ANNEX C

REVERSE-FLOW VISCOMETERS

C.1 GENERAL

The reverse-flow viscometers for transparent and opaque liquids include the Cannon-Fenske opaque, Zeitfuchs cross-arm, BS/IP/RF, and Lantz-Zeitfuchs viscometers. Unlike the modified Ostwald and suspended-level viscometers, the sample of liquid flows into a timing bulb not previously wetted by sample, thus allowing the timing of liquids whose thin films are opaque. Reverse-flow viscometers are used for the measurement of kinematic viscosities of opaque and transparent liquids up to 100 000 mm^2/s.

C.2 APPARATUS

For the reverse-flow viscometers, detailed drawings, size designations, nominal viscometer constants, kinematic viscosity range, capillary diameter and bulb volumes for each viscometer are shown in figures 16 to 19.

C.3 OPERATING INSTRUCTIONS

C.3.1 A standard operating procedure applicable to all glass capillary kinematic viscometers is contained in ISO 3104. Operating instructions for the reverse-flow viscometers are outlined in C.3.2 to C.3.8 with emphasis on procedures that are specific to a particular instrument or this group of instruments.

C.3.2 Select a clean, dry calibrated viscometer which will give a flow time greater than 200 s and a kinetic energy correction of less than 0,2 %.

C.3.3 Charge the viscometer in the manner dictated by the design of the instrument, this operation being in conformity with that employed when the instrument was calibrated. If the sample is thought to contain fibres or solid particles, filter through a 75 μm screen during charging.

C.3.3.1 To charge the Cannon-Fenske opaque viscometer, invert the viscometer and apply suction to the tube L, immersing tube N in the liquid sample. Draw liquid through tube N, filling bulb D to filling mark G. Wipe any 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. Close tube N with a rubber stopper or a short length of rubber tube with a screw clamp.

C.3.3.2 Mount the Zeitfuchs cross-arm viscometer in the constant-temperature bath, keeping tube N vertical. Introduce the 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 filling mark G on the siphon tube.

C.3.3.3 Mount the Lantz-Zeitfuchs viscometer in the constant-temperature bath, keeping tube N vertical. Introduce sufficient sample through tube N to completely fill bulb D, overflowing slightly into overflow tube K. If the sample is poured at a temperature above the test temperature, wait 15 min for the sample in the viscometer to attain the bath temperature and add more sample to overflow slightly into tube K.

C.3.3.4 Mount the BS/IP/RF viscometer in the constant-temperature bath, keeping tube L vertical. Pour the 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 filling mark H, and then arrest its flow by closing the timing tube with a cork or rubber stopper in the tube L. Add more liquid if necessary to bring the upper meniscus slightly above filling mark G. After allowing the sample to attain the bath temperature (see C.3.4) and any air bubbles to rise to the surface, gently loosen the stopper, allowing the sample to flow to the lower filling mark H, and again arrest the 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 filling mark G.

C.3.4 Allow the viscometer to remain in the constant-temperature bath a sufficient time to ensure that the sample reaches temperature equilibrium (for liquids of low kinematic viscosity, 20 min at 40 °C, 25 min at 100 °C, or 30 min at 135 °C).

C.3.5 For the Cannon-Fenske opaque and BS/IP/RF viscometers, remove the stopper in tubes N and L, respectively, and allow the sample to flow by gravity. For the Zeitfuchs cross-arm viscometer, apply slight vacuum to tube M (or pressure to tube N) to clause 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. For the Lantz-Zeitfuchs viscometer, apply slight vacuum to tube M (or pressure tube N with tube K closed) until the lower meniscus is opposite the lower timing mark E; allow the sample to flow by gravity.

C.3.6 Measure to the nearest 0,2 s the time required for the leading edge of the meniscus to pass from timing mark E to timing mark F. If the flow time is less than the minimum flow time specified for the viscometer, select a viscometer with a smaller diameter capillary and repeat steps C.3.3 to C.3.6.

C.3.7 Using this viscometer or a second viscometer, repeat steps C.3.3 to C.3.6, making a duplicate determination of viscosity. Calculate the kinematic viscosity. If the two determinations differ by less than 0,35 %, report the average of the calculated kinematic viscosities.

C.3.8 Clean the viscometer thoroughly by several rinsings with an appropriate solvent completely miscible with the sample, followed by a completely volatile solvent. Dry the viscometer by passing a slow stream of filtered, dry air through the viscometer for 2 min, or until the last trace of solvent is removed.

INTERNATIONAL STANDARD ISO 3105-1976 (E)/ERRATUM

Published 1979-06-01

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Glass capillary kinematic viscometers — Specification and operating instructions

ERRATUM

Page 18

In figure 11, change "M – 7" to "M – 6" and "N – 6" to "N – 7".

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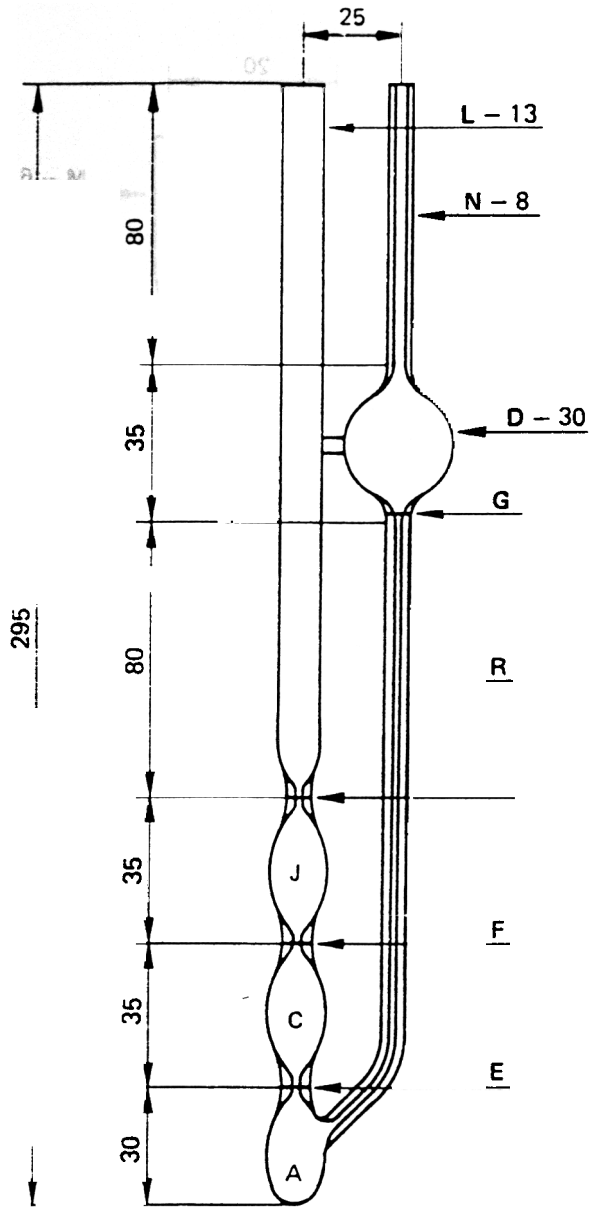
Dimensions in millimetres



For tolerances on lengths, see 3.2

FIGURE 16 – Cannon-Fenske opaque viscometer

TABLE 18 – Dimensions and kinematic viscosity ranges

Size No.	Nominal viscometer constant	Kinematic viscosity range*	Inside diameter of tube R	Inside diameter of tube N and tubes E, F, and I	Volume bulbs A, C and J	Volume bulb D
	$(mm^2/s)/s$	mm^2/s	mm (± 2 %)	mm (± 5 %)	ml (± 5 %)	ml (± 5 %)
25	0,002	0,4 to 2	0,31	3,0	1,6	11
50	0,004	0,8 to 4	0,42	3,0	2,1	11
75	0,008	1,6 to 8	0,54	3,0	2,1	11
100	0,015	3 to 15	0,63	3,2	2,1	11
150	0,035	7 to 35	0,78	3,2	2,1	11
200	0,1	20 to 100	1,02	3,2	2,1	11
300	0,25	50 to 200	1,26	3,4	2,1	11
350	0,5	100 to 500	1,48	3,4	2,1	11
400	1,2	240 to 1 200	1,88	3,4	2,1	11
450	2,5	500 to 2 500	2,20	3,7	2,1	11
500	8	1 600 to 8 000	3,10	4,0	2,1	11
600	20	4 000 to 20 000	4,00	4,7	2,1	13

200 s minimum flow time for all sizes.

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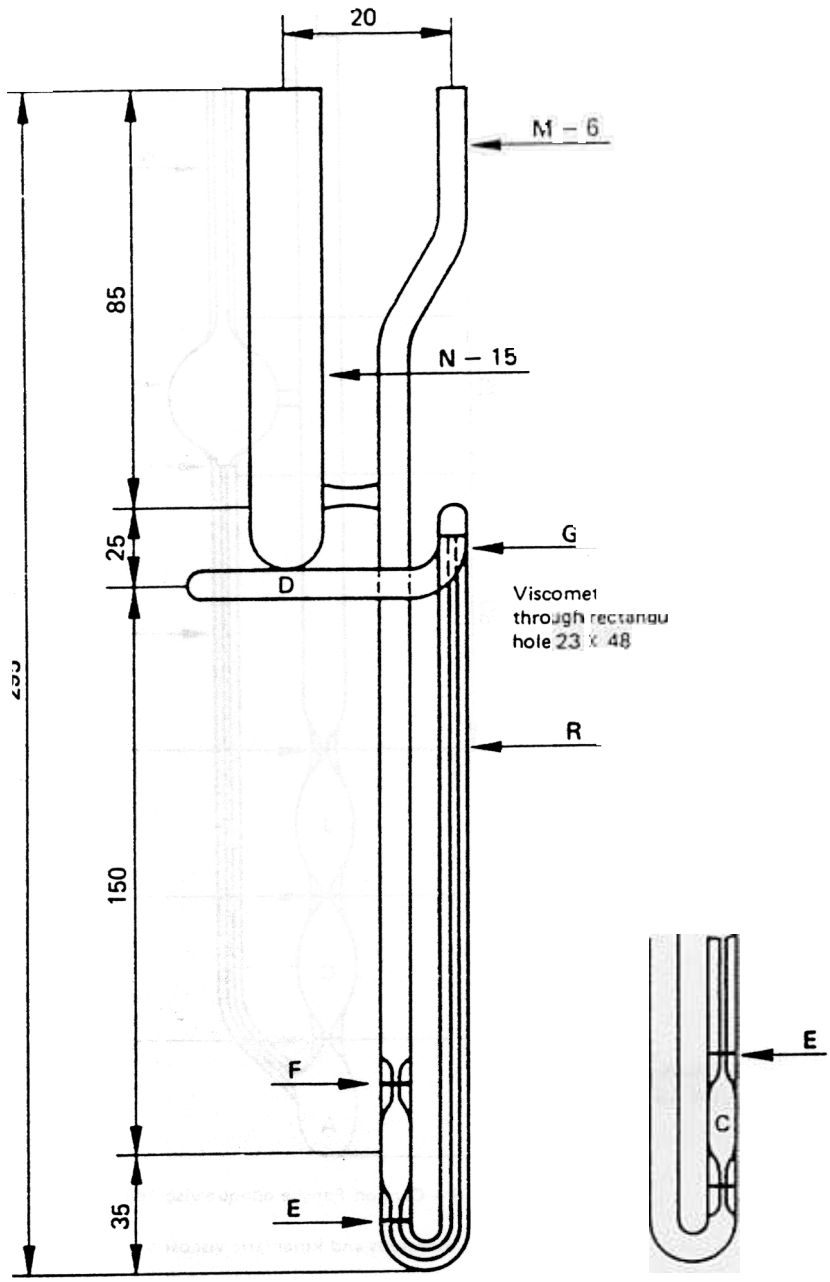

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Size No.	Nominal viscometer constant $(mm^2/s)/s$	Kinematic viscosity range* mm^2/s	Inside diameter of tube R mm (± 2 %)	Length of tube R mm	Lower bulb volume ml (± 5 %)	Horizontal tube diameter mm (± 5 %)
1	0,003	0,6 to 3	0,27	210	0,3	3,9
2	0,01	2 to 10	0,35	210	0,3	3,9
3	0,03	6 to 30	0,46	210	0,3	3,9
4	0,10	20 to 100	0,64	210	0,3	3,9
5	0,3	60 to 300	0,84	210	0,3	3,9
6	1,0	200 to 1 000	1,15	210	0,3	4,3
7	3,0	600 to 3 000	1,42	210	0,3	4,3
8	10,0	2 000 to 10 000	1,93	165	0,25	4,3
9	30,0	6 000 to 30 000	2,52	165	0,25	4,3
10	100,0	20 000 to 100 000	3,06	165	0,25	4,3

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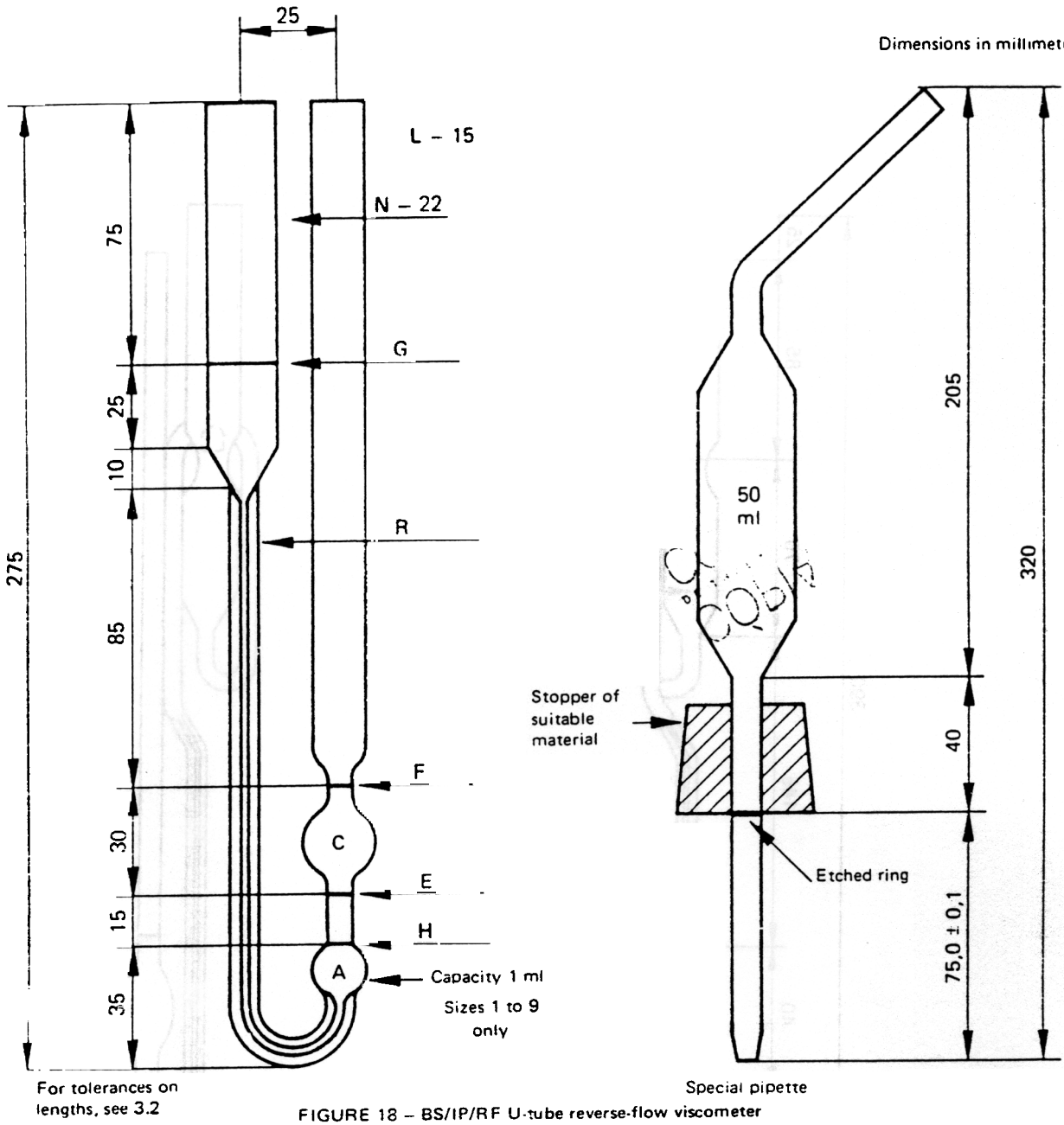
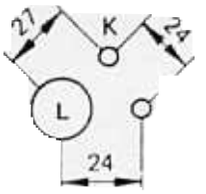


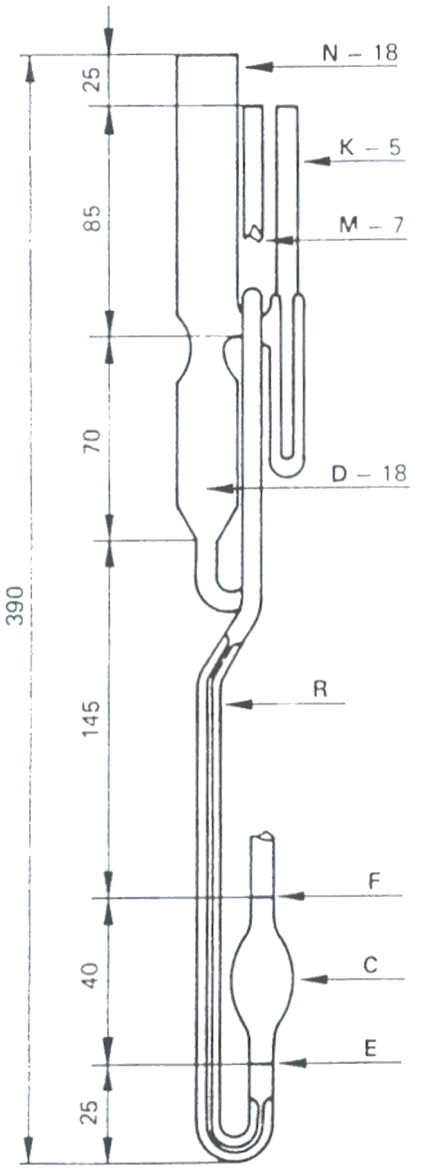
FIGURE 18 – BS/IP/RF U-tube reverse-flow viscometer

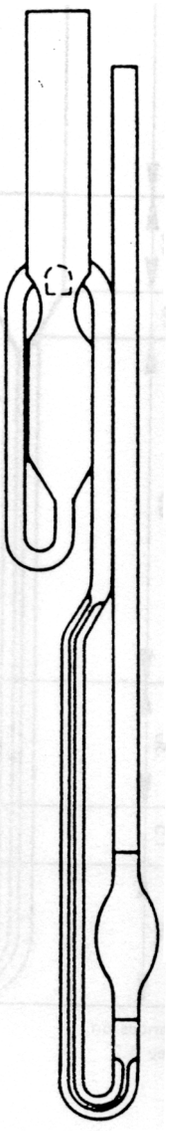
TABLE 20 – Dimensions and kinematic viscosity ranges

Size No.	Nominal viscometer constant (mm² s⁻¹ s	Kinematic viscosity range* mm²/s	Inside diameter of tube R mm (± 2 %)	Length of tube R mm	Inside diameter at E, F, and H mm	Volume bulb C ml (± 5 %)
1	0,003	0,6 to 3	0,51	185	3,0 to 3,3	4,0
2	0,01	2 to 10	0,71	185	3,0 to 3,3	4,0
3	0,03	6 to 30	0,93	185	3,0 to 3,3	4,0
4	0,1	20 to 100	1,26	185	3,0 to 3,3	4,0
5	0,3	60 to 300	1,64	135	3,0 to 3,3	4,0
6	1,0	200 to 1 000	2,24	185	3,0 to 3,3	4,0
7	3,0	600 to 3 000	2,93	185	3,3 to 3,6	4,0
8	10	2 000 to 10 000	4,00	185	4,4 to 4,8	4,0
9	30	6 000 to 30 000	5,5	185	6,0 to 6,7	4,0
10	100	20 000 to 100 000	7,70	210	7,70	4,0
11	300	60 000 to 300 000	10,00	210	10,00	4,0

200 s minimum flow time for all sizes.







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Lantz-Zeltfuchs type reverse-flow viscometer

Dimensions and kinematic viscosity ranges

Size No.	Nominal viscometer constant $(mm^2/s)/s$	Kinematic viscosity range* mm^2/s	Inside diameter of tube R mm (± 2 %)	Length of tube R mm	Volume bulb C ml (± 5 %)
5	0,3	60 to 300	1,65	490	2,7
6	1,0	200 to 1 000	2,25	490	2,7
7	3,0	600 to 3 000	3,00	490	2,7
8	10,0	2 000 to 10 000	4,10	490	2,7
9	30,0	6 000 to 30 000	5,20	490	2,7
10	100,0	20 000 to 100 000	5,20	490	0,85

200 s minimu