
Rheology —

Part 1:

**Vocabulary and symbols for rotational
and oscillatory rheometry**

Rhéologie —

*Partie 1: Vocabulaire et symboles pour la rhéométrie rotative et
oscillatoire*

STANDARDSISO.COM : Click to view the full PDF of ISO 3219-1:2021



STANDARDSISO.COM : Click to view the full PDF of ISO 3219-1:2021



COPYRIGHT PROTECTED DOCUMENT

© ISO 2021

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

	Page
Foreword	iv
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Symbols	8
Alphabetical index	10

STANDARDSISO.COM : Click to view the full PDF of ISO 3219-1:2021

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).

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.

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*, Subcommittee SC 5, *Physical-chemical properties*.

This first edition cancels and replaces the second edition (ISO 3219:1993), which has been technically revised.

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

- the terms and definitions have been moved to ISO 3219-1, the general principles have been moved to ISO 3219-2;
- new terms and definitions have been added;
- [Table 1](#) on symbols 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 1: Vocabulary and symbols for rotational and oscillatory rheometry

1 Scope

This document specifies general terms and definitions that are used in the context of rotational and oscillatory rheometry.

Further terms and definitions can be found in the other parts of the ISO 3219 series where they are used.

2 Normative references

There are no normative references in this document.

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:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1 absolute value of the complex shear modulus

$|G^*|$

ratio of the amplitude of the *shear stress* τ_0 (3.41) and the amplitude of the *shear strain* γ_0 (3.40)

Note 1 to entry: The absolute value of the complex shear modulus $|G^*|$ has the unit pascal (Pa).

3.2 absolute value of the complex shear viscosity

$|\eta^*|$

ratio of the amount of the complex shear modulus $|G^*|$ (3.1) and the *angular frequency* ω (3.5)

Note 1 to entry: The absolute value of the complex shear viscosity $|\eta^*|$ has the unit pascal multiplied by seconds (Pa·s).

3.3 amplitude sweep

oscillatory test with variable amplitude at a constant *angular frequency* ω (3.5)

3.4 angular displacement angular deflection

φ

angular measure where the angle is indicated by the length of the arc

Note 1 to entry: The angular displacement has the unit radians (rad).

**3.5
angular frequency**

ω
temporal change of the *angular displacement* φ (3.4) in oscillation

Note 1 to entry: The angular frequency ω has the unit radians per second (rad·s⁻¹) or, since rad is dimensionless (i.e. metre divided by metre), the unit reciprocal seconds (s⁻¹).

Note 2 to entry: The angular frequency ω , in reciprocal seconds (s⁻¹), is linked to the frequency f , in hertz (Hz) or in reciprocal seconds (s⁻¹), via the following relation:

$$\omega = 2\pi \cdot f$$

**3.6
angular velocity**

Ω
temporal change of the *angular displacement* φ (3.4) in rotation

Note 1 to entry: The angular velocity Ω has the unit radians per second (rad·s⁻¹).

Note 2 to entry: The angular velocity Ω , in radians per second (rad·s⁻¹), is linked to rotational speed n , in reciprocal seconds (s⁻¹), via the following relation:

$$\Omega = 2\pi \cdot n$$

**3.7
continuous ramp**

type of test where the specified variable from the initial value to the final value varies monotonously and constantly during the test

Note 1 to entry: The continuous ramp is performed by linear or logarithmic presetting.

Note 2 to entry: An alternative to the continuous ramp is the *step ramp* (3.46).

**3.8
elastic behaviour
elasticity**

property of a material to show reversible deformation and storage of mechanical energy

**3.9
flow curve**

graphical representation of the relation between *shear stress* τ (3.41) and *shear rate* $\dot{\gamma}$ (3.38)

**3.10
frequency**

f
oscillation per unit of time

Note 1 to entry: The frequency f has the unit hertz (Hz), where 1 Hz is 1 oscillation per second.

Note 2 to entry: The frequency f , in hertz (Hz) or in reciprocal seconds (s⁻¹), is linked to the *angular frequency* ω (3.5) in reciprocal seconds (s⁻¹) via the following formula:

$$f = \frac{\omega}{2\pi}$$

**3.11
frequency sweep**

oscillatory test (3.24) with variable *angular frequency* ω (3.5) at a constant amplitude

3.12**ideal-elastic behaviour
Hookean behaviour**

property of a material to show an immediate, fully reversible recovery after *deformation* (3.47)

3.13**in-phase component of the complex shear viscosity
dynamic viscosity** η'

real part of the complex shear viscosity η^*

Note 1 to entry: The dynamic viscosity η' has the unit pascal multiplied by seconds (Pa·s).

3.14**kinematic viscosity** ν

ratio of *shear viscosity* η (3.42) and density ρ

Note 1 to entry: The kinematic viscosity ν has the unit square metres per second ($\text{m}^2\cdot\text{s}^{-1}$).

3.15**laminar flow**

flow where infinitesimally thin layers are moved in parallel to each other

Note 1 to entry: All calculations of rheological parameters for absolute measuring geometries (see ISO 3219-2) only apply on the assumption of laminar flow.

3.16**linear viscoelastic range****LVR**

range where the *shear strain* γ (3.40) is proportional to the *shear stress* τ (3.41)

3.17**linearity limit** $[\tau_L, \gamma_L]$

point on the curve $\tau(\gamma)$ or $\gamma(\tau)$, above which the ratio of *shear stress* τ (3.41) and *shear strain* γ (3.40) is not anymore constant

Note 1 to entry: The linearity limit is given as shear stress τ_L with the unit pascal (Pa) and as shear strain γ_L which is dimensionless.

3.18**loss angle****phase angle** δ

phase shift between *shear stress* τ (3.41) and *shear strain* γ (3.40) at a harmonic steady-state excitation

Note 1 to entry: The loss angle δ has the unit degrees ($^\circ$) or radians (rad).

3.19**loss factor****damping factor** $\tan \delta$

ratio of *shear loss modulus* G'' (3.36) and *shear storage modulus* G' (3.39)

Note 1 to entry: The loss factor $\tan \delta$ is dimensionless.

3.20

Newtonian flow behaviour ideal-viscous flow behaviour

behaviour where the *shear viscosity* η (3.42) is independent of *shear rate* $\dot{\gamma}$ (3.38), *shear stress* τ (3.41) and time t

3.21

Newtonian standard sample

sample of a Newtonian liquid whose viscosity values and its traceability to a national measurement standard for the viscosity unit have been documented

3.22

non-Newtonian flow behaviour

behaviour where the *shear viscosity* η (3.42) is dependent on *shear rate* $\dot{\gamma}$ (3.38), *shear stress* τ (3.41) and/or time t

3.23

normal force

F_n

force acting perpendicularly to the surface of a volume element

Note 1 to entry: The normal force F_n has the unit newton (N).

Note 2 to entry: Normal forces can either be triggered by *shear deformation* (3.40) of the sample or be applied by the rheometer. In addition to this, not shear induced normal forces can be caused by the sample preparation or by changes during the measurement (e.g. swelling, drying, and shrinking).

3.24

oscillatory test

test where both shear planes of the measuring geometry harmonically oscillate around the same axis of rotation

3.25

oscillatory test with controlled (shear) strain oscillatory test with controlled (shear) deformation oscillatory test with CD

oscillatory test where the amplitude of the *shear deformation* γ_0 (3.40) and the *angular frequency* ω (3.5) are given

3.26

oscillatory test with controlled (shear) stress oscillatory test with CS

oscillatory test where the amplitude of the *shear stress* τ_0 (3.41) and the *angular frequency* ω (3.5) are given

3.27

out-of-phase component of the complex shear viscosity

η''

imaginary part of the complex shear viscosity η^*

Note 1 to entry: The out-of-phase component of the complex shear viscosity η'' has the unit pascal multiplied by second (Pa·s).

3.28

rheology

science of *deformation* (3.47) behaviour and flow behaviour of materials

3.29

rheometry

part of *rheology* (3.28) that covers the measurement of *deformation* (3.47) behaviour and flow behaviour of materials

3.30**rheopexy
rheoplectic behaviour**

reversible, time-dependent increase of *shear viscosity* η (3.42) at a constant *shear rate* $\dot{\gamma}$ (3.38) or *shear stress* τ (3.41)

3.31**rotational speed
rotational frequency**

n

number of rotations per unit time

Note 1 to entry: The rotational speed n has the SI unit reciprocal seconds (s^{-1}), in practice it is often given in reciprocal minutes (min^{-1}).

3.32**rotational test**

test where both shear planes of the measuring geometry are rotating relative to each other around the same axis of rotation

3.33**rotational test with controlled (shear) rate
rotational test with CR**

rotational test where the *shear rate* $\dot{\gamma}$ (3.38) is given as a function of time t

Note 1 to entry: In case there is no absolute measuring geometry (see ISO 3219-2) used, it is a speed-controlled *rotational test* (3.32).

3.34**rotational test with controlled (shear) stress
rotational test with CS**

rotational test where the *shear stress* τ (3.41) is given as a function of time t

Note 1 to entry: In case there is no absolute measuring geometry (see ISO 3219-2) used, it is a torque-controlled *rotational test* (3.32).

3.35**shear compliance**

J

ratio of *shear deformation* γ (3.40) and *shear stress* τ (3.41)

Note 1 to entry: The shear compliance J is the reverse of the *shear modulus* G (3.37).

Note 2 to entry: The shear compliance J has the unit reciprocal pascal (Pa^{-1}).

3.36**shear loss modulus
viscous shear modulus**

G''

measure of the *viscous behaviour* (3.54) of a viscoelastic material

Note 1 to entry: The shear loss modulus G'' has the unit pascal (Pa).

Note 2 to entry: The shear loss modulus G'' is the imaginary part of the complex shear modulus G^* .

3.37**shear modulus**

G

ratio of *shear stress* τ (3.41) and *shear strain* γ (3.40)

Note 1 to entry: The shear modulus G has the unit pascal (Pa).

3.38

shear rate
shear strain rate
shear deformation rate

$\dot{\gamma}$

time dependent change of the *shear strain* γ (3.40)

Note 1 to entry: The shear rate $\dot{\gamma}$ has the unit reciprocal seconds (s⁻¹).

3.39

shear storage modulus
elastic shear modulus

G'

measure of the *elastic behaviour* (3.8) of a viscoelastic material

Note 1 to entry: The shear storage modulus G' has the unit pascal (Pa).

Note 2 to entry: The shear storage modulus G' is the real part of the complex shear modulus G^* .

3.40

shear strain
shear deformation

γ

deformation of the sample caused by tangential displacement

Note 1 to entry: The shear strain γ is dimensionless. Alternatively, it is stated as a percentage (%), where 100 % = 1.

3.41

shear stress

τ

ratio of tangentially acting force and shear plane

Note 1 to entry: The shear stress τ has the unit pascal (Pa).

Note 2 to entry: An alternative symbol is σ .

3.42

shear viscosity

η

ratio of *shear stress* τ (3.41) and *shear rate* $\dot{\gamma}$ (3.38):

$$\eta = \frac{\tau}{\dot{\gamma}}$$

Note 1 to entry: The shear viscosity η has the unit pascal multiplied by seconds (Pa·s).

3.43

shear-thickening flow behaviour
dilatant flow behaviour

property of a material to show increasing *steady-state shear viscosity* η_{st} (3.45) with increasing *shear rate* $\dot{\gamma}$ (3.38) or *shear stress* τ (3.41)

3.44

shear-thinning flow behaviour
pseudoplastic flow behaviour

property of a material to show decreasing *steady-state shear viscosity* η_{st} (3.45) with increasing *shear rate* $\dot{\gamma}$ (3.38) or *shear stress* τ (3.41)

3.45**steady-state shear viscosity** η_{st}

time-independent value of *shear viscosity* η (3.42) at a constant *shear rate* $\dot{\gamma}$ (3.38) or constant *shear stress* τ (3.41)

$$\eta_{st}(\dot{\gamma}) = \lim_{t \rightarrow \infty} \eta(t, \dot{\gamma}) \text{ or } \eta_{st}(\tau) = \lim_{t \rightarrow \infty} \eta(t, \tau)$$

Note 1 to entry: The steady-state shear viscosity η_{st} has the unit pascal multiplied by seconds (Pa·s).

3.46**step ramp**

type of test where the specified variable from the initial value to the final value varies monotonously and discretely during the test

Note 1 to entry: The step ramp is performed by linear or logarithmic presetting.

Note 2 to entry: An alternative to the step ramp is the continuous ramp (3.7).

3.47**strain****deformation**

change of the shape or the volume of a body

3.48**thixotropy****thixotropic behaviour**

reversible, time-dependent decrease of *shear viscosity* η (3.42) at a constant *shear rate* $\dot{\gamma}$ (3.38) or *shear stress* τ (3.41)

3.49**torque** M

product of the length of the lever arm and the amount of the perpendicularly applied force

Note 1 to entry: The torque M has the unit newton multiplied by metres (N·m).

Note 2 to entry: The lever arm corresponds to the distance, in metres (m), from the axis of rotation.

3.50**transient shear viscosity** η_{tr}

time-dependent value of the *shear viscosity* η (3.42)

$$\eta_{tr}(\tau, t) = \frac{\tau(t)}{\dot{\gamma}} \text{ or } \eta_{tr}(\dot{\gamma}, t) = \frac{\tau}{\dot{\gamma}(t)}$$

Note 1 to entry: The transient shear viscosity η_{tr} has the unit pascal multiplied by seconds (Pa·s).

3.51**viscoelasticity**

property of a material to show both *elastic behaviour* (3.8) and *viscous behaviour* (3.54)

3.52**viscosity**

measure of the inner flow resistance of a material

Note 1 to entry: For details on different viscosity terms, see also *absolute value of the complex shear viscosity* (3.2), *in-phase component of the complex shear viscosity* (3.13), *kinematic viscosity* (3.14), *out-of-phase component of the complex shear viscosity* (3.27), *shear viscosity* (3.42), *steady-state shear viscosity* (3.45) and *transient shear viscosity* (3.50).

3.53

viscosity curve

graphical representation of *shear viscosity* η (3.42), typically shown as a function of *shear rate* $\dot{\gamma}$ (3.38) or *shear stress* τ (3.41)

Note 1 to entry: Measurements can also be performed in oscillation mode, typically represented as relation between *absolute value of the complex shear viscosity* $|\eta^*|$ (3.2) and *angular frequency* ω (3.5).

3.54

viscous behaviour

property of a material to dissipate *deformation energy*

3.55

yield point

yield stress

yield value

τ_y
shear stress τ (3.41) below which a material does not flow

Note 1 to entry: The yield point τ_y has the unit pascal (Pa).

3.56

zero-shear viscosity

η_0

limit of the *steady-state shear viscosity* (3.45) function for *shear rates* $\dot{\gamma}$ (3.38) towards zero

$$\eta_0 = \lim_{\dot{\gamma} \rightarrow 0} \eta_{st}(\dot{\gamma})$$

Note 1 to entry: The zero-shear viscosity η_0 has the unit pascal multiplied by seconds (Pa·s).

4 Symbols

The symbols and units of the properties defined in this document are given in [Table 1](#).

Table 1 — Symbols and units

Property	Symbol	Unit
absolute value of the complex shear modulus	$ G^* $	Pa
absolute value of the complex shear viscosity	$ \eta^* $	Pa·s
amplitude of shear strain	γ_0	1
amplitude of shear stress	τ_0	Pa
angular displacement, angular deflection	φ	rad
angular frequency	ω	rad·s ⁻¹ or s ⁻¹
angular velocity	Ω	rad·s ⁻¹
complex shear viscosity	η^*	Pa·s
frequency	f	Hz
in-phase component of the complex shear viscosity, dynamic viscosity	η'	Pa·s
kinematic viscosity	ν	m ² ·s ⁻¹
linearity limit	$[\tau_L, \gamma_L]$	[Pa, 1]
loss angle, phase angle	δ	° or rad
loss factor, damping factor	$\tan \delta$	1
normal force	F_n	N
out-of-phase component of the complex shear viscosity	η''	Pa·s
rotational speed, rotational frequency	n	s ⁻¹ or min ⁻¹