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Rheology —

Part 2: General principles of rotational and oscillatory rheometry

Rhéologie —

Partie 2: Principes généraux de la rhéométrie rotative et oscillatoire

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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).

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 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 139, *Paints and varnishes,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement), and in cooperation with ISO/TC 61, *Plastics*, SC 5, *Physical-chemical properties*.

This document cancels and replaces ISO 3219:1993, which have been technically revised. The main changes compared to the previous editions are as follows:

— plate-plate measuring geometry has been added;

— relative measuring geometries have been added;

— oscillatory rheometry has been added.

A list of all parts in the ISO 3219 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.

Rheology —

Part 2: General principles of rotational and oscillatory rheometry

1 Scope

This document specifies the general principles of rotational and oscillatory rheometry.

Detailed information is presented in Annex A. Further background information is covered in subsequent parts of the ISO 3219 series, which are currently in preparation.

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 3219-1, *Rheology — Part 1: General terms and definitions for rotational and oscillatory rheometry*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3219-1 and the following 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
measuring gap
space between the boundary surfaces of the measuring geometry

3.2
gap width
h
H_{cc}
H_{cp}
distance between the boundary surfaces of the measuring geometry

Note 1 to entry: The symbol *h* refers to a gap width that can be varied (e.g. plate-plate measuring geometry); the symbol *H* refers to a gap width which is not variable and which is defined by the relevant measuring geometry. H_{cc} is the gap width of the coaxial-cylinders geometry. H_{cp} is the gap width of the cone-plate geometry.

Note 2 to entry: The distance between the boundary surfaces is given by the difference in the radii (coaxial cylinders), the cone angle (cone-plate) or the distance between the two plates.

Note 3 to entry: In cone-plate measuring geometries, the gap width varies as a function of the radius across the measuring geometry. The value H_{cp} is the distance between the flattened cone tip and the plate.

3.3
flow field coefficient
geometric factor
k
quotient of the shear stress factor (3.9) k_τ and the strain factor (3.8) k_γ

Note 1 to entry: The flow field coefficient k relates the angular velocity Ω and torque M to the shear viscosity η of the fluid as given by the following formula:

$$\eta = k \cdot \frac{M}{\Omega}$$

The flow field coefficient k is expressed in radians per cubic metre (rad·m^{-3}). It can be calculated from the shape and dimensions of an *absolute measuring geometry* (3.7).

3.4
no-slip condition
presence of a relative velocity of zero between a boundary surface and the immediately adjacent fluid layer

3.5
wall slip
presence of a non-zero relative velocity between a boundary surface and the immediately adjacent fluid layer

3.6
relative measuring geometry
measuring geometry for which the flow profile and thus the rheological parameters cannot be calculated

Note 1 to entry: For relative measuring geometries, the viscosity shall not be given in pascal multiplied by seconds (Pa·s) except in the case of plate-plate measuring geometries if the correction referred to in 6.3.3.1.2 is used.

3.7
absolute measuring geometry

measuring geometry for which the flow profile and thus the rheological parameters can be calculated exactly for the entire sample, regardless of its flow properties

3.8
strain factor
k_γ
proportionality factor between the angular deflection φ and shear strain γ for *absolute measuring geometries* (3.7)

Note 1 to entry: The absolute value of the strain factor corresponds to the absolute value of the shear rate factor. The latter is the proportionality factor between the shear rate $\dot{\gamma}$ and the angular velocity Ω.

Note 2 to entry: This factor is called the shear rate factor in the rotation test and the strain factor in the oscillatory test.

Note 3 to entry: The strain factor k_γ has units of reciprocal radians (rad^{-1}).

3.9
shear stress factor
k_τ
proportionality factor between the torque M and the shear stress τ for *absolute measuring geometries* (3.7)

Note 1 to entry: The shear stress factor k_τ has units of reciprocal cubic metres (m^{-3}).

4 Symbols

Table 1 — Symbols and units

Meaning	Symbol	Unit
Absolute value of the complex shear modulus	$\lvert G^* \rvert$	Pa
Absolute value of the complex viscosity	$\lvert \eta^* \rvert$	Pa·s
Acceleration of the angular deflection	$\ddot{\varphi}$	rad·s^{-2}
Amplitude of the angular deflection of the motor	$\varphi^*_{M,0}$	rad
Amplitude of angular deflection of torque transducer	$\varphi^*_{D,0}$	rad
Amplitude of the angular deflection	φ_0	rad
Amplitude of the angular velocity	$\dot{\varphi}_0$	rad·s^{-1}
Amplitude of the shear rate	$\dot{\gamma}_0$	s^{-1}
Amplitude of the shear strain	γ_0	1
Amplitude of the shear stress	τ_0	Pa
Amplitude of the torque	M_0	N·m
Angular acceleration of motor	$\ddot{\varphi}^*_M$	rad·s^{-2}
Angular acceleration of torque transducer	$\ddot{\varphi}^*_D$	rad·s^{-2}
Angular deflection	φ	rad
Angular deflection of motor	φ^*_M	rad
Angular deflection of sample	φ^*_P	rad
Angular deflection of torque transducer	φ^*_D	rad
Angular frequency	ω	rad·s^{-1} or s^{-1}
Angular velocity across the measuring gap	$\omega(r)$	rad·s^{-1}
Angular velocity (presented in brackets: as the time derivative of the angular deflection)	Ω, $(\dot{\varphi})$	rad·s^{-1}
Angular velocity of motor	$\dot{\varphi}^*_M$	rad·s^{-1}
Angular velocity of torque transducer	$\dot{\varphi}^*_D$	rad·s^{-1}
Coefficient of bearing friction	D_L	N·m·s
Coefficient of friction	D	N·m·s
Complex angular deflection	φ^*	rad
Complex shear modulus	G^*	Pa
Complex torque	M^*	N·m
Complex viscosity	η^*	Pa·s
Cone angle	α	° or rad
Deflection path	s	m
Drive loss factor	$\tan\zeta$	1
Drive phase angle	ζ	rad
Face factor	c_L	1
Flow field coefficient, geometric factor	k	rad·m^{-3}
Frequency	f	Hz

NOTE The parameters marked with an * refer to complex-valued parameters whose real part is denoted by ′ and imaginary part by ″.