

Method for

Graphical presentation of the complex modulus of damping materials

Committees responsible for this British Standard

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- Cranfield Institute of Technology
- Department of Trade and Industry (National Engineering Laboratory)
- Electricity Supply Industry in England and Wales
- Engineering Equipment and Materials Users' Association
- Health and Safety Executive
- Institute of Sound and Vibration Research
- Institution of Mechanical Engineers
- Lloyd's Register of Shipping
- Ministry of Defence
- Power Generation Contractors' Association (BEAMA Ltd.)
- Society of British Aerospace Companies Ltd.
- Society of Environmental Engineers
- Society of Motor Manufacturers and Traders Ltd.
- University of Manchester

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National foreword

This British Standard has been prepared under the direction of the General Mechanical Engineering Standards Policy Committee. It is identical with ISO 10112:1991 “*Damping materials — Graphical presentation of the complex modulus*”, which was prepared by Technical Committee ISO/TC 108 of the International Organization for Standardization (ISO) and in the development of which the United Kingdom played an active part.

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Summary of pages

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

Damping is one potential approach to reducing vibration levels in a structural system. Damping is the dissipation of vibratory energy by converting it into heat, as distinguished from transporting it to another part of the system. When the damping is due to internal energy dissipation within a material which is part of the structural system, and when the damping is of engineering significance, the material is called a vibration damping material. The energy dissipation is due to molecular or crystal-lattice interactions and can be measured in terms of the stress/strain hysteresis loop of the vibration damping material. Other possible sources of damping, such as plastic deformations in the joints, relative slip at joints, air pumping in the joints, acoustic radiation of energy, eddy current losses, etc., are not covered in this International Standard. The mechanical properties of most damping materials depend on frequency, temperature and strain amplitude at large strains; since this International Standard is restricted to linear behaviour, it does not cover the strain amplitude effect.

1 Scope

This International Standard establishes the graphical presentation of the complex modulus of viscoelastic vibration damping materials which are macroscopically homogeneous, linear and thermorheologically simple. The complex modulus may be the shear modulus, Young's modulus, bulk modulus, longitudinal wave propagation modulus, or Lamé modulus. This graphical presentation is convenient and sufficiently accurate for many vibration damping materials.

The preferred nomenclature (parameters, symbols and definitions) is also given.

The primary purpose of this International Standard is to improve communication among the diverse technological fields concerned with vibration damping materials.

2 Nomenclature

2.1 Complex modulus

The operator form of the constitutive equation for the linear, isothermal, isotropic, macroscopically homogeneous, thermorheologically simple [see equation (7)] viscoelastic material being deformed in shear is defined [1] as

$$P(p_R)\tau(t) = Q(p_R)\gamma(t) \quad \dots (1)$$

where

$\tau(t)$ is the shear stress;

$\gamma(t)$ is the shear strain;

$P(p_R)$ and $Q(p_R)$ are polynomials in p_R .

The operator p_R is defined as

$$p_R = d/dt_R \quad \dots (2)$$

The reduced time differential dt_R is defined as

$$dt_R = dt/\alpha_T(T) \quad \dots (3)$$

where

t is time, in seconds;

$\alpha_T(T)$ is the dimensionless temperature shift function [2] dependent on temperature, T , in kelvin.

The Fourier transform (f.t.) of equation (1) leads to the definition of G , the complex shear modulus valid for steady-state sinusoidal stress and strain, as

$$G(j\omega_R) = \tau^*(j\omega_R)/\gamma^*(j\omega_R) = Q(j\omega_R)/P(j\omega_R) \quad \dots (4)$$

where $\tau^*(j\omega_R)$ denotes the f.t. of $\tau(t)$.

The reduced circular frequency, ω_R , is given as

$$\omega_R = \omega\alpha_T(T) = 2\pi f_R = 2\pi f\alpha_T(T) \quad \dots (5)$$

which is a product of ω , the circular frequency, in radians per second, and the dimensionless temperature shift function, while f_R and f denote the reduced cyclic frequency and the cyclic frequency, in hertz.

The complex shear modulus is dependent on both frequency and temperature

$$G = G(\omega, T) \quad \dots (6)$$

If (and only if) the dependency is expressed as

$$G = G(j\omega_R) = G[j\omega\alpha_T(T)] \quad \dots (7)$$

then the material is called thermorheologically simple (TRS). Furthermore, equations (1) to (7) apply only to linear conditions.

Alternatively, consider a viscoelastic material element which undergoes a sinusoidal shear strain [3]

$$\gamma = \gamma_A \sin \omega t \quad \dots (8)$$

which lags the sinusoidal shear stress by the phase angle δ_G :

$$\tau = \tau_A \sin(\omega t + \delta_G) \quad \dots (9)$$