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Plastics — Determination of drawing characteristics of thermoplastics in the molten state

Plastiques — Détermination des caractéristiques d'étirage des thermoplastiques à l'état fondu

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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*.

This second edition cancels and replaces the first edition (ISO 16790:2005), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the normative references have been updated;

— the figure keys have been completed;

— the test procedure and parameters have been revised.

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.

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Plastics — Determination of drawing characteristics of thermoplastics in the molten state

1 Scope

This document specifies a method for determining the drawing and break characteristics of molten plastics. The method involves the measurement of the force generated in deforming a molten filament under defined extrusion temperature and drawing conditions.

Data is generated under non-isothermal and non-homogeneous deformation conditions. However, it is useful for the interpretation of polymer behaviour in extensional flow.

The method is suitable for thermoplastics moulding and extrusion materials that can be extruded using a capillary extrusion rheometer, or an extruder with capillary rod die or other extrusion devices and have sufficient melt strength to be handled without difficulty.

The method is applicable to chemically stable materials that produce a uniform extrudate free from heterogeneities, bubbles, unmelted impurities, etc.

This method can provide information on

— processability for all extrusion techniques,

— the effect of mechanical and thermal history, and

— the effect of chemical structure, such as branching, entanglements and molecular mass.

This technique is one of a number of techniques that can be used to measure the extensional flow behaviour of a material. This method of measurement does not necessarily reproduce the drawing conditions to which thermoplastics are subjected to during their processing.

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 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 11443, *Plastics — Determination of the fluidity of plastics using capillary and slit-die rheometers*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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/

3.1
drawing
process of stretching a filament of polymer melt that is being continuously formed by a capillary extrusion rheometer or extruder or other extrusion device

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3.2
melt strength
F_b
value of the melt tension at break of the extrudate

Note 1 to entry: Also known as the force to break.

Note 2 to entry: It is expressed in newtons.

3.3
draw ratio at break
DR
ratio of the *drawing velocity* (3.7) of the material at break to the *mean velocity* (3.4) of the material flowing from the die

3.4
mean velocity
v_m
average velocity of the extrudate at the die exit, determined as the ratio of volume flow rate to die cross-sectional area

Note 1 to entry: It is expressed in metres per second.

3.5
initial diameter
D_i
maximum diameter the extrudate attains after swelling on exiting from the die, the extrudate not yet having been subjected to significant drawing

Note 1 to entry: Initial diameter is expressed in metres.

Note 2 to entry: If no swelling of the extrudate occurs after exiting the die, the initial diameter is taken as the diameter of the die.

Note 3 to entry: This method can be unsuitable for testing materials that do not exhibit swelling of the extrudate after exiting the die as such materials will be difficult to handle in drawing off and will exhibit small *drawing forces* (3.8).

3.6
initial velocity
v_i
velocity of the extrudate near the die exit after swelling, the extrudate not yet having been subjected to significant *drawing* (3.1)

Note 1 to entry: It is determined at the position of the initial diameter of the extrudate.

Note 2 to entry: It is expressed in metres per second.

3.7
drawing velocity
v_t
velocity imposed on the lower end of the extrudate by the drawing unit

Note 1 to entry: It is expressed in metres per second.

3.8
drawing force
F_t
force exerted on the extrudate by the drawing unit

Note 1 to entry: It is expressed in newtons.

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3.9
drawing length
l_e
distance between the die exit and the point where the extrudate first contacts the drawing unit's rotating wheels

Note 1 to entry: It is expressed in metres.

3.10
drawing acceleration
a
rate of increase in the *drawing velocity* (3.7)

Note 1 to entry: It is expressed in metres per square second.

3.11
drawing velocity at break
v_b
velocity recorded at break when a constant *drawing acceleration* (3.10) is used

Note 1 to entry: It is expressed in metres per second.

4 Principle

Molten polymer is extruded from a capillary rheometer, extruder or other extrusion device at a specified temperature. The extrudate is drawn from the die by take-off wheels. Two techniques are used.

a) A series of take-off wheel velocities is used to determine the drawing force as a function of the drawing velocity.

b) A constant rate of acceleration of the take-off wheels is used to determine the melt strength (force to break) of the extrudate.

5 Apparatus

5.1 Apparatus for heating the polymer and forming the extrudate

5.1.1 General

The device to supply the molten polymer at a controlled temperature and flow rate shall consist of a heatable barrel [either a capillary extrusion rheometer (5.1.2) or an extruder (5.1.3)], the bore of which is closed at the bottom end by a die (see Figure 1). The test pressure shall be exerted on the melt contained in the barrel by a piston, a screw or pressurized gas.

5.1.2 Capillary extrusion rheometer

If a capillary extrusion rheometer is used, it shall have capillary dies, a piston, a temperature-measuring device and a pressure-measuring device meeting the requirements of ISO 11443.

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