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Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity

Produits pétroliers — Liquides opaques et transparents — Détermination de la viscosité cinématique et calcul de la viscosité dynamique

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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.

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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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This document was prepared by Technical Committee ISO/TC 28, *Petroleum and related products, fuels and lubricants from natural or synthetic sources*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 19, *Gaseous and liquid fuels, lubricants and related products of petroleum, synthetic and biological origin*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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This fourth edition cancels and replaces the third edition (ISO 3104:2020), which has been technically revised.

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

~~Manual~~ Procedure (Procedure A) has been designated as the referee rest method in case of dispute;

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~~the~~ DCT requirements have been updated in Table 1;

~~allowable~~ DCT drift in 7.3 has been aligned with Table 1;

~~extra~~ instructions for quality control have been added referring to the new publication of Part 4 of ISO 4259-4;

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— complying thermometers have been updated in Table B2;

— the calculation has been corrected in Annex D;

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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Introduction

Many petroleum products and some non-petroleum materials are used as lubricants. The correct operation of equipment depends upon the appropriate viscosity of the liquid being used. In addition, the viscosity of many petroleum fuels is important for the estimation of optimum storage, handling and operational conditions. Thus, the accurate measurement of viscosity is essential to many product specifications.

This document describes two test methods: Procedure A (manual) and Procedure B (automated). Procedure A is the referee test method (or reference test method) to resolve doubts or dispute.

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Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity

WARNING — This document does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of users of this document to take appropriate measures to ensure the safety and health of personnel prior to the application of this document, and to determine the applicability of any other restrictions.

1 Scope

This document specifies Procedure A, using manual glass viscometers, and Procedure B, using glass capillary viscometers in an automated assembly, for the determination of the kinematic viscosity, ν , of both transparent and opaque products. The scope includes liquid petroleum products, FAME (fatty acid methyl ester (FAME)), paraffinic diesel, hydrotreated vegetable oil (HVO), gas to liquid (GTL) and biofuel diesel mixtures up to 50% FAME. The kinematic viscosity is determined by measuring the time for a volume of liquid to flow under gravity through a calibrated glass capillary viscometer. The dynamic viscosity, η , is obtained by multiplying the measured kinematic viscosity by the density, ρ , of the liquid. The range of kinematic viscosities covered in this test method is from 0,2 mm²/s to 300 000 mm²/s over the temperature range -20 °C to +150 °C.

NOTE The result obtained from this document is dependent upon the behaviour of the sample and is intended for application to liquids for which primarily the shear stress and shear rates are proportional (Newtonian flow behaviour). If, however, the viscosity varies significantly with the rate of shear, different results can be obtained from viscometers of different capillary diameters. The procedure and precision values for residual fuel oils, which under some conditions exhibit non-Newtonian behaviour, have been included.

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 3105:1994, *Glass capillary kinematic viscometers — Specifications and operating instructions*

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

ASTM E2877-12, *Standard Guide for Digital Contact Thermometers*

~~ISO 4259-4, *Petroleum and related products — Precision of measurement methods and results — Part 4: Use of statistical control charts to validate 'in statistical control' status for the execution of a standard test method in a single laboratory*~~

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>

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— IEC Electropedia: available at <https://www.electropedia.org/>

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3.1 kinematic viscosity

ν
resistance to flow of a fluid under gravity

Note 1 to entry: For gravity flow under a given hydrostatic head, the pressure head of a liquid is proportional to its density, ρ . For any particular viscometer, the time of flow of a fixed volume of fluid is directly proportional to its kinematic viscosity, ν :

$$\nu = \eta / \rho$$

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where η is the *dynamic viscosity* (3.2) coefficient.

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3.2 dynamic viscosity

η
ratio between the applied shear stress and rate of shear of a liquid

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Note 1 to entry: It is a measure of the resistance to flow or deformation of a liquid.

Note 2 to entry: The term dynamic viscosity is also used in a different context to denote a frequency-dependent quantity in which shear stress and shear rate have a sinusoidal time dependence.

Note 3 to entry: Dynamic viscosity may also be called coefficient of dynamic viscosity or absolute viscosity.

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3.3 density

ρ
mass per unit volume of a substance at a given temperature

4 Principle

The time is measured for a fixed volume of liquid to flow under gravity through the glass capillary of a calibrated viscometer under a reproducible driving head and at a known and closely controlled temperature. The kinematic viscosity is the product of the measured flow time and the calibration constant of the viscometer.

5 Reagents and materials

5.1 Cleaning solution, strongly-oxidizing cleaning solution or alkaline cleaning solutions can be used.

Alkaline cleaning solutions with a pH of greater than 10 are not recommended as they have been shown to change the viscometer calibration. If these are used, then the viscometer calibration should be verified to ensure there is no change.

5.2 Sample solvent, completely miscible with the sample. A prewash of an aromatic solvent such as toluene or heptane can be necessary to remove asphaltenic material. When cleaning capillaries inside the bath, the boiling point of the cleaning solution shall be higher than the bath temperature.

5.3 Drying solvent, suitable and volatile at the used temperature. Filter before use. If moisture remains, use a drying solvent miscible with water (5.4).

NOTE When cleaning capillaries inside the bath and if the bath temperature is higher than 50 °C, acetone is not suitable.

5.4 Water, deionized or distilled, conforming to Grade 3 of ISO 3696. Filter before use.

5.5 Certified viscosity reference standards (CRM), produced by a reference material producer that meet and meeting the requirements of ISO 17034⁽⁶⁾. They shall be characterized in accordance with a standard practice for the basic calibration of master viscometers and characterization of viscosity oils, such as in ASTM D2162⁽⁹⁾-21. The certified values shall be traceable to the international agreed value of distilled water (1,003 4 mm²/s at 20 °C as specified in ISO/TR 3666⁽²⁾).

6 Apparatus

6.1 **Drying tubes**, consisting of a desiccant drying system of either externally mounted drying tubes or an integrated desiccant drying system which is designed to remove ambient moisture from the capillary tube. Ensure that they are packed loosely and that the desiccant is not saturated with water.

6.2 **Sample filter**, micron screen or fretted (sintered) glass filter, no more than 75 µm.

6.3 **Reagent filter**, micron screen or fretted (sintered) glass filter, no more than 11 µm.

6.4 **Ultrasonic bath**, unheated, with an operating frequency between 25 kHz to 60 kHz and a typical power output of ≤100 W, of suitable dimensions to hold container(s) placed inside of bath, for use in effectively dissipating and removing air or gas bubbles that can be entrained in viscous sample types prior to analysis. It is permitted to use ultra-sonic baths with operating frequencies and power outputs outside this range. However, it is the responsibility of the laboratory to conduct a data comparison study to confirm that the results determined with and without the use of such ultrasonic baths do not materially impact results.

6.5 Manual apparatus

6.5.1 **Glass capillary viscometer**, calibrated in accordance with ISO 3105.

The viscometer shall have a certificate of calibration provided by a laboratory that meets ISO/IEC 17025⁽⁵⁾. The calibration constant should be checked before first use of the capillary and only changed if necessary.

The calibration constant, C , is dependent upon the gravitational acceleration at the place of calibration. The variation in the value of g across the earth's surface is about 0,5 % due to latitude plus approximately 0,003 % per 100 m altitude. Apply a gravity correction to the viscometer calibration constant as in Formula (1), if the acceleration of gravity of the testing laboratory differs by more than 0,1 % of the calibration laboratory.

$$C_2 = \left(\frac{g_2}{g_1}\right) C \quad (1)$$

where the g_1 and g_2 are, respectively, the calibration laboratory and the testing laboratory.

NOTE Calculation of acceleration of gravity values can be found in Reference [24].

IMPORTANT — Viscometers used for silicone fluids, fluorocarbons and other liquids, which are difficult to remove using a cleaning agent, shall be reserved for the exclusive use of those fluids, except during their calibration. Subject such viscometers to calibration checks at frequent intervals. The solvent washings from these viscometers shall not be used for the cleaning of other viscometers. If the viscometer is cleaned using the material in 5.1 then the user shall verify the calibration before further use.

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