INTERNATIONAL

Designation: A348/A348M − 05 (Reapproved 2021)

Standard Test Method for Alternating Current Magnetic Properties of Materials Using the Wattmeter-Ammeter-Voltmeter Method, 100 to 10 000 Hz and 25-cm Epstein Frame[1]

This standard is issued under the fixed designation A348/A348M; 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 test method covers the determination of the magnetic properties of flat-rolled magnetic materials using Epstein test specimens with double-lap joints in the 25-cm Epstein frame. It covers determination of core loss, rms and peak exciting current, exciting power, magnetic field strength, and permeability. This test method is commonly used to test grain-oriented and nonoriented electrical steels but may also be used to test nickel-iron, cobalt-iron, and other flat-rolled magnetic materials.

1.2 This test method shall be used in conjunction with Practice A34/A34M and Test Method A343/A343M.

1.3 Tests under this test method may be conducted with either normal ac magnetization or with ac magnetization and superimposed dc bias (incremental magnetization).

1.4 In general, this test method has the following limitations:

1.4.1 *Frequency*—The range of this test method normally covers frequencies from 100 to 10 000 Hz. With proper equipment, the test method may be extended above 10 000 Hz. When tests are limited to the use of power sources having frequencies below 100 Hz, they shall use the procedures of Test Method A343/A343M.

1.4.2 *Magnetic Flux Density* (may also be referred to as *Flux Density*)—The range of magnetic flux density for this test method is governed by the test specimen properties and by the available instruments and other equipment components. Normally, for many materials, the magnetic flux density range is from 1 to 15 kG [0.1 to 1.5 T].

1.4.3 *Core Loss and Exciting Power*—These measurements are normally limited to test conditions that do not cause a test specimen temperature rise in excess of 50°C or exceed 100 W/lb [220 W/kg].

1.4.4 *Excitation*—Either rms or peak values of exciting current may be measured at any test point that does not exceed the equipment limitations provided that the impedance of the ammeter shunt is low and its insertion into the test circuit does not cause appreciably increased voltage waveform distortion at the test magnetic flux density.

1.4.5 *Incremental Properties*—Measurement of incremental properties shall be limited to combinations of ac and dc excitations that do not cause secondary voltage waveform distortion, as determined by the form factor method, to exceed a shift of 10 % away from sine wave conditions.

1.5 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.

1.6 *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.*

1.7 *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

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

Current edition approved June 1, 2021. Published June 2021. Originally approved in 1960. Last previous edition approved in 2015 as A348/A348M – 05 (2015). DOI: 10.1520/A0348_A0348M-05R21.

[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.

A340 Terminology of Symbols and Definitions Relating to Magnetic Testing

A343/A343M Test Method for Alternating-Current Magnetic Properties of Materials at Power Frequencies Using Wattmeter-Ammeter-Voltmeter Method and 25-cm Epstein Test Frame

3. Summary of Test Method

3.1 A representative sample of the magnetic material is cut into Epstein strips and then annealed or otherwise treated in accordance with the appropriate material specification or as agreed between producer and user. The strips are weighed and loaded into the Epstein frame becoming the transformer core. The primary coil is then excited with ac voltage and current at the frequencies and magnetic flux densities of interest and measurements taken. In some cases, a dc magnetic field strength is superimposed (incremental dc bias). The magnetic parameters are then calculated from the data.

4. Significance and Use

4.1 This test method evaluates the performance of flat-rolled magnetic materials over a wide frequency range of ac excitation with and without incremental dc bias, as used on transformers, motors, and other laminated core devices.

4.2 This test method is suitable for design, specification acceptance, service evaluation, and research.

4.3 The application of test results obtained with this test method to the design or evaluation of a particular magnetic device must recognize the influence of the magnetic circuitry upon its performance. Some specific items to consider are size, shape, holes, welding, staking, bolting, bracketing, shorting between laminations, ac waveform, adjacent magnetic fields, and stress.

5. Test Specimens

5.1 The test specimens shall consist of Epstein strips cut from sheets or coiled strips of magnetic materials in accordance with the test lot and sampling requirements of Practice A34/A34M, Sections 5 and 7, and Test Method A343/A343M, Annex A3 (see Note 1).

NOTE 1—Excessive burr and nonflatness of strips can appreciably affect test results.

5.1.1 If specimen is primarily isotropic, cut one half of the strips with grain and one-half cross grain. If anisotropic, cut all with grain. Other ratios of with and cross grain may be chosen by agreement.

5.2 The test specimen shall consist of multiples of four strips. The total number of strips shall be such as to:

5.2.1 Provide sufficient total losses to register within the range of required accuracy of the wattmeter.

5.2.2 Fill the available vertical opening space in the test frame to at least ¼ of its maximum height and

5.2.3 Contain a minimum of twelve strips.

5.3 Check each strip to assure its length and width are accurate to ±0.04 cm [0.4 mm]. If the length is not 30.5 cm [305 mm], use the actual length as described in Sections 9 and 10.

5.4 Table 1 shows the number of Epstein strips that will provide nominal weights of approximately 125, 250, 500, and 1000 g for various strip thicknesses.

6. Basic Circuit (see Fig. 1)

6.1 Fig. 1 shows the essential apparatus and basic circuit connections for this test. The ac source shall be capable of driving the test circuit with an ac sinusoidal waveform voltage of desired amplitude and frequency. The series resistance components, *r* and wattmeter current shunt, in conjunction with the ac source, shall be such as to provide a pure sine wave voltage either at the test frame transformer primary, or if overall negative feedback is implemented, then the pure sine wave shall be at the test frame transformer secondary. The wiring and switches shall be selected to minimize current or voltage reading errors, for example, the voltage connections across *r* shall be made precisely at the resistor terminals so that no wire resistance is effectively added to that of the resistor. Also, all voltage reading or negative feedback components across the secondary of the test frame transformer shall cause negligible loading, that is, shall draw sufficiently low currents to not appreciably affect power or current readings. When a common ground connection is made between primary and secondary of the test frame transformer, the ac source ground connection must be isolated to eliminate ground loop current.

7. Apparatus

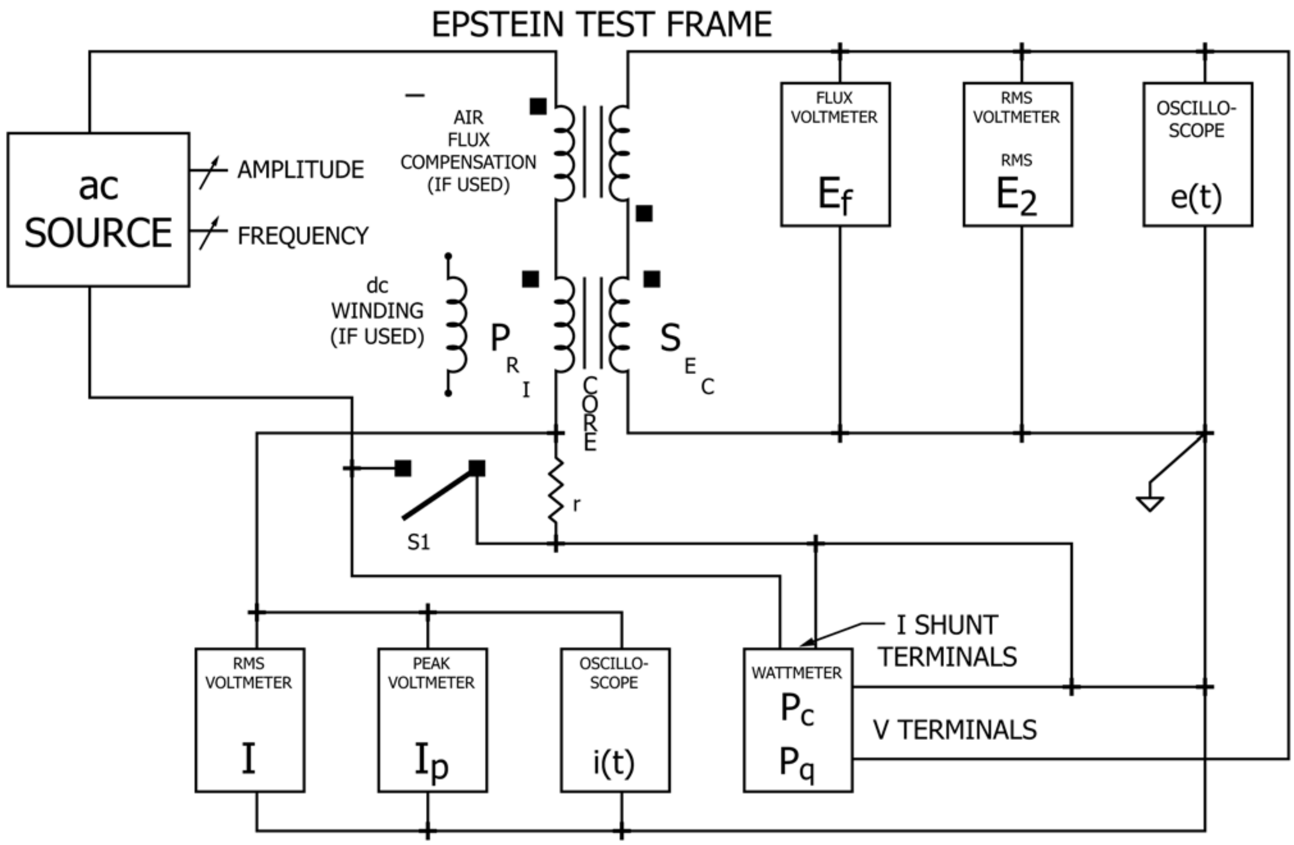
7.1 The test apparatus shall consist of as many of the following components as required to perform the desired measurement functions:

7.2 *Balance or Scale*—The balance or scales used for determining the mass of the test specimen shall weigh to an accuracy of 0.05 %. The calculated test voltage E_f is directly proportional to specimen mass and magnetic flux density (see Note 2).

TABLE 1 Number of Strips for Various Nominal Specimen Weight Epstein Frames (Minimum Strip Length is 28 cm [280 mm])

Nominal Strip Thickness		Number of Strips for Test Specimens of Nominal Weight			
Thick (cm)	Thick (in.)	125 g	250 g	500 g	1000 g
0.079	0.0310	...	...	12	20
0.071	0.0280	...	...	12	24
0.064	0.0250	...	...	12	24
0.056	0.0220	...	...	16	28
0.047	0.0185	...	12	16	32
0.043	0.0170	...	12	20	36
0.039	0.0155	...	12	20	40
0.036	0.0140	...	12	24	44
0.032	0.0125	...	12	24	48
0.028	0.0110	...	16	28	56
0.025	0.0100	...	16	32	60
0.023	0.0090	...	16	36	68
0.020	0.0080	12	20	40	76
0.018	0.0070	12	24	44	88
0.015	0.0060	12	24	52	[A]
0.013	0.0050	16	32	60	[A]
0.010	0.0040	20	40	76	[A]
0.0076	0.0030	24	52	[A]	[A]
0.0051	0.0020	40	76	[A]	[A]
0.0025	0.0010	76	[A]	[A]	[A]

[A] Not recommended.



NOTE 1—The ac source terminals must "float" to prevent ground loop currents. If the wattmeter has a common connection between its V and I terminals, the rest of the circuit must be connected so as to prevent shorting.

NOTE 2—If, during demagnetization, current exceeds the wattmeter maximum rating, Switch S1 is required and is closed.

NOTE 3—A dc winding is required only if incremental properties are to be tested.

NOTE 4—The voltage and current monitoring oscilloscope may be a dual channel type and is optional equipment. Basic circuit-wattmeter-ammeter-voltmeter method, 100 to 10 000 Hz and 25-cm Epstein frame

FIG. 1 Basic Circuit-Wattmeter-Ammeter-Voltmeter Method, 100 to 10 000 Hz and 25–cm Epstein Frame

NOTE 2—Errors in the weight of a specimen will cause errors in magnetic flux density, core loss, and exciting power.

7.3 *Epstein Test Frame:*

7.3.1 The dimensions of the windings, their spacing, and the general precautions and construction details of Test Method A343/A343M, Annex A1, shall apply. The Epstein test frame should be selected to be compatible with the desired test specimen size (see 5.4).

7.3.2 The following numbers of total winding turns are usually commercially available and are suggested for testing at various frequencies:

Frequency, Hz	No. of Turns (Both Primary and Secondary)
Up to 400	700 or 352
400 to 1000	352
1000 to 5000	200 (no air-flux compensator)
5000 to 10 000	100 (no air-flux compensator)

7.3.3 The primary winding is uniformly distributed along the magnetic path and may be wound in multiple layers over the secondary winding. The secondary winding shall be the innermost winding on the coil form and shall be a single layer winding. The primary and secondary shall be wound in the same direction and their starting end connections shall be made at the same corner.

7.3.4 *Air Flux Compensator*—If the Epstein test frame has more than 200 turns, it shall contain an air flux compensator which opposes and balances out the air flux voltage induced in the secondary winding. Such compensation is necessary whenever the permeability of the test specimen is low under high magnetic field strength conditions to avoid serious errors in setting the flux voltage. The air flux compensator allows the true intrinsic induction B_i to be measured. When tests are restricted to moderate magnetic flux density and field strength where test specimen relative permeability remains high, the difference between B and B_i is small and air flux compensation is unnecessary.

7.4 *Flux Voltmeter*—A full wave true average responsive voltmeter calibrated so that its scale reads true average $\times\pi\sqrt{2}/4$, and indicates the same value as an rms voltmeter when measuring pure sine waves, shall be provided for measuring the peak value of the test induction. To meet the precision of this test method, meter error shall not exceed 0.25 % (see Note 3). If the meter impedance is not sufficiently high at the frequency of test, it is necessary to compensate for its loading effect. To evaluate how much the meter loads the circuit, read the rms ammeter and rms voltmeter before and