Designation: D 1673 – 94 (Reapproved 1998)

An American National Standard

Standard Test Methods for Relative Permittivity And Dissipation Factor of Expanded Cellular Polymers Used For Electrical Insulation[1]

This standard is issued under the fixed designation D 1673; 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.

INTRODUCTION

Although fundamentally similar to test methods used for solid electrical insulating materials in sheet or plate form, certain modifications in the procedures and measurement techniques are necessary for the proper determination of the relative permittivities and dissipation factors of foamed or expanded cellular polymers. This is occasioned by the fact that in many, if not most, instances expanded cellular materials have surfaces that preclude the use of conventional electrodes such as metal foil attached by petrolatum and similar adhesives, or conducting silver paint applied by brushing or spraying. Furthermore, it is generally true that slabs or plates of expanded cellular materials are available only in substantially greater thicknesses than those commonly used for test specimens of solid insulation.

1. Scope

1.1 These test methods cover procedures for determining the relative permittivities and dissipation factor of flat sheets or slabs of expanded cellular polymers of both the rigid and flexible types, at frequencies from 60 Hz to 100 MHz. Provision is made for measurements on specimens up to 50 mm (2 in.) in thickness, but it is recommended that specimens greater than 25 mm (1 in.) in thickness shall be tested at frequencies up to a maximum of only about 1 MHz.

1.2 *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:*

D 150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials[2]

D 374 Test Methods for Thickness of Solid Electrical Insulation[2]

D 1056 Specification for Flexible Cellular Materials Sponge or Expanded Rubber[3]

D 1711 Terminology Relating to Electrical Insulating Materials[2]

3. Terminology

3.1 For definitions of relative permittivity, dissipation factor, and loss index, refer to Test Methods D 150 or Terminology D 1711.

4. Significance and Use

4.1 *Relative Permittivity*:

4.1.1 Because a relatively large proportion of their volumes are composed of more or less uniformly distributed, isolated or interconnected gas-filled cells, foamed or expanded cellular polymers always have lower relative permittivities, at a given frequency and temperature, than the solid base resins from which they are prepared.

4.1.2 The relative permittivities of expanded cellular polymers are important because they determine the increase in capacitance between conductors, or between conductors and ground, that will result when a circuit or component is encapsulated in such a material, over their corresponding values before encapsulation (when air is the surrounding medium). Likewise, the relative permittivities of an expanded cellular polymer may serve as a measure of the decrease of such capacitances caused by substitution of the expanded material for a solid encapsulating compound or resin of known relative permittivity.

[1] These test methods are under the jurisdiction of ASTM Committee D-9 on Electrical and Electronic Insulating Materials and are the direct responsibility of Subcommittee D 09.12 on Electrical Tests.

Current edition approved Jan. 15, 1994. Published March 1994. Originally published as D 1673 – 59 T. Last previous edition D 1673 – 79 (1989) $^{\epsilon 1}$.

[2] *Annual Book of ASTM Standards*, Vol 10.01.

[3] *Annual Book of ASTM Standards*, Vol 09.02.

4.1.3 In transmission lines, such as coaxial cable, television lead-in cables, etc., the reduction of relative permittivity of an expanded material from its value in the original solid state has significant usefulness in design, since the capacitance per foot of cable, and such cable characteristics as velocity of propagation and characteristic impedance are all dependent upon the relative permittivity of the insulating material.

4.1.4 In wave guides, radomes, dielectric lenses, etc., for use at radio frequencies, if the cellular polymer is nonmagnetic, the relative permittivity (usually in combination with the dissipation factor) determines such transmission characteristics as velocity of propagation, attenuation distance, decibel loss per meter, phase factor, complex index of refraction, index of absorption, and dielectric conductivity.[4]

4.1.5 The relative permittivity determination may serve as a production control test for batch-to-batch uniformity of a given expanded cellular polymer. For expanded cellular nonpolar polymers (polyethylene, polystyrene, etc.), the relative permittivity measurement may constitute a useful control test on the density of the product.

NOTE 1—For useful information concerning the relationship of the relative permittivity of an expanded cellular material to its density and to the relative permittivity of the solid constituent, see Appendix X1.

4.2 *Dissipation Factor and Loss Index*:

4.2.1 The loss index of an expanded cellular polymer is a measure of the ac power loss in the material. When two materials have the same relative permittivities, their relative dielectric losses per unit volume at a given frequency and applied voltage gradient are directly indicated by their respective dissipation factors.

4.2.2 Since the dielectric loss in an insulating material results in the generation of heat, with a subsequent rise in temperature of the material, it is desirable in most cases that these losses be as low as possible. This is important not only from the standpoint of the overall efficiency of an electrical system but also because the increased temperature generally causes significant changes in both the relative permittivity and loss and thereby may contribute to instability of operation, particularly in radio-frequency circuits.

4.2.3 The dielectric loss, as measured by the dissipation factor and loss index, may serve as a quality control criterion and as a means of determining batch-to-batch uniformity of a product. It is also an excellent means of measuring the effects of weathering, aging, and absorption of moisture by the expanded cellular polymer, these influences generally resulting in substantial increases in the dielectric loss index.

4.2.4 The dissipation factor (usually in combination with the relative permittivity) is useful in estimating the contribution of the dielectric loss to the total attenuation in coaxial cables, and in calculations of the transmission characteristics of radomes, dielectric lenses, and related devices, as indicated in 4.1.4.

[4] For details see von Hippel, A. R., *Dielectrics and Waves*, Part I, John Wiley & Sons, Inc., New York, NY 1954, Ch. 9, pp. 26–37.

5. Apparatus

5.1 *Electrical Measurement Apparatus*, consisting of suitable bridge and resonant-circuit equipment having characteristics as prescribed in Test Methods D 150. Provision shall be made for the performance of relative permittivity and dissipation factor tests at any desired frequency in the range between 60 Hz and 100 MHz.

6. Electrodes

6.1 Expanded cellular polymers, in general, do not have surfaces suitable for attachment of conventional metal foil or conducting paint electrodes, so that prefabricated rigid metal plate electrodes must usually be employed for relative permittivity and dissipation factor tests. Such electrode systems may be of either the direct contact type or the noncontacting type.

6.2 *Direct-Contact Electrode Systems*— Direct-contact type electrodes may be one of the following:

6.2.1 A calibrated micrometer electrode system of the Hartshorn-Ward type, shown in Fig. 1 (Fig. 10 of Test Methods D 150), is particularly useful for samples 50 mm (2 in.) in diameter and up to about 6.35 mm (0.25 in.) thick. This system may be used at any frequency up to 100 MHz. Specimens are lightly clamped and in contact with both electrodes. Care must be observed to avoid compressing or crushing the material.

6.2.2 Two rigid plate electrodes with a single sheet specimen between and in contact with them may be used with the specimen the same size as the electrodes (see Table 1). It may be desirable to enclose this system in a metal box for shielding. A wide range of specimen sizes and thicknesses may be handled by various modifications of this system. However, the upper frequency limit is relatively low for larger thick specimens.

6.2.3 A three-plate electrode system with a double specimen arranged in a sandwich form may be used and is recommended for large sheets of thick materials for tests at relatively low frequencies. The two specimens should be of nearly the same thickness. The two outer plates are connected together and to ground or to the low side of the measuring apparatus. The third (middle) electrode serves as the high side. The system has the advantage of being practically self-shielding.

6.3 *Noncontacting Electrode Systems* (*"Air Gap" Methods*):

6.3.1 A calibrated micrometer electrode system of the Hartshorn-Ward type, shown in Fig. 1 may be used, with the

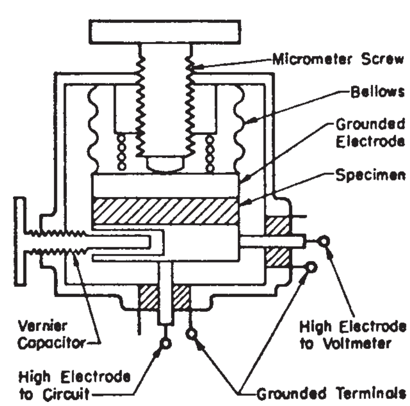

FIG. 1 Micrometer Electrode System