INTERNATIONAL

DOCUMENT

OIML D 17

Edition 1987 (E)

Hierarchy scheme for instruments measuring the viscosity of liquids

Schéma de hiérarchie des instruments de mesure de la viscosité des liquides

OIML D 17 Edition 1987 (E)

ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION
OF LEGAL METROLOGY

Foreword

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States.

The two main categories of OIML publications are:

- **International Recommendations (OIML R)**, which are model regulations that establish the metrological characteristics required of certain measuring instruments and which specify methods and equipment for checking their conformity; the OIML Member States shall implement these Recommendations to the greatest possible extent;

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International Recommendations and International Documents are published in French (F) and English (E) and are subject to periodic revision.

This publication – reference OIML D 17, edition 1987 (E) – which is under the responsibility of TC 17/SC 5 *Viscometry*, was approved by the International Committee of Legal Metrology in 1984.

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HIERARCHY SCHEME
for INSTRUMENTS MEASURING
the VISCOSITY of LIQUIDS

This International Document sets out the hierarchy scheme for instruments measuring the viscosity of liquids in SI units:
$m^2 \cdot s^{-1}$ for kinematic viscosity, and
$Pa \cdot s$ for dynamic viscosity.

The Document establishes the sequence for the verification of viscometers and indicates uncertainties and the main methods of verification. A diagram summarizes this information (see page 7).

1. Primary and secondary standards

1.1. Primary standard of viscosity

1.1.1. The primary standard is intended to reproduce and conserve the values of the viscosity of liquids and to transmit these values to ordinary measuring instruments by means of secondary standards, reference standards and working standards.

1.1.2. The ranges of viscosity of newtonian liquids reproduced by the standard are:

from $4 \cdot 10^{-7}$ to 10^{-1} $m^2 \cdot s^{-1}$ for kinematic viscosity, and

from $4 \cdot 10^{-4}$ to 10^{2} $Pa \cdot s$ for dynamic viscosity.

1.1.3. The primary standard reproduces the values of viscosity with an uncertainty of measurement between 0.03 % to 0.5 %, depending on the measuring range of viscosity; the standard deviation of the measurement results at the lower end of the measuring range shall not exceed 0.03 % (see note 1).

1.1.4. The primary standard is used for the verification of secondary standards. The secondary standards are compared with the primary standard by measurement of the same liquids under the same conditions of temperature and pressure.

1.1.5. The measurement of the viscosity of liquids using the primary standard is based on the comparison of the viscosity of the liquid under examination with the viscosity of freshly prepared, double-distilled water, at a temperature of 20 °C and a pressure of 101 325 Pa.

Under the indicated conditions the following values for the characteristics of double-distilled water are used:
— kinematic viscosity : 1.0038×10^{-6} $m^2 \cdot s^{-1}$
— dynamic viscosity : 1.002×10^{-3} $Pa \cdot s$
— density : 998.203 kg/m^3

Reference : ISO Technical Report ISO/TR 3666-1977.

1.1.6. The primary standard comprises the following:

— a set of free liquid flow capillary viscosimeters for the various measuring ranges, making it possible to measure the viscosity of the calibration liquid by comparison with the viscosity of water; the lengths of the capillary tubes of the viscosimeters of the two largest sizes of the set should be at least 400 mm; the correction for kinetic energy shall not exceed 0.03 % of the measured viscosity;

— a measuring instrument to determine the flow time of the liquid in the viscometers; the instrument error shall not exceed 0.01 % ; the reading error shall not exceed 0.01 s ;

— equipment to control and measure the temperature of the liquid in a thermo-static bath ; the temperature shall not depart from the nominal value by more than ± 0.005 °C ; neither the difference in temperature between any two points in the bath nor the temperature measurement error shall exceed 0.005 °C.

1.2. Secondary standards

1.2.1. Secondary standards are intended for the verification of reference viscometers.

1.2.2. The uncertainty of measurement of the secondary standard shall be between 0.05 % and 0.8 %, depending on the measuring range of viscosity; the standard deviation of the measurement results at the lower end of the measuring range shall not exceed 0.05 % (see note 1).

1.2.3. A secondary standard comprises the following:

— a set of free liquid flow capillary viscometers covering the measuring range from $4 \cdot 10^{-7}$ to 10^{-1} $m^2 \cdot s^{-1}$; the lengths of the capillary tubes of the viscometers of the two largest sizes of the set should be at least 400 mm; the correction for kinetic energy shall not exceed 0.03 % of the measured viscosity ;

— a mesasuring instrument to determine the flow time of the liquid in the viscometers; the instrument error shall not exceed 0.01 % *;* the reading error shall not exceed 0.01 s ;

— equipment to control and measure the temperature of the liquid in a thermostatic bath ; the temperature shall not depart from the nominal value by more than ± 0.01 °C; neither the difference in temperature between any two points in the bath nor the temperature measurement error shall exceed 0.01 °C.

1.3. The primary and secondary standards for measuring the viscosity of liquids should be provided with certificates issued by the competent metrological authorities.

2. Reference standards and working standards

2.1. Reference standards

2.1.1. Sets of free liquid flow glass capillary viscometers (preferably of the Ubbelohde suspended level type, with a capillary tube length of 300 mm) are used as reference standards, as are reference standard liquids.

2.1.2 The maximum uncertainty (calculated on the basis of 2 standard deviations -see note 1) on the determination of reference standard viscometer constants and on the measurement of the viscosity of reference standard liquids shall be between 0.2 % and 1 % depending on the measuring range of viscosity.

2.1.3. Reference standards are used to calibrate working standards and high-accuracy ordinary measuring instruments by direct comparison and by direct measurement.

2.2. Working standards

2.2.1. Sets of free liquid flow glass capillary viscometers (Ubbelohde suspended level type with a capillary tube length from 90 to 120 mm) are used as working standards, as are working standard liquids.

2.2.2. The maximum uncertainties (calculated on the basis of 2 standard deviations - see note 1) on the determination of working standard viscometer constants shall be between 0.5 % to 2.5 % and that on the measurement of the viscosity of working standard liquids between 0.3 % and 2 % depending on the measuring range of viscosity.

2.2.3. Working standards are used to calibrate or verify ordinary measuring instruments by direct comparison an by direct measurement.

2.3. The working standards shall be provided with certificates issued by the competent metrological authorities.

3. Ordinary measuring instruments

3.1. Viscometers of various operating principles, intended for the determination of the viscosity of newtonian and non-newtonian liquids in SI units, are used as ordinary measuring instruments.

3.2. Viscometers shall be verified using newtonian liquids.

3.3. An indication of the errors to be expected in ordinary viscometers is given in the diagram on page 7.

NOTES

1. The experimental standard deviation of the mean of n measurements is determined using the formula:

$$S = \sqrt{\frac{\Sigma\left(X_i - \overline{X}\right)^2}{n(n-1)}}$$

where :

x_i is the i^{th} result of measurement,

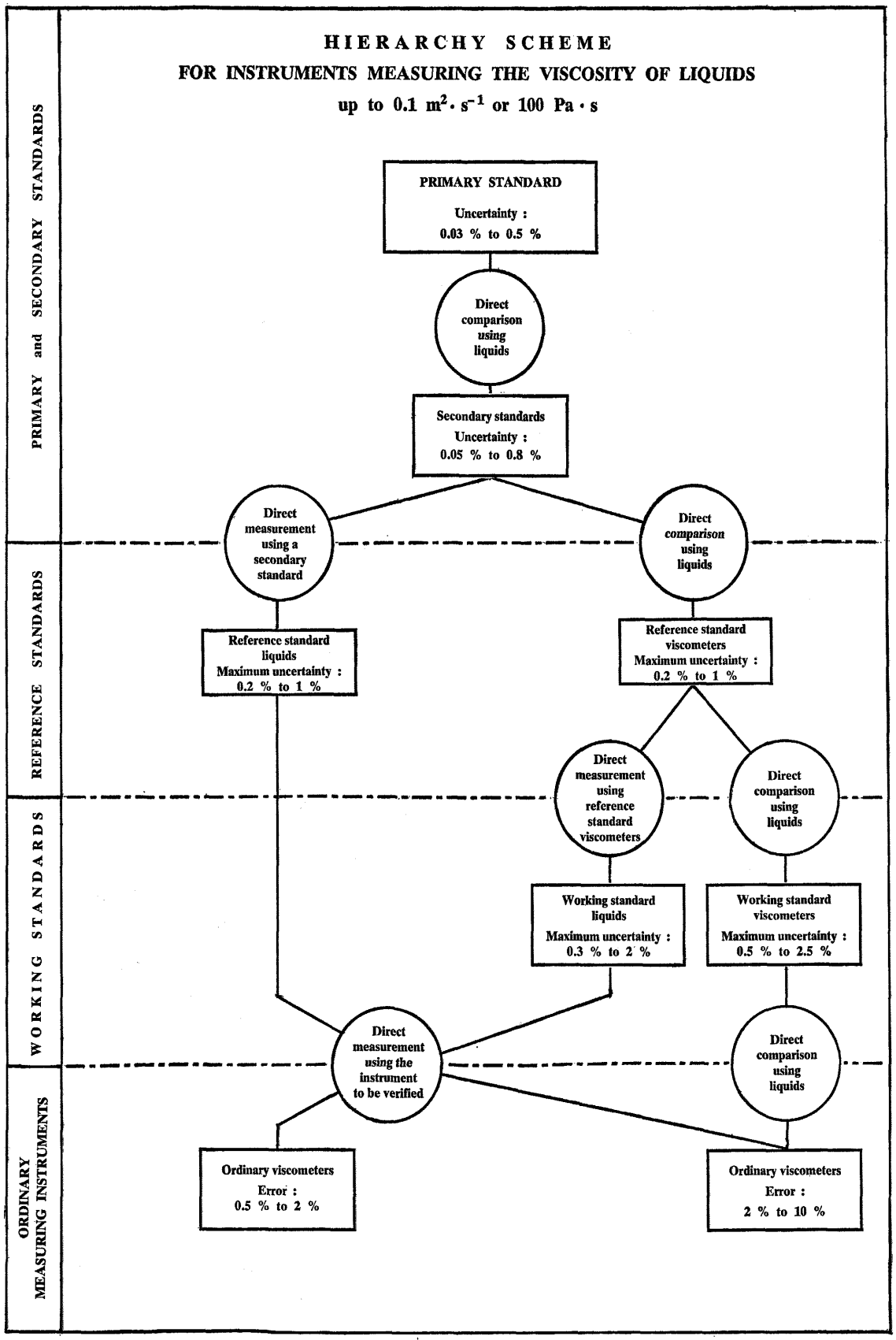
$\overline{x}$ is the arithmetic mean of the n results considered

or, in relative value : $\frac{S}{\overline{X}} \cdot 100 \ \%$

2. The uncertainty on the value of the viscosity of water (point 1.1.5.) is 0.25 %. No allowance was made for this uncertainty in the determination of the uncertainties given in the hierarchy scheme.

3. Ordinary measuring instruments and standards may be verified using standards of higher accuracy in the hierarchy scheme, without necessarily using any intermediary links.

4. The density of the calibration liquid (required for the calculation of dynamic viscosity) shall be determined with an error not exceeding 0.05 %.


HIERARCHY SCHEME
FOR INSTRUMENTS MEASURING THE VISCOSITY OF LIQUIDS
up to 0.1 m² · s⁻¹ or 100 Pa · s
PRIMARY and SECONDARY STANDARDS
REFERENCE STANDARDS
WORKING STANDARDS
ORDINARY MEASURING INSTRUMENTS
PRIMARY STANDARD
Uncertainty :
0.03 % to 0.5 %
Direct comparison using liquids
Secondary standards
Uncertainty :
0.05 % to 0.8 %
Direct measurement using a secondary standard
Direct comparison using liquids
Reference standard liquids
Maximum uncertainty :
0.2 % to 1 %
Reference standard viscometers
Maximum uncertainty :
0.2 % to 1 %
Direct measurement using reference standard viscometers
Direct comparison using liquids
Working standard liquids
Maximum uncertainty :
0.3 % to 2 %
Working standard viscometers
Maximum uncertainty :
0.5 % to 2.5 %
Direct measurement using the instrument to be verified
Direct comparison using liquids
Ordinary viscometers
Error :
0.5 % to 2 %
Ordinary viscometers
Error :
2 % to 10 %

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