



Designation: D7449/D7449M – 22a

Standard Test Method for Measuring Relative Complex Permittivity and Relative Magnetic Permeability of Solid Materials at Microwave Frequencies Using Coaxial Air Line¹

This standard is issued under the fixed designation D7449/D7449M; 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 procedure for determining relative complex permittivity (relative dielectric constant and loss) and relative magnetic permeability of isotropic, reciprocal (non-gyromagnetic) solid materials. If the material is nonmagnetic, it is acceptable to use this procedure to measure permittivity only.

1.2 This measurement method is valid over a frequency range of approximately 1 GHz to over 20 GHz. These limits are not exact and depend on the size of the specimen, the size of coaxial air line used as a specimen holder, and on the applicable frequency range of the network analyzer used to make measurements. The size of specimen dimension is limited by test frequency, intrinsic specimen electromagnetism properties, and the request of algorithm. For a given air line size, the upper frequency is also limited by the onset of higher order modes that invalidate the dominant-mode transmission line model and the lower frequency is limited by the smallest measurable phase shift through a specimen. Being a non-resonant method, the selection of any number of discrete measurement frequencies in a measurement band would be suitable. The coaxial fixture is preferred over rectangular waveguide fixtures when broadband data are desired with a single sample or when only small sample volumes are available, particularly for lower frequency measurements.

1.3 The values stated in either SI units of in inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore each system shall be used independently of the other. Combining values from the two systems is likely to result in non conformance with the standard. The equations shown here assume an $e^{+j\omega t}$ harmonic time convention.

1.4 *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.

1.5 *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

D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation
D1711 Terminology Relating to Electrical Insulation

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 A list of symbols specific to this test method is given in **Annex A1**.

3.2.2 *calibration, n*—a procedure for connecting characterized standard devices to the test ports of a network analyzer to characterize the measurement system's systematic errors. The effects of the systematic errors are then mathematically removed from the indicated measurements. The calibration also establishes the mathematical reference plane for the measurement test ports.

3.2.2.1 *Discussion*—Modern network analyzers have this capability built in. There are a variety of calibration kits that can be used depending on the type of test port. The models used to predict the measurement response of the calibration devices depends on the type of calibration kit. Most calibration kits come with media that can be used to load the definitions of the calibration devices into the network analyzer. Calibration

¹ This test method is under the jurisdiction of ASTM Committee **D09** on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee **D09.12** on Electrical Tests.

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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.

*A Summary of Changes section appears at the end of this standard