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23 November 1977
SUPERSEDING
MIL-N-14411B(MR)
19 August 1966

MILITARY SPECIFICATION

NICKEL-IRON ALLOY, HIGH MAGNETIC PERMEABILITY SHEET, STRIP, ROD, BAR, AND WIRE

This specification is approved for use by the Army Materials and Mechanics Research Center, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers high magnetic permeability nickel-iron sheet, strip, rod, bar, and wire.

1.2 Classification. The alloy material covered by this specification shall have a chemical composition corresponding to one listed in table I. The material as specified (see 6.2) shall be furnished in the following forms and with an applicable temper and finish listed.

1.2.1 Form.

Sheet
Strip
Rod
Bar
Wire

1.2.2 Temper.

Un-annealed (as rolled, as drawn)
Annealed

1.2.3 Finish. The nickel-iron alloy is classified as to finish as follows:

Hot rolled
Cold rolled
Pickled
Polished
Cold drawn
Centerless ground

FSC 9530

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Army Materials and Mechanics Research Center, Watertown, MA 02172 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

Table I. Chemical composition, percent

Composition	Carbon max	Manganese max	Silicon max	Phosphorus max	Sulfur max	Chromium max	Nickel	Molybdenum	Copper	Iron
1	0.03	0.95	0.42	0.02	0.008	-	79.0-80.6	3.8-5.0	-	Rem
2 1/	0.05	1.8	0.50	0.02	0.02	3.0	75.0-77.0	-	4.0-6.0	Rem
3 2/	0.035	0.8	0.50	0.02	0.008	-	47.0-50.0	-	-	Rem
4 2/	0.035	0.8	0.50	0.02	0.008	-	47.0-50.0	-	-	Rem
5	0.02	0.7	0.15	0.02	0.008	-	79.0-80.6	4.8-5.2	-	Rem

1/ Available in all forms. Random - oriented magnetic properties.
2/ Available as strip 0.020 inch or less thickness; semi-oriented magnetic properties.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

STANDARDS

FEDERAL
Fed. Test Method Std. No. 151 - Metals: Test Methods

MILITARY
MIL-STD-129 - Marking for Shipment and Storage

(Copies of specifications, standards, drawings and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

American Society for Testing and Materials (ASTM) Standards

A 341 - Direct Current Magnetic Properties of Materials Using D-C Permeameters and the Ballistic Test Methods, Test for.
A 343 - Alternating Current Magnetic Properties of Materials at Power Frequencies Using Wattmeter-Ammeter-Voltmeter Method and 25-cm Epstein Test Frame, Test for.
A 344 - Electrical and Mechanical Properties of Magnetic Materials, Tests for.
A 346 - Alternating-Current Magnetic Performance of Laminated Core Specimens Using the Modified Hay Bridge Method, Tests for.
A 480 - General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
A 484 - General Requirements for Stainless and Heat-Resisting Wrought Steel Products (Except Wire).
A 555 - General Requirements for Stainless and Heat-Resisting Steel Wire.
A 596 - Direct-Current Magnetic Properties of Materials Using Ring Test Procedures and the Ballistic Methods.
E 18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials, Test for.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

3. REQUIREMENTS

3.1 Chemical composition. The material shall conform to the chemical requirements specified in table I.

3.1.1 Heat analysis. A heat analysis for each lot shall be furnished by the supplier showing the percentage of each element designated in table I.

3.1.2 Product analysis. The chemical composition of each lot as determined by product analysis shall meet the requirements for the specified composition as listed in table I.

3.2 Mechanical properties.

3.2.1 Hardness.

3.2.1.1 Unless otherwise specified (see 6.2), sheet and strip shall have hardness values as shown in table II.

Table II. Hardness

Temper	Hardness Rockwell B
As cold rolled	90 minimum
Annealed	75 maximum

3.2.1.2 Bars, rod, and wire shall meet the hardness requirements specified in the invitation for bids or in the contract or order (see 6.2).

3.3 Magnetic properties. Unless otherwise specified (see 6.2), the magnetic permeability and coercive force of the materials furnished under this specification shall correspond to the values listed in tables III and IV for the appropriate composition, form and thickness of material ordered.

Table III. DC magnetic properties

Composition	Form	Permeability, μ, minimum			μ, maximum	Coercive force max H_C (oersteds)
		B=100 Gausses	B=2500 Gausses	B=5000 Gausses		
1	All	40,000	160,000	-	200,000	0.02 from B=6800 Gausses
2	All	15,000	52,000	-	-	-
3	Sheet[1/] Strip[1/] Bar Rod Wire	7,000	-	60,000	60,000	0.07 from B=10,000 Gausses
4	Strip[2/]	-	-	-	-	-
5	All[2/]					

[1/] 0.026 inch thickness and over.
[2/] Magnetic properties of compositions 4 and 5 to be agreed upon by the manufacturer and purchaser (see 6.2).

Table IV. AC (60 CPS) magnetic properties[1/], sheet-strip[2/]

Composition	Thickness (inch)	Permeability, minimum value				
		B=40 Gausses	B=200 Gausses	B=2000 Gausses	B=4,000 Gausses	B=6,000 Gausses
1	0.025	35,000	39,000	48,000	-	-
	0.014	55,000	60,000	80,000	-	-
	0.006	60,000	80,000	140,000	-	-
	0.002	60,000	80,000	150,000	-	-
2	-	-	-	-	-	-
3	0.020	5,700	9,000	21,000	28,000	-
	0.014	7,500	13,500	28,000	40,000	45,000
	0.006	8,000	14,500	38,000	52,000	65,000
4	0.020	9,500	13,000	26,000	30,000	-
	0.014	10,000	14,500	32,000	40,000	45,000
	0.006	11,000	17,000	46,000	56,000	62,000
5	0.001/0.010	65,000	-	-	-	-

1/ For intermediate thicknesses not shown, minimum permeabilities can be determined by plotting thickness versus minimum values given and obtain minimum value for a given thickness.

2/ 0.025 inch thickness and less.

3.4 Electrical properties. When specified (see 6.2), the specimens representing the sheet, strip, rod, bar or wire shall meet the electrical resistivity requirements of table V.

Table V. Electrical resistivity

Composition	Ohms circular mil/foot ± 5%
1	349
2	336
3	301
4	301
5	393

3.5 Heat treatment. The manufacturer shall determine and conduct the heat treatment required to produce the specified properties. Unless otherwise specified (see 6.2), a statement shall be furnished by the manufacturer describing the heat treatment procedure.

3.6 Dimensions and tolerances. The material shall be furnished in the size and quantity specified in the invitation for bids, contract or order (see 6.2). Unless otherwise specified, dimensional tolerances shall be in accordance with applicable portions of the ASTM specifications listed in table VI. Dimensional tolerances for rod shall be as specified in the procurement documents (see 6.2).

Table VI. Dimensional tolerances

Form and finish	Reference
Sheet, hot rolled and Sheet,, cold rolled	
Weight Thickness Width Length Camber	ASTM A 480
Strip, cold rolled	
Thickness Crown Width Length Camber	ASTM A 480
Bar, hot rolled and Bar, cold rolled	
Size Length Straightness	ASTM A 484
Wire, cold finished	
Size Out-of-round Length	ASTM A 555

3.7 Workmanship. The material shall be uniform in quality and shall be free from defects detrimental to the serviceability of the product.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Lot. A lot shall consist of products of the same size and shape. The material shall have been processed in a similar manner from the same heat or melt. All of the material in a lot shall be submitted for inspection at the same time. When the material in a lot is heat treated in a batch furnace, it shall be from a single furnace charge. Unless otherwise specified, when heat treatment is conducted in a continuous furnace the material in each lot shall be from an uninterrupted continuous furnace run during which the furnace operating conditions are maintained constant.

4.3 Sampling.

4.3.1 For chemical product analysis. When specified (see 6.2) at least one sample shall be taken from each lot for product analysis. Samples shall be taken in accordance with method 111 or 112 of Fed. Test Method Std. No 151.

4.3.2 For mechanical, magnetic and electrical property tests. Unless otherwise specified (see 6.2), at least one sample shall be taken from each lot. The sample shall be representative of the lot and shall be taken in accordance with applicable portions of the referenced test methods or as otherwise specified (see 6.2).

4.4 Examination.

4.4.1 Dimensions and tolerances. A representative number of pieces from each lot shall be measured to determine compliance with the requirements for dimensions and tolerances (see 3.6).

4.4.2 Visual. A representative number of pieces in each lot shall be examined to determine compliance with the requirements for workmanship (see 3.7).

4.4.3 Packaging inspection. Inspection shall be made to determine compliance with the requirements for packaging (see section 5).

4.5 Test procedures.

4.5.1 Chemical composition. Chemical analysis shall be conducted in accordance with method 111 or method 112 of Fed. Test Method Std. No. 151. In case of dispute, the analysis by method 111 shall be the basis for acceptance or rejection.

4.5.2 Mechanical properties. Hardness tests shall be conducted in accordance with ASTM E 18.

4.5.3 Magnetic properties. Unless otherwise specified (see 6.2) DC magnetic properties test shall be conducted in accordance with ASTM A 341 or A 596. AC magnetic properties tests shall be conducted in accordance with ASTM A 343 or A 346.

4.5.4 Electrical properties. Electrical resistivity tests shall be conducted in accordance with ASTM A 344 or as specified in the contract or order.

4.6 Rejection. If any specimen fails to conform to the requirements of this specification, it shall be cause for rejection of the material represented by the specimen subject to the retest provisions of Fed. Test Method Std. No. 151.

5. PACKAGING

5.1 Preservation-packaging. Preservation-packaging shall be in accordance with commercial practice to adequately prevent deterioration or misidentification of the item.

5.2 Packing. Packing shall be in accordance with commercial practice to ensure transportation by common carrier and safe delivery to destination.

5.3 Marking. In addition to any special marking required by the contract or order (see 6.2), shipping containers shall be marked in accordance with MIL-STD-129.

6. NOTES

6.1 Intended use. Material is used in relays, special application transformers, and other magnetic circuit components.

6.2 Ordering data. Procurement documents should specify the following:

a. Title, number and date of this specification.
b. Composition, form, temper and finish required (see 1.2).
c. Hardness requirement if different than table II (see 3.2.1)
d. Electrical resistivity when required (see 3.4).
e. Magnetic property requirements if different than those given in tables III and IV (see 3.3, and footnote to table III).
f. Heat treatment statement when required (3.5).
g. Quantity and dimensions (see 3.6).

h. Sampling for product analysis (see 4.3.1)
i. Sampling for material property tests (see 4.3.2)
j. Magnetic property test procedure (see 4.5.3)
k. Electric property test procedure (see 4.5.4)
l. Special marking requirement (see 5.3)
m. Dimensional tolerance if different than table VI. Dimensional tolerance must be included in the case of rod form (see 3.6).

6.3 Conservation. The alloys covered in this specification should be used only when the use of less critical materials would impair the Military application of apparatus in which they are employed.

Custodian:
Army - MR

Preparing activity:
Army - MR

Review activities:
Army - MI, AR
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Project No. 9530-A003

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DOCUMENT IDENTIFIER *(Number)* AND TITLE MIL-N-14411C(MR), Nickel-Iron Alloy, High Magnetic Permeability Sheet, Strip, Rod, Bar, and Wire

NAME OF ORGANIZATION AND ADDRESS OF SUBMITTER

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