Viscometry

Determination of kinematic viscosity using the Ubbelohde viscometer

Part 1: Apparatus and measurement procedure

DIN 51562-1

ICS 17.060

Supersedes January 1983 edition.

Descriptors: Viscometry, Ubbelohde viscometer, apparatus.

Viskosimetrie – Messung der kinematischen Viskosität mit dem Ubbelohde-Viskosimeter – Teil 1: Bauform und Durchführung der Messung

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

Dimensions in mm

Foreword

This standard has been prepared by Technical Committee *Viskosimetrie* of the *Normenausschuß Materialprüfung* (Materials Testing Standards Committee). It should be used together with DIN 53012 and DIN 51562-4.

The DIN 51562 series of standards comprises the following:

Part 1 Apparatus and measurement procedure

Part 2 Micro-Ubbelohde viscometers

Part 3 Relative change in viscosity at short flow times

Part 4 Calibration of viscometers and determination of uncertainty of measurement

Amendments

This standard differs from the January 1983 edition as follows:

a) Calibration details have been included.
b) Requirements for automatic measuring equipment are now included.
c) Information on the uncertainty of measurement has been included.
d) An additional viscometer size (no. V) has been included.
e) Details relating to the apparatus and test procedure have been changed.

Previous editions

Supplement 1 to DIN 53655: 1947-12; DIN 51562: 1955-04, 1964-10, 1967-03, 1976-02; DIN 51562-1: 1978-12, 1983-01.

1 Scope and field of application

This standard specifies the design and use of Ubbelohde suspended level viscometers with ring measuring marks that indicate the flow volume. Such viscometers are used to determine the kinematic viscosity of Newtonian liquids that are sufficiently transparent to enable the meniscus of the liquid to be observed during measurement.

NOTE: Special automatic measuring devices also allow viscosity measurements of opaque liquids (cf. DIN 51366).

Continued on pages 2 to 10.

Translation by DIN-Sprachendienst.

In case of doubt, the German-language original should be consulted as the authoritative text.

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2 Normative references

This standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the titles of the publications are listed below. For dated references, subsequent amendments to or revisions of any of these publications apply to this standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

DIN 1319-1	Basic concepts in metrology – General concepts
DIN 1319-3	Basic concepts in metrology – Evaluating measurements of a single measurand and expression of uncertainty
DIN 1342-1	Viscosity – Rheological concepts
DIN 51366	Determination of kinematic viscosity of petroleum products using the Cannon-Fenske viscometer for opaque liquids
DIN 51562-3	Determination of kinematic viscosity using the Ubbelohde viscometer – Relative change in viscosity at short flow times
DIN 51562-4	Determination of kinematic viscosity using the Ubbelohde viscometer – Calibration of viscometers and determination of uncertainty of measurement
DIN 53012	Capillary viscometry of Newtonian liquids – Sources of error and corrections
DIN 53017	Determination of temperature coefficient of viscosity of liquids
ISO 3105 : 1994	Glass capillary kinematic viscometers – Specifications and operating instructions
ISO 3585 : 1991	Borosilicate glass 3.3 – Properties
ASTM D 2162-79	Standard method of basic calibration of master viscometers and viscosity oil standards

3 Concepts

The following concepts apply, in addition to those defined in DIN 1319-1 and DIN 1342-1.

3.1 Viscosity standard

A material measure or measuring device which represents the viscosity unit (e.g. when calibrating a viscometer).

3.2 Standard viscometer

For the purposes of this standard, an Ubbelohde capillary viscometer that is traceable to the national viscosity standard.

NOTE: See subclause 8.1 for a description of the Ubbelohde viscometer.

3.3 Standard Newtonian liquid

A Newtonian liquid whose change in viscosity with time is sufficiently small so that it is suitable as a viscosity standard.

3.4 Standard viscosity sample

A sample of a standard Newtonian liquid whose viscosity has been measured and recorded at one or more temperatures using standard viscometers; the traceability of the viscosity values thus obtained to the national viscosity standard shall have been documented. This sample can thus be used as a material measure.

4 Symbols and units

See tables 1 and 2 for symbols and units used in this standard.

For the purposes of this standard, the Reynolds number, Re, is given by (1):

$$Re = 637 \cdot \frac{V}{R \cdot K \cdot t^2} \tag{1}$$

Note that equation (1) only applies when the units given in column 4 of table 1 are used.

The following equations apply to the shear stress and shear rate, respectively:

$$\tau_w = \frac{g \cdot \varrho \cdot h_m \cdot R}{2 \cdot l} \tag{2}$$

$$\dot{\gamma}_w = \frac{4 \cdot V}{\pi \cdot t \cdot R^3} \tag{3}$$

5 Measuring range

This method is suitable for measuring kinematic viscosities within a range of 0,35 to 100 000 mm^2/s (see table 2), with flow times ranging from 200 s to 1 000 s at temperatures from 10 °C to 100 °C.

When using the viscometer at temperatures or flow times outside the above ranges, additional errors of measurement may occur which are not included in the uncertainty of measurement specified in clause 14.

6 Principle

The viscosity of the test liquid is determined by measuring the time it takes for the sample, whose volume is defined by two ring-shaped measuring marks, to flow laminarly through a capillary under the influence of gravity. As a result of the suspended level, the mean pressure head is independent of the filling volume, while the influence of surface tension (see DIN 53012) can generally be neglected.

Table 1: Symbols, quantities and units

Symbol	Quantity	SI unit	Other legal units
$\dot{\gamma}_w$ [1]	Shear rate at the internal wall of capillary (for Newtonian liquids)	s^{-1}	
g	Acceleration due to gravity at the point of measurement	m/s^2	
g'	Acceleration due to gravity at the point of calibration	m/s^2	
h_m	Mean pressure head	m	mm
k	Coverage factor (cf. DIN 1319-3)		
K	Viscometer constant	m^2/s^2	mm^2/s^2
l	Capillary length	m	mm
n	Number of single measurements (flow times) in a measurement series		
R	Capillary radius	m	mm
Re	Reynolds number		
t	Flow time	s	
t_{max}, t_{min}	Longest and shortest flow times in a series of n single measurements	s	
u'_v	Relative uncertainty of viscosity		
u'_K	Relative uncertainty of viscometer constant		
U_v	Temperature coefficient of kinematic viscosity	K^{-1}	
V	Flow volume	m^3	cm^3
Δt_H	Kinetic energy correction	s	
ε_t	Relative difference of flow times in a series of measurements using one viscometer		
ε_v	Relative difference between viscosities measured with two viscometers		
ν	Kinematic viscosity	m^2/s	mm^2/s
ϱ	Density of liquid	kg/m^3	g/cm^3
τ_w	Shear stress at internal wall of capillary	Pa	

[1] D_w may also be used instead of $\dot{\gamma}_w$.