Designation: A 717/A 717M – 01

Standard Test Method for Surface Insulation Resistivity of Single-Strip Specimens [1]

This standard is issued under the fixed designation A 717/A 717M; 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 a means of testing the surface insulation resistivity of single strips or punchings of flat-rolled electrical steel under predetermined conditions of voltage, pressure, and temperature.

1.2 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. 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.

1.3 *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:*

A 34 Practice for Sampling and Procurement Testing of Magnetic Materials [2]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 The term *surface insulation resistivity* used in this method refers to the effective resistivity of a single insulative layer tested between applied bare metal contacts and the base metal of the insulated test specimen. It is not the same as the terms interlaminar resistivity and stack resistivity, which refer to the average resistivity of two adjacent insulative surfaces in contact with each other.

3.2 The apparatus is popularly known as a Franklin tester.

4. Summary of Test Method

4.1 Ten metallic contacts of fixed area are applied to one of the surfaces of the specimen and electrical contact is made with the base metal by two drills. The effectiveness of the surface insulation is then indicated by a measurement of average electrical current flowing between the contacts and the base metal under specified applied voltage. This measurement can be used directly as an indicator of insulation quality or may be converted to an apparent surface insulation resistivity value.

5. Significance and Use

5.1 This test method is particularly suitable for quality control in the application of insulating coatings.

5.2 Surface insulation resistivity is evaluated from a dc current that can range from 0 (perfect insulator) to 1 A (perfect conductor).

5.3 Single readings should not be considered significant since the nature of the test device and specimen are such that successive measurements of a specimen often yield different values.

6. Apparatus

6.1 The apparatus, as shown in Fig. 1 and Fig. 2, shall consist of a contact unit or test head which is attached to the head of a hydraulic press. Its associated measuring equipment, which may be remotely located, includes an ammeter, voltmeter, and voltage regulated dc power supply. When measurements are to be made at elevated temperatures, the platen beneath the specimen is heated and controlled. Detailed descriptions of the various components are given in Annex A1.

7. Sampling

7.1 Samples shall be representative of the steel and shall be cut in a manner to assure representative sampling as described in Practice A 34.

8. Test Specimen

8.1 The width and length of a specimen strip shall be greater than the width and length respectively of the assembly of contacts. The suggested minimum specimen size is 2 by 5 in. [50 by 130 mm].

8.2 A minimum of five specimen strips is recommended.

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[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.

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[2] *Annual Book of ASTM Standards,* Vol 03.04.

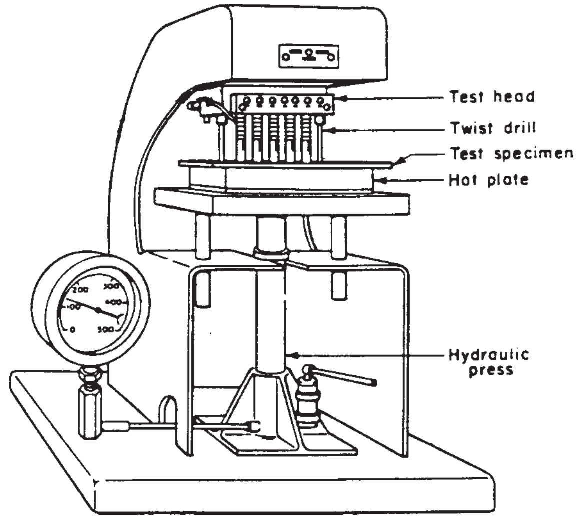

FIG. 1 Apparatus of Surface Insulation Resistivity Measurement

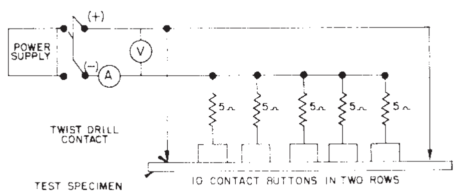

FIG. 2 Diagram of Connections for Contacts and Resistors

8.3 By mutual agreement, tests may be run on Epstein test strips. The Epstein specimens may be less satisfactory than the minimum size specimen suggested in 8.1 because of the tilting effect due to burrs, shearing strains, and disturbances in the coating.

9. Procedure

9.1 To ensure correct contact button conditions, make a short circuit test occasionally by testing a bare metal surface. When the short circuit current is less than 0.99 A, clean the contacts. The use of solvents for cleaning is preferred to abrasives because the latter can result in rounded tips with reduced contact areas.

9.2 The recommended standard pressure for purpose of comparative tests shall be 300 psi [2.1 MPa]. Other pressures, depending upon the application, may be agreed upon by the manufacturer and the purchaser. If more than one test pressure is to be used, apply the pressures in ascending order. During testing, apply the pressures only once, but an applied pressure may be increased to a higher value.

9.3 If both sides of the specimen are coated, do not use the same area to test both sides.

9.4 The recommended standard test temperatures are room temperature and 300°F [150°C]. Other temperatures and the sequence of temperatures, depending upon the application, may be agreed upon by the manufacturer and the purchaser.

9.5 When tests are made at elevated temperatures allow sufficient time (usually 30 s) to heat the specimen to the specified temperature.

9.6 When the insulation may be hygroscopic, a conditioning procedure immediately prior to testing should be mutually agreed upon by manufacturer and purchaser.

9.7 Place the specimen on the platen beneath the test head and position it so that all contacts are within the test area when the test head is brought in contact with the specimen. Apply the specified pressure. Check that the voltage is 0.50 V and read the ammeter.

10. Calculations

10.1 The average of electrical current measurements is usually acceptable for evaluating surface insulation. Average the current readings for each surface. The reported value for a sample shall be the average of both surfaces.

10.2 R_i, the surface insulation resistivity of the test sample (two surfaces in series), may be calculated from I, the average ammeter reading in A, as follows:

$$R_i = 6.45((1/I) - 1) \text{ in } \Omega\cdot\text{cm}^2/\text{lamination}, \quad (1)$$

or

$$R_i = 645((1/I) - 1) \text{ in } \Omega\cdot\text{mm}^2/\text{lamination}.$$

10.3 The equations in 10.2 may be derived as shown in Annex A2.

11. Precision and Bias

11.1 Even with the best practices in design, instrumentation, maintenance, and operation, the repeatability and reproducibility of the test method are greatly influenced by the nature of the surfaces of the test specimens. Hence it is not considered possible to state meaningful values for repeatability and reproducibility that are universally applicable.

12. Keywords

12.1 coating; electrical steel; Franklin tester; insulation; resistivity; single-strip specimens; surface insulation resistivity

ANNEXES

(Mandatory Information)

A1. APPARATUS

A1.1 *Test Head*—The test head shall consist of a mounting block on which are assembled:

A1.1.1 Two parallel longitudinal rows of five vertically mounted steel rods free to move axially against surrounding spiral springs or other means to apply equal pressure.

A1.1.2 Brass, stainless steel, or other suitable metallic contact button on each rod, but insulated from it. Articulation of tips improves contact by compensating for minor misalignments. Avoid soft metals, poor conductors, or metals subject to oxidation or attack by solvents used in cleaning. Due to low-voltage circuitry (0.5 V) all contacting surfaces must be kept clean. Full area contact of tips to coreplate is needed to avoid decreases in Franklin amperage. Check with known samples or standard test blocks. The contact area of each of the ten contact buttons shall be 0.645 cm^2[64.5 mm^2].

A1.1.3 A 5-Ω (±0.1 %) resistor connected to each contact button. Contacts with their individual resistors shall be connected in parallel as shown in Fig. 2.

A1.1.4 Electrical contact with the base metal is made through two ⅛ in. [3 mm] diameter twist drills (preferably carbide-tipped) or hardened and pointed rods. These are vertically mounted and spring loaded in spiral slotted sleeves to impart a twist while piercing the coating.

A1.2 *Hydraulic Press*—The hydraulic press shall have a capacity of 2000 lb [10 000 N], with mountings to accommodate the test head, test specimens or punchings, and a hot plate. The press or hot plate must provide a smooth, flat, and rigid support for the test specimen.

A1.3 *Hot Plate*—The hot plate, when used, shall be suitable for heating to the temperature of test with automatic control to maintain the test temperature.

A1.4 *Test Head Power Supply*—The voltage regulated dc power supply should be capable of voltage regulation of at least 0.5 % at 0.5 V during load changes from zero to 1.0 A and line voltage variations of ±10 %. This maintains the voltage adequately accurate during test and eliminates the necessity for manual voltage adjustment.

A1.5 *Ammeter*—The dc ammeter should be a low impedance 0 to 1 A digital type rated for 0.1 % or better accuracy and have resolution of 0.01 A.

A1.6 *Voltmeter*—The dc voltmeter should be a high impedance 0 to 1 V digital type rated for 0.1 % or better accuracy and have resolution of 0.01 V.

A1.7 *Hot Plate Power Supply*—The plate power supply and temperature control equipment should be capable of automatic temperature control and variable setting features. It may use thermocouples or other temperature sensing elements, but must be able to maintain temperature of the hot plate within 10 F degrees [5 C degrees] of the set temperature.

A2. DERIVATION

A2.1 The equations in 10.2 may be derived as follows:

$$I = E\sum_{n=1}^{10} 1/(R_s + R_n) = 10E/(R_s + (R_j/A_b))$$
$$R_j = A_b(R_s + (10E/I)) \tag{A2.1}$$
$$R_i = 2R_j = 2A_b((10E/I) - R_s)$$

where:

I = ammeter reading in A,
E = applied voltage in V,
= 0.5V,
R_s = resistance of resistor in series with each contact button in Ω,
= 5Ω,
R_n = resistance of surface between single contact button and base metal of the test specimen in Ω,
R_j = surface insulation resistivity of one surface of test sample in Ω·cm^2/surface or Ω·mm^2/surface,
A_b = area of each contact button in cm^2 or mm^2
= 0.645 cm^2 or 64.5 mm^2,
R_i = surface insulation resistivity of test sample (two surfaces in series) in Ω·cm^2/lamination or Ω·mm^2/lamination.