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BSI Standards Publication

Bitumen and bituminous binders — Determination of kinematic viscosity

bsi.

National foreword

This British Standard is the UK implementation of EN 12595:2023. It supersedes BS EN 12595:2014, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PTI/13, Petroleum Testing and Terminology.

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Bitumen and bituminous binders - Determination of kinematic viscosity

Bitumes et liants bitumineux - Détermination de la viscosité cinématique

Bitumen und bitumenhaltige Bindemittel - Bestimmung der kinematischen Viskosität

This European Standard was approved by CEN on 28 May 2023.

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Contents

European foreword

This document (EN 12595:2023) has been prepared by Technical Committee CEN/TC 336 “Bituminous binders”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2024, and conflicting national standards shall be withdrawn at the latest by January 2024.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12595:2014.

In comparison with the previous edition, the main technical changes are:

— deletion of note in scope and new note added to scope regarding assumption of Newtonian behaviour under test conditions;

— removal of dated reference in normative references (ISO 2592);

— formula for the relationship between dynamic and kinematic viscosity added in 3.1;

— “accuracy” changed to “maximum permissible error” in several Clauses (5.2, 5.4, 5.5 and 5.6);

— references to mercury thermometers and total immersion thermometer in 5.2 deleted;

— new sub-Clause 5.7 added on Calibration/Verification;

— additional information on use of viscometers and references to figures added in 7.1;

— mandatory use of two BS/IP/RF viscometers for one determination of kinematic viscosity;

— precision on time for thermal equilibrium and removal of note in 7.2;

— information on validity of individual test data to calculate mean value added in Clause 8; including a new Note 1 and renumbering existing note to Note 2;

— key added to Figures A.1, A.2 and A.3 and correct diameter of bulb in key of Figure A.1;

— Figures A.2 and A.3 revised;

— Table B.1 updated with informative values for viscosity standards;

— Annex C deleted;

— new Annex C introduced with examples on calculation;

— ASTM E77-98 deleted from Bibliography;

— reference to ASTM D2170-01 in Bibliography has been updated and reference (footnote) to Institute of Petroleum deleted.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom

1 Scope

This document specifies a method for the determination of the kinematic viscosity of bituminous binders at 60 °C and 135 °C, in a range from 6 mm^2/s to 300 000 mm^2/s. Other temperatures are possible if calibration constants are known. Bituminous emulsions are not covered within the scope of this method.

Results for this method can be used to calculate dynamic viscosity when the density of the test material is known or can be determined.

NOTE This document assumes Newtonian behaviour of the sample at test conditions.

WARNING — The use of this document can involve hazardous materials, operations and equipment. This document does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this document to identify the hazards and assess the risks involved in performing this test method and to implement sufficient control measures to protect individual operators (and the environment). This includes appropriate safety and health practices and determination of the applicability of regulatory limitations prior to use.

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.

EN 58, *Bitumen and bituminous binders - Sampling bituminous binders*

EN 12594, *Bitumen and bituminous binders - Preparation of test samples*

EN 12607-2, *Bitumen and bituminous binders - Determination of the resistance to hardening under influence of heat and air - Part 2: TFOT method*

EN ISO 2592, *Petroleum and related products - Determination of flash and fire points - Cleveland open cup method (ISO 2592)*

EN ISO 3696:1995, *Water for analytical laboratory use - Specification and test methods (ISO 3696)*

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

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

3.1
kinematic viscosity
ratio between the dynamic viscosity and the density of a liquid at the temperature of measured viscosity

$$\nu = \frac{\eta}{\rho}$$

where

- ν is kinematic viscosity;
- η is dynamic viscosity;
- ρ is density.

Note 1 to entry: Kinematic viscosity is a measure of a liquid's resistance to flow under gravity.

Note 2 to entry: The SI unit of kinematic viscosity is m^2/s; for practical use, a sub-multiple (mm^2/s) is more convenient.

3.2
density
mass of a liquid divided by its volume

Note 1 to entry: When reporting density, the unit of density used, together with the temperature, is explicitly stated, for example kg/m^3.

Note 2 to entry: The SI unit of density is kg/m^3.

3.3
dynamic viscosity
ratio between the applied shear stress and the velocity gradient

Note 1 to entry: Dynamic viscosity is a measure of a liquid's resistance to flow, and is commonly called the viscosity of the liquid.

Note 2 to entry: The SI unit of dynamic viscosity is Pa·s.

3.4
Newtonian liquid
liquid with a viscosity that is independent of the rate of shear

Note 1 to entry: The constant ratio of the shear stress to the velocity gradient is the dynamic viscosity of the liquid. If this ratio is not constant, the liquid is non-Newtonian.

4 Principle

The time for a fixed volume of the liquid to flow through the capillary of a calibrated glass capillary viscometer under an accurately reproducible head and at a closely controlled temperature is determined (efflux time). The kinematic viscosity is calculated by multiplying the efflux time in seconds by the viscometer calibration factor.

5 Apparatus

Usual laboratory apparatus and glassware, together with the following:

5.1 Viscometer, Cannon-Fenske, BS/IP/RF and the Zeitfuchs Cross-Arm viscometers[1], capillary-type, made of borosilicate glass, suitable for this method are described in Figure A.1, Figure A.2 and Figure A.3, and Table A.1, Table A.2 and Table A.3. Other viscometers are allowed if test results obtained are comparable.

Calibrated viscometers are available from commercial suppliers. Details regarding the calibration of viscometers are given in Annex B.

5.2 Temperature measuring device.

A temperature measuring device (combining sensor and reading unit) shall:

— have a range from at least 55 °C to 140 °C;

— be readable to 0,05 °C or less;

— have a maximum permissible error of 0,1 °C.

NOTE For practical reasons, separate temperature measuring devices for individual temperature ranges can be used.

Sensors based on platinum resistance thermometers have been found suitable but other principles are also allowed. The temperature measuring device shall be calibrated regularly.

When measuring and controlling nominally constant temperatures, as in this test method, the thermal response time can be rather high (e.g. slow response to a change in temperature). Care shall be taken to consider this aspect since low thermal response times of the sensor can indicate greater cyclic variations than the bituminous material in practice experiences.

5.3 Bath, suitable for immersion of the viscometer so that the liquid reservoir or the top of the capillary, whichever is uppermost, is at least 20 mm below the top of the bath level, and with provisions for visibility of the viscometer and the thermometer. Firm supports for the viscometer shall be provided, or the viscometer shall be an integral part of the bath. The efficiency of the stirring and the balance between heat losses and heat input shall be such that the temperature of the bath medium does not vary by more than 0,3 °C (measurement at 60 °C) or 0,5 °C (measurement at 135 °C) over the length of the viscometer, or from viscometer to viscometer in the various bath positions.

Water, conforming to grade 3 of EN ISO 3696:1995, is a suitable bath liquid for determinations at 60 °C. USP white oil or any paraffinic or silicone oil with a flash point above 215 °C has been found suitable for determination at 135 °C. The flash point shall be determined in accordance with EN ISO 2592.

5.4 Timer, stop watch (spring or battery driven) graduated in divisions of 0,1 s or less and with a maximum permissible error of 0,5 s over 1 000 s when tested over intervals of not less than 15 min. Verify the maximum permissible error frequently.

5.5 Electrical timing devices, for use only on electrical circuits the frequencies of which have a maximum permissible error of 0,5 s over 1 000 s. Verify the maximum permissible error frequently.

NOTE Alternating currents, the frequencies of which are intermittently and not continuously controlled, as provided by some public power systems, can cause large errors, particularly over short timing intervals, when used to actuate electrical timing devices.

[1] This information is given for the convenience of users of this document and does not constitute an endorsement by CEN of this product. Equivalent products may be used if they can be shown to lead to the same results.

5.6 Automatic or semi-automatic equipment are allowed providing that they meet the specifications and maximum permissible errors for temperature regulation and time described in Clause 5 and have been shown to achieve the same precision as given in Clause 10 and are fully calibrated.

5.7 Calibration/Verification, all equipment shall be calibrated/verified at least once per year.

6 Preparation of test samples

The laboratory sample shall be taken in accordance with EN 58. Prepare the sample in accordance with EN 12594.

Bring the viscometer and the sample to the test temperature (in order to avoid correction of constants of the viscometer). Stir the sample thoroughly without entrapment of air. If the temperature has dropped to 30 °C or more below the test temperature, reheat the sample.

Immediately charge the viscometer or, if the test is to be made at a later time, pour approximately 20 ml into one or more clean and dry containers having an approximate volume of 30 ml and immediately seal with an airtight closure.

7 Procedure

7.1 Test conditions

Maintain the bath (5.3) at the test temperature to within ± 0,3 °C (measurements at 60 °C) or ± 0,5 °C (measurements at 135 °C). Apply the necessary corrections, if any, to all thermometer readings.

Select a clean, dry viscometer giving an efflux time greater than 60 s and preheat it to the test temperature.

Charge the viscometer in the manner dictated by the design of the instrument, as described in the following.

To charge the Cannon-Fenske opaque viscometer (Figure A.1), invert the viscometer and apply vacuum to the tube L, immersing tube N in the liquid sample. Draw liquid through tube N, filling bulb D to filling mark G. Wipe excess sample off tube N and invert the viscometer to its normal position. Mount the viscometer in the constant-temperature bath keeping tube L vertical.

Apply a stopper to the top of the apertures of tube L when bulb A is nearly 4/5th filled.

Mount the BS/IP/RF viscometer (Figure A.2) in the constant temperature bath keeping tube L vertical. Pour sample through tube N to a point just above filling mark G; allow the sample to flow freely through capillary R, taking care that the liquid column remains unbroken, until the lower meniscus is about 5 mm below the filling mark H and then arrest its flow by closing the timing tube with a cork or rubber stopper in tube L.

Add more liquid if necessary to bring the upper meniscus slightly above mark G.

After allowing the sample to attain bath temperature and any air bubbles to rise the surface, gently loosen the stopper allowing the sample to flow to the lower filling mark H and again arrest flow. Remove the excess sample above filling mark G by inserting the special pipette until its cork rests on top of tube N; apply gentle suction until air is drawn through. The upper meniscus shall coincide with mark G.

Mount the Zeitfuchs Cross-Arm viscometer (Figure A.3) in the constant temperature bath, keeping tube N vertical. Introduce sample through tube N taking care not to wet the sides of tube N, into the cross-arm D until the leading edge stands within 0,5 mm of fill mark G on the siphon tube.

For the Zeitfuchs Cross-Arm and BS/IP/RF viscometer, it is mandatory to use two viscometers. For Cannon-Fenske, for practical reasons it is recommended also to prepare two viscometers in case testing needs to be repeated, e.g. due to invalid results.

7.2 Determination and measurement

Allow the viscometer to remain in the bath at constant temperature for at least 1 h to ensure that the sample reaches temperature equilibrium. The test shall be performed within 4 h.

For the Cannon-Fenske and BS/IP/RF viscometers, remove the stopper in tube L and allow the sample to flow by gravity until the lower meniscus is opposite the lower timing mark E.

For the Zeitfuchs Cross-Arm viscometer, apply slight vacuum to tube M or pressure to tube N-15, see Figure A.3) to cause the meniscus to move over the siphon tube and about 30 mm below the level of tube D in capillary R. Gravity flow is thus initiated.

Measure to the nearest 0,1 s the time required for the leading edge of the meniscus to pass from timing mark E to timing mark F and from F to I (Cannon-Fenske). If this efflux time is less than 60 s, select a viscometer of smaller capillary diameter and repeat the operation.

NOTE 1 Time intervals between 60 s and 400 s are practical, but intervals can be extended up to 1 000 s.

Upon completion of the test, clean the viscometer thoroughly by several rinsings with an appropriate solvent completely miscible with the sample, followed by a completely volatile solvent. An alternative cleaning procedure is to put the capillary viscometer upside down in oven and allow the bitumen to drop out. After this, use solvent. For both methods dry the tube by passing a slow stream of filtered dry air through the capillary for 2 min, or until the last trace of solvent is removed. Periodically clean the instrument with a suitable non-caustic cleaner to remove organic deposits, rinse thoroughly with water conforming to grade 3 of EN ISO 3696:1995, and residue-free acetone and dry with filtered dry air.

Using alkaline glass cleaning solutions can result in a change of viscometer calibration and is not recommended. Other cleaning methods (like pyrolysis) may be appropriate at temperatures which do not damage the volumetric glassware. In this case, it is recommended to verify the viscometer frequently to note changes as soon as possible.

NOTE 2 Pyrolysis is not a suitable procedure for viscometers with fixed, non-removable metal ring holders.

8 Calculation

Calculate the kinematic viscosity, ν, in m^2/s, using results from timing marks, using Formula (1):

$$\nu = C \times t \tag{1}$$

where

C is the calibration constant of the viscometer, in m^2/s^2;

t is the efflux time, in s.

While for Zeitfuchs Cross-Arm and BS/IP/RF, the viscosity is calculated per viscometer, for Cannon-Fenske the viscosity calculation is performed per individual bulb. Consequently, validity of results is also determined on these respective sections.

For tests carried out with time readings from 60 s to 1 000 s, calculate the coefficient of variance CV, which is sample standard deviation divided by the mean value in %, using Formula (2):

$$CV = \frac{s}{\bar{x}} \times 100 \left[\% \right] \tag{2}$$

where

s is the sample standard deviation;

$\bar{x}$ is the mean value.

NOTE 1 Formula (2) is applicable to the verification of the results obtained from the different bulbs or tube sections respectively of the same viscometer. Formula (2) can also be used to verify the individual results obtained from two viscometers if only one of the individual viscometer´s bulbs/tube sections is within the time range.

The maximum acceptable range of two results that are obtained, respectively, from two bulbs belonging to the same viscometer, corresponds to a coefficient of variance of 1 %.

The maximum acceptable range of the mean values that are obtained, respectively, from two viscometers, corresponds to a coefficient of variance of 2 %.

If the appropriate maximum coefficient of variance is exceeded, discard the results and repeat the test from Clause 6 on a second sample test container.

If the appropriate range of coefficient of variance is exceeded again, report all individual results and the coefficient of variance under Clause 11 e).

NOTE 2 Annex C provides examples on the calculations of sample standard deviation and coefficient of variance.

9 Expression of results

Together with the test temperature, express the kinematic viscosity as the mean value of the viscosities calculated from the readings for all bulbs or tube sections used, having flow time reading from 60 s to 1 000 s, to three significant figures below 1 000 mm^2/s or as the whole number above this value.

10 Precision

10.1 Repeatability

The difference between two successive test results, obtained by the same operator with the same apparatus under constant operating conditions on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the value given in Table 1 in only one case in twenty.

10.2 Reproducibility

The difference between two single and independent results obtained by different operators working in different laboratories on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the values given in Table 1 in only one case in twenty.

Table 1 — Precision values

	Repeatability *r* % of mean	**Reproducibility** *R* % of mean
at 135 °C		
< 600 mm²/s	4	6
≥ 600 mm²/s	4	9
at 60 °C		
soft bitumen	7	9
soft bitumen after hardening (TFOT)	9	20
kinematic viscosity (KV) ratio at 60 °C (only for KV ratio < 1,5)	6	16
Kinematic Viscosity ratio at 60 °C is the ratio of kinematic viscosity at 60 °C of bituminous binder conditioned according to EN 12607-2 over the kinematic viscosity at 60 °C of original unconditioned binder.		

These precision data are not automatically applicable to modified bitumen. For modified bitumen, they should only be used for guidance until criteria data are available.

11 Test report

The test report shall contain at least the following information:

a) type and complete identification of the sample under test;

b) reference to this document (including year of publication);

c) apparatus used (Viscometer type, size and ID number);

d) result of the test (see Clause 9);

e) any deviation, by agreement or otherwise, from the procedure specified;

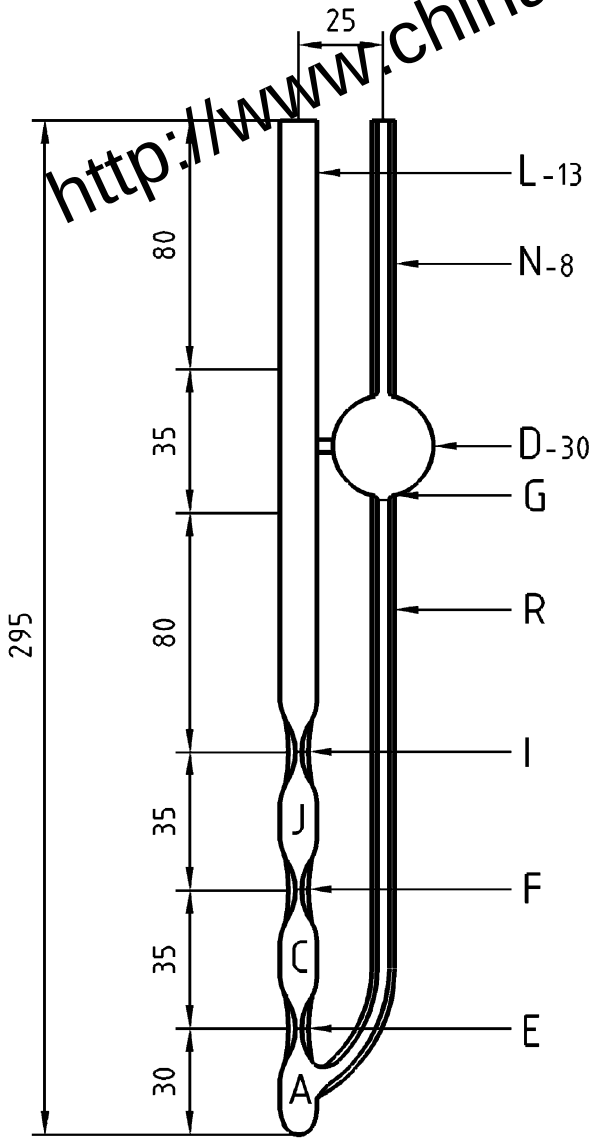
f) any unusual features observed;

g) date of the test.

Annex A
(normative)

Specifications of viscometers

Dimensions in millimetres



Key

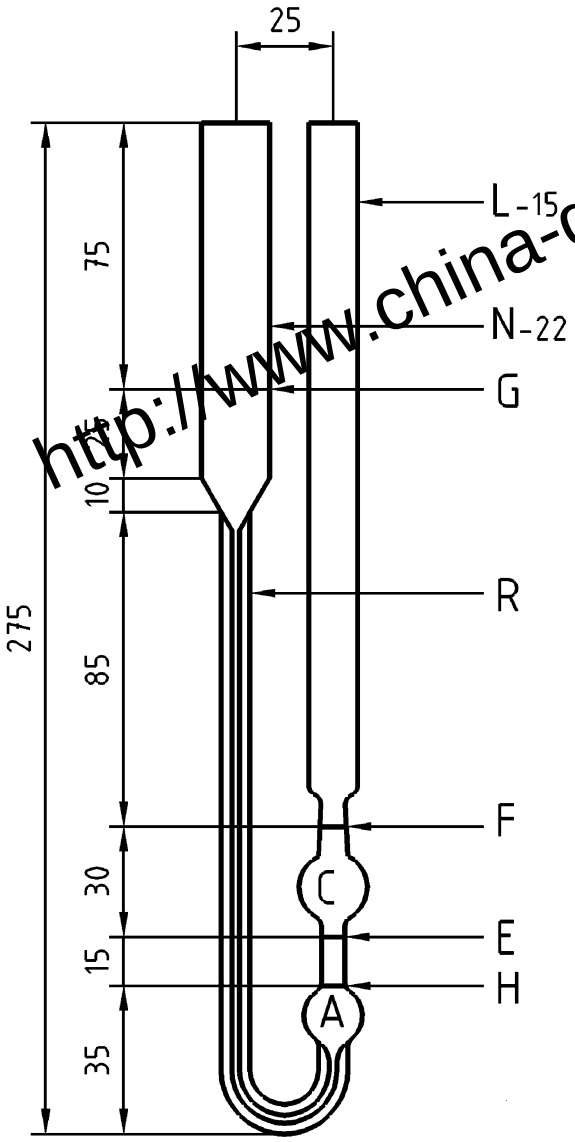
A	Bulb A	R	Capillary tube
C	Bulb C	Dimensions needed for construction of viscometer:	
J	Bulb J	L	Tube, diameter 13 mm
G	Filling mark	N	Tube, diameter 8 mm
E, F and I	Division marks	D	Reservoir bulb, diameter 30 mm

Figure A.1 — Cannon-Fenske opaque viscometer for opaque and transparent liquids

Table A.1 — Dimensions and kinematic viscosity ranges for the Cannon-Fenske viscometer

Size No.	Nominal viscometer constant	Kinematic viscosity range	Inside diameter of tube R	Inside diameter of tubes N and G, tubes E, F and I	Volume bulbs A, C, and J	Volume bulb D
			(± 2 %)	(± 5 %)	(± 5 %)	(± 5 %)
	mm^2/s^2	mm^2/s	mm	mm	ml	ml
200	0,1	6 to 100	1,02	3,2	2,1	11
300	0,25	15 to 200	1,26	3,4	2,1	11
350	0,5	30 to 500	1,48	3,4	2,1	11
400	1,2	72 to 1 200	1,88	3,4	2,1	11
450	2,5	150 to 2 500	2,20	3,7	2,1	11
500	8	480 to 8 000	3,10	4,0	2,1	11
600	20	1 200 to 20 000	4,00	4,7	2,1	13

Dimensions in millimetres



Key

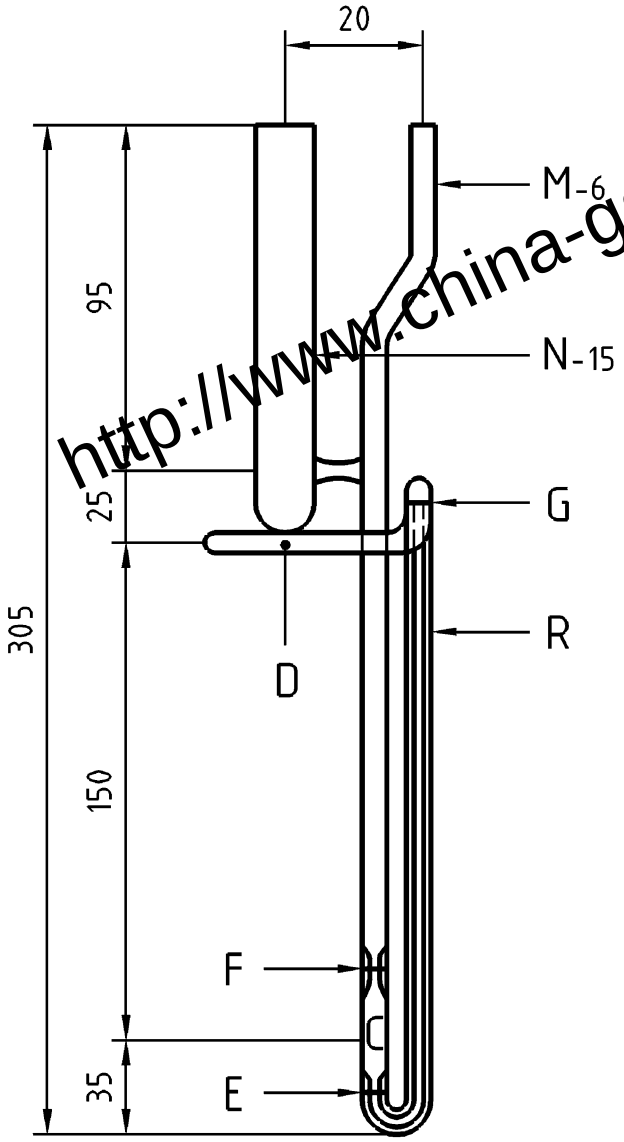
A	Reservoir bulb A	R	Capillary tube
C	Bulb C	Dimensions needed for construction of viscometer:	
E and F	Timing marks	L	Tube, diameter 15 mm
G and H	Filling marks	N	Tube, diameter 22 mm

Figure A.2 — Example of BS/IP/RF U-tube reverse flow viscometer for opaque liquids

Table A.2 — Dimensions and kinematic viscosity ranges for the BS/IP/RF viscometer

Size No.	Nominal viscometer constant	Kinematic viscosity range	Inside diameter of tube R	Length of tube R	Inside diameter at E, F and H	Volume bulb C
			(± 2 %)			(± 5 %)
	mm^2/s^2	mm^2/s	mm	mm	mm	ml
4	0,1	6 to 100	1,26	185	3,0 to 3,3	4,0
5	0,3	18 to 300	1,64	185	3,0 to 3,3	4,0
6	1,0	60 to 1 000	2,24	185	3,0 to 3,3	4,0
7	3,0	180 to 3 000	2,93	185	3,3 to 3,6	4,0
8	10	600 to 10 000	4,00	185	4,4 to 4,8	4,0
9	30	1 800 to 30 000	5,50	185	6,0 to 6,7	4,0
10	100	6 000 to 100 000	7,70	210	7,7	4,0
11	300	18 000 to 300 000	10,00	210	10,0	4,0

Dimensions in millimetres



Key

C	Bulb C	R	Capillary tube
D	Cross-arm	Dimensions needed for construction of viscometer:	
E and F	Timing marks	M	Tube, diameter 6 mm
G	Filling mark	N	Tube, diameter 15 mm

Figure A.3 — Zeitfuchs cross-arm viscometer for transparent and opaque liquids

Table A.3 — Dimensions and kinematic viscosity ranges for the Zeitfuchs cross-arm viscometer

Size	Nominal viscometer constant	Kinematic viscosity range	Inside diameter of tube R	Length of tube R from G to E	Lower bulb volume	Horizontal tube diameter
			(± 2 %)		(± 5 %)	(± 5 %)
	mm^2/s^2	mm^2/s	mm	mm	ml	mm
4	0,10	6 to 100	0,64	210	0,3	3,9
5	0,3	18 to 300	0,84	210	0,3	3,9
6	1,0	60 to 1 000	1,15	210	0,3	4,3
7	3,0	180 to 3 000	1,42	210	0,3	4,3
8	10,0	600 to 10 000	1,93	165	0,25	4,3
9	30,0	1 800 to 30 000	2,52	165	0,25	4,3
10	100,0	6 000 to 100 000	3,06	165	0,25	4,3

Annex B
(informative)

Calibration of viscometers

B.1 General

Annex B describes the materials and procedures used for calibrating, or checking the calibration of viscometers used in this document. Capillary viscometers shall preferably be calibrated at the intended operational temperature.

B.2 Reference materials

Viscosity oil standards conforming to ASTM and having approximate kinematic viscosities as shown in Table B.1.

Certified kinematic viscosity values established are supplied with each sample.

Table B.1 — Viscosity oil standards

Viscosity oil standards[a]	Approximate kinematic viscosity mm^2/s			
	at 37,8 °C (100 °F)	at 25 °C	at 50 °C	at 100 °C
S60	60	120	35	7,5
S200	200	410	120	23
S600	600	1 200	300	49
S2000	2 000	5 300	800	72
S8000	8 000	25 000	3 200	...
S30000	27 000	79 000	11 000	630

[a] The viscosity standards cited in Table B.1 are examples cited according to the reference system of the following firm:

Cannon Instrument Company
2139 High Tech Road
State College, PA 16803
USA

This information is given for the convenience of users of this document and does not constitute an endorsement by CEN of the product named. Equivalent products may be used if they can be shown to lead to the same results.

B.3 Calibration

B.3.1 Calibration of routine viscometer by means of viscosity standards

B.3.1.1 Select from Table B.1 a liquid standard having a minimum efflux time of 200 s at the calibration temperature (preferably 37,8 °C). Determine the efflux time to the nearest 0,1 s using the

procedure described in Clause 7 and calculate the viscometer constant, C, in square millimetres per square second, using Formula (B.1) as follows:

$$C = \frac{v}{t} \quad \text{(B.1)}$$

where

v is the viscosity of standard liquid, in mm²/s;

t is the efflux time, in s.

It is recommended to avoid the use of a silicone oil as a viscosity oil for calibration. It renders the viscometers unsuitable for further use.

NOTE The viscometer constant is independent of temperature for BS/IP/RF "U-tube viscometers".

B.3.1.2 The Cannon-Fenske opaque viscometer (see Figure A.1) has a fixed volume of sample charged at the fill temperature. If the test temperature differs from the fill temperature, the viscometer constant is calculated using Formula (B.2) as follows:

$$C_T = C_0\left[1 + F\left(T_t - T_f\right)\right] \quad \text{(B.2)}$$

where

C_T is the viscometer constant at temperature T;

C_0 is the viscometer constant when filled and tested at the same temperature;

F is the temperature dependence factor;

T_t is the test temperature, in °C;

T_f is the fill temperature, in °C.

B.3.1.3 Calculate the temperature dependence constant by using Formula (B.3):

$$F = 4\alpha\left[\frac{V}{\pi d^2 \mathrm{h}}\right] = \left[\frac{4V\left(\rho_f - \rho_t\right)}{\pi d^2 \mathrm{h}\rho_t\left(T_t - T_f\right)}\right] \quad \text{(B.3)}$$

where

V is the volume of charge, in cm³;

d is the average diameter of the meniscus in the upper reservoir bulb, in cm;

h is the average driving head, in cm;

α is the coefficient of thermal expansion of the test sample between the fill temperature and the test temperature;

ρ_f is the density at the fill temperature, in g/cm³;

ρ_t is the density at the test temperature, in g/cm³;

T_t is the test temperature, in °C;

T_f is the fill temperature, in °C.

B.3.1.4 If the viscometer is used at a location other than the calibration laboratory, the C constant should be corrected for the difference in the acceleration of gravity, g, at the two locations using Formula (B.4) as follows:

$$C_2 = \left(\frac{g_2}{g_1}\right) \times C_1 \quad \text{(B.4)}$$

where

C_2 is the calibration constant determined in the testing laboratory;

C_1 is the calibration constant determined in the calibrating laboratory;

g_2 is the acceleration of gravity at the testing laboratory;

g_1 is the acceleration of gravity at the calibrating laboratory.

Certificates for viscometers should state the value of g at the location of the calibrating laboratory. Failure to correct for gravity can result in errors of 0,2 %.

B.3.2 Calibration of routine viscometer by means of standard viscometer

Select any petroleum oil or bitumen having an efflux time of at least 200 s. Select also a standard viscometer of known C constant or a routine viscometer of the same type that has been calibrated by comparison with a reference viscometer. Calibrated viscometers are available from a number of commercial suppliers. Mount the standard viscometer together with the viscometer to be calibrated in the same bath and determine the efflux times of the oil by the procedure described.

Calculate the C constant using Formula (B.5) as follows:

$$C_1 = \frac{\left(t_2 \times C_2\right)}{t_1} \quad \text{(B.5)}$$

where

C_1 is the C constant of routine viscometer;

t_1 is the efflux time to nearest 0,1 s in routine viscometer;

C_2 is the C constant of standard viscometer;

t_2 is the efflux time to nearest 0,1 s in standard viscometer.

Annex C
(informative)

Example for calculation of results

Sample standard deviation is calculated according Formula (C.1a):

$$\sigma = \sqrt{\frac{\Sigma\left(x_i - \overline{x}\right)^2}{\left(n-1\right)}} \quad \text{(C.1a)}$$

where

x_i is the observed value (measured test result);

$\overline{x}$ is the mean value of results;

n is the number of values.

If n = 2, a simplified equation given in Formula (C.1b) can be used.

$$\sigma = \frac{\left|a-b\right|}{\sqrt{2}} \quad \text{(C.1b)}$$

where

a is result No. 1;

b is result No. 2

Coefficient of variance CV is calculated according Formula (C.2):

$$CV = \frac{\sigma}{\overline{x}} \times 100\ \% \quad \text{(C.2)}$$

EXAMPLE

Sample A: 300 mm²/s

Sample B: 307 mm²/s

$\overline{x}$ = 303,5 mm²/s

x_1 = 300 mm²/s

x_2 = 307 mm²/s

n = 2

Sample standard deviation σ is calculated according to Formula (C.1a).

Sum of squared deviations = $\Sigma\ (x_i - \overline{x})^2 = (300 - 303{,}5)^2 + (307 - 303{,}5)^2 = 12{,}25 + 12{,}25 = 24{,}5$.

$$\sigma = \sqrt{\frac{24,5}{(2-1)}} = \sqrt{24,5} \approx 4,95$$

Coefficient of variance CV is calculated according to Formula (C.2).

$$CV = \frac{\sigma}{\bar{x}} = \frac{4,95}{303,5} \times 100 \approx 1,63\ \%$$

If Sample A and Sample B are bulbs or tube sections in the same viscometer, then the results are rejected ($CV > 1$ %).

If Sample A and Sample B are results from two viscometers, then the result is accepted ($CV \leq 2$ %).

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