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AMERICAN NATIONAL STANDARD

RESONANCE METHOD FOR MEASURING THE DYNAMIC MECHANICAL PROPERTIES OF VISCOELASTIC MATERIALS

ANSI S2.22-1998

Accredited Standards Committee S2, Mechanical Vibration and Shock

Standards Secretariat
Acoustical Society of America
120 Wall Street, 32nd Floor
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ANSI S2.22-1998

American National Standard

Resonance Method for Measuring the Dynamic Mechanical Properties of Viscoelastic Materials

Secretariat

Acoustical Society of America

Approved 22 June 1998

American National Standards Institute, Inc.

Abstract

This Standard defines a method for measuring the dynamic mechanical properties of viscoelastic materials using longitudinal resonance in a bar-shaped test sample. The dynamic mechanical properties are expressed in terms of the frequency dependence of Young's modulus and loss factor at a given reference temperature. The Standard provides information for constructing such equipment and analyzing the results obtained.

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Foreword

[This Foreword is for information only, and is not a part of ANSI S2.22-1998 *American National Standard Resonance Method for Measuring the Dynamic Mechanical Properties of Viscoelastic Materials*.]

This Standard was developed under the jurisdiction of Accredited Standards Committee S2, Mechanical Vibration and Shock, which has the following scope:

> *Standards, specifications, methods of measurement and test terminology in the fields of mechanical vibration and shock and condition monitoring and diagnostics of machines, but excluding those aspects which pertain to biological safety, tolerance, and comfort.*

At the time this Standard was submitted to Accredited Standards Committee S2, Mechanical Vibration and Shock, for approval, the membership was as follows:

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Suggestions for improvements of this Standard will be welcomed. Send suggestions for improvement to Accredited Standards Committee S2, Mechanical Vibration and Shock, in care of the ASA Standards Secretariat, 120 Wall Street, 32nd Floor, New York, New York 10005-3993, USA. E-mail: asastds@aip.org; Telephone: +1 212 248 0373; Fax +1 212 248 0146.

American National Standard

Resonance Method for Measuring the Dynamic Mechanical Properties of Viscoelastic Materials

0 Introduction

Viscoelastic materials are used extensively to reduce vibration amplitudes in structural systems through dissipation of energy (damping) or isolation of components, and in acoustic applications which require a modification of the reflection, transmission, or absorption of energy. Such systems often require specific dynamic mechanical properties in order to function in an optimum manner. Energy dissipation is due to interactions on the molecular scale and can be measured in terms of the lag between stress and strain in the material. The viscoelastic properties, modulus and loss factor, of most materials depend on frequency, temperature, and strain amplitude. The choice of a specific material for a given application determines the system performance. This Standard applies to the linear behavior observed at small strain amplitudes.

1 Scope, purpose, and applications

1.1 Scope

This Standard defines a procedure for measurement and analysis of the dynamic properties of viscoelastic materials using a resonance method. The Standard applies to materials used in sound and vibration damping systems operating at frequencies from a fraction of a hertz to about 20 kHz.

1.2 Purpose

The purpose of this Standard is to assist users of this method in setting up the measurement equipment, performing the measurements, and analyzing the resultant data. A further purpose is to promote uniformity in the use of this method.

1.3 Applications

This Standard applies to the use of the resonance method to evaluate material characteristics for research, quality control, and materials selection.

2 Informative references

[1] *ASTM D 792-91, Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement*.

[2] T. Pritz, ''Transfer Function Method for Investigating the Complex Modulus of Acoustic Materials: Rod-like Specimen,'' *J. Sound and Vibration* **81**, 359-376 (1982).

[3] W. M. Madigosky and G. F. Lee, ''Improved resonance technique for material characterization,'' *J. Acoust. Soc. Am.* **73**, 1374-1377 (1983).

[4] J. L. Buchanan, ''Numerical solution for the dynamic moduli of a viscoelastic bar,'' *J. Acoust. Soc. Am.* **81**, 1775-1786 (1987).

[5] J. D. Ferry, *Viscoelastic Properties of Polymers*, 3rd ed., Wiley, New York, 1980, pp 264-320.

3 Definitions

For the purposes of this Standard, the following definitions apply:

3.1 Young's modulus. Quotient of tensile stress, in pascals, to resulting tensile strain, or fractional change in length. Young's modulus for viscoelastic materials is a complex quantity with symbol E^*, having a real part E' and an imaginary part E''. Unit, pascal (Pa).

NOTE – Physically, the real component of Young's modulus represents elastic stored mechanical energy. The imaginary component is a measure of mechanical energy loss. See 3.2.

3.2 loss factor. Ratio of the imaginary part of the Young's modulus of a material to the real part of the Young's modulus (the tangent of the argument of the complex Young's modulus).

NOTE – When there is energy loss in a material, the strain lags the stress by a phase angle, δ. The loss factor is equal to tan δ.

3.3 fast Fourier transform. An algorithm or calculation procedure for obtaining the discrete Fourier transform (DFT) with a greatly reduced number of arithmetic operations compared with a direct evaluation.