ANNEX B

SUSPENDED-LEVEL VISCOMETERS

B.1 GENERAL

The suspended-level viscometers include the BS/IP/SL, BS/IP/SL(S), BS/IP/MSL, Ubbelohde, FitzSimons, Atlantic, Cannon-Ubbelohde, and Cannon-Ubbelohde semi-micro designs. The distinctive feature of suspended-level viscometers is that the liquid is suspended in the capillary which it fills completely. This suspension ensures a uniform driving head of liquid independent of the quantity of sample charged into the viscometer, making the viscometer constant independent of temperature. By making the diameter of the lower meniscus approximately equal to the average diameter of the upper meniscus, the surface tension correction is greatly reduced. Suspended-level viscometers are used for the measurement of the kinematic viscosities of transparent, Newtonian liquids up to 100 000 mm^2/s.

B.2 APPARATUS

For the suspended-level viscometers, detailed drawings, size designations, nominal viscometer constants, kinematic viscosity range, capillary diameter and bulb volumes for each viscometer are shown in figures 8 to 15.

B.3 OPERATING INSTRUCTIONS

B.3.1 A standard operating procedure, applicable to all glass capillary kinematic viscometers, is contained in ISO 3104. Operating instructions for the suspended-level types are outlined in B.3.2 to B.3.8 with emphasis on procedures that are specific to this group of viscometers.

B.3.2 Select a clean, dry calibrated viscometer which will give a flow time greater than 200 s or the minimum shown in the table of dimensions, whichever is the greater.

B.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.

B.3.3.1 Charge the Ubbelohde and Cannon-Ubbelohde viscometers by tilting the instrument about 30° from the vertical and pouring sufficient sample through tube L into bulb A so that when the viscometer is returned to the vertical the meniscus is between filling marks G and H, and tube P completely fills without entrapping air. Mount the viscometer in the constant-temperature bath, keeping tube L vertical. To facilitate charging very viscous liquids, the viscometer may be inverted with tube L placed in the sample. Apply vacuum to tube N, closing tube M by a finger or rubber stopper; draw sufficient sample into tube L such that after wiping L clean and placing the viscometer in the constant-temperature bath, bulb A will fill as described above.

B.3.3.2 Charge the BS/IP/SL, BS/IP/SL(S), BS/IP/MSL, and FitzSimons viscometers through tube L with sufficient sample to fill bulb A, but not bulb B. The viscometer may be mounted vertically in the constant-temperature bath either prior to or following charging of the sample into the viscometer.

B.3.3.3 Permanently mount the Atlantic viscometer in the constant-temperature bath with the enlargement S resting on the top-split collar, and the lower end of capillary tube R, 25 mm from the bottom of the bath. Pour the sample into a clean 50 ml beaker. Charge the viscometer by positioning the beaker and sample under tube L so that it will be immersed in the sample. Slowly apply vacuum to tube N by turning the three-way stopcock O to vacuum. Draw the sample into the viscometer filling capillary R, timing bulb C, and partially filling upper bulb D. Close stopcock O, holding the sample in the viscometer. If only a small sample is available, a short length of rubber-tipped glass tubing can be placed in the beaker with the rubber against the bottom of capillary tube R, and the sample drawn up as above.

B.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, 10 min at 40 °C, 15 min at 100 °C, or 20 min at 135 °C; highly viscous liquids may require double this time).

B.3.5 Except for the Atlantic viscometer which already has the sample in position, close tube M with the finger and use vacuum (or pressure, if the sample contains volatile constitutes) to draw the sample slowly through bulb C to about 8 mm above the upper timing mark E. Release the vacuum from tube N and immediately place a finger from tube M to tube N holding the meniscus above timing mark E until the lower meniscus has dropped below the end of capillary R in bulb B. Release the finger and allow the sample to flow by gravity.

B.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 200 s, select a smaller capillary viscometer and repeat steps B.3.3 to B.3.6.

B.3.7 Repeat steps B.3.5 and B.3.6, making a duplicate measurement of flow time. If the two measurements agree within 0,2 %, use the average for calculating kinematic viscosity.

B.3.8 Clean the viscometer thoroughly by several rinsings with an appropriate solvent completely miscible with the sample, followed by rinsing with 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.

Dimensions in millimetres

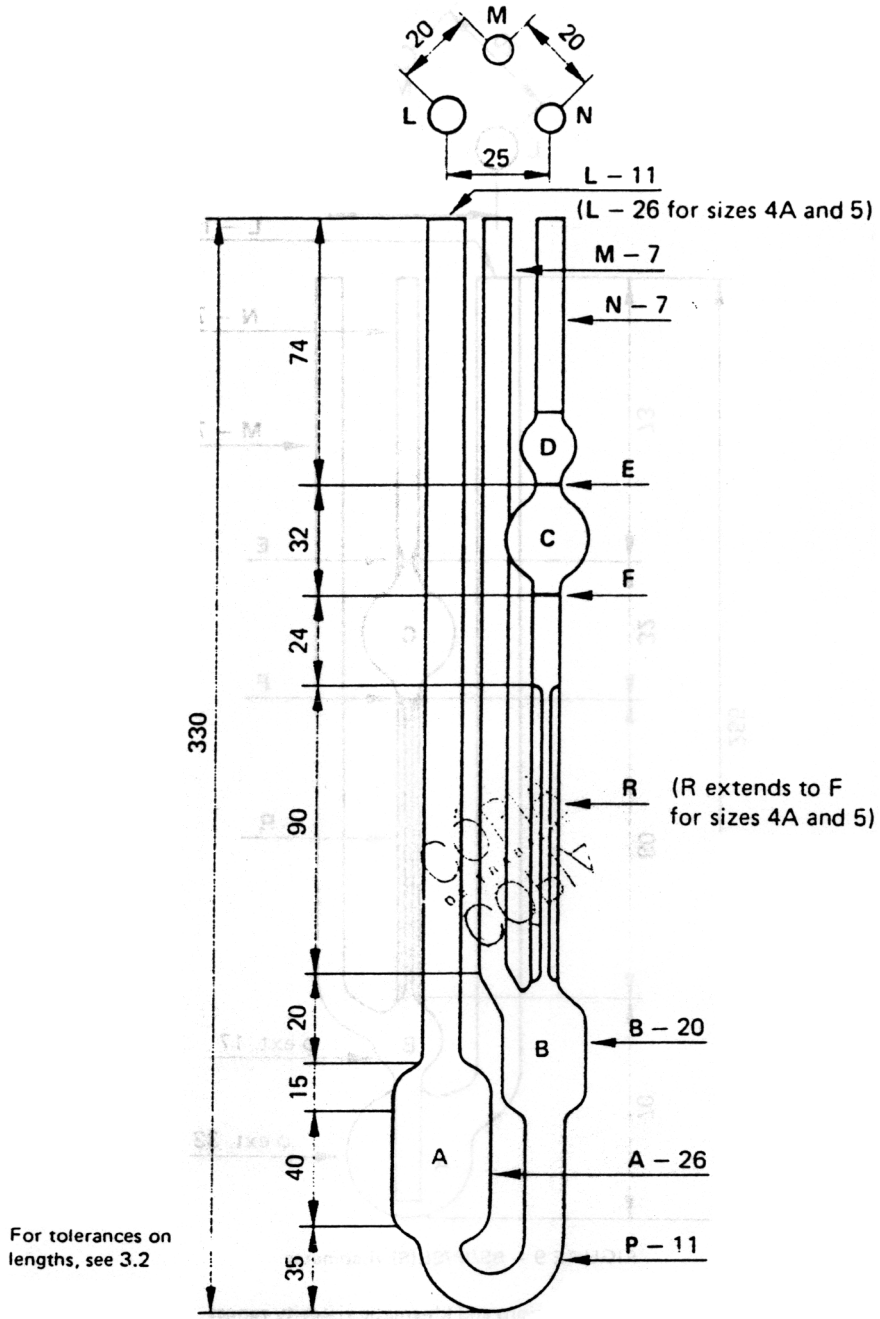


FIGURE 8 – BS/IP/SL viscometer

TABLE 10 – 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 %)	Volume bulb C ml (± 5 %)	Inside diameter of tube N mm
1	0,01	3,5* to 10	0,64	5,6	2,8 to 3,2
1A	0,03	6 to 30	0,84	5,6	2,8 to 3,2
2	0,1	20 to 100	1,15	5,6	2,8 to 3,2
2A	0,3	60 to 300	1,51	5,6	2,8 to 3,2
3	1,0	200 to 1 000	2,06	5,6	3,7 to 4,3
3A	3,0	600 to 3 000	2,74	5,6	4,6 to 5,4
4	10	2 000 to 10 000	3,70	5,6	4,6 to 5,4
4A	30	6 000 to 30 000	4,97	5,6	5,6 to 5,4
5	100	20 000 to 100 000	6,76	5,6	6,8 to 7,5

* 350 s minimum flow time; 200 s minimum flow time for all other

Dimensions in millimetres

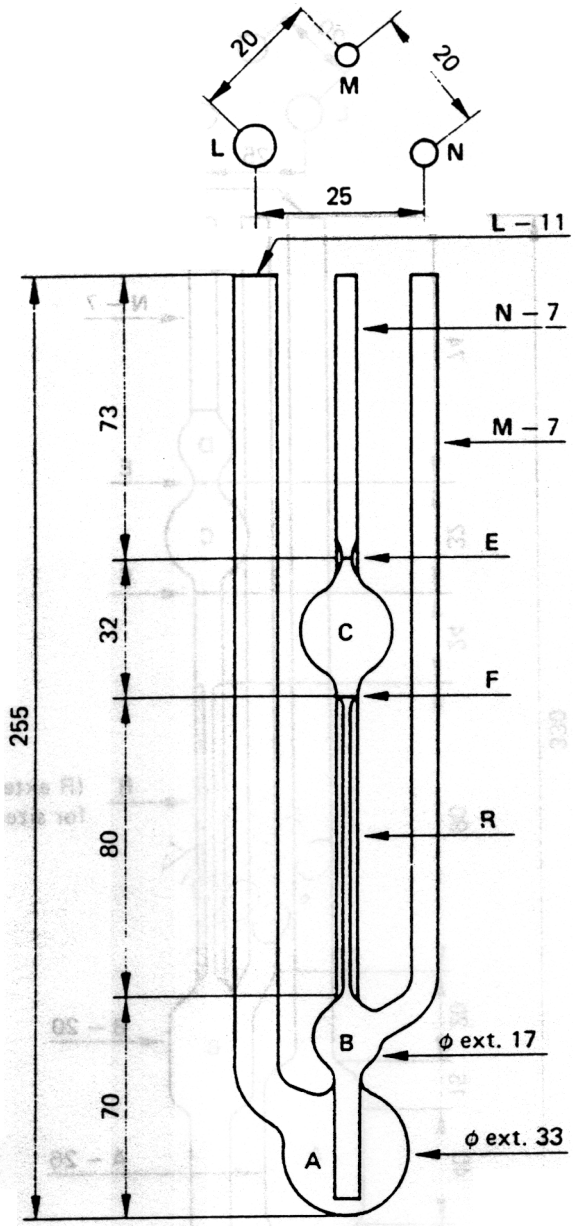


FIGURE 9 – BS/IP/SL(S) viscometer

TABLE 11 – 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 %)	Volume bulb C ml (± 5 %)	Inside diameter of tube N mm	Inside diameter of tube at E mm
1	0,0008	1,05* min	0,36	5,6	2,8 to 3,2	3
2	0,003	2,1** to 3	0,49	5,6	2,8 to 3,2	3
3	0,01	3,8*** to 10	0,66	5,6	2,8 to 3,2	3
4	0,03	6 to 30	0,87	5,6	2,8 to 3,2	3
5	0,1	20 to 100	1,18	5,6	2,8 to 3,2	3
6	0,3	60 to 300	1,55	5,6	2,8 to 3,2	3
7	1,0	200 to 1 000	2,10	5,6	3,7 to 4,3	4
8	3,0	600 to 3 000	2,76	5,6	4,6 to 5,4	5
9	10,0	2 000 to 10 000	3,80	5,6	4,6 to 5,4	5

1 320 s minimum flow time;
600 s minimum flow time;
380 s minimum flow time;
200 s minimum flow time for all other sizes.

Dimensions in millimetres

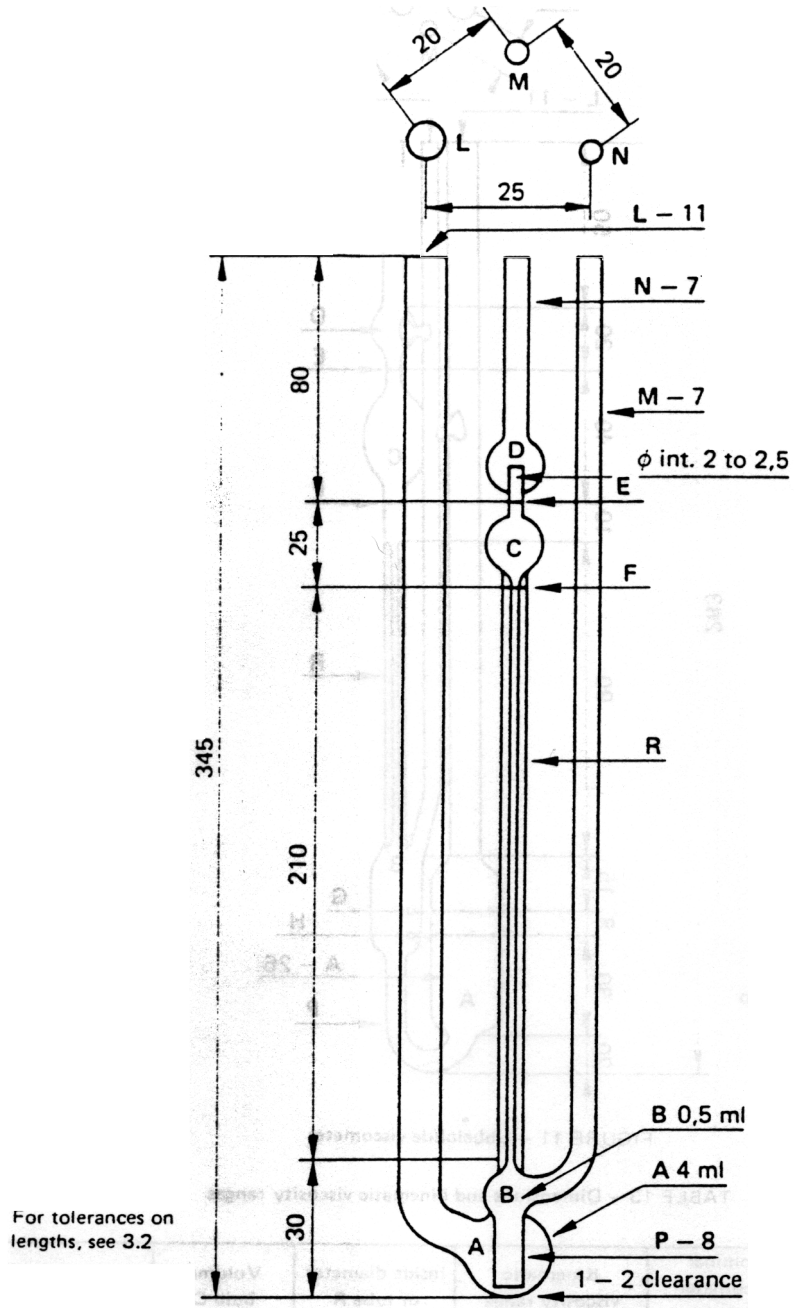


FIGURE 10 – BS/IP/MSL viscometer

TABLE 12 – Dimensions and kinematic viscosity ranges

Size No.	Nominal viscometer constant (mm²/s)/s	Kinematic viscosity range* mm²/s	Inside diameter of tube R mm (± 2 %)	Volume bulb C ml (± 5 %)	Inside diameter of tubes N and P mm
1	0,003	0,6 to 3	0,35	1,2	4 to 6
2	0,01	2 to 10	0,45	1,2	4 to 6
3	0,03	6 to 30	0,62	1,2	4 to 6
4	0,1	20 to 100	0,81	1,2	4 to 6
5	0,3	60 to 300	1,10	1,2	4 to 6
6	1,0	200 to 1 000	1,45	1,2	4 to 6
7	3,0	600 to 3 000	1,98	1,2	4 to 6

* 200 s minimum flow time for all sizes.

Dimensions in millimetres

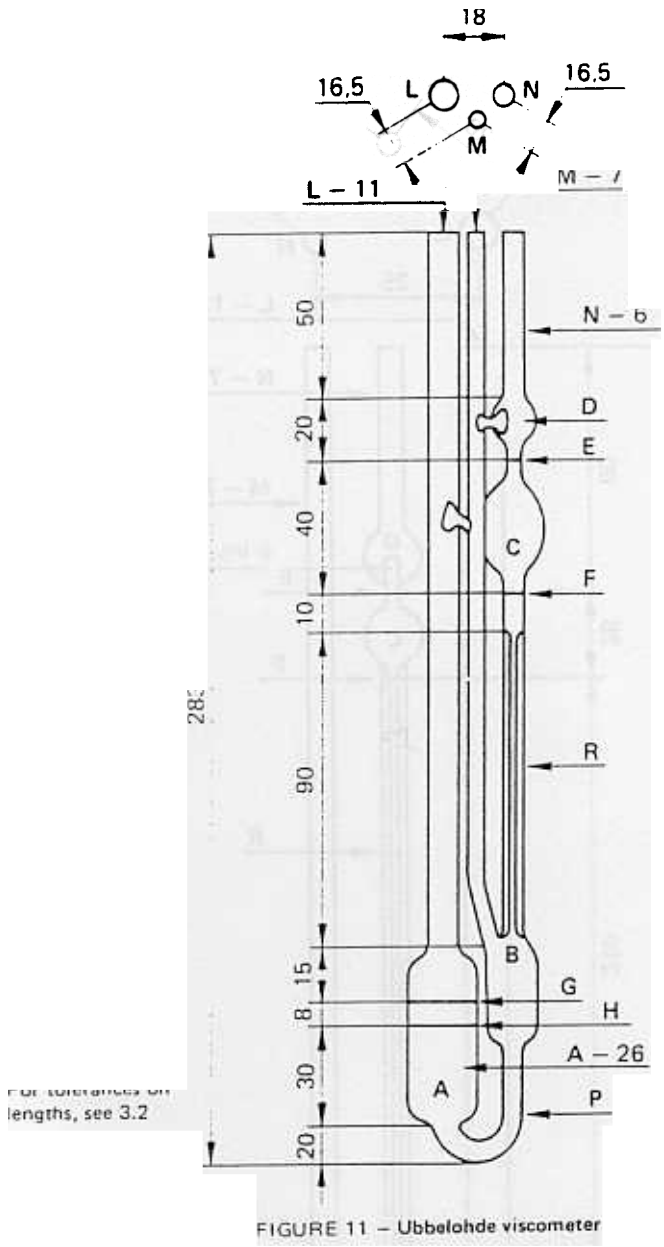


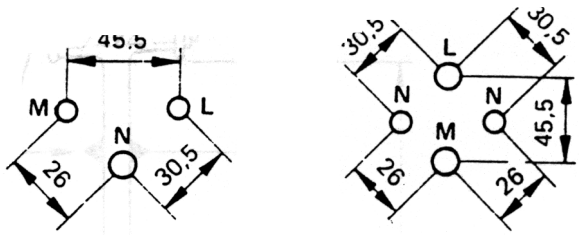
FIGURE 11 – Ubbelohde viscometer

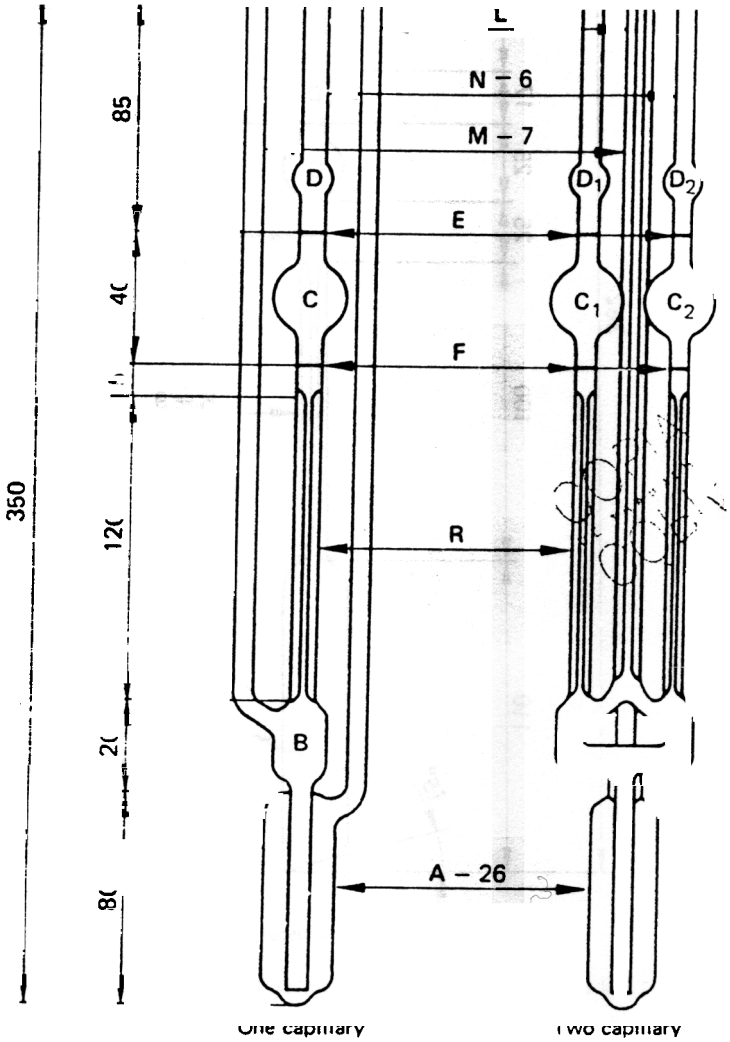
TABLE 13 – Dimensions and kinematic viscosity ranges

Size No.	Nominal viscometer constant (mm²/s)/s	Kinematic viscosity range mm²/s	Inside diameter of tube R mm (± 2 %)	Volume bulb C ml (± 5 %)	Inside diameter of tube P mm (± 5 %)
0	0,001	0,3* to 1	0,24	1,0	6,0
0C	0,003	0,6 to 3	0,36	2,0	6,0
0B	0,005	1 to 5	0,46	3,0	6,0
1	0,01	2 to 10	0,58	4,0	6,0
1C	0,03	6 to 30	0,73	4,0	6,0
1B	0,05	10 to 50	0,88	4,0	6,0
2	0,1	20 to 100	1,03	4,0	6,0
2C	0,3	60 to 300	1,36	4,0	6,0
2B	0,5	100 to 500	1,55	4,0	6,0
3	1,0	200 to 1 000	1,83	4,0	6,0
3C	3,0	600 to 3 000	2,43	4,0	6,0
3B	5,0	1 000 to 5 000	2,75	4,0	6,5
4	10	2 000 to 10 000	3,27	4,0	7,0
4C	30	6 000 to 30 000	4,32	4,0	8,0
4B	50	10 000 to 50 000	5,20	5,0	8,5
5	100	20 000 to 100 000	6,25	5,0	10,0

300 s minimum flow time; 200 s minimum flow time for all other sizes.

Dimensions in millimetres





For tolerances on lengths, see 3.2

One capillary Two capillary

FIGURE 12 – FitzSimons viscometer

TABLE 14 – Dimensions and kinematic viscosity ranges

Size No.	Nominal viscometer constant (mm²/s)/s	Kinematic viscosity range* mm²/s	Inside diameter of tube R mm (± 2 %)	Volume bulb C ml (± 5 %)
1	0,003	0,6 to 3,0	0,43	3,0
2	0,01	2 to 10	0,60	3,7
3	0,035	7 to 35	0,81	3,7
4	0,10	20 to 100	1,05	3,7
5	0,25	50 to 250	1,32	3,7
6	1,20	240 to 1 200	1,96	3,7

200 s minimum flow time for all sizes.

Dimensions in millimetres

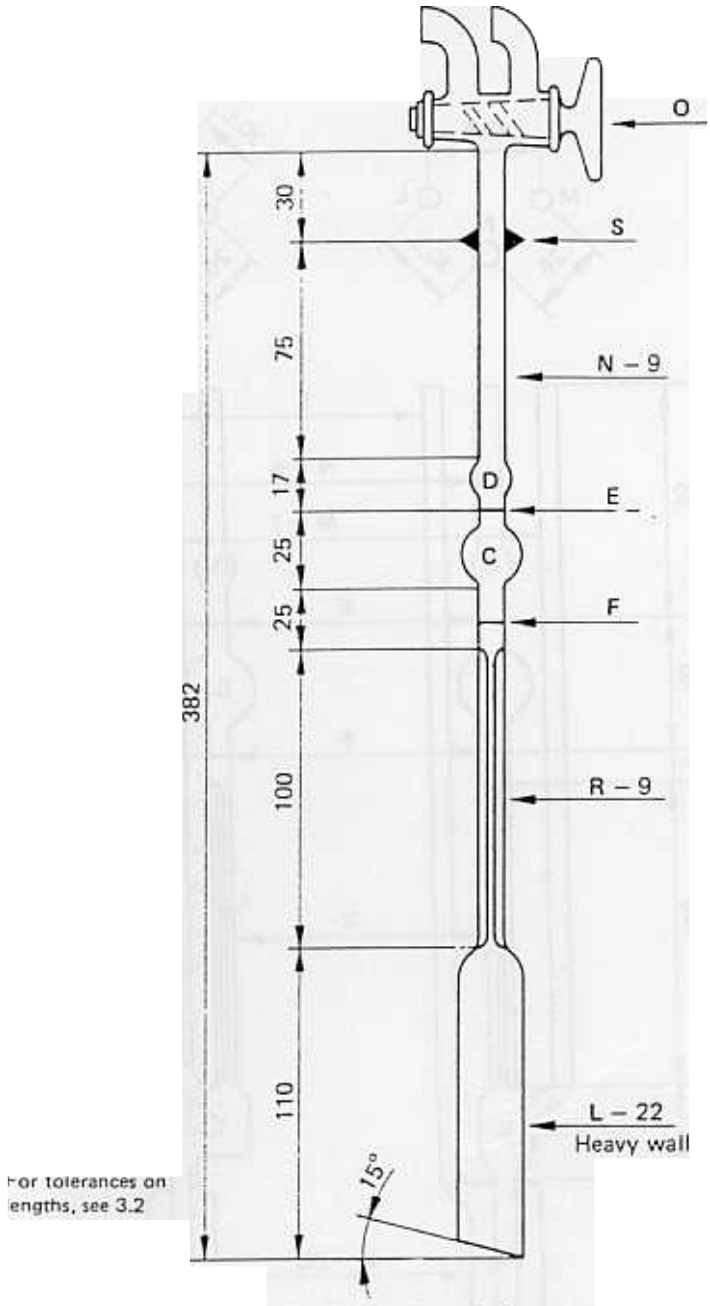


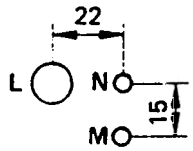
FIGURE 13 – Atlantic viscometer

TABLE 15 – 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 %)	Volume bulb C ml (± 5 %)
0C	0,003	0,75* to 3	0,42	3,2
0B	0,005	1 to 5	0,46	3,2
1	0,01	2 to 10	0,56	3,2
1C	0,03	6 to 30	0,74	3,2
1B	0,05	10 to 50	0,83	3,2
2	0,1	20 to 100	1,00	3,2
2C	0,3	60 to 300	1,31	3,2
2B	0,5	100 to 500	1,48	3,2
3	1,0	200 to 1 000	1,77	3,2
3C	3,0	600 to 3 000	2,33	3,2
3B	5,0	1 000 to 5 000	2,64	3,2

250 s minimum flow time; 200 s minimum flow time for all other

Dimensions in millimetres



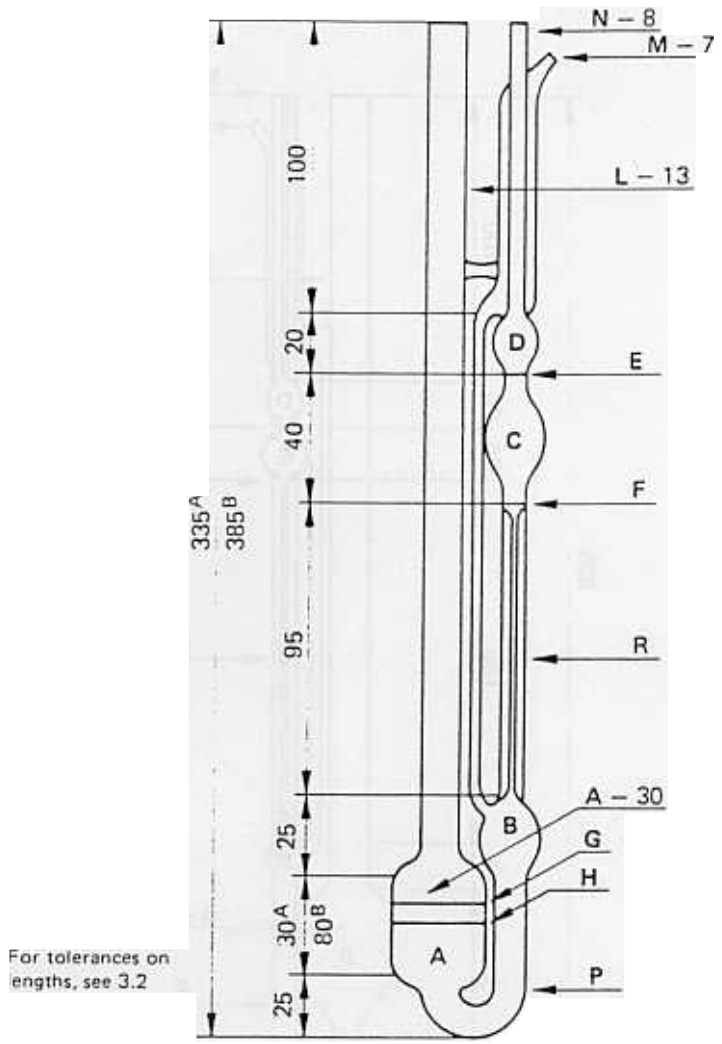
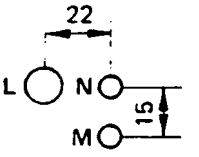


FIGURE 14 – Cannon-Ubbelohde (A) and Cannon-Ubbelohde dilution (B) viscometer

TABLE 16 – 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 %)	Volume bulb C ml (± 5 %)
25	0,002	0,5* to 2	0,31	1,5
50	0,004	0,8 to 4,0	0,44	3,0
75	0,008	1,6 to 8,0	0,54	3,0
100	0,015	3 to 15	0,63	3,0
150	0,035	7 to 35	0,78	3,0
200	0,1	20 to 100	1,01	3,0
300	0,25	50 to 250	1,26	3,0
350	0,5	100 to 500	1,48	3,0
400	1,2	240 to 1 200	1,88	3,0
450	2,5	500 to 2 500	2,25	3,0
500	8	1 600 to 8 000	3,00	3,0
600	20	4 000 to 20 000	3,75	3,0
650	45	9 000 to 45 000	4,60	3,0
700	100	20 000 to 100 000	5,60	3,0

* 250 s minimum flow time; 200 s minimum flow time for all other sizes.



Dimensions in millimetres

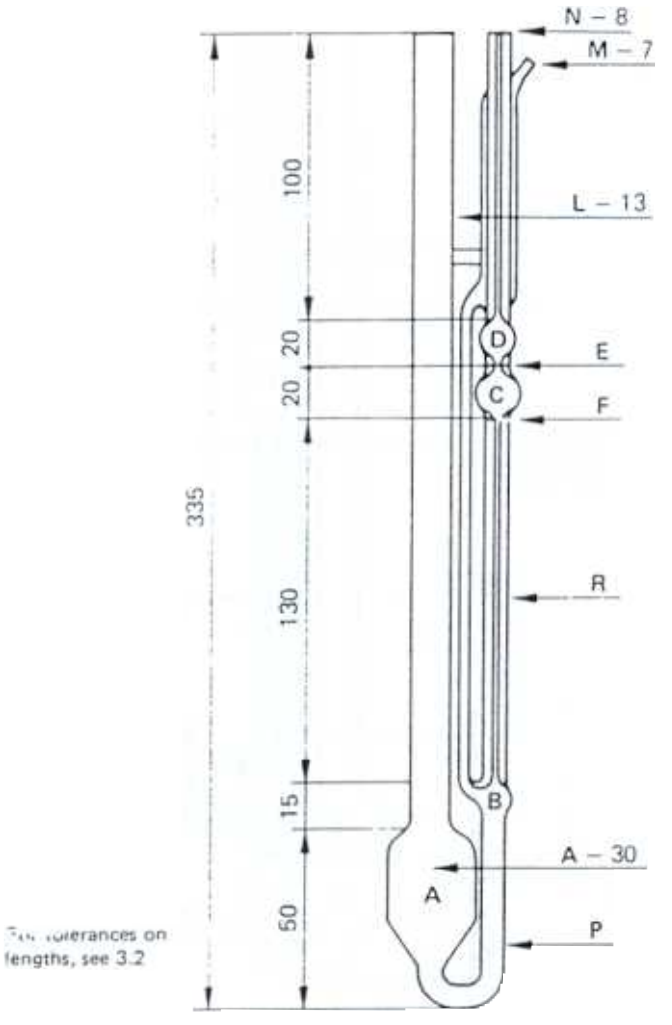


FIGURE 15 – Cannon-Ubbelohde semi-micro viscometer

TABLE 17 – Dimensions and kinematic viscosity ranges

Size No.	Nominal viscometer constant	Kinematic viscosity range*	Inside diameter of tube R	Volume bulb C	Inside diameter of tubes N, E, F and P
	$(mm^2/s)/s$	mm^2/s	mm (± 2 %)	ml (± 5 %)	mm
25	0,002	0,4 to 2,0	0,22	0,30	1,2 to 1,4
50	0,004	0,8 to 4	0,25	0,30	1,2 to 1,4
75	0,008	1,6 to 8	0,30	0,30	1,2 to 1,4
100	0,015	3 to 15	0,36	0,30	1,2 to 1,4
150	0,035	7 to 35	0,47	0,30	1,2 to 1,4
200	0,1	20 to 100	0,61	0,30	1,4 to 1,7
300	0,25	50 to 250	0,76	0,30	1,5 to 1,8
350	0,5	100 to 500	0,90	0,30	1,8 to 2,2
400	1,2	240 to 1 200	1,13	0,30	2,1 to 2,5
450	2,5	500 to 2 500	1,40	0,30	2,4 to 2,8
500	8	1 600 to 8 000	1,85	0,30	2,7 to 3,1
600	20	4 000 to 20 000	2,35	0,30	3,7 to 4,0

* 200 s minimum flow time for all sizes.