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**Plastics — Determination of dynamic  
mechanical properties —**

**Part 4:  
Tensile vibration — Non-resonance  
method**

*Plastiques — Détermination des propriétés mécaniques  
dynamiques —*

*Partie 4: Vibration en traction — Méthode hors résonance*

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## 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.

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](http://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](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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](http://www.iso.org/iso/foreword.html).

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

This third edition cancels and replaces the second edition (ISO 6721-4:2008), which has been technically revised. 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](http://www.iso.org/members.html).

# Plastics — Determination of dynamic mechanical properties —

## Part 4: Tensile vibration — Non-resonance method

### 1 Scope

This document describes a forced, non-resonance method for determining the components of the tensile complex modulus  $E^*$  of polymers at frequencies typically in the range 0,01 Hz to 100 Hz.

NOTE 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 0,01 GPa to 5 GPa. Although materials with moduli outside this range can be studied, alternative modes of deformation are intended to be used for higher accuracy [i.e. a shear mode for  $G' < 0,01$  GPa (see ISO 6721-6) and a flexural mode for  $E' > 5$  GPa (see ISO 6721-3 or ISO 6721-5)].

This method is particularly suited to the measurement of loss factors 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 display dynamic properties over an extended frequency range at different temperatures.

### 2 Normative references

[ISO 6721-4:2019](#)

<https://standards.iteh.ai/catalog/standards/iso/b22baefd-4df6-4de9-8098-2548b52958ad/iso-6721-4-2019>

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

The specimen is subjected to a sinusoidal tensile force or deformation at a frequency significantly below the fundamental resonance frequency for the clamped/free longitudinal mode (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 factor are calculated using formulae given in [Clause 10](#).

## 5 Test device

### 5.1 Loading assembly

#### 5.1.1 General

The requirements on the apparatus are that it shall permit measurements of the amplitudes of, and the phase angle between, the force and displacement cycles for a specimen subjected to a sinusoidal tensile force or deformation. Various designs of apparatus are possible: a suitable version is shown schematically in [Figure 1](#). A sinusoidal force is generated by the vibrator V and applied to one end of the specimen S by means of the clamp C<sub>1</sub>. The amplitude and frequency of the vibrator table displacement are variable and monitored by the transducer D. The member between V and C<sub>1</sub> 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 load 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](#).

At the other end of the specimen, a second clamp C<sub>2</sub> is connected to a force transducer F which is supported by a rigid frame. The member between C<sub>2</sub> and F shall also have sufficient stiffness and low thermal conductance.

Alternatively, the force can also be calculated from the current supplied to the vibrator.

#### 5.1.2 Clamps

The clamps shall be capable of gripping the test specimen with sufficient force to prevent the specimen from slipping during the tensile deformation and maintaining the force at low temperatures. Any misalignment of the clamps 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 applied tensile force. A clamp design with self-aligning faces is recommended since this will maintain alignment of the specimen axis with the axis of the load assembly independently of specimen thickness.

The derivation of a length correction (see [10.2.5](#)) requires measurements of specimen stiffness for different values of the specimen length as defined by the clamp separation. These may be made on a single specimen if one of the clamps has a hole in the centre of its base through which the specimen may pass as the clamp separation is reduced.

#### 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 calibrations of the transducers shall be traceable to national standards for the measurement of force and length. The calibrations shall be accurate to  $\pm 2$  % of the minimum force and displacement cycle amplitudes applied to the specimen for the purpose of determining dynamic properties.

### 5.2 Electronic data-processing equipment

Data-processing equipment shall be capable of recording the force and displacement cycle amplitudes to an accuracy of  $\pm 1$  %, the phase angle between the force and displacement cycles to an accuracy of  $\pm 0,1^\circ$  and the frequency to an accuracy of  $\pm 10$  %.

### 5.3 Temperature measurement and control

According to ISO 6721-1.