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# Plastics — Determination of dynamic mechanical properties —

## Part 5: Flexural vibration — Non-resonance method

*Plastiques — Détermination des propriétés mécaniques dynamiques —*

*Partie 5: Vibration en flexion — Méthode hors résonance*



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# Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.



This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 5, *Physical-chemical properties*.

This second edition cancels and replaces the first edition (ISO 6721-5:1996), which has been technically revised. It also incorporates the Amendment ISO 6721-5:1996/Amd.1:2007. The main changes compared to the previous edition are as follows:



— the document has been revised editorially;

— normative references have been changed to undated.

A list of all parts in the ISO 6721 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

# Plastics — Determination of dynamic mechanical properties —

# Part 5: Flexural vibration — Non-resonance method

## 1 Scope

This document describes a flexural, non-resonance method for determining the components of the flexural complex modulus $E_f^*$ of polymers at frequencies typically in the range 0,01 Hz to 100 Hz. Higher-frequency measurements can be made, but significant errors in the dynamic properties measured are likely to result (see 10.2.2 and 10.2.3). The method is suitable for measuring dynamic storage moduli in the range 10 MPa to 200 GPa.

NOTE Although materials with moduli less than 10 MPa can be studied, more accurate measurements of their dynamic-mechanical properties can be made using shear modes of deformation (see ISO 6721-6).

This method is particularly suited to the measurement of loss factors greater than 0,02 and can therefore be conveniently used to study the variation of dynamic properties with temperature and frequency through most of the glass-rubber relaxation region (see ISO 6721-1). The availability of data determined over wide ranges of both frequency and temperature enables master plots to be derived, using frequency/temperature shift procedures, which present dynamic properties over an extended frequency range at different temperatures.



## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 6721-1, *Plastics — Determination of dynamic mechanical properties — Part 1: General principles*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6721-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

## 4 Principle

A test specimen is subjected to a sinusoidal transverse force or displacement at a frequency significantly below the fundamental flexural resonance frequency (see 10.2.2). The amplitudes of the force and displacement cycles applied to the specimen and the phase angle between these cycles are measured. The storage and loss components of the flexural complex modulus and the loss factor are calculated using formulae given in Clause 10.

# 5 Apparatus

## 5.1 Loading assembly

### 5.1.1 General

The requirements for the loading assembly are that it shall permit measurements of the amplitudes of, and phase angle between, the force and displacement cycles for a specimen subjected to a transverse sinusoidal force or displacement. Various designs of apparatus are possible, two of them are illustrated schematically in Figures 1 and 2. In Figure 1 a), a sinusoidal displacement is generated by the vibrator V and applied to the specimen S through moving clamps $C_1$ located close to the opposite ends of the specimen. The amplitude and frequency of the vibrator table displacement are variable and monitored by the transducer D. The specimen is held at its centre by a fixed clamp $C_2$ and thus undergoes sinusoidal flexural deformations. The sinusoidal force applied in deforming the specimen is monitored by a force transducer F connected to $C_2$. The members between the clamps $C_1$ and V, and between $C_2$ and F, shall be much stiffer than the specimen and shall have a low thermal conductance if the specimen is to be enclosed in a temperature-controlled cabinet.

While each member of the loading assembly may have a much higher stiffness than the specimen, the presence of clamped or bolted connections can significantly increase the apparatus compliance. It may then be necessary to apply a compliance correction as described in 10.2.4.

Various other loading assemblies may be employed as alternatives to that detailed above. For example, the specimen may be simply supported and deformed in three-point flexure, as illustrated in Figure 1 b). Furthermore, the force on the specimen may be calculated from the current supplied to the vibrator, thus eliminating the need for a separate force transducer. With this method (see Figure 2), that part of the force generated by the vibrator current is used to accelerate the drive shaft and to deform the drive-shaft suspension Su in parallel with the specimen. That part of the generated force used to deform the specimen shall be determined with the aid of a separate calibration with the specimen absent.



### 5.1.2 Load stage

The clamps shall be capable of gripping the test specimen with a force which is sufficient to prevent the specimen from slipping during the flexural deformation, and to maintain the force at low temperatures.

With the simply supported specimen [Figure 1 b)], the supports (rollers or fixed round supports) shall contact the specimen along parallel lines and have radii sufficiently large to avoid significant indentation of the specimen and thereby minimize consequent errors in the measured moduli and loss factors.

The separation between the two outer clamps and between the outer supports shall be variable so that specimens of different length can be accommodated and length corrections may be determined for the clamped specimens (see 10.2.5). A facility to permit small variations in the clamp separation [Figure 1 a)] would also allow for thermal expansion of the specimens and is necessary to avoid errors in the apparent moduli due to buckling of the specimens at high temperatures.

Any misalignment of the load stage with respect to the force transducer will produce a lateral component of the force applied to the transducer during loading of the specimen. The alignment of the loading assembly and test specimen shall be such that any lateral component recorded by the transducer is less than 1 % of the longitudinal force.

### 5.1.3 Transducers

The term transducer in this document refers to any device capable of measuring the applied force or displacement, or the ratio of these quantities, as a function of time. The calibration of the transducers shall be traceable to national standards for the measurement of force and length. The calibration shall be accurate to ±2 % of the minimum force and displacement cycle amplitudes applied to the specimen for the purpose of determining dynamic properties.

 