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Plastics — Resins in the liquid state or as emulsions or dispersions — Determination of apparent viscosity using a single cylinder type rotational viscometer method

Plastiques — Résines à l'état liquide ou en émulsions ou dispersions — Détermination de la viscosité apparente par la méthode du viscosimètre rotatif de type à un cylindre

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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).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 5, *Physical-chemical properties*.

This third edition cancels and replaces the second edition (ISO 2555:1989), which has been technically revised. The main changes compared to the previous edition are as follows:

a) the name of the equipment has been changed to "single cylinder type rotational viscometer" and the method of determination of viscosity is described with more general terms to avoid reference to specific brand names;

b) the commercially available main models and spindles have been summarized;

c) digital type viscometer has been added;

d) the accuracy of test method has been added;

e) the calibration method has been added.

Introduction

A rotational viscometer is composed of a spindle, a torque measuring device and a spring. There are three types of rotational viscometers with regard to difference of the spindle:

a) single cylinder type (used in this document, i.e. ISO 2555);

b) coaxial cylinder type (used in ISO 3219[2]);

c) cone-plate type (used in ISO 3219[2]).

Single cylinder type rotational viscometers measure viscosity under non-constant shear rate. Coaxial cylinder type and cone-plate type instruments measure viscosity under constant shear rate.

When using a single cylinder type instrument, the measured viscosity is relative to measuring conditions. Conditions are therefore intended to be specified for viscosity measurements.

For Newtonian fluids, the viscosity value remains the same even if different viscosity measuring methods from this document and ISO 3219 are used.

With non-Newtonian fluids the measured viscosity changes depending on shear rate. The viscosity determined using different measuring methods such as methods from this document and ISO 3219 therefore may differ from each other, depending on shear rates used during measurements.

The Brookfield method has contributed a lot to determination of liquid viscosity. With its simple measuring low-cost equipment, the principles underlying the Brookfield technique still remain an important element in determination of viscosity of liquids.

This document is largely based on the Brookfield method established in 1989. However, some of the instruments mentioned in the previous edition of this document have long been discontinued. Moreover, although analogue (or the so-called “dial”) type was the predominant viscometer type at that time, the use has now shifted to digital viscometers in the recent years, increasing the need for this document to be revised.

The terms and standards introduced in this new edition are based on ISO 1652[1].

Currently, digital viscometer has become the mainstream. However, analogue (or dial) viscometer is still used and cannot be removed from the method. This document allows the use of both analogue (or dial) viscometer and digital viscometer.

Plastics — Resins in the liquid state or as emulsions or dispersions — Determination of apparent viscosity using a single cylinder type rotational viscometer method

1 Scope

This document specifies a method of determining apparent viscosity of resins in a liquid state using a single cylinder type rotational viscometer.

The method can be used for viscosity measurements in the range from 0,02 Pa · s to 60 000 Pa · s.

This document is applicable to both Newtonian and non-Newtonian liquids and the measured apparent viscosity depends on the velocity gradient to which the liquids are subjected during the measurement.

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
single cylinder type rotational viscometer
apparatus that determines viscosity by measuring the torque acting on a cylinder or a disc surface rotating in laminar flow condition at constant angular velocity

3.2
spindle
rotational symmetric object in the form of a cylinder or disc connected to a vertically rotating shaft

3.3
apparent viscosity
viscosity of liquids/fluids determined from the measured torque using predetermined calibration table

Note 1 to entry: For non-Newtonian fluids the apparent viscosity depends on the shear rate. With these types of viscometer, the velocity gradient is not the same for every point of the spindle. Thus, for a non-Newtonian fluid, the result is not strictly the true "viscosity at a known velocity gradient" and therefore is conventionally called the apparent viscosity.

4 Principle

4.1 General

A rotational symmetric spindle is driven at constant rotational speed in the liquid being measured.

The resistance exerted by the fluid on the spindle, which depends on the viscosity of the liquid, creates a torque which is measured by a suitable device.

The apparent viscosity measured using a single cylinder type rotational viscometer is obtained by multiplying the torque readout with a coefficient which depends on the rotational speed and characteristics of the spindle. With digital viscometers, viscosity is displayed by setting a certain rotational speed and entering the correct spindle number.

This method applies to Newtonian and non-Newtonian matter.

4.2 Operating principle

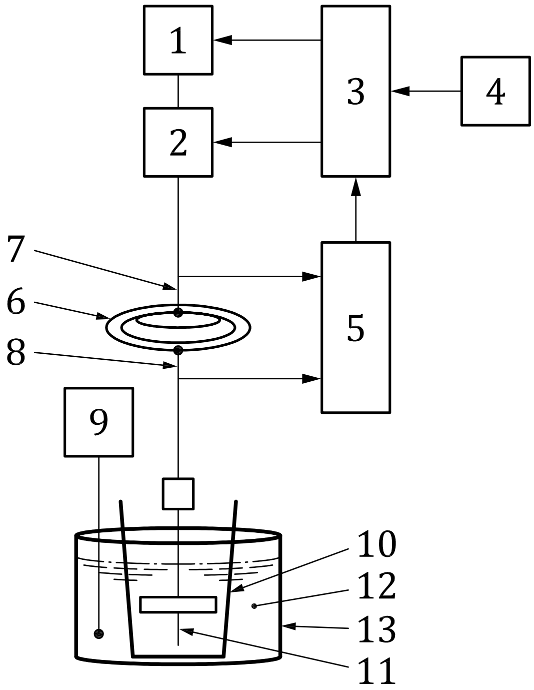
With analogue viscometer, a synchronous motor rotates a vertical shaft through a gear-box. This vertical shaft drives, through a spiral spring, a second lower shaft, forming an extension of the first. A removable spindle is attached to this second shaft and is immersed in the liquid under test. These two shafts rotate at the same frequency but, when the spindle is immersed there is an angular deviation between them which is a function of the resistance of the liquid to the rotation of the spindle, i.e. the liquid viscosity. Because of the difficulty of taking readings while the needle and dial are both rotating, a dial-needle locking system allows the reading to be taken after the motor has stopped.

With digital viscometers, an angle deviation between a vertical shaft and a second lower shaft is automatically read using the device for angle deviation measurement. Figure 1 shows a schematic drawing of the operating principle of a digital viscometer.

4.3 Brief description

Analogue viscometer body is equipped with an electric switch, synchronous motor, gear-box with its rotational speed change button, spiral spring, dial and needle, and dial-needle locking system.

Digital viscometer body is equipped with an electric switch, synchronous motor, the input device of the rotational speed, the input of the spindle, spiral spring, spindle, CPU, display and measurement of the angular deviation system.



Key

1 viscosity (display)
2 motor
3 CPU
4 input device of the rotational speed and spindle number
5 device of angle deviation measurement between the spindle and the motor
6 spring
7 first vertical shaft
8 second lower shaft
9 temperature measuring device
10 guard stirrup
11 spindle
12 liquid
13 beaker
← electrical signals or input

Figure 1 — Schematic drawing of the operating principle of a digital viscometer

5 Apparatus

5.1 Single cylinder type rotational viscometer

Depending on the viscosity of liquid and the desired precision, viscometer models L, R, H(A) or H(B) are chosen for measurement of sample viscosity. These viscometer models are categorized, based on the torque range. R is used as a standard format. L is used when the viscosity is low. H(A), H(B) is used when the viscosity is high.

The interchangeable spindles are made of metal and are in the form of cylinders or discs, which can be fixed on to main shaft of the viscometer. L1 to L4 are to be used with model L and R1 to R7 can be used for models R, H(A) and H(B) type viscometers.

A guard stirrup as specified in Annex B can be used to protect the device and the spindle. Using a guard stirrup shall not change measurement conditions.

The guard stirrups consist of a metal plate with a “U” form to protect the spindles.

The shape and dimensions of guard stirrups and spindles are given in Annex B. The size of the beaker shall be adapted depending on use of a guard stirrup.

With an analogue viscometer, the deviation is measured by a horizontal needle, fixed to the spindle shaft, moving on a horizontal dial fixed to the first (motor) shaft and consequently rotating with this shaft. When the spindle is rotating in air, the needle shall be calibrated to the “0” graduation of the dial.

A digital viscometer measures automatically the deviation between the spindle and the motor.

Figure 2 shows an example of a single cylinder type rotational viscometer for model L. Figure 3 shows an example of a single cylinder type rotational viscometer for model R, H(A) and H(B).

Figure 2 — Example of single cylinder type rotational viscometer for Model L

Figure 3 — Example of single cylinder type rotational viscometer for model R, H(A) and H(B)

Each viscometer consists of the following:

— the viscometer body; model L, R, H(A), H(B) depending on the liquid to be tested; with plastics, model R is most commonly used, with highly viscous samples model H(A) or H(B) is recommended, while with less viscous samples model L is recommended. The maximum value of the measurement, L < R < H(A) < H(B);

— for model L: Four interchangeable spindles numbered from L1 to L4 (L1 being the largest);

— for model R, H(A), H(B): Seven interchangeable spindles numbered from R1 to R7 (R1 being the largest).

All spindles carry a mark that indicates the immersion level in the liquid (see F in Table B.1).

Characteristics of single cylinder type rotational viscometer models are given in Table 1.

Table 1 — Characteristics of single cylinder type rotational viscometer models

Viscometer model	Maximum torque µN·m	Spindles numbered
L	67,37	L1 L2 L3 L4
R	718,7	R1 R2 R3 R4 R5 R6 R7
H(A)	1 437,4	R1 R2 R3 R4 R5 R6 R7
H(B)	5 749,6	R1 R2 R3 R4 R5 R6 R7

The shapes and sizes of the spindles are such that the viscosities corresponding to a maximum torque indication on the meter, for the various rotational frequencies, are those given in Table 2 and Table 3.

