Designation: A 904 – 98

Standard Specification for 50 Nickel-50 Iron Powder Metallurgy (P/M) Soft Magnetic Parts[1]

This standard is issued under the fixed designation A 904; 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 the magnetic properties of 50 nickel-50 iron parts fabricated by powder metallurgy techniques and is intended for parts that require high magnetic permeability, high electrical resistivity, low coercive field strength, and low hysteresis loss. It differs from the wrought alloy specification (see Specification A 753) because these parts are porous. A number of magnetic properties such as permeability are proportional to the sintered density.

1.2 This specification deals with P/M parts in the sintered or annealed condition. Should the sintered parts be subjected to any secondary operation that causes mechanical strain, such as machining or sizing, they should be resintered or annealed.

1.3 The values stated in either customary (cgs-emu and inch-pound) units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with this specification.

2. Referenced Documents

2.1 *ASTM Standards:*

A 34/A 34M Practice for Sampling and Procurement Testing of Magnetic Materials[2]

A 340 Terminology of Symbols and Definitions Relating to Magnetic Testing[2]

A 596/A 596M Test Method for Direct-Current Magnetic Properties of Materials Using the Ballistic Method and Ring Specimens[2]

A 753 Specification for Nickel-Iron Soft Magnetic Alloys[2]

A 773/A 773M Test Method for Magnetic Properties of Materials Using Ring and Permeameter Procedures with Electronic Hysteresigraphs[2]

B 328 Test Method for Density, Oil Content and Interconnected Porosity of Sintered Powder Metal Structural Parts and Oil-Impregnated Bearings[3]

E 1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel and in Iron, Nickel and Cobalt Alloys[4]

3. Terminology

3.1 The terms and symbols used in this specification are defined in Terminology A 340.

4. Ordering Information

4.1 Orders for parts conforming to this specification shall include the following information.

4.1.1 Reference to this standard and year of issue/revision.

4.1.2 Reference to an applicable part drawing.

4.1.3 Quantity required.

4.1.4 A critical cross section of the part shall be defined and so indicated on the applicable part drawing. The location of the critical section is by mutual agreement between the purchaser and producer (see 6.2).

4.1.5 Magnetic property requirements if they are other than stated in 7.5.

4.1.6 Certification of chemical analysis or magnetic property evaluation, or both (Sections 5 and 7).

4.1.7 Marking and packaging requirements (Section 12).

4.1.8 Exceptions to this specification or special requirements such as functional testing as mutually agreed upon by the producer and purchaser.

5. Chemical Composition

5.1 The chemical composition of the parts shall conform to the requirements prescribed in Table 1.

5.2 Determination of metallic constituents shall be by a method acceptable to both producer and purchaser. Analysis of

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[2] *Annual Book of ASTM Standards,* Vol 03.04.

[3] *Annual Book of ASTM Standards,* Vol 02.05.

[4] *Annual Book of ASTM Standards,* Vol 03.06.

TABLE 1 Chemical Requirements (in Weight Percent)

Element	%
Nickel	46 -51
Carbon	0.02 max
Oxygen	0.10 max
Nitrogen	0.01 max
Others[A]	0.5 max
Iron[B]	balance

[A] Others refers to trace elements that are to be regarded as incidental and not deliberate additions.

[B] Iron is the balance by difference. Quantitative analysis of this element is not required.

carbon, nitrogen, sulfur, and oxygen shall be done in accordance with Test Methods E 1019.

6. Sintered Density Requirements

6.1 Magnetic and residual induction of P/M parts strongly depend on density. The density of P/M parts is determined by the compressibility of the powder, the compacting pressure, and sintering practice (temperature, time, and atmosphere).

6.2 Parts produced in conformance with this specification shall have a minimum sintered density of 6.99 g/cm^3 [6990 kg/m^3] in the critical section of the part. The critical section shall be defined by agreement between the purchaser and producer.

6.3 Sintered density shall be determined in accordance with Test Method B 328.

7. Magnetic Property Requirements

7.1 Because of the nature of P/M parts production, magnetic testing of each lot is not required by this specification. However, it is strongly recommended that the purchaser require the producer to conduct periodic magnetic evaluations and to certify such results. Such magnetic property evaluations shall be conducted in the manner described below.

7.2 When requested, each lot of parts should be sintered with at least one and preferably three ring test specimens which comply with the geometric requirements listed in Practice A 34/A 34M. The ring specimen(s) shall be produced from the same mixed lot of powder used to produce the parts.

7.3 The magnetic properties shall be determined in accordance with Test Methods A 596/A 596M or A 773/A 773M.

7.4 For the purpose of this specification, only the coercive field strength determined from a maximum applied magnetic field strength of 15 Oe [1200 A/m] needs to be determined. Other magnetic properties may be specified by mutual agreement between the purchaser and producer.

7.5 *Coercive Field Strength Requirements*—Parts supplied to this specification shall exhibit a maximum coercive field strength of 0.4 Oe [32 A/m].

7.6 Since magnetic properties are strongly affected by process conditions, refer to the appendixes for typical values and explanatory notes.

8. Workmanship, Finish and Appearance

8.1 The parts shall be uniform in composition and uniform in density within critical sections.

8.2 If parts are sectioned or fractured, there shall be no readily recognizable defects.

9. Sampling

9.1 A lot shall consist of parts of the same form and dimensions, produced from a single mixed powder batch and from an unchanged process, without discontinuity in production, and submitted for inspection at one time.

9.2 The purchaser and producer shall agree upon a representative number of specimens for testing.

10. Rejection and Rehearing

10.1 Parts that fail to conform to the requirements of this specification shall be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer may make claim for a rehearing.

10.2 The disposition of rejected parts shall be subject to agreement between the purchaser and producer.

11. Certification

11.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have either been tested or inspected as directed in this specification and the requirements have been met.

11.2 When specified in the purchase order or contract, a report of the test results shall include:

11.2.1 Chemical composition,

11.2.2 Part density in the critical section,

11.2.3 Magnetic test results, if required by purchaser, and

11.2.4 The results of any other tests stipulated in the purchase order or contract.

12. Packaging and Package Marking

12.1 Packaging shall be subject to agreement between the purchaser and producer.

12.2 Parts furnished under this specification shall be in a container identified by the name or symbol of the parts producer.

13. Keywords

13.1 coercive field strength; PIM parts; powder metallurgy (PIM); 50 Ni-50 Fe

APPENDIXES

(Nonmandatory Information)

X1. Typical Magnetic Properties

X1.1 Typical dc magnetic properties, based on interlaboratory studies, are listed in Table X1.1. These results were obtained using a sintering practice of 2300°F [1260°C] in dry hydrogen or in vacuum. The influence of sintered density is shown. The data provided are for information only and are not requirements in this specification.

TABLE X1.1 Typical dc Magnetic Properties

	Sintered Density, g/cm^3 [kg/m^3]		
	7.0 [7000]	7.3 [7300]	7.5 [7500]
Relative Maximum Permeability	8100	9400	9900
Maximum flux density, G	9000	10000	11000
[T]	0.9	1.0	1.1
Residual Induction, G	7500	8500	9000
[T]	0.75	0.85	0.90
Coercive Field Strength, Oe	0.3	0.3	0.3
[A/m]	24	24	24

X1.2 Maximum flux density, residual induction, and coercive field strength are measured from a maximum applied magnetic field strength of 15 Oe [1200 A/m].

X2. Heat Treatment of Magnetic Test Specimens and Parts

X2.1 The magnetic properties within this specification are for as-sintered parts. As such, the magnetic properties may not be at optimum values especially the relative maximum permeability and coercive field strength. To achieve optimum properties, the parts must be annealed to promote grain growth.

X2.2 A general heat treatment to improve magnetic properties is as follows:

X2.2.1 Place parts in a sealed retort or equivalent,

X2.2.2 Introduce a circulated dry hydrogen atmosphere having an entrance dewpoint of –60°F [–51°C] or lower,

X2.2.3 Heat to a temperature of 2050 to 2160°F [1120 to 1180°C] and hold for 4 h at temperature, and

X2.2.4 Cool to room temperature at a rate not to exceed 200°F/h [110°C/h].