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AMERICAN NATIONAL STANDARD

GRAPHICAL PRESENTATION OF THE COMPLEX MODULUS OF VISCOELASTIC MATERIALS

ANSI S2.24-2001

Accredited Standards Committee S2, Mechanical Vibration and Shock

Standards Secretariat
Acoustical Society of America
35 Pinelawn Road, Suite 114E
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American National Standard

Graphical Presentation of the Complex Modulus of Viscoelastic Materials

Secretariat

Acoustical Society of America

Approved 3 July 2001

American National Standards Institute, Inc.

Abstract

This Standard specifies the procedure for generating a graphical presentation of the frequency and temperature dependence of the complex modulus of viscoelastic materials. This Standard is the National counterpart of ISO 10112, Damping materials - Graphical presentation of the complex modulus.

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Foreword

[This Foreword is for information only, and is not a part of ANSI S2.24.2001 *American National Standard Method of Graphical Presentation of the Complex Modulus of Viscoelastic Materials*.]

This Standard was developed under the jurisdiction of Accredited Standards Committee S2, Mechanical Vibration and Shock. This Standard is the National counterpart of ISO 10112, Damping materials - Graphical presentation of the complex modulus.

Accredited Standards Committee S2, Mechanical Vibration and Shock, has the following scope:

> *Standards, specifications, methods of measurement and test, and 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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D. J. Evans, *Vice Chair*
S. B. Blaeser, *Secretary*

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U.S. Naval Surface Warfare Center, Crane Div.	A. Parkes D. Kristler (*Alt.*)
Vibration Institute	R. L. Eshleman

Individual Experts of Accredited Standards Committee S2, Mechanical Vibration and Shock, were:

P. K. Baade	L. A. Herstein	D. L. Johnson

Working Group S2/WG4, Characterization of the Dynamic Properties of Viscoelastic Polymers, which assisted Accredited Standards Committee S2, Mechanical Vibration and Shock, in the development of this Standard, had the following membership:

W. M. Madigosky, *Chair*
B. Hartmann, *Vice-Chair (deceased)*

D. A. Brown	D. L. Hunston	A. D. Nashif
R. J. Deigan	R. F. Landel	J. M. Niemiec
J. J. Dlubac	G. F. Lee	L. Rogers
J. J. Fedderly	J. D. Lee	J. P. Szabo

We are saddened by the sudden death of Dr. Bruce Hartmann who contributed enormously to the series of standards on dynamic mechanical properties. This standard is hereby dedicated to his memory and to the immeasurable service and scientific expertise he provided the acoustics community.

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, 35 Pinelawn Road, Suite 114E, Melville, New York 11747, USA.

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American National Standard

Graphical Presentation of the Complex Modulus 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 acoustical applications which require a modification of the reflection, transmission, or absorption of energy. The viscoelastic properties, modulus and loss factor, of most materials depend on frequency, temperature, and strain amplitude. This Standard applies to the linear behavior observed at small strain amplitudes.

Since the modulus and loss factor are functions of frequency and temperature, the presentation of either function requires, in principle, a three dimensional plot. For a thermorheologically simple material, however, the frequency dependence and the temperature dependence are not independent and a two dimensional presentation in the form of a nomogram shall be used. This Standard describes how to generate such a presentation and is the counterpart of ISO 10112 [3] .

1 Scope, purpose, and applications

1.1 Scope

The mechanical properties of most viscoelastic materials depend on frequency, temperature, and strain amplitude at large strains. This Standard is restricted to small total strain and linear behavior. It does not cover the effects of static pre-strain or of dynamic strain amplitude.

1.2 Purpose

The primary purpose of this Standard is to improve communication among the diverse technological fields concerned with vibration damping materials and to establish a standard format for presentation of data.

1.3 Applications

This Standard applies to presentation of modulus and loss factor data of viscoelastic materials as functions of temperature and frequency.

2 Informative references

[1] ANSI S2.21-1998, *American National Standard Method for Preparation of a Standard Material for Dynamic Mechanical Measurements*.

[2] ANSI S2.22-1998, *American National Standard Resonance Method for Measuring the Dynamic Mechanical Properties of Viscoelastic Materials*.

[3] ISO 10112:1991, *Damping materials - Graphical presentation of the complex modulus.*

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

[5] S. Havriliak and S. Negami, A Complex Plane Representation of Dielectric and Mechanical Relaxation Processes in Some Polymers, Polymer 8, 161–210 (1967).

[6] D. I. G. Jones, A reduced temperature nomogram for characterization of damping material behavior, Shock and Vibration Bulletin, 48, 13–22 (1978).

[7] L. E. Nielsen and R. F. Landel, *Mechanical Properties of Polymers and Composites*, 2nd ed., Dekker, New York, 1994, pp 143–149.

3 Definitions

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

3.1 Shear modulus

The complex shear modulus, G^*, is defined as

$$G^* = \tau^* / \gamma^* = G' + iG'' \qquad (1)$$

where τ^* is complex shear stress, γ^* is complex shear strain, G' is the real part of the complex shear modulus, $i = \sqrt{-1}$, and G'' is the imaginary part of the complex shear modulus.

3.2 loss factor (tan δ). The ratio of the imaginary part of the shear modulus of a material to the real part of the modulus given by tan $\delta = G''/G'$ where δ is the argument of the complex shear modulus. The loss factor is expressed as a dimensionless