



Standard Specification for Soft Magnetic Iron Parts Fabricated by Powder Metallurgy Techniques¹

This standard is issued under the fixed designation A811; 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 parts produced from iron powder metallurgy materials.

1.2 This specification deals with powder metallurgy 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 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.

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

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](#)

[A596/A596M Test Method for Direct-Current Magnetic Properties of Materials Using the Ballistic Method and Ring Specimens](#)

[A773/A773M Test Method for Direct Current Magnetic Properties of Low Coercivity Magnetic Materials Using Hysteresigraphs](#)

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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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.

[B962 Test Methods for Density of Compacted or Sintered Powder Metallurgy \(PM\) Products Using Archimedes' Principle](#)

[E1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques](#)

3. Terminology

3.1 The terms and symbols used in this specification are defined in Terminology [A340](#).

4. Ordering Information

4.1 Purchase orders for parts conforming to this specification shall include the following information:

4.1.1 Reference to this specification 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 user and the producer ([6.2](#)),

4.1.5 Magnetic property requirements if they are other than stated in [Table 1](#),

4.1.6 Whether certification of chemical analysis or magnetic property evaluation is required (Sections [5](#) and [7](#)),

4.1.7 Marking and packaging requirements (Section [12](#)), and

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

5. Chemical Composition

5.1 The chemical composition of the parts shall conform to the requirements prescribed in [Table 2](#).

5.2 Determination of metallic constituents shall be by a method acceptable to both the producer and the user. Analysis of carbon, oxygen, sulfur, and nitrogen shall be done in accordance with Test Methods [E1019](#).

6. Sintered Density Requirements

6.1 Magnetic and residual induction of powder metallurgy parts strongly depend on density. The density of powder

TABLE 1 Maximum Coercive Field Strength Requirements

Grade	Coercive Field Strength
1	140 A/m (1.8 Oe)
2	160 A/m (2.0 Oe)
3	180 A/m (2.3 Oe)

TABLE 2 Chemical Requirements (weight percent)

Element	%
Carbon, max	0.03
Oxygen, max	0.10
Nitrogen, max	0.01
Others ^A	0.50, max
Iron ^B	balance

^A Others refers to trace elements which 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.

metallurgy 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 6.6 Mg/m³ in the critical section of the part. The critical section shall be defined by agreement between the user and the producer.

6.3 Sintered density shall be determined in accordance with Test Method **B962**.

7. Magnetic Property Requirements

7.1 Because of the nature of powder metallurgy parts production, magnetic testing of each lot is not required by this specification. Nevertheless, it is strongly recommended that the user require the producer to conduct periodic magnetic evaluations and to certify such results. Such magnetic property evaluations shall be conducted in the following manner.

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 **A34/A34M**. 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 **A596/A596M** or **A773/A773M**.

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

7.5 *Coercive Field Strength Requirements*—Three grades, defined by coercive field strength, are stipulated by this specification and are listed in **Table 1**. The coercive field strength requirement for Grade 3 was developed from an interlaboratory study. The values for Grades 1 and 2 are based on a literature review and are believed to reflect the current industry capabilities.

7.6 *Magnetic Aging*—Nitrogen introduced during sintering can cause time-dependent degradation of magnetic properties.

Therefore, when requested by the user, the producer shall test for aging. To determine the susceptibility of the parts to aging, the test ring(s) should be heated in air for either 100 h at 150 ± 5 °C or 600 h at 100 ± 5 °C and the coercive field strength remeasured. A change in coercive field strength of 10 % or more of the original value is evidence that aging has occurred.

7.7 Since magnetic properties are strongly affected by process conditions, refer to **Appendix X1** 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 user 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 or supplier may make claim for a rehearing.

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

11. Certification

11.1 When specified in the purchase order or contract, the user 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 the following:

11.2.1 Chemical composition,

11.2.2 Part density in the critical section,

11.2.3 Magnetic test results, if required by user, 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 user and the 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; iron; powder metallurgy; powder metallurgy parts

APPENDIX

(Nonmandatory Information)

X1. TYPICAL MAGNETIC AND MECHANICAL PROPERTIES

X1.1 Typical magnetic and mechanical properties, based on interlaboratory studies, are listed in **Table X1.1**, **Table X1.2**, and **Table X1.3**. **Table X1.1** contains properties typically achieved when sintering is conducted at 1120 °C in dissociated ammonia. **Table X1.2** contains properties typically achieved when sintering is conducted at 1120 °C in dry hydrogen or in a vacuum. **Table X1.3** contains properties typically achieved when sintering is conducted at 1260 °C in dry hydrogen or in

a vacuum. The influence of sintered density is shown in all three tables. The data provided are for information only and are not requirements in this specification.

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

TABLE X1.1 1120 °C Sinter in Dissociated Ammonia

Sintered Density (Mg/m ³)		6.6	6.9	7.2
(Relative) maximum permeability		1 700	2 100	2 700
Maximum flux density	T	0.90	1.05	1.20
	(G)	9 000	10 500	12 000
Residual induction	T	0.78	0.90	1.05
	(G)	7 800	9 000	10 500
Coercive field strength	A/m	170	170	170
	(Oe)	2.1	2.1	2.1
0.2 % offset yield strength	MPa	75	120	155
	(psi)	11 000	17 000	22 500
Ultimate tensile strength	MPa	120	190	255
	(psi)	18 000	27 500	37 000
Percent elongation, 25.4 mm		6	11	16
Apparent hardness	(HRF)	40	50	55

TABLE X1.2 1120 °C Sinter in Dry Hydrogen or Vacuum

Sintered Density (Mg/m ³)		6.6	6.9	7.2
(Relative) maximum permeability		1 800	2 300	2 900
Maximum flux density	T	0.95	1.05	1.20
	(G)	9 500	10 500	12 000
Residual induction	T	0.82	0.97	1.10
	(G)	8 200	9 700	11 000
Coercive field strength	A/m	140	140	140
	(Oe)	1.8	1.8	1.8
0.2 % offset yield strength	MPa	75	120	155
	(psi)	11 000	17 000	22 500
Ultimate tensile strength	MPa	130	190	260
	(psi)	19 000	28 000	37 500
Percent elongation in 25.4 mm		8	12	17
Apparent hardness	(HRF)	40	50	55

TABLE X1.3 1260 °C Sinter in Dry Hydrogen or Vacuum

Sintered Density (Mg/m ³)		6.6	6.9	7.2
(Relative) maximum permeability		2 800	3 300	3 800
Maximum flux density	T	1.00	1.15	1.30
	(G)	10 000	11 500	13 000
Residual induction	T	0.85	1.00	1.15
	(G)	8 500	10 000	11 500
Coercive field strength	A/m	130	130	130
	(Oe)	1.6	1.6	1.6
0.2 % offset yield strength	MPa	70	110	145
	(psi)	10 000	16 000	21 000
Ultimate tensile strength	MPa	140	200	260
	(psi)	20 000	29 000	38 000
Percent elongation in 25.4 mm		10	15	20
Apparent hardness	(HRF)	38	45	50

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