**SLOVENSKI STANDARD**
**SIST EN ISO 3219-2:2021**

**01-julij-2021**

**Nadomešča:**
**SIST EN ISO 3219:1997**

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**Reologija - 2. del: Splošna načela za rotacijsko in oscilacijsko reometrijo (ISO 3219 -2:2021)**

Rheology - Part 2: General principles of rotational and oscillatory rheometry (ISO 3219-2:2021)

Rheologie - Teil 2: Allgemeine Grundlagen der Rotations- und Oszillationsrheometrie (ISO 3219-2:2021)

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Rhéologie - Partie 2: Principes généraux de la rhéométrie rotative et oscillatoire (ISO 3219-2:2021)

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**Ta slovenski standard je istoveten z:** **EN ISO 3219-2:2021**

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**ICS:**

| | | |
|---|---|---|
| 83.080.01 | Polimerni materiali na splošno | Plastics in general |

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

# EN ISO 3219-2

May 2021

ICS 83.080.01

Supersedes EN ISO 3219:1994

English Version

## Rheology - Part 2: General principles of rotational and oscillatory rheometry (ISO 3219-2:2021)

Rhéologie - Partie 2: Principes généraux de la rhéométrie rotative et oscillatoire (ISO 3219-2:2021)

Rheologie - Teil 2: Allgemeine Grundlagen der Rotations- und Oszillationsrheometrie (ISO 3219-2:2021)

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# European foreword

This document (EN ISO 3219-2:2021) has been prepared by Technical Committee ISO/TC 35 "Paints and varnishes" in collaboration with Technical Committee CEN/TC 139 “Paints and varnishes” the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2021, and conflicting national standards shall be withdrawn at the latest by November 2021.

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# INTERNATIONAL STANDARD

# ISO 3219-2

First edition
2021-05

## 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

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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.

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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*.

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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.

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# 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*

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## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3219-1 and the following apply.

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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.

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**3.3**
**flow field coefficient**
**geometric factor**
*k*
quotient of the shear stress factor (3.9) $k_\tau$ and the strain factor (3.8) $k_\gamma$

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

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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.

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**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**
$k_\gamma$
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 $k_\gamma$ has units of reciprocal radians (rad$^{-1}$).

**3.9**
**shear stress factor**
$k_\tau$
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 $k_\tau$ has units of reciprocal cubic metres (m$^{-3}$).

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## 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 | $\varphi_0$ | 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 | $\gamma_0$ | 1 |
| Amplitude of the shear stress | $\tau_0$ | 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 | $\varphi$ | rad |
| Angular deflection of motor | $\varphi_M^*$ | rad |
| Angular deflection of sample | $\varphi_P^*$ | rad |
| Angular deflection of torque transducer | $\varphi_D^*$ | rad |
| Angular frequency | $\omega$ | 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) | $\Omega$, $(\dot{\varphi})$ | 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 | $\varphi^*$ | rad |
| Complex shear modulus | $G^*$ | Pa |
| Complex torque | $M^*$ | N·m |
| Complex viscosity | $\eta^*$ | Pa·s |
| Cone angle | $\alpha$ | ° or rad |
| Deflection path | $s$ | m |
| Drive loss factor | $\tan\zeta$ | 1 |
| Drive phase angle | $\zeta$ | 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 ″. | | |

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**Table 1** *(continued)*

| Meaning | Symbol | Unit |
|---|---|---|
| Gap width | $h$ | m |
| Gap width defined by the coaxial cylinders geometry | $H_{cc}$ | m |
| Gap width defined by the cone-plate geometry | $H_{cp}$ | m |
| Geometry compliance | $C_G$ | rad·(N·m)$^{-1}$ |
| Imaginary part of the complex viscosity | $\eta''$ | Pa·s |
| Imaginary unit | i | 1 |
| Loss angle, phase angle | $\delta$ | rad |
| Loss factor | tan$\delta$ | 1 |
| Moment of inertia | $I$ | N·m·s$^2$ |
| Real part of the complex viscosity | $\eta'$ | Pa·s |
| Rotational speed | $n$ | s$^{-1}$ or min$^{-1}$ |
| Sample torque | $M_P^*$ | N·m |
| Shear force | $F$ | N |
| Shear loss modulus, viscous shear modulus | $G''$ | Pa |
| Shear modulus | $G$ | Pa |
| Shear plane | $A$ | m$^2$ |
| Shear rate factor | $k_{\dot{\gamma}}$ | rad$^{-1}$ |
| Shear rate, shear deformation rate | $\dot{\gamma}$ | s$^{-1}$ |
| Shear storage modulus, elastic shear modulus | $G'$ | Pa |
| Shear strain, shear deformation | $\gamma$ | 1 or % |
| Shear stress | $\tau$ | Pa |
| Shear stress factor | $k_\tau$ | m$^{-3}$ |
| Shear viscosity | $\eta$ | Pa·s |
| Strain factor | $k_\gamma$ | rad$^{-1}$ |
| Temperature | $T$ | °C or K |
| Time | $t$ | s |
| Torque | $M$ | N·m |
| Torque applied by motor | $M_M^*$ | N·m |
| Torque caused by bearing friction | $M_L^*$ | N·m |
| Torque caused by transducer inertia | $M_I^*$ | N·m |
| Torque measured by transducer | $M_m^*$ | N·m |
| Torsional compliance of the measurement system | $C$ | rad·(N·m)$^{-1}$ |
| Velocity | $v$ | m·s$^{-1}$ |
| NOTE The parameters marked with an * refer to complex-valued parameters whose real part is denoted by ′ and imaginary part by ″. | | |

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## 5 Measuring principles

### 5.1 General

There are rotational tests, oscillatory tests and various step tests. The different tests can be combined with one another.


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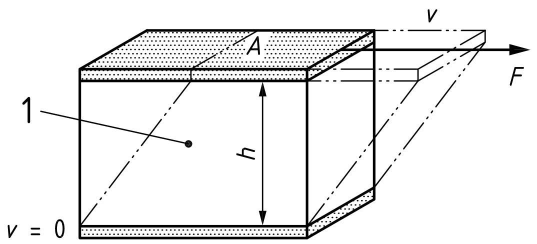
These can be carried out using various measuring types: controlled deformation (CD), controlled rate (CR) or controlled stress (CS).

## 5.2 Rotational rheometry

In the basic rotational test, the sample is subjected to constant or variable loading in one direction. The shear viscosity $\eta$ is calculated from the measured data. The corresponding mechanical input and response parameters are listed in Tables A.1 and A.3. The basic parameters of the test can be represented schematically in terms of the two-plates model. An infinitesimal element of the measuring geometry is considered in this subclause (see Figure 1). The two-plates model consists of two parallel plates, each with a surface area $A$ and with a gap width $h$, between which the sample is located. The velocity of the lower plate is zero ($v$ = 0). The upper plate is moved by a defined shear force $F$, which results in a velocity $v$. It is assumed that the sample between the plates consists of layers that move at different velocities of between $v$ = 0 and $v$.




**Key**

1 sample
$v$ velocity
$A$ shear plane
$h$ gap width
$F$ shear force

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**Figure 1 — Two-plate model with a simplified schematic representation of the basic parameters of a rotational test**

With this model, the following parameters are calculated using Formulae (1) to (3):

$$\tau = \frac{F}{A} \tag{1}$$

where

$\tau$ is the shear stress, in pascals;

$F$ is the shear force, in newtons;

$A$ is the shear plane, in square metres.

$$\dot{\gamma} = \frac{v}{h} \tag{2}$$

where

$\dot{\gamma}$ is the shear rate, in reciprocal seconds;

$v$ is the velocity, in metres per second;

$h$ is the gap width, in metres.

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