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Plastics — Elasticity index — Determination of elastic property of melts

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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).

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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*.

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.

Introduction

Many thermoplastic materials show similar viscosities, but elastic properties can vary significantly, which can lead to inappropriate applications.

The definition of an elasticity index describing the elastic properties of resins in a similar way as the viscosity is indicated by the melt flow rate opens a possibility to designate the elastic properties using a simple characteristic number.

Selecting G' at a particular frequency as elasticity index can no longer describe the complete behaviour of materials with varying frequency. But considering the success MFR/MVR (see ISO 1133-1 and ISO 1133-2) as characteristic numbers of viscosity the elasticity index provides a similar useful characteristic number for the elasticity of materials.

Plastics — Elasticity index — Determination of elastic property of melts

1 Scope

This document specifies a procedure for the determination of an elasticity index based on measurements of the shear storage modulus using oscillatory rheometers, establishes general principles, and gives guidelines for performance of measurements. The elasticity index is applicable to all thermoplastics and viscoelastic materials for which the elastic behaviour is a crucial application property.

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*

ISO 6721-10, *Plastics — Determination of dynamic mechanical properties — Part 10: Complex shear viscosity using a parallel-plate oscillatory rheometer*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6721-1, ISO 6721-10 and the following apply.

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

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

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

3.1
elasticity index
characteristic number describing the elastic properties of plastic melts or viscoelastic materials which is defined as storage modulus G' measured at fixed angular frequency with specific strain, stress, and temperature

Note 1 to entry: It is expressed in pascals.

4 Principle

This shall be in accordance with ISO 6721-10 for parallel plate geometry.

For cone and plate geometry, the same principle applies while the angle between the cone and plate is less than 5°.

5 Apparatus

5.1 Measurement apparatus

This shall be in accordance with ISO 6721-10 with the alternative option of using a cone and plate measurement geometry.

5.2 Temperature-controlled enclosure

This shall be in accordance with ISO 6721-10.

5.3 Temperature measurement and control

This shall be in accordance with ISO 6721-10.

5.4 Plate/specimen assembly

This shall be in accordance with ISO 6721-10 for parallel plate geometry. The plate diameter is typically in the range of 20 mm to 50 mm, and the specimen thickness lies in the range of 0,5 mm to 3 mm.

For cone and plate geometry, the angle between the cone and plate shall be less than 5°. The specimen assembly comprises concentric, circular cone and plate with the specimen held between them. The surface finish of cone and plate shall be in accordance with that of parallel plates. The results may be dependent on the type of material that is used to form the surfaces of the plates. This can be identified by testing using plates with different surface materials. The diameter of cone and plate, and the specimen thickness are in accordance with parallel plates. The total variation in the cone and plate separation around peripheral due to non-concentricity of the cone and plate plates shall be less than ±0,01 mm. Variation in the cone and plate separation around peripheral during testing shall be less than ±0,01 mm.

5.5 Calibration

This shall be in accordance with ISO 6721-10.

6 Sampling

This shall be in accordance with ISO 6721-10.

7 Procedure

7.1 Test temperature

This shall be in accordance with ISO 6721-10.

7.2 Zeroing the gap

This shall be in accordance with ISO 6721-10.

7.3 Introducing the test specimen

This shall be in accordance with ISO 6721-10.

7.4 Conditioning the test specimen

This shall be in accordance with ISO 6721-10.

7.5 Test mode (controlled stress or controlled strain)

This shall be in accordance with ISO 6721-10.

The shear storage modulus G' shall be measured at a fixed frequency (for example, 1,0 rad/sec.) Stress, strain and temperature can be varied with materials to be tested. The angular frequency can be selected other than 1,0 rad/sec if it is not appropriate to achieve material data at 1,0 rad/sec.

7.6 Determination of thermal stability of sample material

This shall be in accordance with ISO 6721-10.

7.7 Determination of region of linear-viscoelastic behaviour

7.7.1 In the controlled-strain mode

When working in the controlled-strain mode, determine the maximum permissible amplitude of oscillation by performing a strain sweep. The strain sweep shall be made using the same specimen assembly geometry, and at the same temperature similar to those to be used in subsequent testing. It can be necessary to carry out strain measurements at more than one oscillation frequency to check for any dependence of the limit of linear-viscoelastic behaviour on the angular frequency. Test the specimen by increasing the amplitude of oscillation over a range of values, preferably commencing with a strain, measured at ≥75 % of the radius of the plate, of not more than 1 %.

Measure the shear storage modulus G' as functions of the amplitude of oscillation to determine the maximum permissible amplitude of oscillation for measurements within the linear-viscoelastic region.

The maximum value of the strain to be used in actual testing shall be less than the lowest value of the strain at which a difference of 5 % occurred in the values of parameter G' compared with their values in the linear-viscoelastic region. If it is not possible to determine properties within the linear-viscoelastic region, this shall be stated in the test report.

NOTE For some materials, the linear-viscoelastic region is confined to very small strains. The associated measurement errors prevent properties being determined reliably in this region.

7.7.2 In the controlled-stress mode

When working in the controlled-stress mode, determine the range of linear-viscoelastic behaviour by performing a stress sweep. The stress sweep shall be made using the same specimen assembly geometry, and the same temperature to be used in subsequent testing. Test the specimen by increasing the torque over a range of values, preferably commencing with a torque that results in a strain, measured at the edge of the plate.

Measure the shear storage modulus G' as function of the torque to determine the maximum permissible torque for measurements within the linear-viscoelastic region.

The maximum value of the applied torque to be used in actual testing shall be less than the lowest value of the torque at which a deviation of 5 % occurred in the values of any of the parameter G' compared with their values in the linear-viscoelastic region. If it is not possible to determine properties within the linear-viscoelastic region, this shall be stated in the test report (see note to 7.7.1).

7.7.3 Confirmation of linear-viscoelastic behaviour

This shall be in accordance with ISO 6721-10.

If the rheometer program provides stress-strain hysteresis loop, non-linearity of materials may be determined from the plot.

7.8 Air entrapment

This shall be in accordance with ISO 6721-10.

8 Expression of results

The elastic index (EI) shall be given together with angular frequency (ω), stress (σ), strain (ε) and temperature (T) used for measurement of G':

For controlled strain mode, EI (ω, ε, σ, T)

EXAMPLE 1 EI (1,0 rad/sec, 10,0 %, 22,2 MPa, 210,0 °C)

For controlled stress mode, EI (ω, σ, ε, T)

EXAMPLE 2 EI (1,0 rad/sec, 22,2 MPa, 10,0 %, 210,0 °C)

EIs shall be averaged from 5 times repeated measures.

9 Test report

The test report shall include the following information:

a) a reference to this document, i.e. ISO 23673:2021;

b) the date of the test;

c) all details necessary for identification of the material tested;

d) details of preparation and loading of the specimen between the parallel plates or cone and plate;

e) a description of the rheometer used, including the plate diameter, plate separation, angle between cone and plate as applicable, and the material forming the plate surface;

f) the preheating time, in seconds;

g) details of the equilibrating time and any pre-shear conditioning;

h) the thermal-stability time, in seconds;

i) the test duration, in seconds;

j) elasticity index together with angular frequency, stress, strain, and temperature in the form of:

   EI (ω, ε, σ, T) for controlled strain mode

   or

   EI (ω, σ, ε, T) for controlled stress mode;

k) details of any corrections applied to the data;

l) any visual observations of melt fracture or degradation of the specimen, or entrapment of air bubbles or other defects in the specimen;

m) any test conditions agreed on that deviate from this document.