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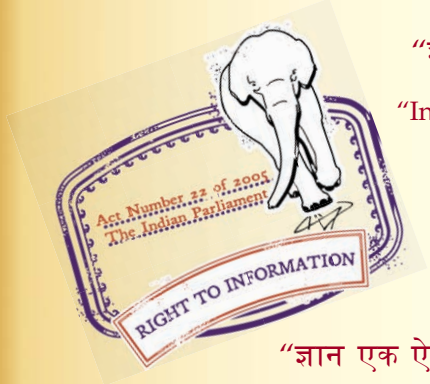
IS 13621 (1993): Determination of dielectric constant of wood under microwave frequencies- Method of test [CED 9: Timber and Timber Stores]



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"Invent a New India Using Knowledge"

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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IS 13621 : 1993
(Reaffirmed 2003)

भारतीय मानक

लकड़ी के परावैद्युत स्थिरांक का सूक्ष्मतरंग आवृतियों के अन्तर्गत निर्धारण – परीक्षण विधि

Indian Standard

DETERMINATION OF DIELECTRIC CONSTANT OF WOOD UNDER MICROWAVE FREQUENCIES — METHOD OF TEST

UDC 674·03 : 621·317·333·6

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

February 1993

Price Group 2

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Timber Sectional Committee had been approved by the Civil Engineering Division Council.

Dielectric properties of wood offer a potential method for determining moisture content and density by non-destructive electrical measurement, besides being an important design factor where wood is to be used in a structure subjected to electromagnetic field. It is also significant in understanding wood-water interaction and molecular structure of wood.

Microwave benches under S, J, X bands of frequencies are abundantly available and provide an easy and accurate method for determining dielectric constant of wood in comparison to other methods at lower range of frequencies.

In preparing this standard, considerable assistance has been rendered by Forest Research Institute, Dehra Dun.

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

DETERMINATION OF DIELECTRIC CONSTANT OF WOOD UNDER MICROWAVE FREQUENCIES — METHOD OF TEST

1 SCOPE

This standard covers method of detemining dielectric constant of wood under microwave frequencies.

2 REFERENCES

Indian Standard IS 707 : 1976 'Glossary of terms applicable to timber technology and utilization (*second revision*)' is necessary adjunct to this standard.

3 TERMINOLOGY

3.1 For the purpose of this standard, the definitions given in IS 707 : 1976 and the following shall apply.

3.2 Dielectric Constant

The ratio of capacitance of a material and the capacitance of air is defined as dielectric constant or the electrical permittivity of the material.

4 APPARATUS

4.1 The apparatus is shown schematically in Fig. 1.

4.2 The apparatus consists of a microwave bench on which the instruments given in **4.2.1** to **4.2.9** shall be fitted.

4.2.1 *Klystron Power Supply*

It energizes the Klystron tubes at various voltage for generating microwave.

4.2.2 *Klystron Tube (Reflex Type)*

It is a single cavity microwave tube that makes use of the principle of velocity modulation.

4.2.3 *Isolator*

It is a two part non-reciprocal microwave component used to isolate oscillator from load.

4.2.4 *Variable Attenuator (Rotary Wave Attenuator)*

It consists of three sections of circular wave guide with a resistive film.

4.2.5 *Cavity Frequency Meter*

It consists of a cylindrical tunable cavity mounted with its axis perpendicular to the main wave guide.

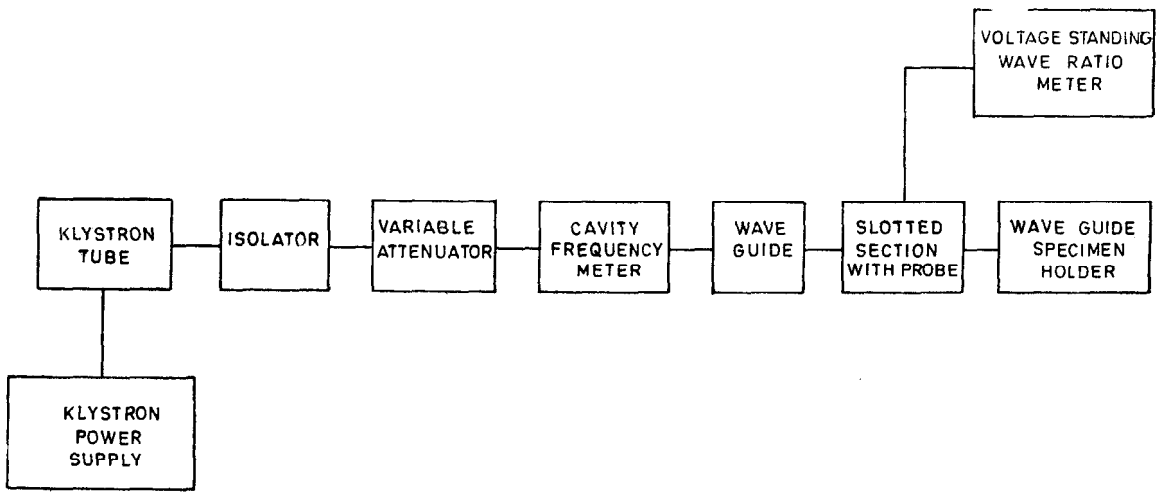

FIG. 1 SCHEMATIC DIAGRAM OF THE EQUIPMENT REQUIRED FOR DETERMINATION OF DIELECTRIC CONSTANT OF WOOD

4.2.6 *Wave Guides*

These are transmission lines which are used to transfer energy at microwave frequencies from one point to another.

4.2.7 *Slotted Section of Bench with Probe*

Accurately machined section of a wave guide having a longitudinal slot in the centre of the broad wall of the guide.

4.2.8 *Voltage Standing Wave Ratio (VSWR) Meter*

It is a volt-meter to measure the voltage of the maxima and minima of the standing EM waves.

4.2.9 *Specimen Holder*

It consists of a section of a wave guide in which an adjustable low loss, contacting choke type short is fitted.

5 TEST SPECIMEN

The specimen shall have the cross section so as to fit tightly in the wave guide and length equal to the quarter wave length inside the timber at operating frequency. The specimens shall be free from defects and shall be conditioned to a constant mass at 65 ± 5 percent RH and 27 ± 2°C in a suitable conditioning chamber before test.

6 PROCEDURE

6.1 Measurement of Guide Wave Length

Standing wave pattern shall be established by energizing klystron power supply and klystron tube. The probe shall be moved along the length of the bench so as to locate the position of the two successive minima indicated in the VSWR meter. To have the accurate reading, the gain in VSWR meter may be energized by means of the variable attenuater. The distance between successive minima shall be noted and multiplied by two to give the guide wave length (λg).

6.2 Measurement of Frequency

For measurement of frequency of the signal, probe shall be moved to the maxima voltage point and the position of the plunger of the cavity frequency meter shall be so adjusted as to observe the dip in the VSWR meter. The reading of the micrometer of the frequency meter shall be noted. This reading shall be adjusted through the calibration chart of the frequency meter and the frequency of the signal shall be recorded. The dielectric constant can be determined at any microwave frequency ranging from 1 GH_z to 15 GHz. However, 10 GHz is recommended (1 GHz = 10^9 cycle/s).

6.3 Record of the Shift in Minimum Position Due to Specimen

The probe shall be kept at a minima position and the reading on the bench shall be taken. The specimen shall now be placed in the wave guide in contact with the short circuit plate and the position of the new displaced minima shall be recorded. The difference in the two positions of the minima shall be the shift (Δ) due to the insertion of the specimen.

6.4 Determination of Moisture Content of the Specimen

The specimen shall be weighed immediately after recording the shift. The specimen shall then be kept in ventilated oven at 103 ± 2°C till it attains a constant mass and oven dried mass of the specimen shall be recorded. The moisture content of the specimen at the time of test shall be calculated by the formula given below:

$$M = \frac{W - W_0}{W_0} \times 100$$

M = Moisture content, percent;

W = Mass of the specimen in g at the time of test; and

W_0 = Oven dry mass of the specimen in g.

6.5 Calculation

The dielectric constant shall be calculated using the following formulae:

$$K = \frac{\lambda g}{2\pi t} \cdot \tan\left[\frac{2\pi(\Delta + t)}{\lambda g}\right] \quad \ldots\ldots (1)$$

$$K = \frac{\tan X}{X} \quad \ldots\ldots (2)$$

$$= \frac{1 + (aX)^2/(\pi t)^2}{1 + (2a/\lambda g)^2} \quad \ldots\ldots (3)$$

By keeping the values of λg, t and Δ in the first formula, K shall be calculated. X shall be calculated from the second formula by using $\frac{\tan X}{X}$ tables. The dielectric constant shall then be calculated by the third formula.

where

K = propagation constant for the low loss due to dielectric medium in the wave guide,

λg = Wave length of the signal in the air filled wave guide,

Δ = Shift in the minima position due to specimen,

X = Intermediate function,

t = Specimen length,

a = Width of the wave guide (width of the specimen), and

ε = Dielectric constant

7 REPORT

The test report shall include the following:

a) Species of timber,

b) Grain direction in the specimen with respect to the direction of the electric field of the wave propagation,

c) Moisture content,

d) Operating frequency, and

e) Dielectric constant.

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