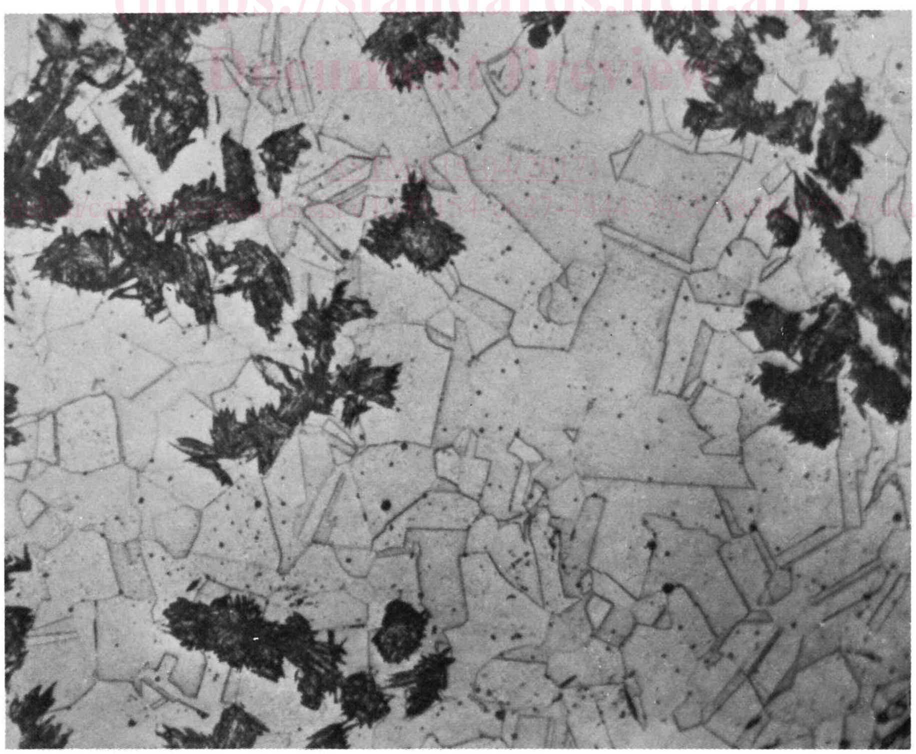

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FIG. 2 Partially Transformed Specimen

TABLE 1 Chemical Requirements

Element	Composition, %
Iron, nominal	53 [A]
Nickel, nominal	29 [A]
Cobalt, nominal	17 [A]
Manganese, max	0.50
Silicon, max	0.20
Carbon, max	0.04
Aluminum, max	0.10 [B]
Magnesium, max	0.10 [B]
Zirconium, max	0.10 [B]
Titanium, max	0.10 [B]
Copper, max	0.20
Chromium, max	0.20
Molybdenum, max	0.20

[A] The iron, nickel, and cobalt requirements listed are nominal. They shall be adjusted by the manufacturer so that the alloy meets the requirements for coefficient of thermal expansion given in Table 4.
[B] The total of aluminum, magnesium, zirconium, and titanium shall not exceed 0.20 %.

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 by the supplier or 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).

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7. Grain Size

7.1 Strip and sheet for deep drawing shall have an average grain size not larger than ASTM No. 5 (Note 1), and no more than 10 % of the grains shall be larger than No. 5 when measured in accordance with Test Methods E112.

NOTE 1—This corresponds to a grain size of 0.065 mm, or 16 grains/in.^{2} of image at 100 ×.

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 and Table 3, E140 for the appropriate conversion between various hardness scales.

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 *Sheet and Strip:*

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.

TABLE 2 Tensile Strength Requirements for Sheet and Strip

Temper Designation	Temper Name	Tensile Strength, ksi(MPa)
A	annealed	82 max (570 max)
B	¼ hard	75 to 90 (520 to 630)
C	half hard	85 to 100 (590 to 700)
D	¾ hard	95 to 110 (660 to 770)
E	hard	100 min (700 min)

TABLE 3 Tensile Strength Requirements for Wire and Rod

Temper Designation	Tensile Strength, ksi (MPa)
A	85 (585) max
B	85 to 105 (585 to 725)
C	95 to 115 (655 to 795)
D	105 to 125 (725 to 860)
E	125 (860) min

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 Method 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 drawing.

11. Thermal Expansion Characteristics

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

12. Test for Thermal Expansion

12.1 Heat the specimen in a hydrogen atmosphere for 1 h at 900°C, followed by 15 min at 1100°C. Between the 900 and 1100°C heat-treatment periods, the specimen may be cooled to room temperature if desired. Cool the specimen from 1100 to 200°C in the hydrogen atmosphere at a rate not to exceed 5°C/min.

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

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NOTE 2—For critical glass sealing applications, it is recommended that the user conduct functional testing in accordance with Practices F14, F140 or F144. Such tests circumvent possible problems with thermal expansion measurements and glass setting point estimates.

NOTE 3—The thermal treatment described in this section is for purposes of the thermal expansion test only. Consult the non-mandatory appendix of this document for guidance on annealing conditions for various product forms.

13. Transformation

13.1 The temperature of the gamma-to-alpha transformation shall be below −78.5°C when the material is tested in accordance with Section 14. However, for material whose smallest dimension is over ⅞ in. (22.2 mm), some localized transformation, acceptable to the purchaser, may be tolerated.

NOTE 4—Lower transformation temperatures, ranging to as low as −196°C, may be negotiated between supplier and purchaser. The −196°C transformation temperature corresponds to immersing a sample (prepared according to 14.1) in liquid nitrogen for a minimum of 1 h.

14. Test for Transformation

14.1 Cut the specimen from any part of the material, but preferably including the entire cross section, degrease it, then heat treat it as described in 12.1. When cool, polish the cross section of the specimen and etch (Note 5) it in accordance with Method E3. Then subject the specimen to the temperature produced by an excess of dry ice in acetone (−78.5°C) for at least 4 h. After the

TABLE 4 Coefficients of Thermal Expansion

Temperature Range, °C	Average Linear Coefficient of Thermal Expansion,[A] µm/m·°C
30 to 400	4.60 to 5.20
30 to 450	5.10 to 5.50

[A] Typical thermal expansion data for the alloy covered by these specifications are provided in Appendix X1.