Designation: A 34/A 34M – 06

Standard Practice for Sampling and Procurement Testing of Magnetic Materials[1]

This standard is issued under the fixed designation A 34/A 34M; 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 practice covers sampling procedures and test practices for determination of various magnetic properties of both soft and hard magnetic materials.

1.2 This practice may be used either in conjunction with, or independent of, the standard test methods and materials specifications under the jurisdiction of ASTM Committee A06. In the former situation, the sampling and testing procedures listed herein shall not supersede those found in the individual test methods and materials specifications. In the latter situation, the sampling and testing procedures listed herein shall strictly apply.

1.3 The values and equations stated in customary (cgs-emu and inch-pound) or SI units are to be regarded separately as standard. Within this standard, SI units are shown in brackets except for the sections concerning calculations where there are separate sections for the respective unit systems. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with this 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]

A 340 Terminology of Symbols and Definitions Relating to Magnetic Testing

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms relating to magnetic testing, reference shall be made to Terminology A 340.

4. Significance and Use

4.1 This practice defines test lots and describes the selection and preparation of test specimens used in the determination of magnetic properties of various materials.

4.2 A method of calculating the density of iron-base electrical steels is given and a table of assumed densities for magnetic testing of commercial soft magnetic alloys is provided.

5. Test Lots

5.1 *Wrought, Flat-Rolled, or Long Products*:

5.1.1 A test lot of wrought, flat-rolled, or long products shall consist of not more than 50 000 lb [23 000 kg] of material.

5.1.2 A test lot may be composed of coils or cut lengths. A test lot of coil product may consist of one or more coils having essentially the same treatment and composition.

5.2 *Amorphous Strip and Wire*:

5.2.1 A test lot shall consist of a continuously cast strip or wire in one coil without breaks. In practice this may represent quantities up to 2200 lb [1000 kg].

5.3 *Powder Metallurgically Produced Parts*:

5.3.1 A test lot shall consist of parts of the same geometry and dimensions, made from powder of the same composition, molded and sintered under the same conditions, which have been submitted for inspection at one time.

5.4 *Cast Parts*:

5.4.1 A test lot shall consist of parts of the same geometry and dimensions, made from the same casting heat, which have been submitted for inspection at one time.

6. Sampling

6.1 *Electrical Steel Coils*:

6.1.1 From test lots in coil form, consisting of only one master coil, prepare the test strips from test sheets cut from one or both ends of the coil.

[1] This practice is under the jurisdiction of ASTM Committee A06 on Magnetic Properties and is the direct responsibility of Subcommittee A06.01 on Test Methods.

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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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6.1.2 When a test lot in coil form consists of several coils sheared or slit from a master coil, the test strips shall be prepared from test sheets representing one or both ends of the master coil.

6.1.3 When a test lot in coil form consists of several coils having essentially the same treatment and composition, test strips shall be prepared from test sheets cut from one or both ends of enough master coils to be representative of the lot.

6.2 *Electrical Steel Cut Lengths*:

6.2.1 When cut lengths are sheared from coil material without subsequent treatments (such as roller leveling or cold rolling), the test on the original coil shall suffice.

6.2.2 Two or more test sheets shall be taken from the same lot of cut length steel that has been cold rolled or leveled. These test sheets shall not lie adjacent to each other, but shall be selected in a manner to assure representative sampling.

6.3 *Wrought Products Other Than Electrical Steels*:

6.3.1 Sampling shall be one sample per each heat applied to the order unless otherwise specified in the appropriate ASTM specification or by mutual agreement between the producer and purchaser.

6.4 *Amorphous Strip and Wire*:

6.4.1 Sampling shall consist of one sample from each end of each continuously cast coil unless otherwise specified in the appropriate ASTM specification or by mutual agreement between the producer and purchaser.

6.5 *Powder Metallurgically Produced Parts*:

6.5.1 Sampling shall consist of one sample per test lot unless otherwise specified in the appropriate ASTM specification or by mutual agreement between the producer and purchaser.

6.6 *Cast Parts*:

6.6.1 Sampling shall consist of one sample per test lot unless otherwise specified in the appropriate ASTM specification or by mutual agreement between the producer and purchaser.

7. Test Specimens

7.1 The test specimens used for the determination of properties of magnetic materials will vary in form, depending upon the test equipment and the dimensions of the material to be tested. Prepare the test specimens in a manner to adequately represent the areas being sampled. Standard forms include flat strips, rings, bars, and links in accordance with the following practices.

7.1.1 *Flat Strips*:

7.1.1.1 Except when otherwise established by mutual agreement between the producer and the purchaser, the Epstein test specimen shall be the standard specimen for determination of the magnetic properties of flat-rolled electrical steels.

7.1.1.2 Standard Epstein test specimens shall be composed of test strips preferably cut from test sheets in a manner shown in Fig. 1 (a) or (b). One half of the strips are cut parallel to and the other half cut perpendicular to the direction of rolling.

7.1.1.3 If the width of the material does not permit cutting of strips perpendicular to the rolling direction, or, if the material has preferred properties in any one direction with respect to the direction of rolling, or, if the material is to be used with the flux in any one direction, all of the strips may be cut in a specified direction which shall be agreed upon by the producer and the purchaser. All lengthwise strips may be selected as shown in Fig. 1 (c).

7.1.1.4 When fewer than the total number of strips obtained from the sampled area are needed for the test specimen, the excess strips should be discarded equally from all locations in the sampled area. For instance, if approximately ¼ of the total strips obtained is excess, every fourth strip should be discarded.

7.1.1.5 The Epstein test specimen shall consist of strips sheared or punched in a width of 3.00 cm [30.0 mm] and not less than 28.0 cm [280 mm] long. If for ease of assembling the specimen in the test frame, it is desired to use strips slightly longer than 28.0 cm [280 mm], a length of 30.5 cm [305 mm] is recommended.

7.1.1.6 Test strips shall be nearly rectangular as possible and shall conform to the specified dimensions within ±0.08 cm [0.8 mm].

7.1.1.7 Test strips shall be cut with sharp shears or dies to avoid excessive burring or distortion.

7.1.1.8 Reports of test shall state specifically the manner in which the test strips were cut if other than one half parallel and the other half perpendicular to the direction of rolling.

7.1.2 *Rings*:

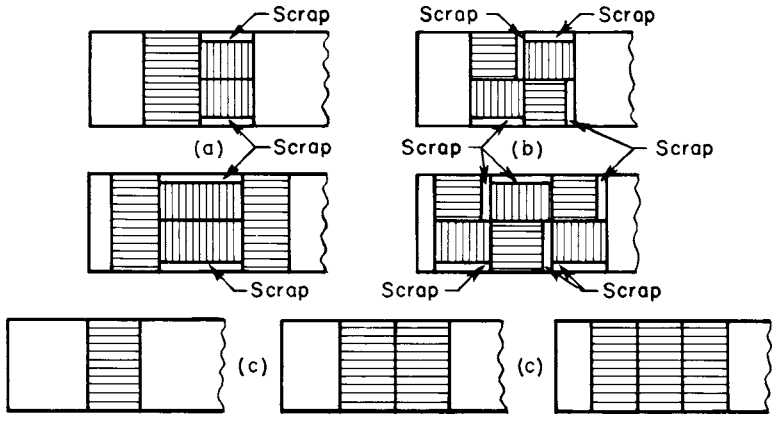


FIG. 1 Suggested Distribution of Strips To Be Cut from Sheets for Magnetic Tests

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7.1.2.1 Ring specimen may be punched, laser cut, spirally wound, forged, machined, sintered, or cast. The specimens shall be of uniform radial width and cross-sectional area. They shall be continuous, having no joints or welds except where specified or established by mutual agreement.

7.1.2.2 The ratio of mean diameter to radial width shall not be less than 10:1.

7.1.2.3 Sharp dies or shears shall be used in the preparation of ring specimens of flat-rolled sheet material.

7.1.2.4 If the radial width of punched rings is less than 3.0 cm [30 mm], work-hardened portions shall be removed before testing by a heat treatment practice acceptable to both the producer and the purchaser. Spirally wound cores must also be heat treated before testing.

7.1.3 *Bars*:

7.1.3.1 Bar or rod specimens may be rolled, forged, machined, or cast. They shall be straight and of uniform cross section and of sufficient size to meet the requirements of the testing equipment used.

7.1.4 *Links*:

7.1.4.1 Link specimens have the shape of a ring, flattened to form semicircular ends and straight, parallel sides. The semicircular parts of a link shall have a ratio of mean diameter to radial width not less than 10:1.

8. Uniformity of Test Specimens

8.1 The cross section of the test specimens shall be as uniform along the magnetic path length as commercial practice permits. Any deviation from uniformity shall be as agreed upon between the producer and purchaser. Specimens shall be prepared and heat treated without warping. Cast specimens shall be machined or ground to a cross section uniform within 1 % unless otherwise agreed upon between the producer and the purchaser.

9. Cross-Sectional Area of Test Specimens

9.1 *Density Method*—The cross-sectional area shall be calculated from measurements of weight and length using a density value in accordance with Section 10. This method shall be used for the following specimen types:

9.1.1 Epstein strips.

9.1.2 Laminated stacks of rings or other shapes.

9.1.3 Spirally wound strip, tape, and wire cores.

9.1.4 Shaped bar and wire of a cross section not accurately measurable with a micrometer or calipers.

9.2 *Direct Measurement*—The cross-sectional area shall be calculated from direct measurements using a micrometer or caliper. This method shall be used for the following specimen types:

9.2.1 Bar and wire.

9.2.2 Rings machined from solid samples.

9.2.3 Powder metallurgically produced parts.

9.2.4 Cast parts.

9.2.5 Link specimens.

10. Density

10.1 For the determination of cross-sectional area of laminated or spirally wound test specimens, a calculation based on length, weight, and density is more accurate than measured dimensions.

10.1.1 Table 1 gives typical densities for commercial soft magnetic alloys.

10.2 *Electrical Steels (Customary Units)*:

10.2.1 For iron base alloys, the average relationship between density and silicon content or silicon and aluminum content, both in weight percent, is given by the equation:

$$\delta = 7.865 - 0.065\ (\text{percent silicon} + 1.7 \times \text{percent aluminum}) \quad (1)$$

where:

δ = density, g/cm^3.

10.3 *Electrical Steels (SI Units)*:

10.3.1 For iron base alloys, the average relationship between density and silicon content or silicon and aluminum content, both in weight percent, is given by the equation:

$$\delta = 7865 - 65\ (\text{percent silicon} + 1.7 \times \text{percent aluminum}) \quad (2)$$

where:

δ = density, kg/m^3.

10.4 *Other Materials*—For other alloys, the measured density or, if necessary, an estimated value, shall be used. Refer to

TABLE 1 Densities of Soft Magnetic Materials

Iron Base Alloys	Density (g/cm^3) [A]
Low carbon magnetic iron	7.86
17 % Cr Type 430 stainless	7.60
12 % Al-Fe	6.74
16 % Al-Fe	6.53
Silicon-Iron and Aluminum-Bearing Silicon-Iron Alloys	
(% Si + 1.7 × % Al)	Assumed density (g/cm^3)
0–0.62	7.85
0.63–1.38	7.80
1.39–2.15	7.75
2.16–2.92	7.70
2.93–3.69	7.65
3.70–4.46	7.60
4.47–5.23	7.55
Nickel-Iron Alloys	
45 % Ni-Fe	8.17
48.5 % Ni-Fe	8.25
52 % Ni-Fe	8.30
77 % Ni, 2 % Cr, 5 % Cu-Fe	8.58
78.5 % Ni-Fe	8.60
80 % Ni, 4 % Mo-Fe	8.74
80 % Ni, 5 % Mo-Fe	8.77
Nickel (99.95 % Ni + Co)	8.90
Cobalt-Iron Alloys	
27 % Co, 0.6 % Cr-Fe	7.95
36 % Co-Fe	8.00
49 % Co, 2 % V-Fe	8.12
49 % Co-Fe	8.15
Cobalt	8.85
Amorphous Alloys	
Iron base	7.20
Nickel base	7.90
Cobalt base	7.59

[A] To convert density to SI units of kg/m^3, multiply by 1000.

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Table 1 or to the appropriate ASTM specification for the density to be used in magnetic testing.

11. Temperature of Test

11.1 All tests shall be made at 25 ± 5°C unless agreed upon by the producer and purchaser.

12. Inspection and Rejection

12.1 If the results of the test of the original specimen fail to meet the specifications for the properties desired, then two additional specimens shall be prepared from the same test lot and tested. If the test results of each of these two additional test specimens meet the specifications, the test lot shall be accepted. When a report is required, the worst of the two passing retest values shall be reported.

13. Keywords

13.1 density; electrical steel; magnetic material; magnetic test

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