Designation: A927/A927M − 18 (Reapproved 2022)

Standard Test Method for Alternating-Current Magnetic Properties of Toroidal Core Specimens Using the Voltmeter-Ammeter-Wattmeter Method[1]

This standard is issued under the fixed designation A927/A927M; 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 several ac magnetic properties of either laminated ring or toroidal tape wound cores made from flat rolled product.

1.2 This test method covers test equipment and procedures for determination of specific core loss, specific exciting power, and peak permeability for power and audio frequencies (50 Hz to 20 000 Hz) under sinusoidal flux conditions.

1.3 This test method, because of the use of a feedback-controlled power amplifier, is well suited for determination of ac magnetic properties at magnetic flux densities above the knee of the magnetization curve and is particularly useful for testing of high-saturation iron-cobalt alloys (for example, alloys listed in Specification A801), although use of this test method is not restricted to a particular type of material.

1.4 This test method shall be used in conjunction with Practice A34/A34M and Terminology A340.

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. 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 non-conformance with the 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

A340 Terminology of Symbols and Definitions Relating to Magnetic Testing

A697/A697M Test Method for Alternating Current Magnetic Properties of Laminated Core Specimen Using Voltmeter-Ammeter-Wattmeter Methods

A801 Specification for Wrought Iron-Cobalt High Magnetic Saturation Alloys (UNS R30005 and K92650)

3. Significance and Use

3.1 This test method is a derivative of Test Method A697/A697M specifically designed for testing of toroidal cores which are not covered in Test Method A697/A697M and for testing at magnetic flux densities above the knee of the magnetization curve.

3.2 Specimen size typically ranges from 1 in. to 1.25 in. [25.4 mm to 31.8 mm] in inside diameter to 1.5 in. [38.1 mm] in outside diameter with weights ranging from 30 g to 60 g. Provided the test equipment is suitably chosen, there is no obvious limit to the overall size of core that can be tested. If basic material properties are desired, then the requirements of 5.1 must be observed.

3.3 The reproducibility and repeatability of this test method are such that this test method is suitable for design, specification acceptance, service evaluation, and research and development.

3.4 When testing under sinusoidal flux conditions at magnetic flux densities approaching saturation, highly peaked magnetizing waveforms will be present, and the test instruments used must have crest factor capabilities of at least 3; otherwise erroneous results will be obtained.

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[1] This test method is under the jurisdiction of ASTM Committee A06 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.

4. Apparatus

4.1 The apparatus for testing under this test method shall consist of as many of the components, described below and schematically illustrated in Fig. 1, as required to perform the measurements.

4.2 *Signal Generator*—For testing at other than line frequency (50 Hz or 60 Hz), a low distortion sine wave signal generator is required. The frequency accuracy of the signal generator should be within ±0.1 %. To prevent dc biasing of the magnetizing current waveform, a blocking capacitor or isolation transformer should be installed between the signal generator and power amplifier.

4.3 *Power Amplifier*—A linear power amplifier should be used (see Note 1). The signal from the secondary winding of the test specimen is used for negative feedback control of the magnetizing waveform. Depending on the power amplifier used, it may be necessary to install feedback signal conditioning equipment such as an attenuator or amplifier; however, the signal conditioning equipment must not distort the feedback waveform nor load the secondary winding. Fig. 1 also shows an audio choke connecting the output and feedback terminals of the amplifier. This choke is intended to prevent dc bias being introduced into the magnetizing waveform by providing dc feedback to the power amplifier. Without such a choke, the dc offset current present in certain power amplifiers will result in large dc output currents. This choke may not be needed depending on the make and model of power supply. Further reduction or elimination of bias can be achieved by installing an isolation transformer to transformer couple the primary circuit.

NOTE 1—Audio amplifiers are suitable in some instances, although the small specimen cross section and the relatively few primary turns typically used results in a low Q circuit and, therefore, difficulty in maintaining sinusoidal flux at magnetic flux densities approaching saturation. In addition, an impedance matching transformer may be required to improve power transfer.

4.4 *Wattmeter*—An electronic wattmeter with appropriate voltage, current and wattage ranges, and bandwidth must be used. The full-scale accuracy of the wattmeter must be better than ±0.5 %. The wattmeter must have a crest factor capability of at least 3 and be capable of accurate measurements at low-power factors. The wattmeter must be able to measure rms current and rms voltage to an accuracy of ±0.5 % or better; otherwise, separate instruments meeting this accuracy requirement must be used.

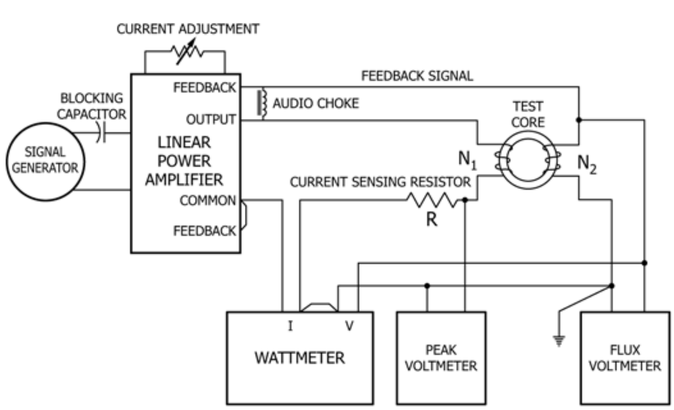

FIG. 1 Schematic Illustration of Test Apparatus

4.5 *Flux Voltmeter*—The flux voltmeter must be a true average responding, high-impedance voltmeter calibrated to read $\sqrt{2}\ \pi/4$ times the full wave rectified average voltage so that its indications will be identical to those of a true rms voltmeter when reading a pure sinusoidal voltage. The rated full-scale accuracy must be ±0.5 % or better.

4.6 *Current-Sensing Resistor (Optional)*—When peak permeability is to be measured, a noninductive, high-precision, low-thermal coefficient of resistance current-sensing resistor shall be used. The resistor must be rated to carry the maximum current used in the test.

4.7 *Peak Voltmeter (Optional)*—When peak permeability is to be determined, a high-impedance peak-reading voltmeter shall be used to measure the voltage drop across the current-sensing resistor. The voltmeter must have a full-scale accuracy of ±1 % or better, a crest factor of at least 3, and appropriate bandwidth.

4.8 *Oscilloscope (Optional)*—An oscilloscope displaying both the magnetizing current waveform and secondary voltage permits the operator to observe the waveforms. This is particularly useful when setting up the test for the first time. The oscilloscope must have a very high input impedance to avoid loading of the secondary winding.

5. Test Specimen

5.1 The test specimen must be either a stack of toroidal (washer ring) laminations formed by punching, machining, or etching or a toroidal tape wound core. For measurement of basic material properties, the ratio of inside to outside diameter must be 0.82 or greater.

6. Procedure

6.1 The test specimen should be heat treated after fabrication. Bent or otherwise damaged laminations or tape cores shall be discarded.

6.2 The core shall be weighed to an accuracy of ±0.1 % or better and the inside and outside diameters measured to an accuracy of 0.1 % or better.

6.3 The laminations or tape core should be enclosed in a rigid, nonconductive case (core box) or placed in a suitable fixture to avoid winding stresses. The test core should fill the core box or fixture as fully as possible to minimize air flux.

6.4 Primary and secondary windings, N_1 and N_2, are applied; the secondary winding should be applied first. Both windings should be uniformly wound over the circumference of the toroid. The secondary winding may use finer diameter wire than the primary winding, which should be of sufficient diameter to carry the magnetizing current without overheating. Alternately, a fabricated magnetizing fixture may be used provided the windings are uniformly distributed over the length of the core.

6.5 If the number of turns on the secondary winding is not equal to the number of turns on the primary winding, additional