



Designation: A753 – 21

Standard Specification for Wrought Nickel-Iron Soft Magnetic Alloys (UNS K94490, K94840, N14076, N14080)¹

This standard is issued under the fixed designation A753; 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 commonly used wrought nickel-iron soft magnetic alloys produced or supplied expressly for use in magnetic cores and other parts requiring high magnetic permeability, high electrical resistivity, low coercive field strength, and low core loss.

1.2 This specification covers materials supplied by a producer or converter to the form and physical condition desired for fabrication into parts that will later be given a final heat treatment to achieve the desired magnetic characteristics. It covers materials supplied in the form of forging billet; hot-rolled plate, strip, and bar; cold-finished bar; cold-rolled and annealed sheet and strip; shaped bar and wire; and wire.

1.2.1 This specification does not cover either powder metallurgically produced or cast parts.

1.2.2 This specification lists requirements for strip products having isotropic or semi-isotropic magnetic properties but does not include requirements for anisotropic or square hysteresis loop alloys or alloys processed to yield flattened hysteresis loops by use of heat treatments in an applied magnetic field.

1.2.3 This specification does not cover alloys modified by the addition of elements such as sulfur and selenium to enhance machinability.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to customary (cgs-emu and inch-pound) units which are provided for information only and are not considered standard.

1.3.1 There are selected values presented in two units, both of which are in acceptable SI units. These are differentiated by the word “, or,” as in “g/cm³, or, (kg/m³).” In addition, values for mean linear coefficient of expansion in Table X1.1 are shown solely in $\mu\text{m}/\text{m}/^\circ\text{C}$ in keeping with prior versions of this standard.

¹ This specification is under the jurisdiction of ASTM Committee A06 on Magnetic Properties, and is the direct responsibility of Subcommittee A06.02 on Material Specifications.

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1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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

- A34/A34M Practice for Sampling and Procurement Testing of Magnetic Materials
- A340 Terminology of Symbols and Definitions Relating to Magnetic Testing
- A341/A341M Test Method for Direct Current Magnetic Properties of Soft Magnetic Materials Using D-C Permeameters and the Point by Point (Ballistic) Test Methods
- A480/A480M Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
- A484/A484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings
- A555/A555M Specification for General Requirements for Stainless Steel Wire and Wire Rods
- A596/A596M Test Method for Direct-Current Magnetic Properties of Materials Using the Point by Point (Ballistic) Method and Ring Specimens
- A772/A772M Test Method for AC Magnetic Permeability of Materials Using Sinusoidal Current
- A773/A773M Test Method for Direct Current Magnetic Properties of Low Coercivity Magnetic Materials Using Hysteresigraphs
- E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

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.

E1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Inert Gas Fusion Techniques

3. Terminology

3.1 Except as noted in 3.1.1 below, the terms and symbols used in this specification are defined in Terminology A340.

3.1.1 Permeability values listed in Table 4 and Table 5, are relative permeabilities, that is, the absolute value divided by the magnetic constant. Permeability values will not make further reference to the qualifying term, “relative.”

4. Classification

4.1 Four specific alloy types are covered in Table 1.

TABLE 1 Specific Alloy Types

Alloy Type	UNS Number ^A	Nickel Range, % ^B
1	K94490	43.5 to 46.5
2	K94840	47.0 to 49.0
3	N14076	75.0 to 78.0
4	N14080	79.0 to 82.0

^A UNS refers to the Unified Numbering System, an alloy identification system supported by ASTM. Refer to Practice E527 for details.

^B Alloy Types 3 and 4 have additions of molybdenum, copper, and chromium to improve magnetic performance.

4.2 Alloy Type 2 in thin-strip form (thickness less than or equal to 0.51 mm (0.020 in.)) is available in two different grades. Grade 1 is semi-isotropic and is recommended for use in transformer laminations. Grade 2 is isotropic and is recommended for use in rotating machinery laminations and magnetic shielding parts. These grades are the result of different mill processing (that is, cold-rolling and annealing) practices and cannot be created by changes in the final heat treatment given to the laminations or parts.

5. Ordering Information

5.1 Orders for material conforming to this specification shall include the following information:

5.1.1 Reference to this specification and year of issue or revision.

5.1.2 Alloy type (Section 4) and grade where appropriate.

5.1.3 Dimensions and tolerances (Section 12).

5.1.4 Quantity (weight or number of pieces as appropriate).

5.1.5 Form and condition (Section 7).

5.1.6 Magnetic property requirements if they are other than those listed in this specification.

5.1.7 Certification of chemical analysis and magnetic quality evaluation.

5.1.8 Marking and packaging requirements.

5.1.9 *End Use*—Whenever possible, the user should specify whether the material will be machined, blanked into flat pieces, blanked and formed, deep drawn to shape, wound into a core, punched into laminations, or photo-etched. This will help the producer to provide the most suitable material for the user’s fabricating practices.

5.1.10 Exceptions to this specification or special requirements such as mechanical property requirements.

6. Chemical Composition

6.1 The alloys shall conform to the requirements prescribed in Table 2. Since magnetic performance is paramount, analysis variations are permitted by mutual agreement between the user and producer.

6.2 Determination of metallic constituents and phosphorus shall be by a method(s) acceptable to both producer and user. Analysis of carbon and sulfur shall be done in accordance with Test Methods E1019.

7. Form and Condition

7.1 These materials are capable of being produced in a wide variety of forms and conditions suitable for further manufacture into specific magnetic articles. The desired form and condition shall be specified and should be discussed with the producer before ordering to assure receiving the appropriate product. Available forms and conditions are:

7.1.1 *Forging Billet*—Hot worked; hot worked with surfaces prepared by grinding.

7.1.2 *Hot-Rolled Plate, Strip, and Bar*—Hot-rolled; hot-rolled and acid cleaned; hot-rolled and annealed; hot-rolled, annealed, and acid cleaned; hot-rolled and mechanically cleaned; mechanical properties as specified.

7.1.3 *Cold-Finished Bars*—Cold-drawn; cold-drawn and centerless ground; cold-drawn and annealed to specified mechanical properties.

7.1.4 *Cold-Rolled Sheet and Strip*—Cold-rolled; deep draw quality; cold-rolled and annealed to specified mechanical properties.

7.1.5 *Wire*—Cold-drawn; cold-drawn and annealed to specified mechanical properties.

7.1.6 *Shaped Bar and Wire*—Cold-worked; cold-worked and annealed to specified mechanical properties.

8. Magnetic Property Requirements—General Requirements

8.1 *Test Methods*—Because of the extremely high magnetic permeabilities developed in these alloys after heat treatment, the use of permeameters (Test Method A341/A341M) is expressly forbidden. Allowable test methods are those using ring-type specimens.

TABLE 2 Chemical Requirements (Weight Percent)

	Alloy 1 UNS K94490	Alloy 2 UNS K94840	Alloy 3 UNS N14076	Alloy 4 UNS N14080
Carbon, max.	0.05	0.05	0.05	0.05
Manganese, max.	0.80	0.80	1.5	0.80
Silicon, max.	0.50	0.50	0.50	0.50
Phosphorus, max.	0.03	0.03	0.02	0.02
Sulfur, max.	0.01	0.01	0.01	0.01
Chromium	0.30 max.	0.30 max.	2.0-3.0	0.30 max.
Nickel	43.5-46.5	47.0-49.0	75.0-78.0	79.0-82.0
Molybdenum	0.30 max.	0.30 max.	0.50 max.	3.5-6.0
Cobalt, max.	0.50	0.50	0.50	0.50
Copper	0.30 max.	0.30 max.	4.0-6.0	0.30 max.
Iron ^A	balance	balance	balance	balance

^A Iron is the balance by difference. Quantitative analysis of this element is not required.