INTERNATIONAL STANDARD

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Mechanical vibration and shock — Characterization of the dynamic mechanical properties of visco-elastic materials —

Part 4: **Dynamic stiffness method**

Vibrations et chocs mécaniques — Caractérisation des propriétés mécaniques dynamiques des matériaux visco-élastiques —

Partie 4: Méthode de la raideur dynamique

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 18437-4 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*.

ISO 18437 consists of the following parts, under the general title *Mechanical vibration and shock — Characterization of the dynamic mechanical properties of visco-elastic materials*:

— *Part 2: Resonance method*

— *Part 3: Cantilever shear beam method*

— *Part 4: Dynamic stiffness method*

The following parts are under preparation:

— *Part 1: Principles and guidelines*

— *Part 5: Poisson's ratio based on finite element analysis*

Introduction

Visco-elastic materials are used extensively to reduce vibration magnitudes, of the order of hertz to kilohertz, in structural systems through dissipation of energy (damping) or isolation of components, and in acoustical applications that require modification of the reflection, transmission, or absorption of energy. The design, modelling and characterization of such systems often require specific dynamic mechanical properties (the Young, shear, and bulk moduli and their corresponding loss factors) 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 visco-elastic 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. The goal of this part of ISO 18437 is to provide details, in principle, of the operation of the direct dynamic stiffness method, the measurement equipment used in performing the measurements, and the analysis of the resultant data. A further aim is to assist users of this method and to provide uniformity in the use of this method. This part of ISO 18437 applies to the linear behaviour observed at small strain amplitudes, although the static stiffness may be non-linear.

Mechanical vibration and shock — Characterization of the dynamic mechanical properties of visco-elastic materials —

Part 4:
Dynamic stiffness method

1 Scope

This part of ISO 18437 specifies a direct method for measuring the complex dynamic moduli of elasticity (the Young, shear and bulk moduli, and their respective loss factors corresponding to the tensile, shear and all compressive strains) for polymeric (rubbery and viscous polymers, as well as rigid plastics) materials over a wide frequency and temperature range. Measurements are performed by the dynamic stiffness method, which uses electric signals from sensors attached to a test piece. These signals are proportional to the dynamic forces acting on the test piece and the strains in the test piece due to the effect of these forces.

The measurement frequency range is determined by the size of test piece, the accuracy required on the dynamic modulus measurements, the relationship between the stiffness of the oscillation generator and the stiffness of the test piece, and by the resonance characteristics of the test fixture used.

The method presented in this part of ISO 18437 allows measurement under any static pre-load allowed for the test piece (including the test piece having the non-linear characteristics under different static loads), but under small dynamic (acoustic) strains, *i.e.*, in limits where the linear properties of the test piece are not distorted. Depending on the pre-load conditions, the relation between the moduli is unique.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 472, *Plastics — Vocabulary*

ISO 483, *Plastics — Small enclosures for conditioning and testing using aqueous solutions to maintain the humidity at a constant value*

ISO 2041, *Mechanical vibration, shock and condition monitoring — Vocabulary*

ISO 4664-1, *Rubber, vulcanized or thermoplastic — Determination of dynamic properties — Part 1: General guidance*

ISO 6721-1, *Plastics —Determination of dynamic mechanical properties — Part 1: General principles*

ISO 6721-4, *Plastics — Determination of dynamic mechanical properties — Part 4: Tensile vibration — Non-resonance method*

ISO 6721-6, *Plastics — Determination of dynamic mechanical properties — Part 6: Shear vibration — Non-resonance method*

ISO 10112, *Damping materials — Graphical presentation of the complex modulus*

ISO 10846-1, *Acoustics and vibration — Laboratory measurement of vibro-acoustic transfer properties of resilient elements — Part 1: Principles and guidelines*

ISO 23529, *Rubber — General procedures for preparing and conditioning test pieces for physical test methods*

NOTE ISO 10846-1 is concerned with the global measurement of dynamic input and transfer stiffness and mechanical resistance of resilient fixtures. This part of ISO 18437 is concerned with the characterization of the dynamic Young modulus, shear modulus, bulk modulus, and corresponding loss factors of the visco-elastic materials that are used in the fixtures.

3 Terms and definitions

For the purposes of this part of ISO 18437, the terms and definitions given in ISO 472, ISO 483, ISO 2041, ISO 4664-1, ISO 6721-1, ISO 6721-4, ISO 6721-6, ISO 10112, ISO 10846-1, ISO 23529, and the following apply.

3.1
dynamic mechanical properties
⟨visco-elastic materials⟩ fundamental elastic properties, *i.e.*, elastic modulus, shear modulus, bulk modulus and loss factor

3.2
damped structure
structure containing elements made from damping materials

3.3
Young modulus
modulus of elasticity
E
ratio of the normal stress to linear strain

NOTE 1 Adapted from ISO 80000-4-18.1:2006[9].

NOTE 2 The Young modulus is expressed in pascals.

NOTE 3 The complex Young modulus, E^*, for a visco-elastic material is represented by $E^* = E' + \mathrm{i}E''$, where E' is the real (elastic) component of the Young modulus and E'' is the imaginary (loss modulus) component of the Young modulus. The real component represents elastically stored mechanical energy, while the imaginary component is a measure of mechanical energy loss.

3.4
shear modulus
modulus of rigidity
Coulomb modulus
G
ratio of the shear stress to the shear strain

NOTE 1 Adapted from ISO 80000-4-18.2:2006[9].

NOTE 2 The shear modulus is expressed in pascals.

NOTE 3 The complex shear modulus, G^*, for a visco-elastic material is represented by $G^* = G' + \mathrm{i}G''$, where G' is the real (elastic) component of the shear modulus and G'' is the imaginary (loss modulus) component of the shear modulus.

