Fire Research Note No 972

AN IMPROVED METHOD FOR MEASURING THE DRAINAGE RATE OF FIRE-FIGHTING FOAMS

by

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SUMMARY

The 25 per cent drainage times of fire-fighting foams have hitherto been determined using a 1400 ml pan, 18.7 cm diam. x 5 cm deep ($7\frac{3}{8}$ in x 2 in). This method was shown to have a low level of reproducibility when testing foam from a 5 l/min (1.1 gal/min) branchpipe. It was found that the sample size must be related to the flow rate of the foam stream being tested, and to its uniformity. Details of a new 6320 ml drainage pan, 20 cm diam. x 20 cm deep (7.9 in x 7.9 in) are given, which is suitable for testing foam from a 5 l/min branchpipe. The 25 per cent drainage time was found to be independent of pan diameter but changed with pan depth. Details of a new 1630 ml drainage pan, 10 cm diam. x 20 cm deep (3.9 in x 7.9 in) are given, which gives the same drainage time as the 6320 ml pan, and is suitable for testing foam from a laboratory generator at 0.75 l/min (0.1 gal/min). It is recommended that 25 per cent drainage times should always be measured in a pan of this depth, to give comparable results between laboratories.

KEY WORDS: Foam, drainage

DEPARTMENT OF THE ENVIRONMENT AND FIRE OFFICES COMMITTEE

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INTRODUCTION

A 5 l/min (1.1 gal/min) foam branchpipe for use as a laboratory reference standard had been designed and is described in Fire Research Notes Nos 970 and 971. The new branchpipe was used in two series of collaborative tests, in five laboratories, to define the reproducibility of foam property determinations. The first collaborative test series resulted in 25 per cent drainage times varying from 5.8 min to 7.7 min. This variation was greater than that of the expansion or shear stress and investigations were made to determine why this occurred. These resulted in the adoption of a new method for measuring the drainage rate, which is described in this report.

THE FIRST COLLABORATIVE BRANCHPIPE TEST

Five branchpipes were constructed according to the detailed engineering drawing in Fire Research Note No.571. The discharge rates of all five branchpipes were first determined using clean water, in one laboratory, at a discharge pressure of 690 kPa (100 lb/in^2), to verify the uniformity of the five branchpipes. Each of the five laboratories was provided with one of the branchpipes and a sample of the same batch of protein foam liquid. Three determinations of the 25 per cent drainage time were made in each laboratory using a 4 per cent solution and 690 kPa discharge pressure. The 25 per cent drainage time was determined by first measuring the expansion of the foam by filling a 1250 ml beaker, by a weighing method. The 1400 ml drainage pan[2], shown in Fig.1, was then used to measure the 25 per cent drainage time, its contents being calculated from its volume and the foam expansion. Table 1 gives the results of this first collaborative test.

Table 1

Results of collaborative test in 5 laboratories
with 1400 ml drainage pan

Laboratory	Branchpipe No.	Discharge rate l/min	25 per cent drainage time min
A	5	4.9	7.4) 8.35) 7.68 7.3)
B	2	4.8	5.9) 5.9) 5.77 5.5)
C	1	5.1	7.2) 6.9) 7.0 7.0)
D	3	4.9	7.3) 7.4) 6.7 5.5)
E	6	5.0	7.2) 7.2) 7.1 7.0)

These results give the following measures of variability

	Standard deviation per cent	No. of observations
Between laboratories - average of 3 results in each	± 9.1	5
Between single tests in any one laboratory	± 8.1	15

A number of possible causes of the variability of the drainage time can be suggested, as follows:

a. The branchpipes were not sufficiently uniform

b. The expansion measurement, upon which the drainage time calculation depends, was inaccurate

c. The drainage pan did not always fill uniformly with the same quantity of foam

d. The differing water quality in the various laboratories affected the results

e. The temperature of the air, the premix, and the foam, varied from laboratory to laboratory

f. The premix time was not constant for all tests

g. Other unspecified variations.

A systematic investigation was pursued to discover the most important origins of the variability of the drainage time.

BRANCHPIPE DIFFERENCES

Branchpipes A and B, which had given the highest and lowest results in the collaborative test, were tested together in laboratory B. The sample of protein used in the collaborative test, and also another sample - protein 255 - were used. Table 2 shows the results.

Table 2

Branchpipe Nos 2 and 5 tested in laboratory B

Protein sample	Branchpipe No.	25 per cent drainage time - min	Standard deviation per cent	No. of observations
255	2	5.55	± 1.9	(6)
"	5	5.6		
Collaborative	2	6.1	± 6.4	(7)
Sample	5	6.3		

These results showed good agreement between the two branchpipes when tested in the same laboratory and eliminated differences in the mechanical details of the branchpipes as the principal cause of the variation.

PREMIX TIME

Using the collaborative sample, four tests, using one premix, were made over a period of 30 minutes. The drainage times of the consecutive tests were 6.35, 6.2, 6.25, 6.6 minutes. These results indicated that premix time was not the principal source of variation, but further data on this point was obtained later in the investigation.

EXPANSION DETERMINATION

Ten expansion determinations had a standard deviation of ± 1.3 per cent, and the accuracy of the expansion determination is not therefore an important variable.

DRAINAGE PAN CONTENTS

The accuracy with which the drainage pan is filled was determined by making 10 tests and weighing the pan. The ten results had a standard deviation of ± 1.25 per cent, and the accuracy of pan filling is therefore not an important variable.

RELATIONSHIP BETWEEN DRAINAGE TIME AND QUANTITY DRAINED

Because the drainage rate changes continuously, it was suggested that the use of the 25 per cent drainage time may be misleading because drainage rate slows up and a 10 per cent difference in time may represent a smaller difference in the quantity drained. Figure 2 shows the total drainage plotted against time when using the 1400 ml pan. At the 25 per cent drainage time of 6 minutes, the sample was draining at approximately 6 ml per min - ie 17 per cent change in time is associated with a 15 per cent change in the volume drained. Thus we see that, quite fortuitously, for this sample of protein foam, the time and volume measurements near the 25 per cent drainage point, are both changing at almost the same percentage rate, and no misleading deductions will arise from this relationship.

EVIDENCE OF AN UNRECOGNISED SOURCE OF ERROR

With the object of discovering whether a change in water quality was important, branchpipes Nos 2& 5 were next tested in laboratory A, having previously been tested in laboratory B. Two 1400 ml drainage pans were used - one from each laboratory. Table 3 gives the results obtained.

Table 3

Comparison of branchpipes 2 and 5 in laboratory A - collaborative protein sample

Branchpipe No.	25 per cent drainage time - min (average of 3 tests)	
	Pan A	Pan B
2	7.15	6.5
5	6.2	6.9

The standard deviation of the 12 individual tests was ± 7.5 per cent and the results approximated to a normal distribution about their mean. During these tests the air temperatures and premix temperatures were measured and remained substantially constant at 18-19°C for the premix, and 20-21°C for the air. Only one quality of water was used. These tests indicated that a source of error existed in the drainage test, which had not been recognised, and it was believed that the freedom with which the draining liquid would flow from the pan, through the 5 mm (0.2 in) diam. outlet, was associated with the erratic results.

TEMPERATURE

The twelve tests made in laboratory A were all conducted with small variations in the temperatures of the air and the premixes, and yet the 25 per cent drainage time had a standard deviation of ± 7.5 per cent. It was thus apparent that factors other than temperature cause a substantial variation, but it does not follow that temperature does not affect the results.

Figure 3 shows all the drainage times, obtained on the collaborative sample, which have so far been discussed, plotted against the air temperature, and in Fig.4 plotted against the premix temperature. Both figures suggest that temperature may have an effect upon the drainage time but the other causes of variation prevent any valid assessment being made.

E J Jablonski[1] investigated the effect of temperature upon the drainage rate of protein using this same 1400 ml drainage pan. Quite complicated relationships were found using a laboratory foam generator, but the foam produced by a typical hand-line nozzle showed only 6 per cent change in drainage time when the premix temperature was changed from 4.4 to 21°C (40-70°F), while the expansion increased from 7.1 to 8.0.

It was decided to minimise the temperature effect by adjusting all future premixes to slightly above or below 20°C, according to the air temperature, aiming to produce foam at 20°C. It was found that by using a glass thermometer, with no case, and a continuous movement, the temperature of the foam could be obtained, and this reduced temperature to a single variable.

TESTS WITH 1800 ml DRAINAGE PAN

Some simple tests with the 1400 ml drainage pan showed that if the pan were filled with water and then allowed to drain in the normal test manner, some water would remain in the pan, distributed as a film, a meniscus forming at the edge of the outlet hole. The quantity retained could be 5 ml +, and varied on repeat tests; this is a significant amount.

A new drainage pan was constructed according to Fig.5. The straight height of the side was maintained the same as the 1400 ml pan, while the diameter was increased slightly to a round metric figure. The pan was sloped to a central outlet, the angle of slope being 11° as compared with 4° in the 1400 ml pan. Thus with the increased slope and the shorter drainage path, good drainage should be assisted.

The outlet was fitted with a perspex tube, 12.7 mm diam. x 25 mm long (0.5 in x 0.98 in) so that the draining liquid could be observed and the operator could ensure that all the liquid was run-off, through the brass cock at the lower end of the perspex tube.

The base of the pan was turned from a brass block to ensure an accurate slope to the outlet hole and a base not easily dented by rough treatment. The perspex tube had a capacity of 5 ml, as compared with a total pan volume of 1800 ml, and any error depending upon whether or not the tube fills with foam will not be significant.

Initially the pan had a sharp-edged 6.4 mm (0.25 in) diam. outlet into the perspex tube. When tested with water, a meniscus would form across the 6.4 mm outlet, permitting some water to remain in the pan. The outlet was increased to 12.7 mm diam.; this prevented a meniscus forming across the outlet but a meniscus formed around the sharp edge of the outlet and a lenticle of water was retained in the pan. The sharp edge of the inlet to the 12.7 mm diam. tube was then rounded to present a curvature of 3.2 mm (0.13 in) radius and this prevented the retention of liquid, providing the pan was completely free of traces of grease. These tests with water represent the most stringent conditions, and drainage was noticeably faster when detergent solution was used.

The 1800 ml pan was tested using a new batch of foam liquid - protein 421. Forty tests were made using 8 premixes. The average drainage time was 5.6 min. The standard deviation was $\pm$ 5.43 per cent, which shows a small improvement on the 1400 ml pan, but this may be because of the larger number of tests giving a more accurate value. A standard deviation of $\pm$ 5.4 per cent still indicates an undiscovered cause of variation; the stop watch errors and the pan filling errors being much less, and we know, in this case, that there was no error due to hold-up of liquid in the drainage pan, nor to temperature differences, or changes in water quality.

Figure 6 shows the results plotted out in the order in which they were obtained. It can be seen that there is a correlation of the variation with the premix. The standard deviation on an individual premix is ± 3.5 per cent. With some premixes fairly constant results were obtained, but with other premixes the drainage times showed a progressive fall. The premixes were made up very carefully and no explanation of these differences was apparent. The foam temperatures on all these tests were measured and did not appear to explain the variations, although some appreciable temperature differences occurred throughout the 40 tests.

It was known that synthetic foam liquid does not show any great change with premix time so the branchpipe was tested with a 2 per cent solution of synthetic liquid and the 1800 ml pan. The drainage time of 11 tests on 3 premixes had a standard deviation of ± 7.3 per cent, ie no improvement as compared with protein foam.

The next step was to test the 1800 ml pan using synthetic foam produced in a laboratory generator, because it was thought that the 5 l/min branchpipe might not be producing foam of constant quality. Fourteen tests using 3 premixes had a standard deviation of ± 3.4 per cent. This was the best result so far obtained and demonstrated that drainage times with a reasonably good level of reproducibility could be obtained with the 1800 ml drainage pan and also that samples of foam obtained from the branchpipe were not as uniform as those from the laboratory generator.

The 1400 ml pan was then tested using the laboratory generator and synthetic foam. Fourteen tests had a standard deviation of ± 2.7 per cent indicating that the new 1800 ml pan had no superiority in accuracy. In the 1400 ml pan the average drainage time was 3.45 minutes while in the new pan the average time was 3.1 minutes, which shows the superiority of the new pan in permitting the liquid to drain efficiently.

TESTS WITH A 60 cm DIAM. DRAINAGE TANK

It was now apparent that the branchpipe does not produce uniform foam and that this was the sought after reason for the variations in the drainage times. Calculations show that the 1400 ml drainage pan is filled by the branchpipe in 1.9 seconds and the 1800 ml pan in 2.45 seconds. Using the laboratory foam generator the filling times are respectively 14 and 18 seconds. If the variations in the branchpipe foam properties are occurring at random about a mean value the problem can be overcome by taking a much larger sample. If, however, the branchpipe can establish a number of different patterns of operation, which once established tend to persist, taking a larger sample may not show much improvement.

The fire tank used in the UK Defence Standard[3] test was used to explore these possibilities. The tank is 60 cm diam. with 10 cm straight sides, and a steep cone base with an included angle of 90°. At the base of the cone is a perspex tube 6.35 cm diam. and 61 cm long, in which the drainage can be observed and measured.

Foam was discharged into the tank from the branchpipe for a period of 1 minute, ie 5000 ml of liquid, and the times for 5, 10, 15, 20 and 25 per cent of the liquid to collect in the perspex tube were noted.

Synthetic foam was used first. The 5 per cent and 10 per cent drainage times were noted satisfactorily, but the higher readings became progressively more difficult to make accurately because the drainage rate increased so much that the interface was indefinite. Protein foam, batch 421, was then used, and the interface position could be determined satisfactorily, although it was becoming a little difficult on the 25 per cent reading.

The standard deviation of 12 tests with protein foam varied with the percentage drainage as follows.

Table 4

Drainage of protein foam in 45,000 ml tank - 12 tests

Percentage drainage	Average drainage time - 12 results min	Standard deviation
5	7.2	$\pm$ 2.4 per cent
10	8.4	$\pm$ 2.5 " "
15	9.4	$\pm$ 2.75 " "
20	10.3	$\pm$ 2.6 " "
25	11.4	$\pm$ 3.6 " "

These results show that only the 25 per cent drainage time was affected by difficulty in reading the interface. The standard deviation of $\pm$ 2.6 per cent for the 20 per cent drainage time is an excellent result and shows that the use of a much larger sample provides a solution to measuring the drainage rate of the branchpipe foam accurately. By modifying the dimensions of the tank and drainage collection tube the interface problem could be overcome and the test would be very simple to conduct.

This solution however has one unfortunate drawback. Besides using the 5 litre per minute branchpipe to characterize a foam liquid, we also require to duplicate the foam in the laboratory generator to conduct fire tests. We could not use the large tank to measure the drainage rate of the generator foam, to match it with the branchpipe foam, because $7\frac{1}{2}$ minutes would be required to fill the tank from the generator.

THE FUNDAMENTAL PROBLEM

The problem can now be stated in general terms viz, if we wish to match two foam streams of substantially different rates, a small drainage pan will be unsatisfactory because it samples the large stream over a very short period of time, while a large pan will be unsatisfactory because the filling time from the small stream will compare in magnitude with the drainage time.

That this is a problem of practical importance has been well demonstrated in the past by the difficulties encountered in obtaining agreement between different laboratories in the UK Defence Standard test which requires 227.3 l/min (50 gal/min) branchpipe foam to be matched with 0.68 l/min (0.15 gal/min) generator foam.

EXPERIMENTS TO OBTAIN A SMALL REPRESENTATIVE SAMPLE OF BRANCHPIPE FOAM

One solution to this problem is to split the branchpipe foam stream so that it is sampled at a small rate over a longer period, chosen to fill the 1800 ml pan in approximately the same time as the generator, ie 18 seconds.

Considerable effort was made to devise a simple effective means of accomplishing this, but without success. It was found that by-pass devices, such as apertures on the branchpipe outlet would behave differently with different foams, and a device adjusted to operate reasonably with protein foam would not function with a lower viscosity synthetic foam.. Another problem was that when a foam jet was divided into two streams there was a tendency for the two streams to be drawn together again by the air currents generated by the jets so that they coalesced into a single jet again.

EXPERIMENTS WITH 6320 ml AND 1630 ml DRAINAGE PANS

Another possibility of surmounting this problem is to use two different drainage pans for the branchpipe and generator foam. Although the drainage rate will depend upon the geometry of the pan it will be substantially independent of the diameter, and therefore two pans which are different in size but which give the same drainage rate can be constructed providing they have identical depths.

Two such pans were constructed as shown in Figs 7 and 8 and Fig.9 shows the pans in use. The design features developed for the 1800 ml pan were retained but both pans were made with 20 cm straight sides, one being 20 cm diam. and the other 10 cm diam.

In order to avoid confusion all 25 per cent drainage times should indicate the depth of the pan used in the test, eg

25 per cent 5 cm drainage time = x min

25 per cent 20 cm drainage time = y min

The two pans had the following characteristics:

20 cm diam. x 20 cm deep = 6320 ml = 8.5 s filling from branchpipe at expansion 9

10 cm diam. x 20 cm deep = 1630 ml = 16 s filling from generator at expansion 9

These dimensions were chosen as a reasonable compromise.

The large pan was limited in size to prevent it becoming too cumbersome, while the small pan was limited by the increasing difficulty of filling as the diameter is decreased.

The two pans were tested in laboratory B, using protein 421, and branchpipe foam, and the smaller pan was tested using generator foam.

Table 5

Comparison of 20 cm deep pans of different diameters

Type of protein foam	Pan size - ml	Average 25 per cent drainage time - min	Standard deviation - per cent	No. of observations
Branchpipe	6320	7.8	± 2.4	11
"	1630	7.9	± 2.75	11
Generator	1630	8.6	± 2.7	11

These results showed that the two pans, with different diameters but the same height, gave the same 25 per cent drainage time when filled with the same foam, and can therefore be used to match foam streams of different sizes.

The standard deviation of ± 2.75 per cent obtained using the 10 cm diam. x 20 cm deep 1630 ml pan, and branchpipe foam, was considerably better than expected and should have matched the standard deviation of ± 5.4 per cent obtained in the 40 tests with the 1800 ml pan 5 cm (2 in) deep. It may be that the 11 tests were insufficient to give a close estimate of the standard deviation but the possibility exists that the accuracy of the drainage rate determination improves when the depth of the drainage pan is increased, without increasing the volume. This possibility is examined in further detail later.

The 6320 ml pan was also used in a collaborative test in five laboratories.

Table 6

Tests with 6320 ml pan in various laboratories

5 laboratories
5 branchpipes
4 tests in each laboratory = 20 tests
Protein 421

Average 25 per cent drainage time = 8.6 min

Standard deviation of an individual test in a single laboratory =
± 3.0 per cent (20 observations)

Standard deviation of average of 4 results in any laboratory =
± 4.6 per cent (5 observations).

This collaborative test showed that, by using the new 6320 ml drainage pan, all laboratories could determine the drainage time of the branchpipe foam with an improved reproducibility as compared with the original 1400 ml pan which gave a standard deviation of a single result in any laboratory ± 6.8 per cent in the first collaborative test. The differences between laboratories substantially in excess of a standard deviation of ± 2.6 per cent must be attributable to other variables than those associated with the drainage test itself, eg branchpipe, temperature and water quality.

The use of the 6320 ml pan in the second collaborative test reduced the standard deviation of the average of 4 results in any laboratory to 4.7 per cent as compared with 10 per cent for the average of 3 results in the first collaborative test using the 1400 ml pan. This represents a very valuable improvement in the agreement between laboratories. Using this improved drainage pan it should now be possible to investigate the causes of variation, other than the drainage rate measurement, and effect further improvement in the agreement between laboratories.

Table 7

Summary of Principal tests

Drainage pan and test description	Foam liquid	Foam production method	Average 25 per cent drainage time min	Standard deviation of 25 per cent drainage time per cent	No. of observations
1400 ml pan - 5 labs - between labs	Protein	Branch	6.8	± 9.1	5
" " " - single test - one lab	"	"	"	± 8.1	15
1400 ml pan - Branchpipe 2 - Lab.B	Protein 255	Branch 2	5.55	) ± 1.9	6
" " " 5 "	"	Branch 5	5.6	)	
1400 ml pan - Branchpipe 2 - Lab.B	Protein	Branch 2	6.1	) ± 6.4	7
" " " 5 "	"	"	6.3	)	
1400 ml pan A - Branchpipe 2 - Lab.A	Protein	Branch 2	7.15	) ± 7.5	12
" pan B " " "	"	"	6.5	)	
" pan A " 5 "	"	Branch 5	6.2	)	
" pan B " " "	"	"	6.9	)	
1800 ml pan	Protein 421	Branch	5.6	± 5.4	40
" "	Synthetic	"	–	± 7.3	11
" "	"	Generator	3.1	± 3.4	14
1400 ml pan	"	"	3.45	± 2.7	14
45000 ml tank	Protein 421	Branch	10.3	± 2.6	12
6320 ml pan - Lab.B	"	"	7.8	± 2.4	11
1630 ml pan - "	"	"	7.9	± 2.75	11
1630 ml pan - "	"	Generator	8.6	± 2.7	11
6320 ml pan - 5 Labs - single test any 1 Lab	"	Branch	8.6	± 3.0	20
6320 ml pan - 5 Labs - average of 4 results	"	"	8.6	± 4.6	5
Expansion determination - 2 l	Protein 255	Branch	-	± 1.3	10
1400 ml pan filling	"	"	-	± 1.25	10

Table 7 gives a summary of the principal tests leading to the adoption of the 6320 ml pan for branchpipe foam and the 1630 ml pan for generator foam.

CONSIDERATION OF THE EFFECT OF SAMPLE DEPTH ON 25 PER CENT DRAINAGE TIME DETERMINATION

Figure 10 gives the observed drainage against time for protein foam when allowed to drain in two pans of different depths - 5 cm and 20 cm, while Fig.11, which is developed from Fig.10, shows the drainage rates per unit cross-sectional area from the two pans.

Referring to Fig.11, the drainage test has 3 distinct phases.

In phase 1 no drainage occurs (but decay by diffusion will be proceeding).

In phase 2 the drainage rate increases rapidly - the flow being progressively augmented by liquid from the upper positions of the sample.

In phase 3, the rate at which liquid can drain through the foam exceeds the rate at which it is being liberated by decay and the drainage rate changes abruptly from a progressively increasing rate to a decreasing rate.

Now when the shallow 5 cm deep pan is used the 25 per cent drainage time is composed approximately thus,

2 min - phase 1 - no drainage
2 min - phase 2 - increasing drainage
2 min - phase 3 - decreasing drainage

while the 20 cm deep pan gives the following

2 min - phase 1 - no drainage
7 min - phase 2 - increasing drainage.

In the deeper pan, phase 2 contributes a much larger proportion of the 25 per cent drainage time. In this phase the rate at which the liquid can drain through the foam, rather than the decay rate is controlling, the latter being more important in phase 3. It is possible that the variations in quality between small samples of branchpipe foam may affect the decay rate more than the downward percolation rate and if this is so the shallow pan will reveal differences more markedly than the deep pan. Further investigation would be required to determine if this is so.

CONCLUSION AND RECOMMENDATIONS

1. For determining the 25 per cent drainage time of foam streams of around 5 l/min (of liquid) a 6320 ml drainage pan - 20 cm diam. x 20 cm deep - constructed as shown in Fig.7 should be used. The pan must be free from grease and the 25 per cent drainage time should be measured from the commencement of pan filling. The pan contents should be calculated from the foam expansion, which should be determined by making triplicate weighings in a 2 l beaker.

2. Using this procedure it was found that the average of 4 results in one laboratory, using protein foam from a 5 l/min branchpipe, at a temperature of $20^{\circ}C \pm 1^{\circ}C$, had an accuracy of $\pm$ 2.95 per cent ($p = .05$).

3. For determining the 25 per cent drainage time of foam streams of around $\frac{3}{4}$ l/min from laboratory generators, a 1630 ml drainage pan, 10 cm diam. x 20 cm deep constructed as shown in Fig.8, should be used in the same manner.

4. When filled with the same foam, the 1630 and 6320 ml drainage pans gave average 25 per cent drainage times differing by less than 1.5 per cent.

5. Using the 1630 ml drainage pan, the average of 4 results in one laboratory, using protein foam from a 680 ml/min foam generator, had an accuracy of $\pm$ 3.1 per cent ($p = .05$).

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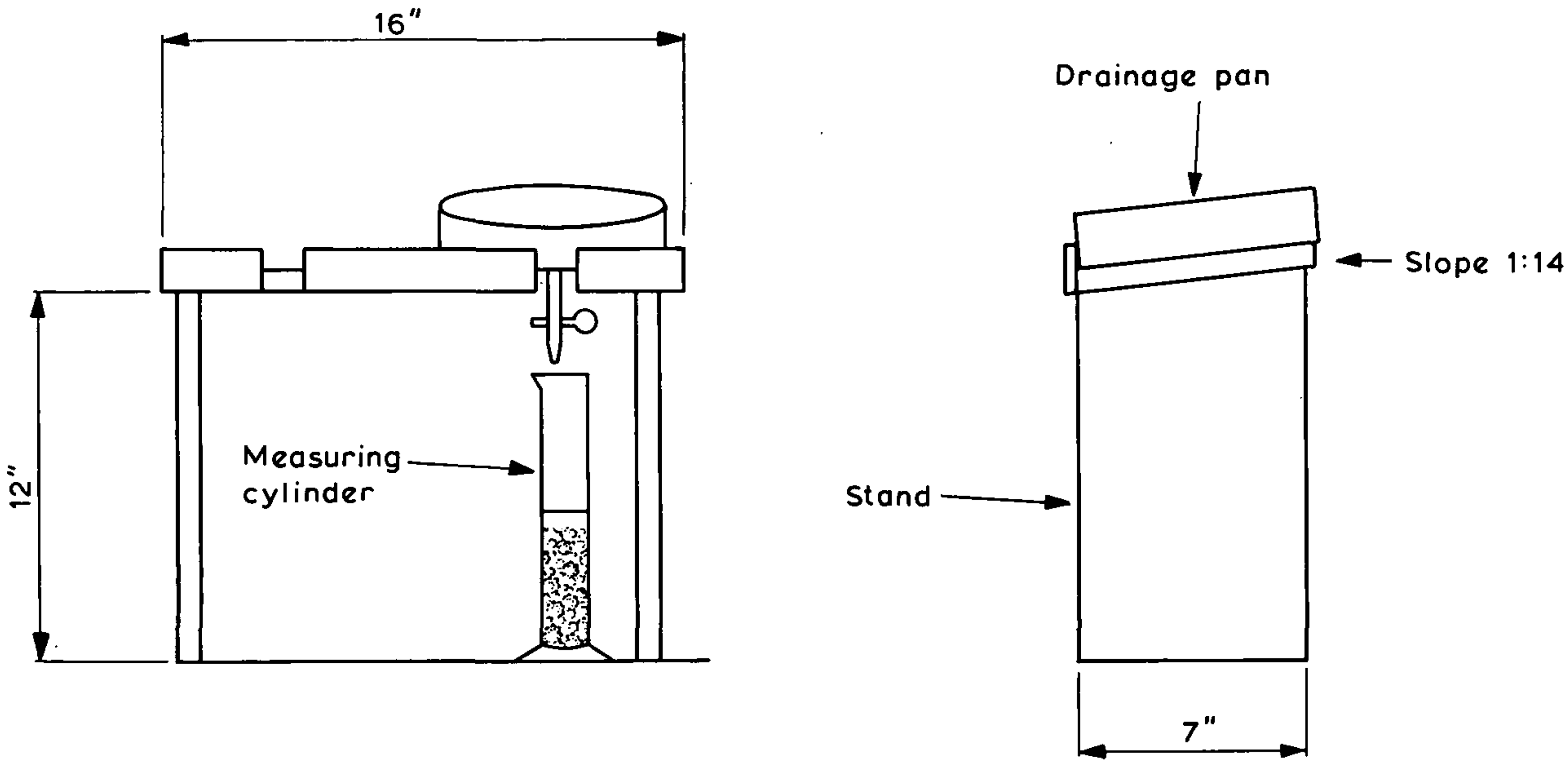

Figure 1 1400 ml drainage pan

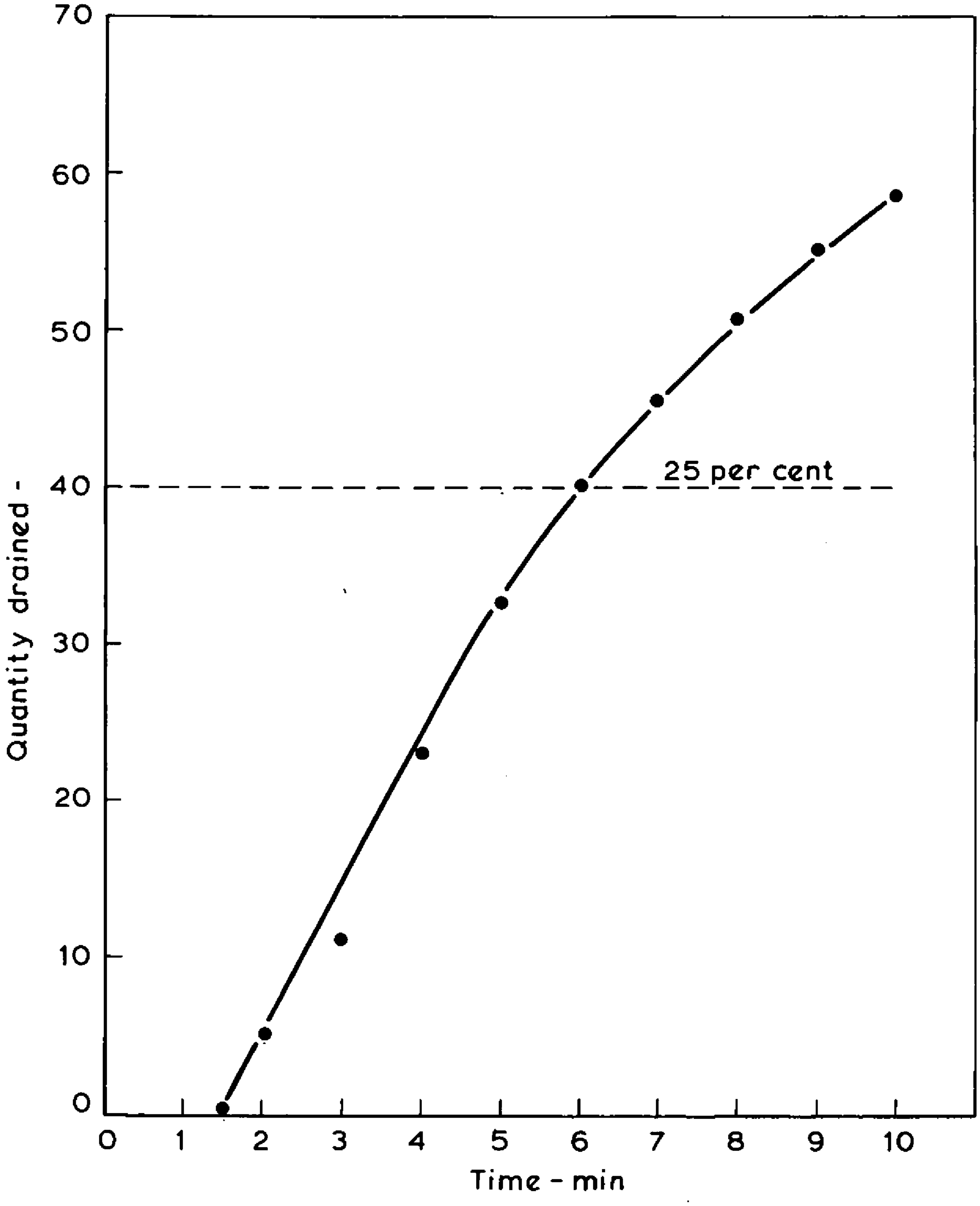

Figure 2 Drainage of protein foam - defence standard 42-3 drainage pan (1400 ml)

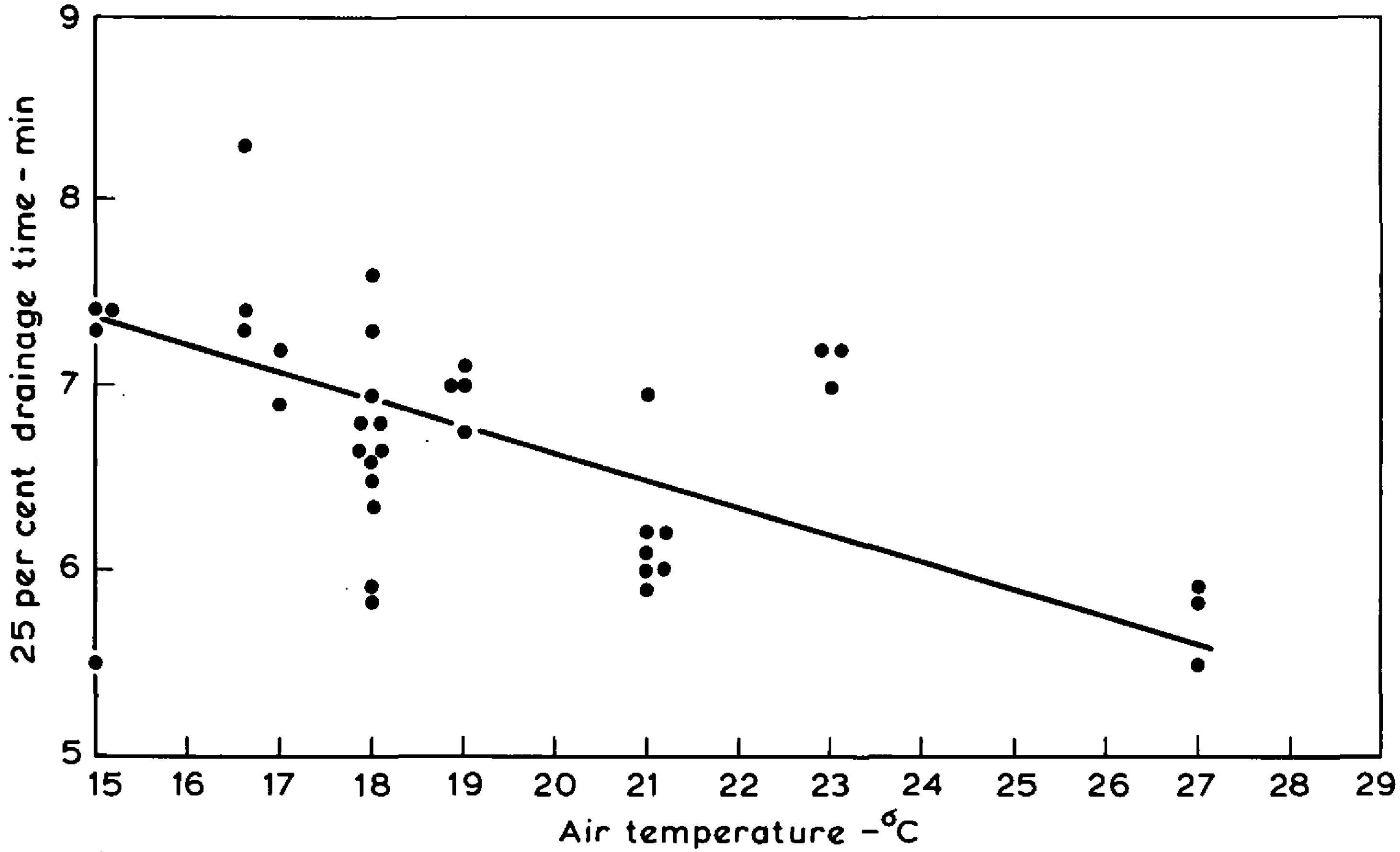

Figure 3 25 per cent drainage times of protein foam from branchpipe at various air temperatures - 5 laboratories

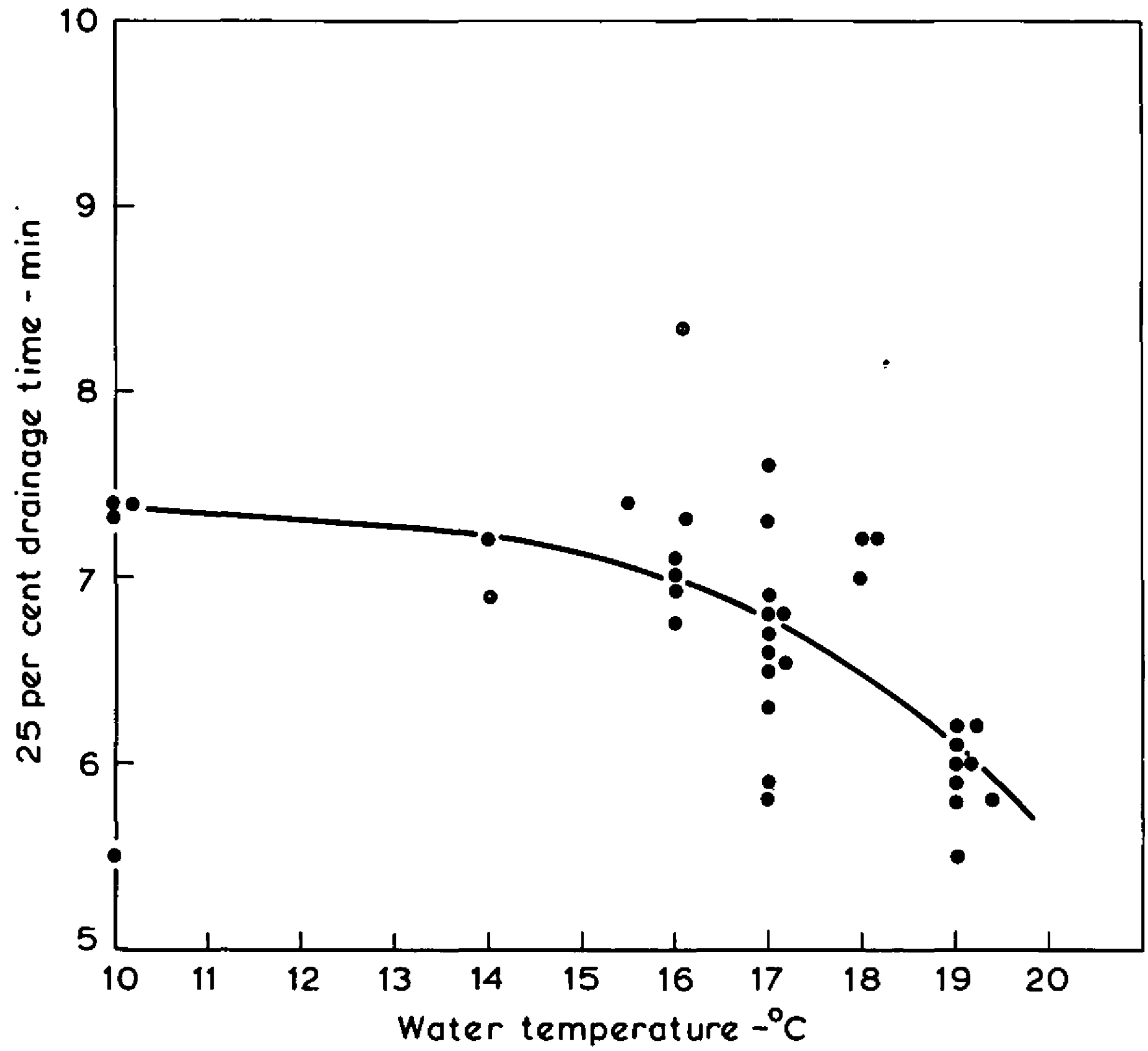

Figure 4 25 per cent drainage times of protein foam from branchpipe at various premix temperatures - 5 laboratories

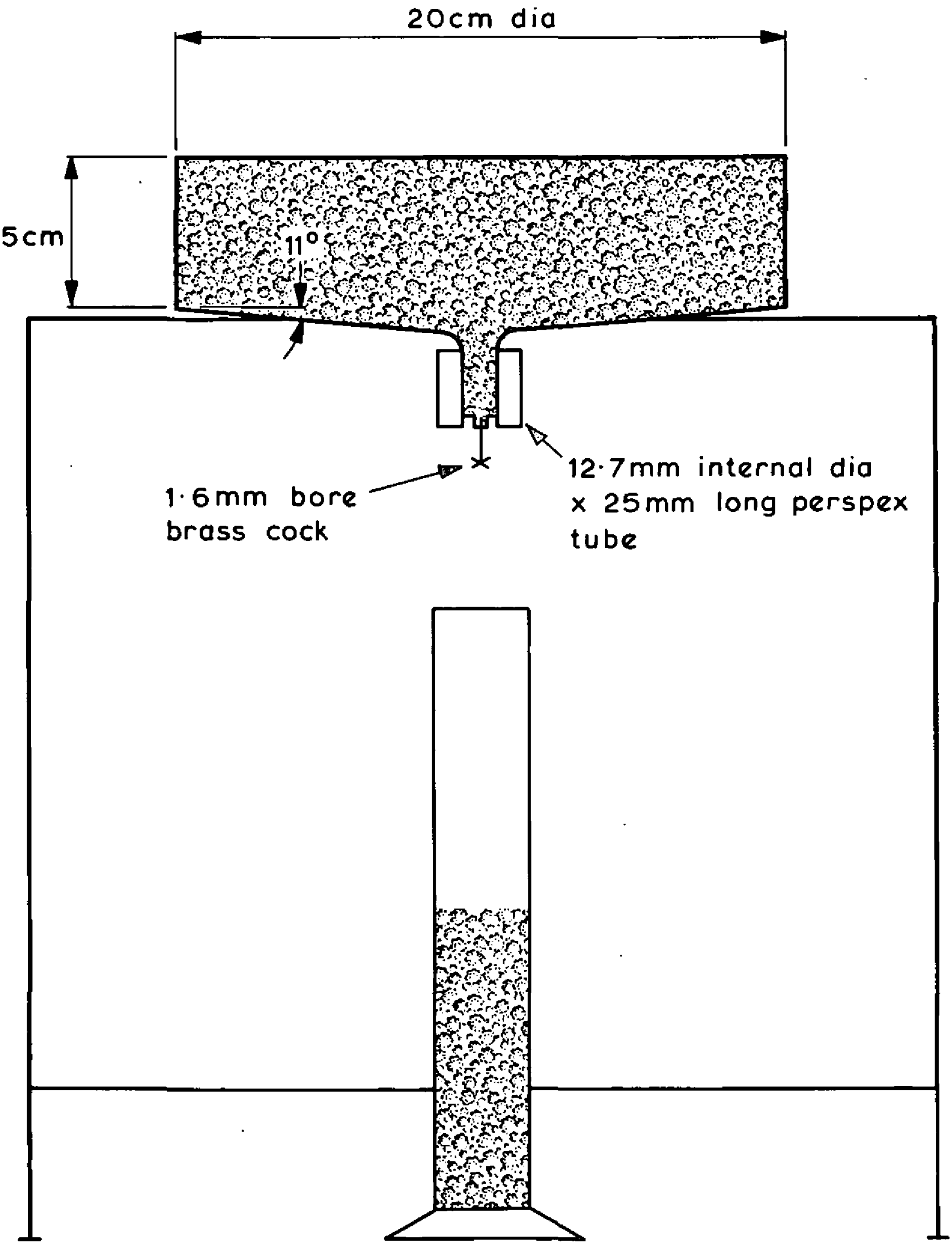

Figure 5 1800ml brass drainage pan and stand

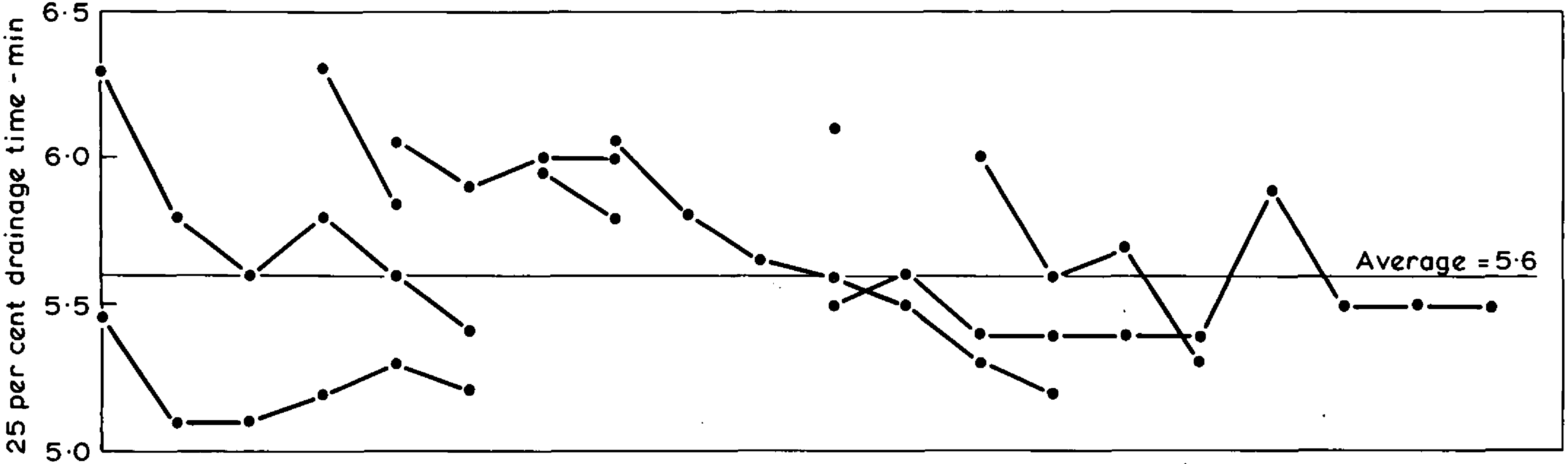

Figure 6 25 per cent drainage times of protein foam from branchpipe in 5cm deep - 1800ml pan. 40 tests on 9 premixes. Each line is one premix.

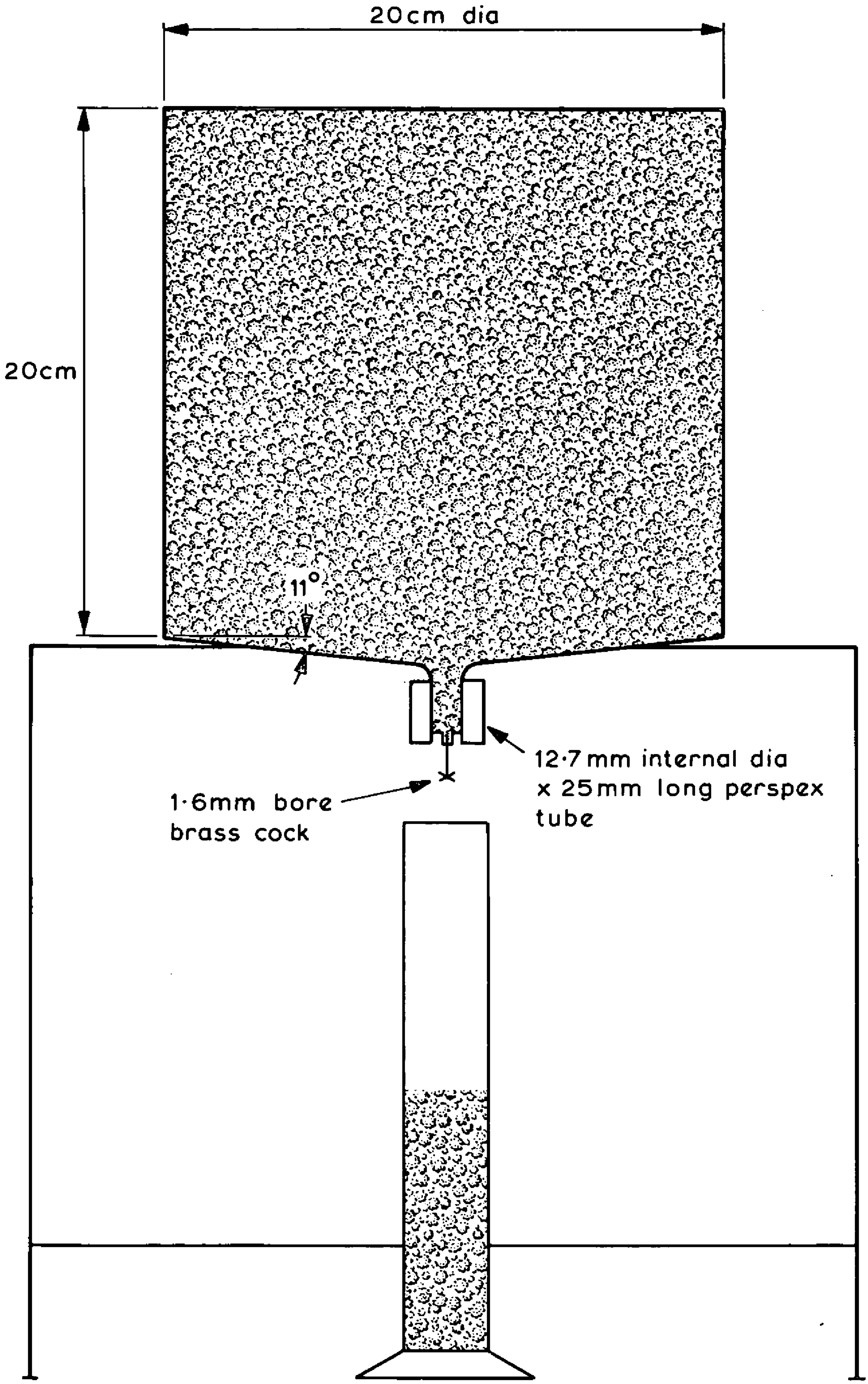

Figure 7 6320ml brass drainage pan and stand

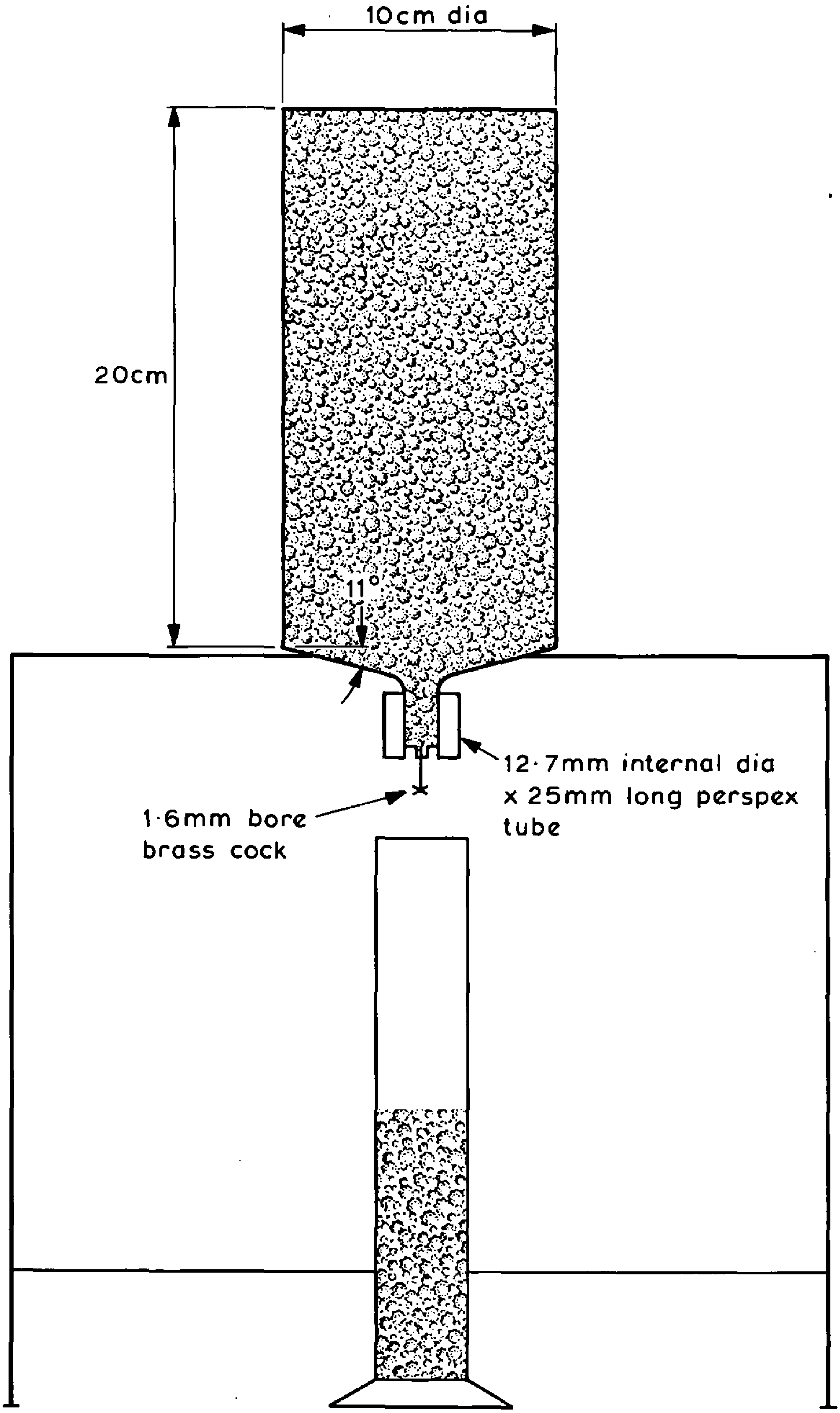

Figure 8   1630 ml brass drainage pan and stand

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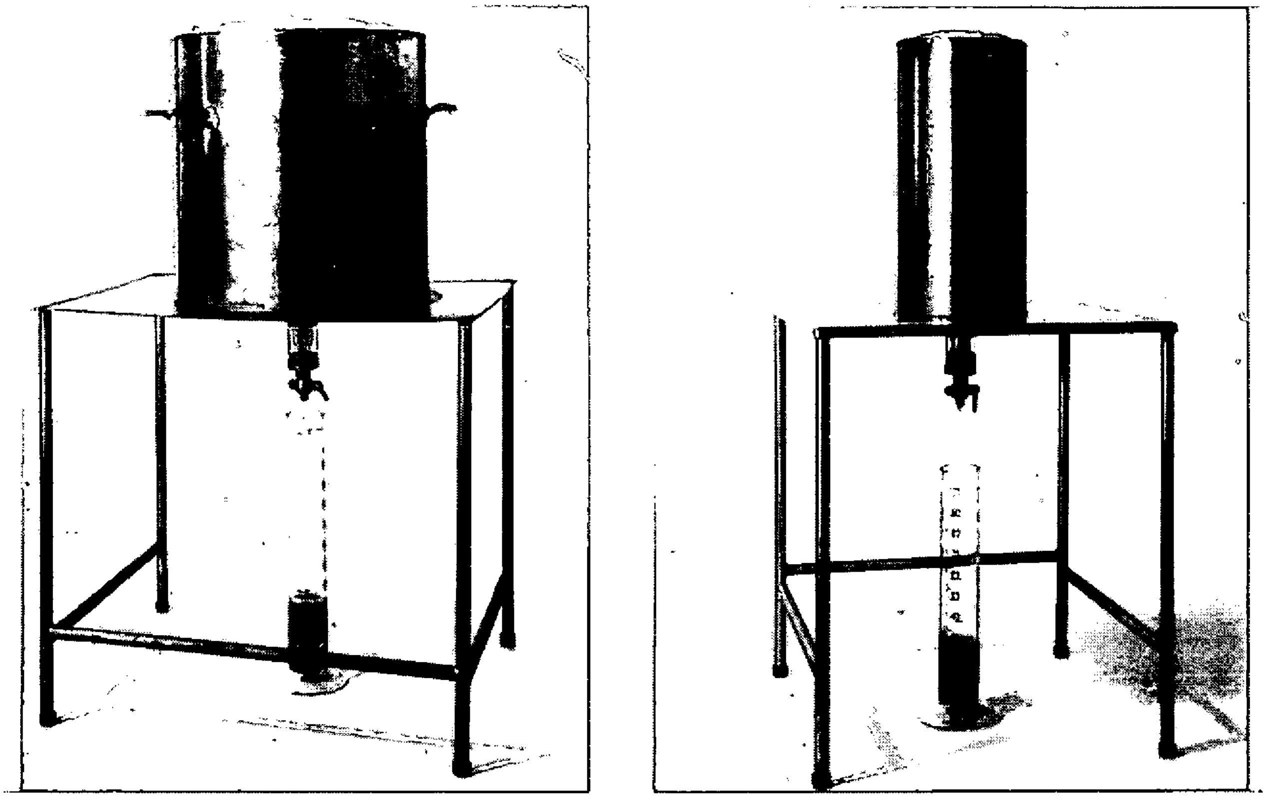

FIG. 9. 20 CM DEEP DRAINAGE PANS - 10 CM AND 20 CM DIAMETER

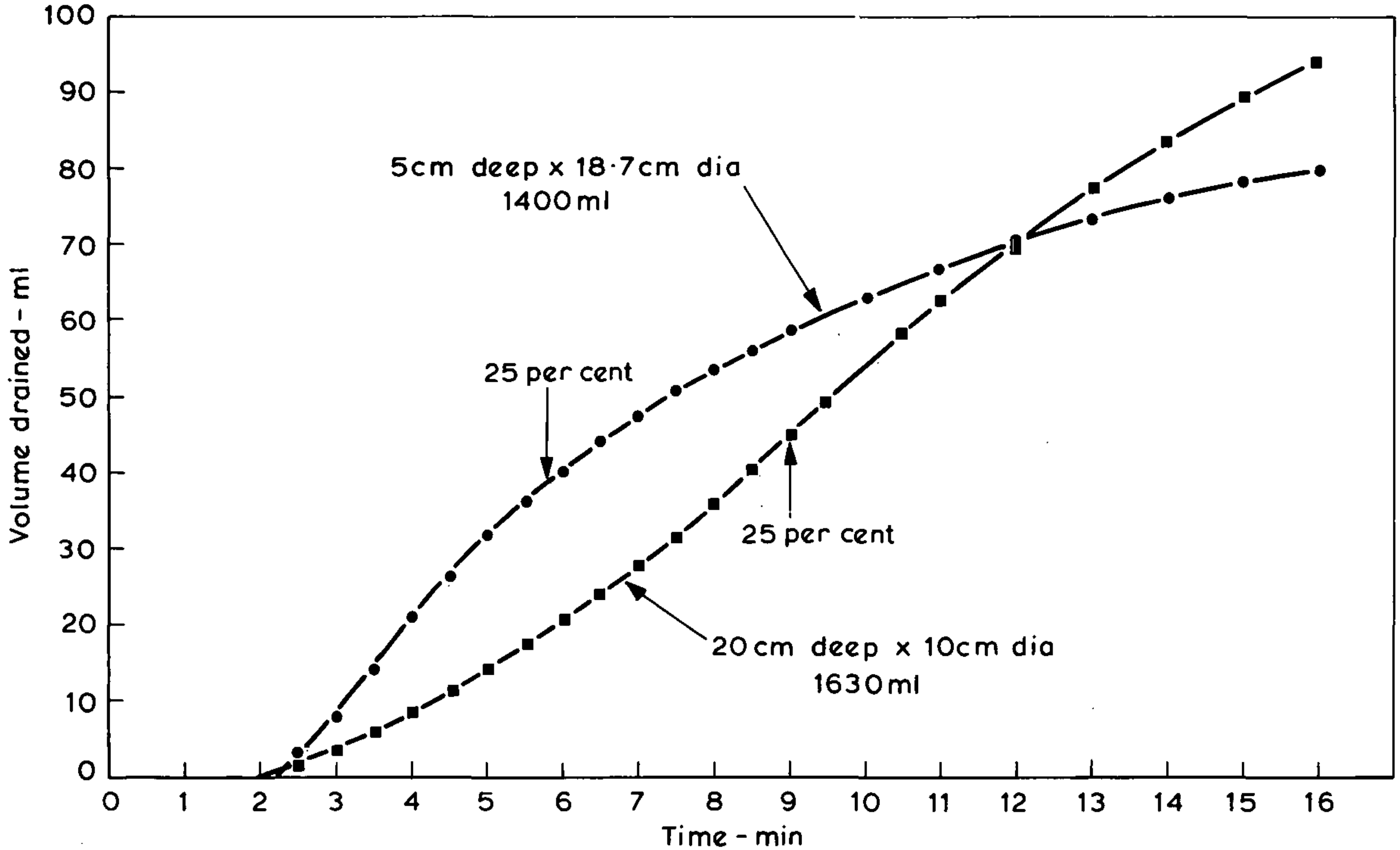

Figure 10 Drainage of protein foam - expansion 9·125 - in two pans with different depths

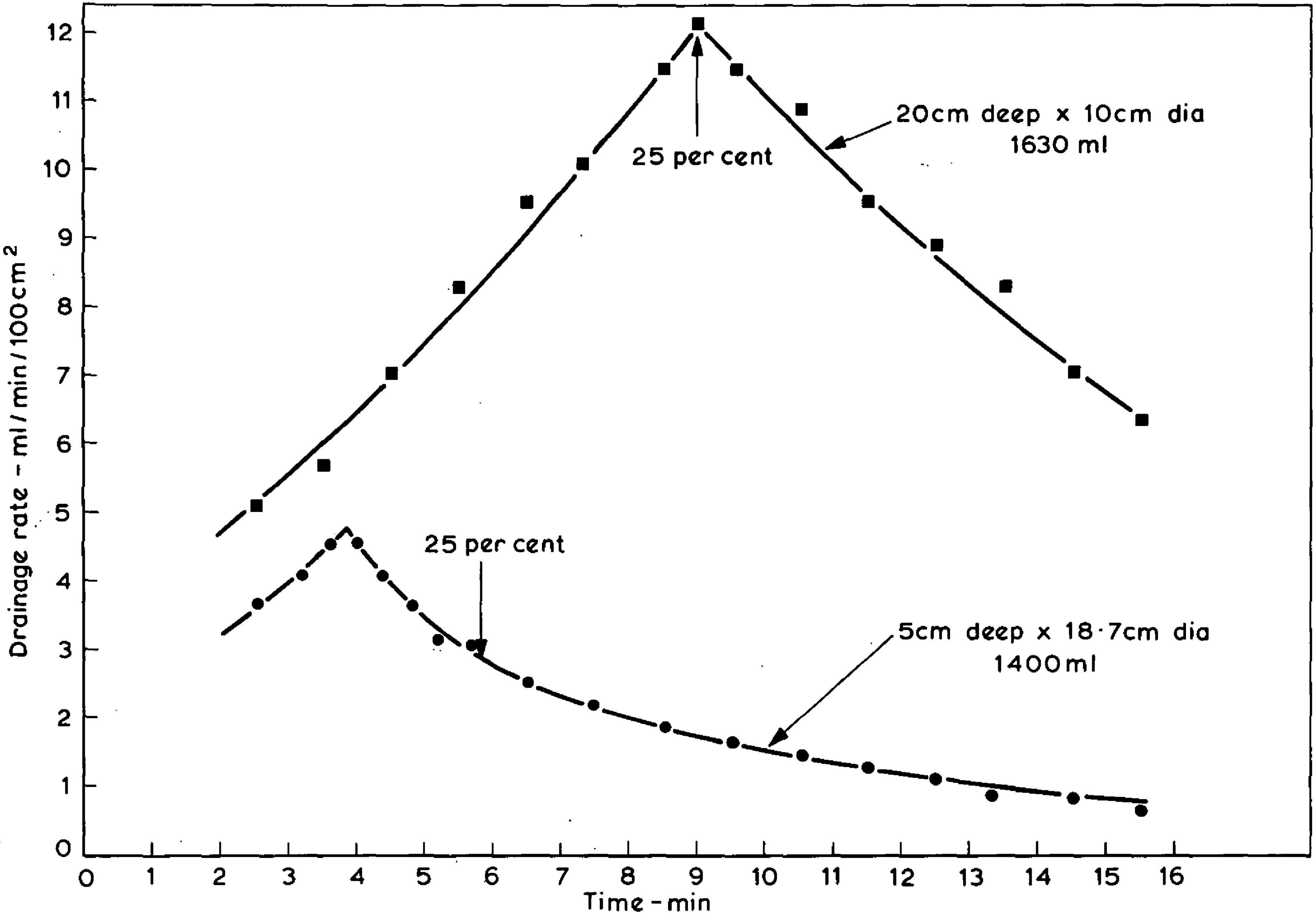

Figure 11 Drainage rate per unit area of protein foam - expansion 9·125 in two pans with different depths