ANNEX A

MODIFIED OSTWALD VISCOMETERS

A.1 GENERAL

The following viscometers of the modified Ostwald type for transparent liquids follow the basic design of the Ostwald viscometer, but are modified to ensure a constant volume test portion in the viscometer :

a) **at the filling temperature :**

Cannon-Fenske routine viscometer

Cannon-Manning semi-micro viscometer

Pinkevitch viscometer

b) **at the test temperature**

Zeitfuchs viscometer

SIL viscometer

BS/U-tube viscometer

BS/U miniature viscometer

The above viscometers are used for the measurement of the kinematic viscosity of transparent Newtonian liquids up to 20 000 mm^2/s.

A.2 APPARATUS

For the modified Ostwald viscometers, detailed drawings, size designations, nominal viscometer constants, kinematic viscosity range, capillary diameter and bulb volumes for each viscometer are shown in figures 1 to 7.

A.3 OPERATING INSTRUCTIONS

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

A.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.

A.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.

A.3.3.1 To charge the Cannon-Fenske routine, Cannon-Manning semi-micro, and Pinkevitch viscometers, invert the viscometer and apply suction to tube L (the Pinkevitch viscometer has a side arm O to which vacuum is applied, with the finger on tube L being used to control the liquid flow) with the tube N immersed in the liquid sample. Draw the sample to timing mark F for the Cannon-Fenske routine and Pinkevitch viscometers and to filling mark G for the Cannon-Manning semi-micro viscometer. Mount the viscometer upright in the constant-temperature bath, keeping tube L vertical.

A.3.3.2 Mount the Zeitfuchs viscometer in the constant-temperature bath, keeping tube L vertical. Pour the sample through tube L to filling mark G. Allow 15 min for the sample to reach the bath temperature and become free of air bubbles. Attach the vacuum line with stopcock and trap to tube K. Slowly draw the sample into timing bulb C by partially opening the stopcock in the vacuum line and partially closing tube N with the finger. Allow the excess liquid to flow into bulb D and through tube K into the trap in the vacuum line. When the liquid in tube L reaches a point 2 to 5 mm above filling mark H, hold it at this point by alternately closing and opening tube N to the atmosphere with the finger for the time shown below to permit the sample to drain from the walls of tube L.

TABLE 2 – Drainage time for various kinematic viscosity ranges

Kinematic viscosity of sample mm^2/s	Drainage time s
Under 10	10 to 20
10 to 100	40 to 60
100 to 1 000	100 to 120
Over 1 000	180 to 200

Adjust the working volume by drawing the meniscus at the bottom of the column of liquid exactly to filling mark H, making sure that the sample completely fills the viscometer between filling mark H and the tip of the over-flow in bulb D; after this final adjustment of the working volume, remove the finger and close or remove the connection of the vacuum source. The final adjustment may be more conveniently made by disconnecting the vacuum and applying pressure to the mounting tube L by use of a rubber bulb.

A.3.3.3 Charge the SIL viscometer by tilting it about 30° from the vertical, with bulb A below capillary R. Introduce enough of the sample into tube L for bulb A to fill completely and overflow into the gallery. Return the viscometer to the vertical position and mount it in the constant-temperature bath so that tube L is vertical. The quantity of sample charged should be such that the level in the lower reservoir is 3 to 14 mm above opening S. The sample will rise in capillary R somewhat higher than opening S. After the temperature equilibrium has been reached, remove any excess sample from the gallery by suction applied to tube K.

A.3.3.4 Mount the BS/U-tube or BS/U/M miniature viscometer in the constant-temperature bath keeping tube L vertical. Using a long pipette to minimize any wetting of tube L above filling mark G, fill bulb A with a slight excess of the sample. After allowing the sample to attain the bath temperature, adjust the volume of the sample to bring the liquid level within 0,2 mm of filling mark G by withdrawing the sample with a pipette.

A.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).

A.3.5 Use vacuum (or pressure if the sample contains volatile constituents) to draw the sample through bulb C to about 5 mm above the upper timing mark E. Release the vacuum, and allow the sample to flow by gravity.

A.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 this flow time is less than the minimum flow time specified for the viscometer, select a viscometer with a smaller diameter capillary and repeat steps A.3.3 to A.3.6.

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

A.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

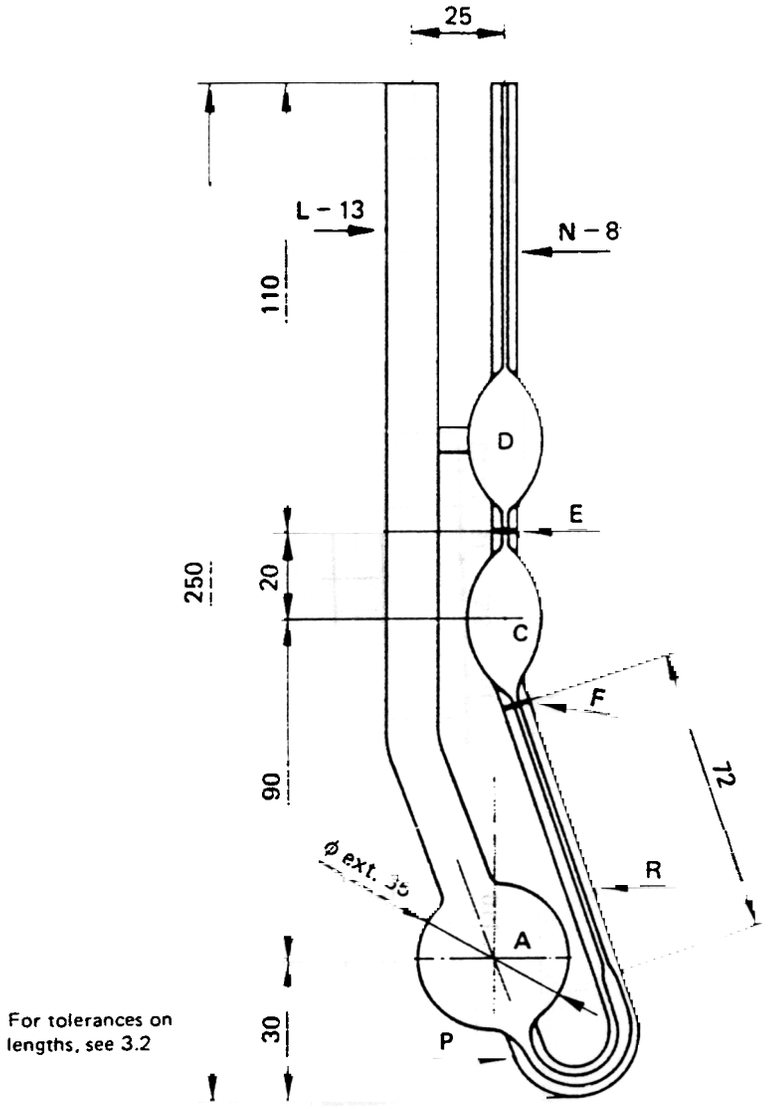


FIGURE 1 – Cannon-Fenske routine viscometer

TABLE 3 – Dimensions and kinematic viscosity ranges

Size No.	Nominal viscometer constant	Kinematic viscosity range	Inside diameter of tube R	Inside diameter of tubes N, E and P	Bulb volume ml (± 5 %)	
	$(mm^2/s)/s$	mm^2/s	mm (± 2 %)	mm	D	C
25	0,002	0,5* to 2	0,30	2,6 to 3,0	3,1	1,6
50	0,004	0,8 to 4	0,44	2,6 to 3,0	3,1	3,1
75	0,008	1,6 to 8	0,54	2,6 to 3,2	3,1	3,1
→ 100	0,015	3 to 15	0,63	2,8 to 3,6	3,1	3,1
150	0,035	7 to 35	0,78	2,8 to 3,6	3,1	3,1
→ 200	0,1	20 to 100	1,01	2,8 to 3,6	3,1	3,1
300	0,25	50 to 250	1,27	2,8 to 3,6	3,1	3,1
350	0,5	100 to 500	1,52	3,0 to 3,8	3,1	3,1
400	1,2	240 to 1 200	1,92	3,0 to 3,8	3,1	3,1
450	2,5	500 to 2 500	2,35	3,5 to 4,2	3,1	3,1
500	8	1 600 to 8 000	3,20	3,7 to 4,2	3,1	3,1
600	20	4 000 to 20 000	4,20	4,4 to 5,0	4,3	3,1

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

Dimensions in millimetres

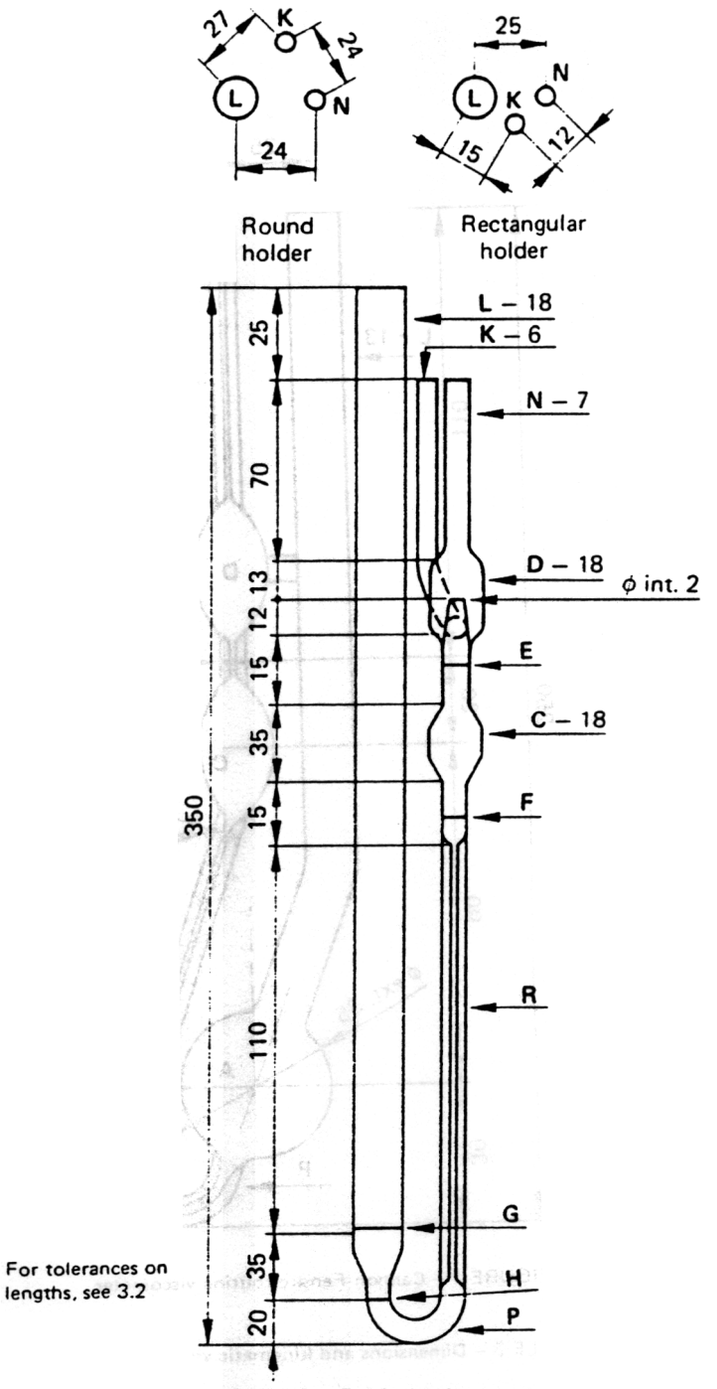


FIGURE 2 – Zeitfuchs viscometer

TABLE 4 – 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 %)	Inside diameter of tubes P, E and F mm	Volume bulb C ml (± 5 %)
1	0,003	0,6 to 3	0,42	3,8 to 4,2	3,0
2	0,01	2 to 10	0,59	3,8 to 4,2	4,0
3	0,03	6 to 30	0,78	3,8 to 4,2	4,0
4	0,1	20 to 100	1,16	3,8 to 4,2	5,0
5	0,3	60 to 300	1,54	3,8 to 4,2	5,0
6	1,0	200 to 1 000	2,08	3,8 to 4,2	5,0
7	3,0	600 to 3 000	2,76	3,8 to 4,2	5,0

200 s minimum flow time for all si.

Dimensions in millimetres

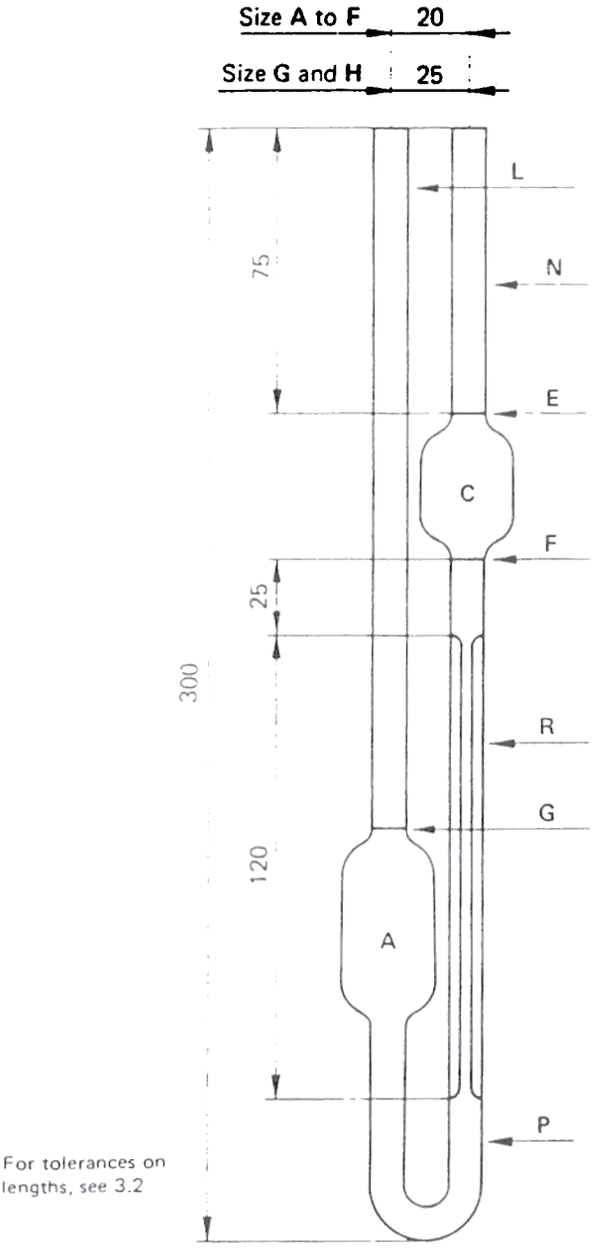


FIGURE 3 – BS/U-tube viscometer

TABLE 5 – Dimensions and kinematic viscosity ranges

Size No.	Nominal viscometer constant	Kinematic viscosity range	Inside diameter of tube R	Outside diameter of tubes**		Volume bulb C	Vertical distance F to G	Outside diameter of bulbs A and C
				L and P	N			
	$(mm^2/s)/s$	mm^2/s	mm (± 2 %)	mm	mm	ml (± 5 %)	mm	mm
A	0,003	0,9* to 3	0,50	8 to 9	6 to 7	5,0	91 ± 4	21 to 23
B	0,01	2,0 to 10	0,71	8 to 9	6 to 7	5,0	87 ± 4	21 to 23
C	0,03	6 to 30	0,88	8 to 9	6 to 7	5,0	83 ± 4	21 to 23
D	0,1	20 to 100	1,40	9 to 10	7 to 8	10,0	78 ± 4	25 to 27
E	0,3	60 to 300	2,00	9 to 10	7 to 8	10,0	73 ± 4	25 to 27
F	1,0	200 to 1 000	2,50	9 to 10	7 to 8	10,0	70 ± 4	25 to 27
G	3,0	600 to 3 000	4,00	10 to 11	9 to 10	20,0	60 ± 3	32 to 35
H	10,0	2 000 to 10 000	6,10	10 to 11	9 to 10	20,0	50 ± 3	32 to 35

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

** Use 1 to 1,25 mm wall tubing for N, P, and L.

Dimensions in millimetres

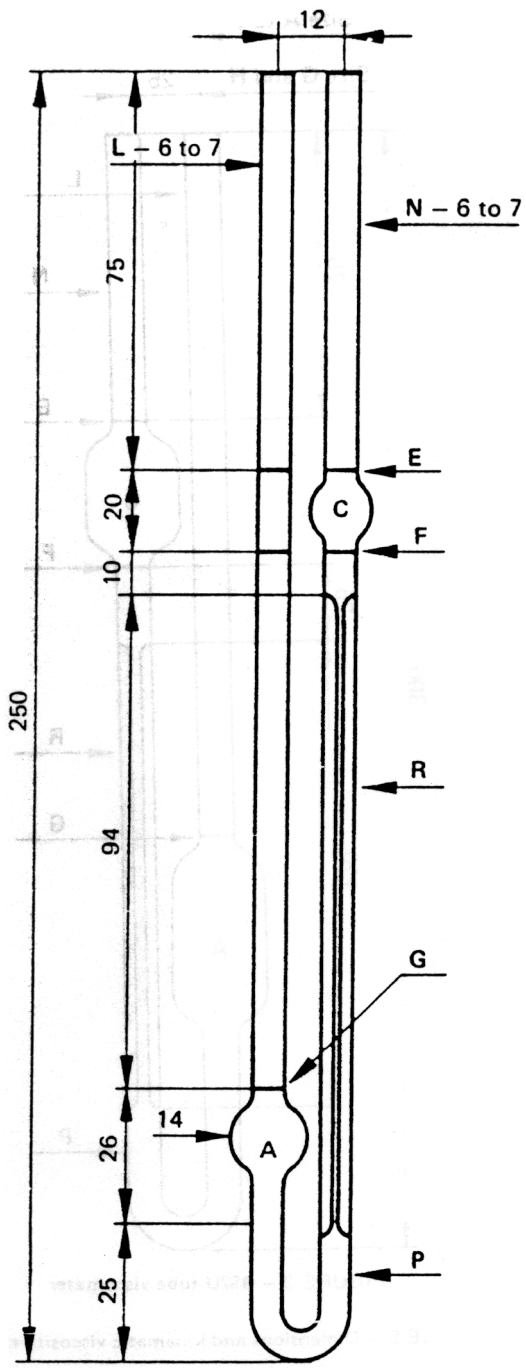


FIGURE 4 – BS/U/M miniature viscometer

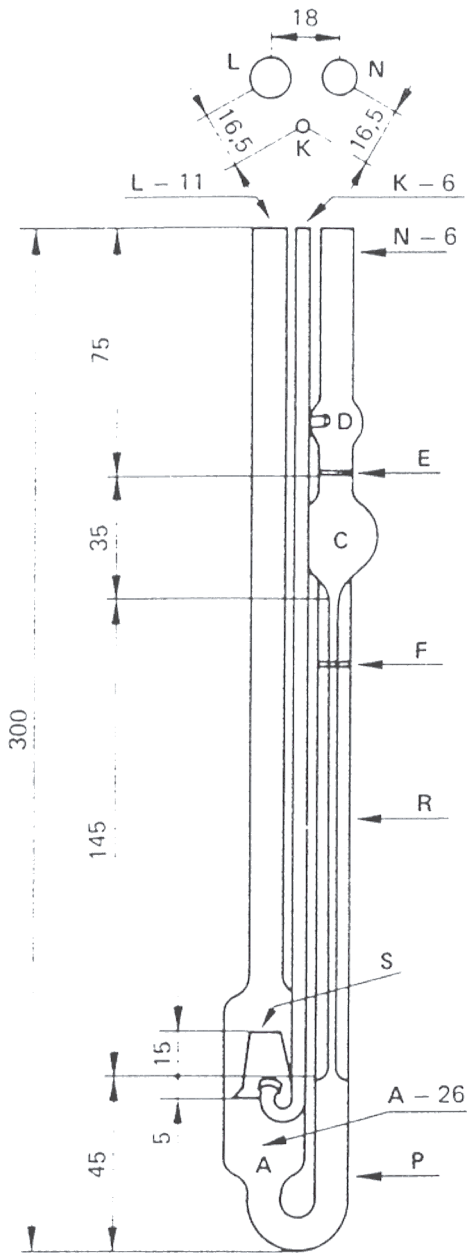
TABLE 6 – Dimensions and kinematic viscosity ranges

Size No.	Nominal viscometer constant $(mm^2/s)/s$	Kinematic viscosity range* mm^2/s	Inside diameter of tube R mm (± 2 %)	Outside diameter of tubes L, N and P** mm	Volume bulb C ml (± 5 %)
M1	0,001	0,2 to 1	0,20	6 to 7	0,50
M2	0,005	1 to 5	0,30	6 to 7	0,50
M3	0,015	3 to 15	0,40	6 to 7	0,50
M4	0,04	8 to 40	0,50	6 to 7	0,50
M5	0,1	20 to 100	0,65	6 to 7	0,50

200 s minimum flow time for all sizes.

Use 1 to 1,25 mm wall tubing for N, P and L.

Dimensions in millimetres



For tolerances on lengths, see 3.2

FIGURE 5 – SIL viscometer

TABLE 7 – 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 %)	Inside diameter of tubes E and P mm	Volume bulb C ml (± 5 %)
0C	0,003	0,6 to 3	0,41	4,5 to 5,5	3,0
1	0,01	2,0 to 10	0,61	4,5 to 5,5	4,0
1C	0,03	6 to 30	0,73	4,5 to 5,5	4,0
2	0,1	20 to 100	1,14	4,5 to 5,5	5,0
2C	0,3	60 to 300	1,50	4,5 to 5,5	5,0
3	1,0	200 to 1 000	2,03	4,5 to 5,5	5,0
3C	3,0	600 to 3 000	2,68	4,5 to 5,5	5,0
4	10,0	2 000 to 10 000	3,61	4,5 to 5,5	5,0

200 s minimum flow time for all sizes.

Dimensions in millimetres

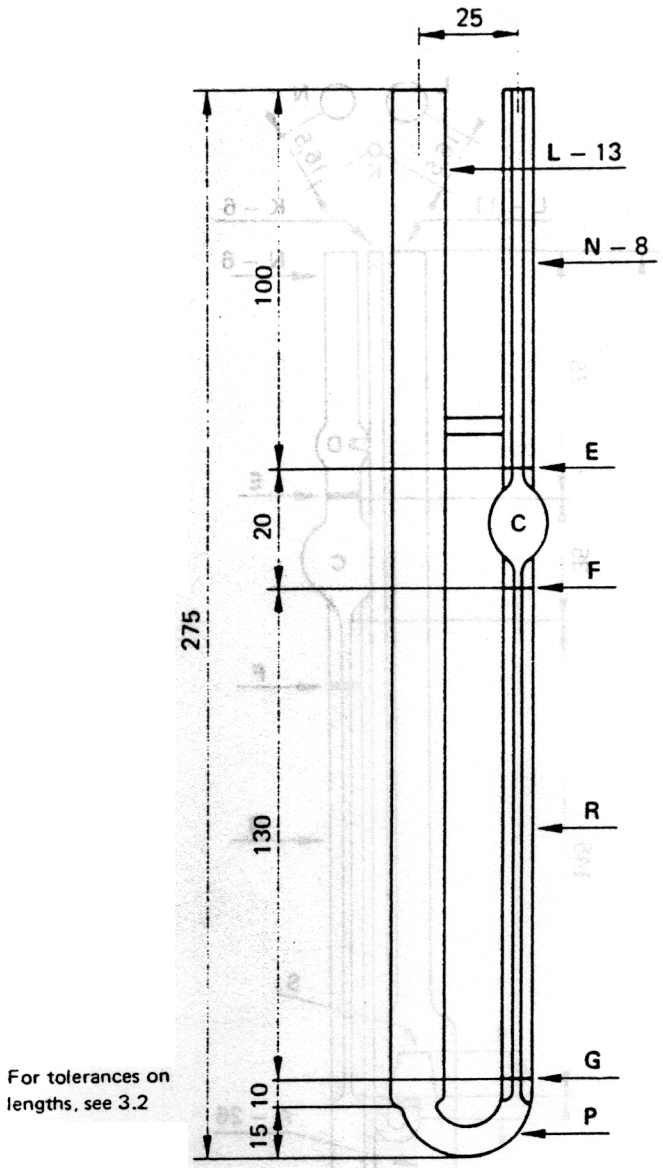


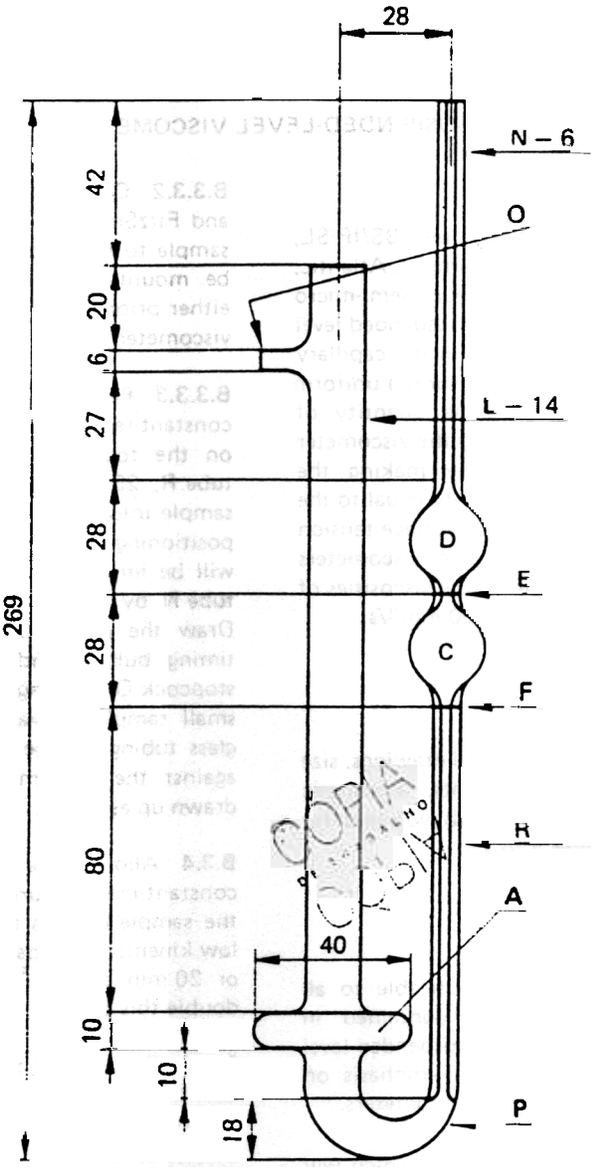
FIGURE 6 – Cannon-Manning semi-micro viscometer

TABLE 8 – Dimension and kinematic viscosity ranges

Size No.	Nominal viscometer constant	Kinematic viscosity range*	Inside diameter of tube R	Inside diameter of tubes		Volume bulb C
				N	P	
	$(mm^2/s)/s$	mm^2/s	mm (± 2 %)	mm	mm	ml (± 5 %)
25	0,002	0,4 to 2,0	0,22 ± 0,01	1,0 to 1,2	0,4 to 0,7	0,31
50	0,004	0,8 to 4	0,26 ± 0,01	1,0 to 1,2	0,5 to 0,8	0,31
75	0,008	1,6 to 8	0,31 ± 0,01	1,1 to 1,3	0,6 to 0,8	0,31
100	0,015	3 to 15	0,36 ± 0,02	1,2 to 1,4	0,7 to 0,9	0,31
150	0,035	7 to 35	0,47 ± 0,02	1,2 to 1,4	0,8 to 1,0	0,31
200	0,1	20 to 100	0,61 ± 0,02	1,4 to 1,7	0,9 to 1,2	0,31
300	0,25	50 to 250	0,76 ± 0,02	1,5 to 1,8	1,2 to 1,6	0,31
350	0,5	100 to 500	0,90 ± 0,03	1,8 to 2,2	1,5 to 1,8	0,31
400	1,2	240 to 1 200	1,13 ± 0,03	2,0 to 2,4	1,6 to 2,0	0,31
450	2,5	500 to 2 500	1,40 ± 0,04	2,2 to 2,6	2,0 to 2,5	0,31
500	8	1 600 to 8 000	1,85 ± 0,05	2,4 to 2,8	2,5 to 2,8	0,31
600	20	4 000 to 20 000	2,35 ± 0,05	3,0 to 3,4	2,7 to 3,0	0,31

200 s minimum flow time for all sizes.

Dimensions in millimetres



For tolerances on lengths, see 3.2

FIGURE 7 – Pinkevitch viscometer

TABLE 9 – Dimensions and kinematic viscosity ranges

Size No.	Nominal viscometer constant	Kinematic viscosity range	Inside diameter of tube R	Bulb volume ml (± 5 %)	
	$(mm^2/s)/s$	mm^2/s	mm (± 2 %)	D	C
0	0,0017	0,6* to 1,7	0,40	3,7	3,7
1	0,0085	1,7 to 8,5	0,60	3,7	3,7
2	0,027	5,4 to 27	0,80	3,7	3,7
3	0,065	13 to 65	1,00	3,7	3,7
4	0,14	28 to 140	1,20	3,7	3,7
5	0,35	70 to 350	1,50	3,7	3,7
6	1,0	200 to 1 000	2,00	3,7	3,7
7	2,6	520 to 2 600	2,50	3,7	3,7
8	5,3	1 060 to 5 300	3,00	3,7	3,7
9	9,9	1 980 to 9 900	3,50	3,7	3,7
10	17	3 400 to 17 000	4,00	3,7	3,7

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