

Recommended methods for the determination of the dielectric properties of insulating materials at frequencies above 300 MHz —

Part 1: General

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee GEL/15, Insulating material, upon which the following bodies were represented:

- British Ceramic Research Ltd.
- British Industrial Ceramic Manufacturers' Association
- Electrical and Electronic Insulation Association (BEAMA Ltd.)
- Electricity Association
- Federation of the Electronics Industry
- Rotating Electrical Machines Association (BEAMA Ltd.)
- Transmission and Distribution Association (BEAMA Ltd.)

This British Standard, having been prepared under the direction of the Electrotechnical Sector Board, was published under the authority of the Standards Board and comes into effect on 15 October 1995

© BSI 11-1999

The following BSI references relate to the work on this standard:
Committee reference GEL/15
Special announcement in *BSI News* April 1995

ISBN 0 580 24784 8

Amendments issued since publication

Amd. No.	Date	Comments

Contents

	Page
Committees responsible	Inside front cover
National foreword	ii
Introduction	1
1 Object and scope	1
2 Definitions	1
3 Factors influencing dielectric properties of dielectric materials	2
4 Survey on measuring methods	3
5 Testing procedure	6
6 Test report	7
Figure 1 — A.C. measuring methods	8

National foreword

This Part of BS 7737 has been prepared by Technical Committee GEL/15. It is identical with IEC 377-1 *Recommended methods for the determination of the dielectric properties of insulating materials at frequencies above 300 MHz — Part 1: General* published by the International Electrotechnical Commission (IEC).

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 8 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Introduction

Methods for the determination of the dielectric properties of insulating materials may be divided roughly into two main groups:

1) Lumped-parameter methods can be used when the wavelength of the applied electromagnetic field is large compared with the dimensions of the specimen. These relatively simple methods are dealt with in IEC Publication 250, Recommended Methods for the Determination of the Permittivity and Dielectric Dissipation Factor of Electrical Insulating Materials at Power, Audio and Radio Frequencies Including Metre Wavelengths, covering the frequency range from power frequencies up to about 300 MHz.

2) Distributed parameter methods shall be used when the spatial variation of the electromagnetic field over the specimen can no longer be ignored. Methods taking account of wave propagation are described in this recommendation, covering the frequency range from about 300 MHz up to optical frequencies.

In a narrow range of frequencies around the “critical” frequency of about 300 MHz (which is shown shadowed in Figure 1, page 8), either one of the main methods may be used, depending mainly on the dimensions and permittivity of the specimen.

1 Object and scope

This recommendation applies to the procedures for the determination of relative permittivity and dielectric dissipation factor and of quantities related to them, such as loss index, of dielectric materials in the microwave frequency region (i.e. frequencies above about 300 MHz up to optical frequencies).

Unlike the test methods employed at lower frequencies (see IEC Publication 250), the test methods dealt with in this recommendation use test specimen and/or test set-up dimensions larger than or comparable to the wavelength of the electromagnetic field of the test frequency.

In theory, the methods described apply only to test materials having the permeability of absolute vacuum. Good approximation in general is obtained for dia- and paramagnetic materials (so-called non-magnetic materials) whereas with ferro- and ferrimagnetic materials special procedures have to be chosen to separate the dielectric and magnetic properties. These latter methods, however, are beyond the scope of this recommendation.

Note on magnetic properties. — Specimens showing magnetic properties may be tested according to this recommendation if permeability is driven into saturation by a d.c. magnetic bias field of sufficient intensity.

With special precautions and by the use of suitably designed measuring cells, liquids and fusible materials can be measured, as well as solid materials, by the methods described.

The measured values are dependent on physical conditions such as frequency, temperature, moisture content, and in special cases on field strength as well.

All measurements and calculations of this recommendation are based on a sinusoidal waveform of angular frequency $\omega = 2\pi f$.

2 Definitions

NOTE 1 All definitions apply only to dielectric materials having the permeability of absolute vacuum.

NOTE 2 For the definitions of terms related to wave propagation used in this recommendation, reference should be made to Groups 05 and 62 of the International Electrotechnical Vocabulary.

2.1

relative complex permittivity ϵ_r^*

the relative complex permittivity ϵ_r^* of a dielectric material is:

$$\epsilon_r^* = \epsilon'_r - j\epsilon''_r = \frac{C_x^*}{C_0} \quad (1)$$

where C_x^* denotes the complex capacitance of a small¹⁾ capacitor in which the space between and around the electrodes is entirely and exclusively filled with the dielectric material in question, and C_0 is the capacitance of the same electrode configuration in absolute vacuum

NOTE The complex capacitance of a capacitor is defined by:

$$j\omega C_x^* = Y_x^* = G_x + j\omega C_x$$

where G_x is the real part (a.c. conductance) and $j\omega C_x$ the imaginary part of the complex admittance Y_x^* of the said capacitor.

as the wavelength of the applied electromagnetic field with increasing frequency approaches the dimensions of the specimen employed, the variation of the electric (and magnetic) field parameters throughout the specimen can no longer be ignored. Therefore, for a proper interpretation of the measured data it is necessary to turn from lumped circuit analysis to wave analysis and transmission line theory. This means also growing sensitivity of results to inhomogeneity and anisotropy of specimens

¹⁾ Small compared with the wavelength within the dielectric.