

July 31, 2002

Reaffirmed by ANSI
July 5, 2007

Reaffirmed by ANSI
August 27, 2012

Reaffirmed by ANSI
August 24, 2017

ANSI S2.22-1998

Reaffirmed by ANSI
June 19, 2020

AMERICAN NATIONAL STANDARD
**RESONANCE METHOD
FOR MEASURING
THE DYNAMIC MECHANICAL
PROPERTIES OF VISCOELASTIC
MATERIALS**

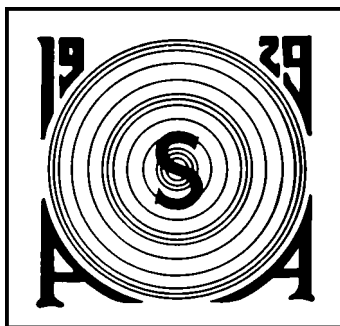
ANSI S2.22-1998

Accredited Standards Committee S2, Mechanical Vibration and Shock

Standards Secretariat
Acoustical Society of America
120 Wall Street, 32nd Floor
New York, New York 10005-3993

The American National Standards Institute, Inc. (ANSI) is the national coordinator of voluntary standards development and the clearing house in the U.S. for information on national and international standards.

The Acoustical Society of America (ASA) is an organization of scientists and engineers formed in 1929 to increase and diffuse the knowledge of acoustics and to promote its practical applications.



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.

AMERICAN NATIONAL STANDARDS ON ACOUSTICS

The Acoustical Society of America (ASA) provides the Secretariat for Accredited Standards Committees S1 on Acoustics, S2 on Mechanical Vibration and Shock, S3 on Bioacoustics, and S12 on Noise. These committees have wide representation from the technical community (manufacturers, consumers, and general-interest representatives). The standards are published by the Acoustical Society of America through the American Institute of Physics as American National Standards after approval by their respective standards committees and the American National Standards Institute.

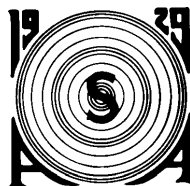
These standards are developed and published as a public service to provide standards useful to the public, industry, and consumers, and to Federal, State, and local governments.

Each of the Accredited Standards Committees [operating in accordance with procedures approved by American National Standards Institute (ANSI)] is responsible for developing, voting upon, and maintaining or revising its own standards. The ASA Standards Secretariat administers committee organization and activity and provides liaison between the Accredited Standards Committees and ANSI. After the standards have been produced and adopted by the Accredited Standards Committees, and approved as American National Standards by ANSI, the ASA Standards Secretariat arranges for their publication and distribution.

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered and that a concerted effort be made towards their resolution.

The use of American National Standards is completely voluntary. Their existence does not in any respect preclude anyone, whether he or she has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

NOTICE: This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken periodically to reaffirm, revise, or withdraw this Standard.



Standards Secretariat
Acoustical Society of America
120 Wall Street, 32nd Floor
New York, New York 10005-3993
USA

Telephone: +1 212 248 0373
Telefax: +1 212 248 0146
E-mail: asastds@aip.org
Internet: <http://asa.aip.org>

© 1998 by the Acoustical Society of America. This Standard may not be reproduced in whole or in part in any form for sale, promotion, or any commercial purpose, or any purpose not falling within the provisions of the Copyright Act of 1976, without prior written permission of the publisher. For permission, address a request to the Standards Secretariat of the Acoustical Society of America.

Contents

	Page
Foreword.	ii
0 Introduction	1
1 Scope, purpose, and applications	1
1.1 Scope	1
1.2 Purpose	1
1.3 Applications	1
2 Informative references	1
3 Definitions	1
3.1 Young's modulus	1
3.2 Loss factor	1
3.3 Fast Fourier transform	1
3.4 Frequency response function	2
3.5 Time-temperature superposition	2
3.6 Shift factor	2
3.7 Glass transition temperature	2
4 Test equipment	2
4.1 Electromagnetic shaker	2
4.2 Accelerometers	2
4.3 Charge amplifiers	2
4.4 Test stand	2
4.5 Environmental chamber	2
4.6 Dual channel spectrum analyzer	3
4.7 Computer	3
5 Operating procedures	3
5.1 Sample preparation and mounting	3
5.2 Data acquisition	3
5.3 Temperature cycle	4
6 Analysis of results	5
6.1 Modulus and loss factor	5
6.2 Time-temperature superposition	5
6.3 Data presentation	6
 Figures	
1 Schematic diagram of resonance apparatus	2
2 Typical acceleration ratio (solid line) and phase (dashed line) vs. frequency	4

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:

D. J. Evans, *Chair*
R. F. Taddeo, *Vice Chair*
A. Brenig, *Secretary*

Acoustical Society of America	D. J. Evans
	R. F. Taddeo (<i>Alt.</i>)
Boyce Engineering International	M. P. Boyce
	C. Meher-Homji (<i>Alt.</i>)
Bruel & Kjaer Instruments	L. J. Pace
	M. Alexander (<i>Alt.</i>)
Endevco Corporation	R. D. Sill
Hewlett Packard Company	N. Olsen
National Electrical Manufacturers Association (NEMA)	D. Rawlings
	E. LaBrush (<i>Alt.</i>)
National Institute of Standards and Technology	D. J. Evans
	B. F. Payne (<i>Alt.</i>)
PCB Piezotronics, Inc.	R. W. Lally
	J. Lin (<i>Alt.</i>)
Sandia Corporation	V. I. Bateman
Schenck Trebel Corporation	B. Dittmar
U.S. Naval Sea Systems Command	R. F. Taddeo
	A. K. Kukk (<i>Alt.</i>)
U.S. Naval Surface Warfare Center	P. C. Shang
	L. D. Cole (<i>Alt.</i>)
Vibration Institute	J. McHugh

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

P. K. Baade	S. I. Hayek	D. F. Muster
G. Booth	L. A. Herstein	D. E. Vendittis
K. M. Eldred	D. L. Johnson	H. E. von Gierke
	A. F. Kilcullen	

Working Group S2/WG79, 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*

B. R. Allen

R. Blaine

D. A. Brown

R. N. Capps

R. J. Deigan

W. A. Driscoll

J. J. Dlubac

J. Duncan

B. Hosten

E. M. Kerwin

M. F. Kluesener

G. F. Lee

J. D. Lee

A. Nashif

S. O. Oyadiji

J. S. Peraro

D. F. Sauter

J. P. Szabo

C. M. Thompson

R. E. Wetton

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 $\tan \delta$.

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.