Designation: D3353 – 18 (Reapproved 2024)

Standard Test Methods for Fibrous-Insulated Magnet Wire[1]

This standard is issued under the fixed designation D3353; 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 These test methods cover the testing of fibrous-insulated electrical conductors, commonly referred to as magnet wire, which are used in electrical apparatus. The test methods are intended primarily for evaluation of the electrical insulating materials used. It is intended that these test methods be used, except where modified by individual specifications for particular applications.

1.1.1 These test methods apply to those magnet wires that are fiber-covered and in which the substrate is bare conductor or is coated with an underlying insulating film as covered by Test Methods D1676. Fiber-covered wires are produced by serving helically or wrapping fibers or fibrous-tape insulation uniformly around the wire in single and multiple layers. The served or wrapped materials are bonded or not bonded to the underlying wire.

1.2 The test methods appear in the following sections:

Procedure	Section
Measurement of Dimensions	7
Electrical Resistance of Conductors	5
Elongation	4
Adhesion and Flexibility	8
Fibrous Coverage	6
Dielectric Breakdown Voltage	9

1.3 This standard and IEC 60851 are similar if not equivalent in technical content.

1.4 This standard and NEMA MW 1000 are similar if not equivalent in technical content.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered 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.* See 8.4.1 and 9.4.1 for specific caution statements.

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]

B193 Test Method for Resistivity of Electrical Conductor Materials

D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

D1676 Test Methods for Film-Insulated Magnet Wire

D1711 Terminology Relating to Electrical Insulation

D5423 Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation

E8 Test Methods for Tension Testing of Metallic Materials [Metric] E0008_E0008M

2.2 *Other Standards:*

IEC 60851 Methods of Test for Winding Wires[3]

NEMA Standards Publication No. MW 1000 on Magnet Wire[4]

3. Terminology

3.1 *Definitions*:

3.1.1 For definitions of terms used in this test method, refer to Terminology D1711.

3.1.2 *Definition of Term(s) Specific to this Standard*:

3.1.2.1 *serving*—a uniform wrapping of fibrous insulation around a magnet wire of bare conductor.

3.1.2.2 *fibrous coverage, of served-magnet wire*—that characteristic which allows a fibrous served magnet wire to be

[1] These test methods are under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and are the direct responsibility of Subcommittee D09.12 on Electrical Tests.

Current edition approved March 1, 2024. Published March 2024. Originally approved in 1974. Last previous edition approved in 2018 as D3353 – 18. DOI: 10.1520/D3353-18R24.

[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.

[3] Available from International Engineering Consortium, 549 West Randolph Street, Suite 600, Chicago IL 60661–2208.

[4] Available from National Electrical Manufacturers Association (NEMA), 1300 N. 17th St., Suite 1752, Rosslyn, VA 22209, http://www.nema.org.

wound around mandrels in a prescribed manner without causing observable openings in the fibrous coverage.

4. Elongation

4.1 *Scope*—This test method covers the determination of the elongation of fibrous insulated magnet wire that results in a fracture of the conductor.

4.2 *Significance and Use*—The elongation determined by this test method provides a general measure of the ductility of the conductor and the effect of the processing to which it has been subjected during the insulating operation.

4.3 *Apparatus*—The equipment shall have a minimum separation sufficient to attach and measure the length of the test specimen between grips, and be capable of elongating the specimen to its breaking point, at a constant rate. The equipment shall be such that the error of the length measurement will be 1 % or less. Suitable, non-slip grips are required that will not damage the specimen in the region of elongation. Drum or capstan type grips have been found to be unsatisfactory.

NOTE 1—See Test Methods E8 for a discussion of machines, gripping devices, and rates of stressing.

4.4 *Procedure:*

4.4.1 Remove the fibrous insulation without distorting the conductor for wire sizes 0.0253 in. (0.6426 mm) (AWG 22) and finer. Do not remove the fibrous insulation from sizes larger than 0.0253 in. (0.6426 mm) (AWG 22).

4.4.2 *Standard Method:* Insert the test specimen into the grips resulting in an original length of 10 ± 0.1 in. (254 ± 2.5 mm) to be stretched. Elongate the wire at a constant rate of 12 ± 1 in./min (305 ± 25 mm/min) until the conductor breaks. Determine the length at break by measuring the final distance between the grips. Discard the results for any specimens that break within ¼ in. (6 mm) of the grips. When breaks occur frequently in this manner, a need for modification of the equipment or technique is indicated.

4.4.3 *Bench Mark Method:* Rectangular, square, or round wire larger than 0.0651 in. (1.654 mm) in diameter is allowed to be tested using bench marks. Measure the original length between bench marks to ensure the distance between the bench marks is 10 ± 0.1 in. (254 ± 2.5 mm). Insert the wire specimen into the grips and locate the bench marks centrally and not more than ½ in. (12.7 mm) from either grip. Elongate the wire specimen at a constant rate of 12 ± 1 in./min (305 ± 25 mm/min) until the conductor breaks. Match the broken ends of the specimen, place together, and measure the final length to the nearest 0.1 in. at break between the bench marks. In order to minimize the effect of local variations in the wire under test, test three specimens of the sample. Discard the results for any specimens that break within ¼ in. (6 mm) of the grips or the bench marks. When breaks occur frequently in this manner, a need for modification of the equipment or technique is indicated.

4.5 *Calculation*—Calculate the elongation as follows:

$$\text{Elongation, \%} = [(A - B)/B] \times 100 \quad (1)$$

where:

A = length at break, and

B = original length

4.6 *Report the Following Information:*

4.6.1 Bare conductor dimensions,
4.6.2 Bare conductor material,
4.6.3 Type and build of film insulation,
4.6.4 Type of fibrous-insulation,
4.6.5 Number of servings,
4.6.6 Direction of servings,
4.6.7 Type of varnish,
4.6.8 Whether or not bench marks are used, and
4.6.9 Individual and average elongation.

4.7 *Precision and Bias:*

4.7.1 This test method has been in use for many years, but no statement of precision has been made and no activity is planned to develop such a statement.

4.7.2 No information is presented on the bias of this procedure in Section 4, for measuring the percent elongation, as no material having an accepted reference value is available.

5. Electrical Resistance of Conductors

5.1 *Scope*—This test method covers the determination of the electrical resistance of fibrous insulated magnet wire conductors.

5.2 *Significance and Use*—Accurate control of resistance is necessary to meet apparatus design parameters. Resistance is expressed in terms of ohms per unit length corrected to 20 °C (68 °F) and is a function of conductor dimensions, resistivity, and temperature. Resistance is affected by the processing operation.

5.3 *Apparatus*—The types of apparatus utilized for measuring resistance and length are specified in Test Method B193.

5.4 *Procedure*—Remove the insulation on both ends of the test specimen for electrical contact. The cleaning operation must not affect the conductor dimensions. Determine the electrical resistance of the test specimen.

NOTE 2—While balancing the bridge, care must be taken to prevent excessive heating of the specimen as a result of prolonged current, and to avoid changes in temperature due to air drafts or to variations in ambient conditions.

5.5 *Report the Following Information:*

5.5.1 Bare conductor dimensions,
5.5.2 Bare conductor material,
5.5.3 Type and build of film insulation,
5.5.4 Type of fibrous-insulation,
5.5.5 Number of servings,
5.5.6 Direction of servings,
5.5.7 Type of varnish,
5.5.8 Test temperature,
5.5.9 Specimen length,
5.5.10 Apparatus used,
5.5.11 Resistance reading, and
5.5.12 Resistance ohms per unit length corrected to 20 °C (68 °F).

5.6 *Precision and Bias:*