Fire Research Note No 980

STORAGE PROPERTIES OF FOUR FOAM LIQUIDS
(FINAL REPORT)

by

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SUMMARY

Fire Research Note No. 933 reported the behaviour in storage of four foam liquids for a period of one year. This report discusses the behaviour of the same liquids up to a period of two years, and of a sample of a more recently introduced fluorochemical liquid for a period of 11 months. The foam liquids were examined using the fire test of U.K. Defence Standard 42-3, Issue 1.

KEY WORDS: Extinguishing agent, tests, foam, protein, storage, fluoroprotein, fluorochemical.

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JOINT FIRE RESEARCH ORGANIZATION

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INTRODUCTION

The object of the investigation, the foam liquids examined, and the storage and experimental procedures, have been described in Fire Research Note No. 933, which gave details of the progress of the investigation up to a period of one year. This report gives the results obtained at the completion of the storage test after a period of two years. The following is a brief description of the procedure which has been described in detail in the interim report.

Four foam liquids were used, protein, fluoroprotein A, fluoroprotein B, and fluorochemical - Type 194. Samples were stored in polythene containers at room temperature (10 - 20°C), and at 38°C. Some samples were subjected to repeated freezing at -18°C. The foam liquids were assessed periodically using 0.28 m^2 petrol fires, and testing each liquid over a range of concentrations.

During the course of the investigation, an improved grade of fluorochemical (Type 196) was marketed as a replacement for Type 194, and results up to a storage period of 11 months are included for this product.

EXPERIMENTAL RESULTS

Figures 1 - 12 show the 90 per cent control times and the 25 per cent drainage times plotted against the test concentration for each of the foam liquids remaining in the test. (The protein samples stored as 4 per cent solution had seriously deteriorated at 6 months and were discarded; fluoroprotein A was not recommended for storage as 4 per cent solution; completion of the freezing tests was included in the interim report).

Figures 14 and 15 show the 90 per cent control times and the 25 per cent drainage times for fluorochemical - Type 196. The initial test data are shown on all the figures for comparison purposes. The expansion, shear stress, and 5-minute fire drainage were recorded for each test, but have been omitted from Figs 1 - 15 to make the results more readily comprehensible. (The expansion

showed few changes, while reductions in the shear stress and increases in the shear stress and increases in the fire drainage were generally related to reductions in the 25 per cent drainage time).

Table 1 records the test data when each sample was used at the recommended concentration after 2 years' storage, together with the initial test data for comparison. The minimum concentration for maximum effectiveness was estimated from the heel of the control time curve as illustrated in Fig. 3, and the deterioration based upon this estimate was calculated, and is given in Table 1.

DISCUSSION

General

The procedure of deriving an estimate of the percentage deterioration from the change in the 90 per cent control time, by using the heel point of the control time x concentration curve, has two shortcomings. In some cases, such as in the fluorochemical tests depicted in Fig. 12, it quantifies the deterioration quite reasonably. In other cases, such as in those depicted in Fig. 2 for protein concentrate stored for 2 years at 38°C, the curve has changed in shape, and it is difficult to choose the heel point. The estimated deterioration of 26 per cent made from Fig. 2 is not so meaningful as, for instance, that of 33 per cent made from Fig. 10, in which case the two curves have the same shape but different positions.

The second shortcoming is well illustrated in Fig. 4 which is for fluoroprotein A stored as concentrate at 38°C. The 25 per cent drainage time fell very significantly and the shear stress also fell, resulting in a more rapid control, and in this case the index shows no deterioration but a 15 per cent improvement. The material has undeniably changed during storage and the changes might well represent a type of deterioration which does not result in an increase in the control time under the artificial conditions of the test, but may be important in practical situations.

In spite of these shortcomings the estimated deterioration as shown in the last column of Table 1 is the best available simple index, and is a useful basis for comparison if its lack of precision is not forgotten. A deterioration of over 50 per cent can be regarded as significant, 25 - 50 per cent as possibly significant, and less than 25 per cent as not significant.

Protein

Concentrate stored at room temperature and at 38°C for two years (Figs 1 and 2) gave very similar fire test results; the control times showing slight improvements on the initial tests. The 25 per cent drainage times showed marked

falls at both temperatures, and these were slightly greater than the falls after one year of storage. The fire drainages had also increased further as compared with the one year results.

Fluoroprotein A

Stored as concentrate at room temperature (Fig. 3) the results were similar to the 1 year test, showing no change from the initial sample except for an improvement in the control times at low concentrations. Stored as concentrate at 38°C for two years (Fig. 4), the 25 per cent drainage time had fallen severely and the fire drainage had almost doubled as compared with the initial test, but the control times were still maintained. When tested after one year at 38°C no marked changes were found, and this example of a rapid change in the drainage characteristics during the second year at 38°C should be borne in mind when planning future storage tests. It also illustrates the difficulty of making predictions from preliminary results.

Fluoroprotein B

After two years at all four regimes (Figs 5, 6, 7, 8), very similar test results were obtained. The control times were as good as, or better than, the initial sample while the 25 per cent drainage time had fallen markedly. At one year the 25 per cent drainage times had shown little change. It is noteworthy that the samples stored as 4 per cent solution kept well, whereas the 4 per cent solutions of protein would not extinguish the test fire after 6 months' storage.

Fluorochemical - Type 194

All the samples showed some increase in control time at the lower test concentrations (Figs 9, 10, 11, 12). The increase for the sample of concentrate stored at 38°C for two years was less than that found after one year - 25 per cent deterioration as compared with 54 per cent. This probably reflects differences between the initial containers which were referred to in the interim report. All four samples extinguished the test fire in an unimpaired time when used at the recommended concentration of 6 per cent.

An important find was that the deterioration, which was appreciable after one year, did not progress further. This is illustrated in Fig. 13 which gives the control times for 6 per cent solution after 1 and 2 years' storage at 38°C - the regime which produced the highest deterioration.

One marked change was noted in the 25 per cent drainage time of the sample stored as 6 per cent solution at 38°C. The initial 25 per cent drainage time

was 2 min 37 s, and this fell to 1 min 50 s after 1 year, and 1 min 25 s after 2 years. The fire drainage increased from 35 per cent to 49 per cent, to 71.5 per cent.

Fluorochemical - Type 196

Figures 14 and 15 show respectively how the control time and the 25 per cent drainage time varied with concentration after 11 months' storage under 3 different regimes. Note that in these two figures the ordinates have a scale double that in the other figures.

Figure 14 shows that no change occurred in the control time, while Fig. 15 indicates that the 25 per cent drainage time had fallen slightly in the case of the two samples stored as 6 per cent solution. Type 196 fluorochemical had a good stability over a period of 11 months.

IMPLICATIONS FOR FUTURE STUDIES

This storage test has shown that marked changes in the characteristics of foam liquids during storage over long periods are of frequent occurrence, and that they can be of sufficient extent to change the effectiveness of the liquids. Only one sample of each of four foam liquids was used in this test and we must not assume that all samples of each liquid will behave similarly. Data on more batches are required, and on all the foam liquids in extensive use.

The test method used in this series employed gentle surface application of the foam. The foams were produced in a laboratory generator. The expansion, shear stress, and drainage, were fixed on the initial test to match those obtained in a 227 l/min branchpipe, and in subsequent retests the same expansion and the same number of improvers were used. This experimental procedure may have important defects. A frequent change occurring during storage is a marked deterioration of the drainage properties of the foam. It therefore seems essential that at each retest the branchpipe foam properties are determined, to ensure that the foam used on the experimental fire matches the foam which the sample being tested would actually produce if used in a branchpipe. It is also possible that foam with deteriorated drainage properties may fail to extinguish when applied with some force to the fuel surface, as will often be the case in practice, and this shortcoming may not be revealed by a gentle surface application test.

Storage at 38°C did not consistently accelerate the changes. In one case freezing caused changes. Storage as premix usually accelerated the changes and sometimes altered their course.

Taking acccunt of the above salient facts and the experience gained in this test, the following is an outline of a practical proposal for a future course of action:

1. Establish a routine, continuing storage trial for foam liquids.
2. Store each liquid as concentrate only in 10 l containers, 4 x 10 l containers of each batch to provide an initial test and retests at 1, 2 and 4 yearly intervals.
3. Store the samples in an unheated, slightly ventilated, opaque sheeted building, situated in the open in U.K. This will result in an annual temperature range of $0^{o}C$ - $25^{o}C$.
4. Use the F.R.S. standard 5 l/min branchpipe to determine the foam properties at each retest.
5. Determine the control and extinguishing time of a 2 m^2 fire using the 5 l/min branchpipe and the foam liquid at its recommended concentration.
6. Simulate the 5 l/min branchpipe foam in a laboratory generator and determine the burnback time on a 0.15 m^2 laboratory fire.
7. Select a single fuel for the two fire tests - an important and difficult decision.

Suppose we have 10 foam liquids in general use and decide to ccmmence such a storage trial on two batches of each, each year. This will require a storage building of 10 m^2, to hold 240 x 10 l samples. There will be 80 tests per annum and fuel usage will be approximately 11,000 l (2,500 gal) per annum.

With a programme on this scale, in the course of a few years a representative knowledge of the storage properties of the principal foam liquids, and their batch to batch variation, would be acquired, which this series of tests has shown to be necessary.

Some development work on the proposed test methods is still required but this is proceeding rapidly.

CONCLUSIONS (INCLUDING INTERIM REPORT)

1. All four foam liquids showed changes of properties during storage, substantial falls in the 25 per cent drainage time and increases in the fire drainage occurring in almost all cases. In some cases changes were most marked in the first year, and in other cases in the second year.

2. In most cases, when the foam liquid was used at the recommended concentration, the time to control the test fire had not increased after 2 years' storage.

3. Protein foam liquid stored as 4 per cent solution was useless after 6 months. Freezing of protein concentrate increased the fire control time, but the 4 per cent solution was not affected by freezing.

4. Fluoroprotein A, as concentrate, had good keeping properties, only the sample stored at 38°C showing a substantial reduction of the 25 per cent drainage time occurring during the second year. (Fluoroprotein A was not recommended for storage as a 4 per cent solution).

5. Fluoroprotein B retained its extinguishing properties under all regimes, but all samples showed a reduction of the 25 per cent drainage time, occurring principally during the second year. The 4 per cent solutions retained their effectiveness for 2 years, and were therefore superior to the protein 4 per cent solutions, which were useless after 6 months.

6. In the fluorochemical (194) tests, initial differences between different drums of the same batch affected the results. After 2 years' storage all samples extinguished the test fire rapidly when used at the recommended concentration. The tests at lower concentrations revealed appreciable deterioration, but this all occurred during the first year and did not increase during the second year.

7. Fluorochemical (196) was tested only after 11 months' storage and showed good stability.

8. The test methods require improving to provide a closer simulation of the practical methods of foam production and application.

9. These tests on a single batch of each of 4 foam liquids for a period of 2 years provide only a meagre amount of information on this important subject. Tests on a substantial number of batches for a longer period should be made. a scheme is outlined for testing 20 batches per annum over a period of 4 years.

Table 1

Initial and 2 year test results when used at recommended concentration (4 or 6 per cent)

Material	Storage concentration per cent	Storage temp	Storage period	Test concentration per cent	Expansion	Shear N/m^2	25 % drainage time min s	90 % control time s	Extinction time s	5 min fire drainage per cent	Minimum concentration for maximum effectiveness	Estimated deterioration per cent
Protein	Concentrate	-	nil	4	8.5	19.3	3 24	75	142	28	1.3	-
"	"	Room temp	2 yrs	4	7.9	15.3	2 06	62	107	39	1.5	13
"	"	38°C	2 yrs	4	8.1	17.3	2 20	68	137	39	1.75	26
Fluoroprotein A	Concentrate	-	nil	4	8.0	21.8	2 57	97	187	28	1.75	
"	"	Room temp	2 yrs	4	8.0	18.5	2 49	77.5	97	30.6	1.5	nil
"	"	38°C	2 yrs	4	6.85	11.5	1 48	81	172	53.5	1.5	nil
Fluoroprotein B	Concentrate	-	nil	4	8.1	7.7	2 40	54	84	35	2.0	-
"	"	Room temp	2 yrs	4	7.9	6.4	1 55	58	86.5	45	1.3	nil
"	"	38°C	2 yrs	4	8.05	7.0	1 57	59	85	47	1.0	nil
"	4 per cent	Room temp	2 yrs	4	7.8	6.4	2 04	58.5	89	44	1.5	nil
"	" " "	38°C	2 yrs	4	7.4	5.75	1 53	54	65	47.5	2.25	11
Fluorochemical Type 194	Concentrate	-	nil	6	11.0	5.0	2 37	44	63	35	1.5	-
"	"	Room temp	2 yrs	6	11.0	5.1	2 20	37	49	53	2.25	33
"	"	38°C	2 yrs	6	11.5	4.5	2 05	43	64	52.5	2.0	25
"	6 per cent	Room temp	2 yrs	6	11.3	4.5	2 10	42	51	57.5	3.5	57
"	" " "	38°C	2 yrs	6	11.8	4.5	1 25	43	56	71.5	4.25	65

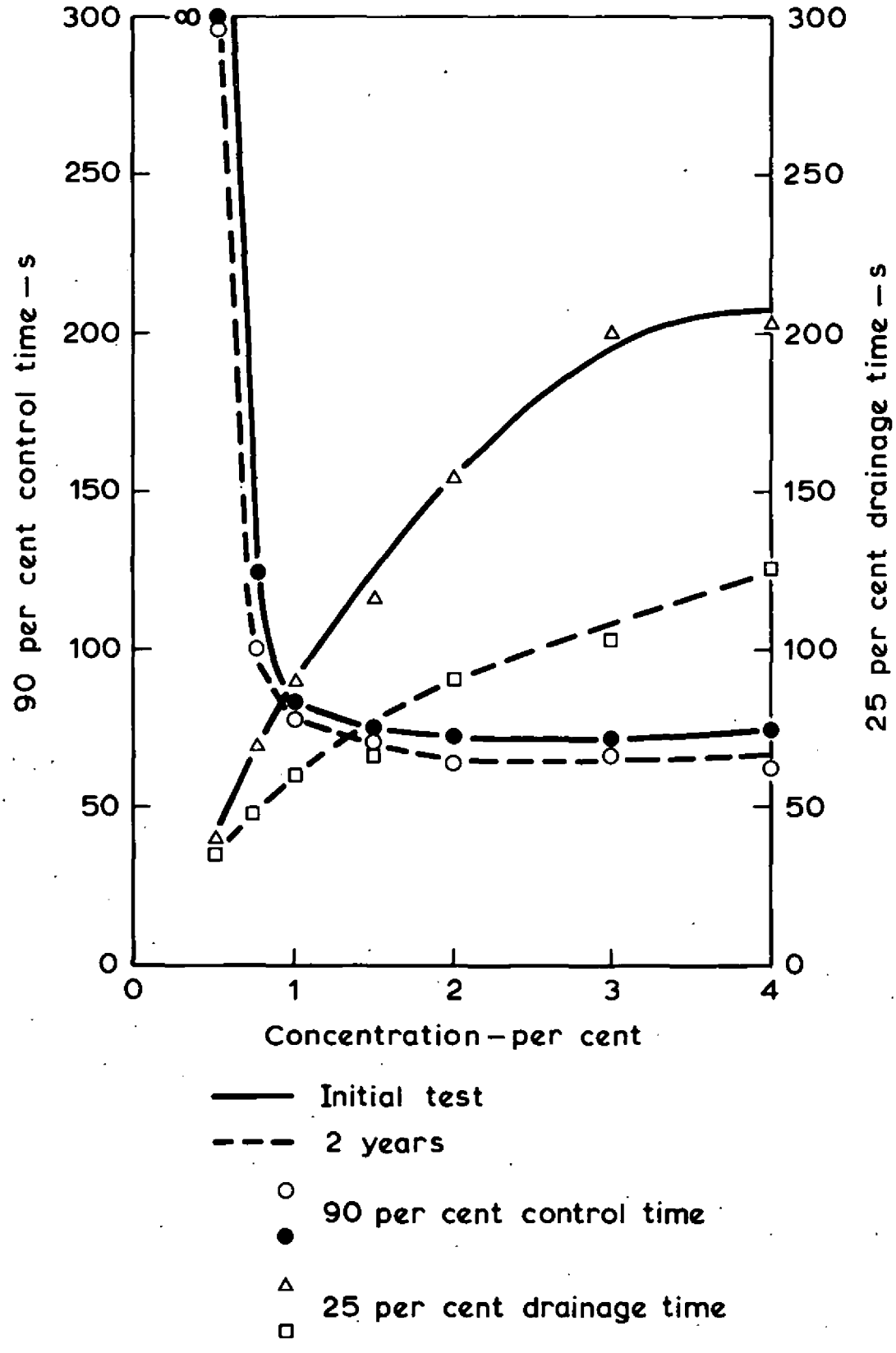

Figure 1 Protein concentrate stored for 2 years at room temperature

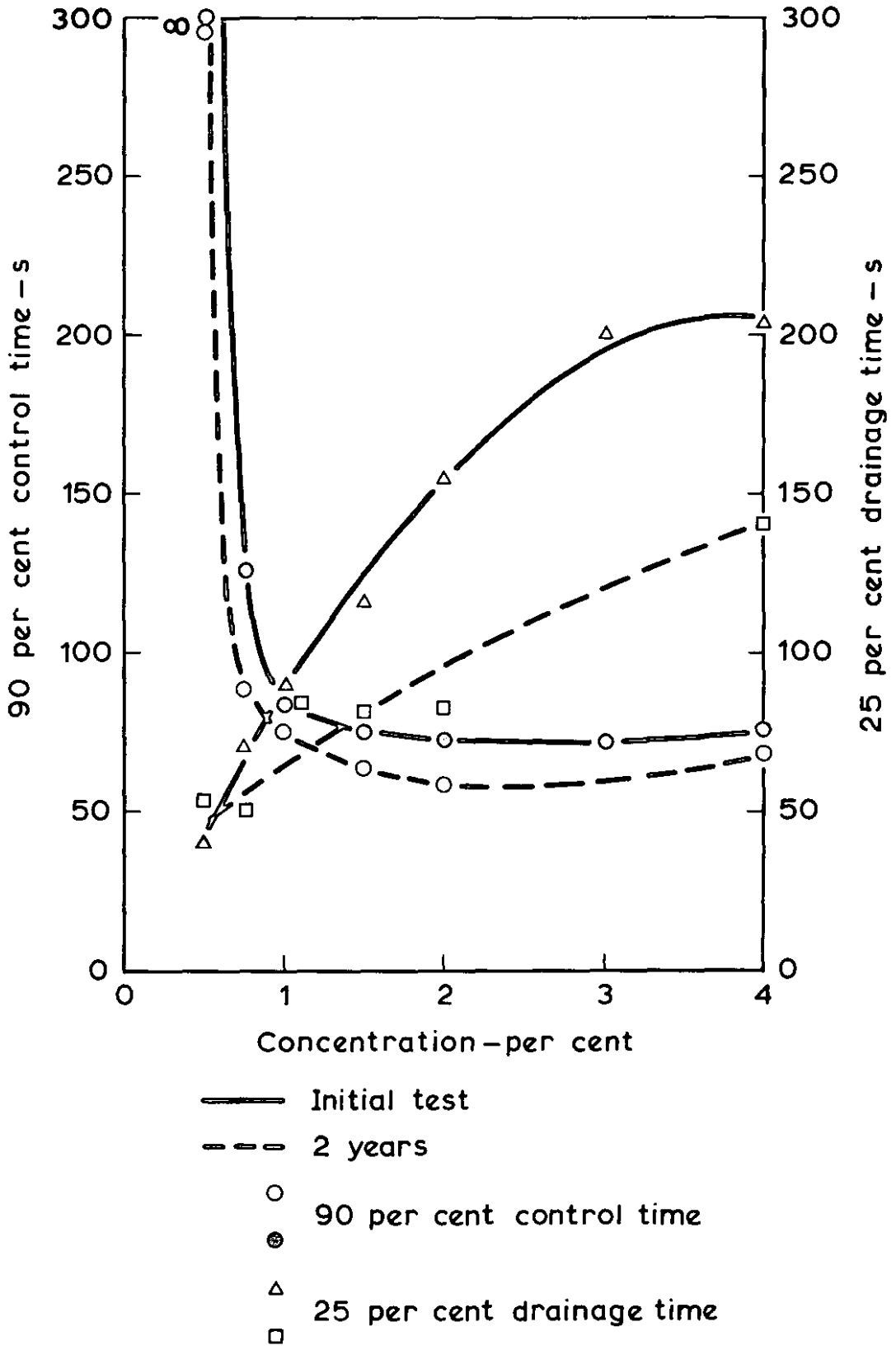

Figure 2 Protein concentrate stored for 2 years at 38°C

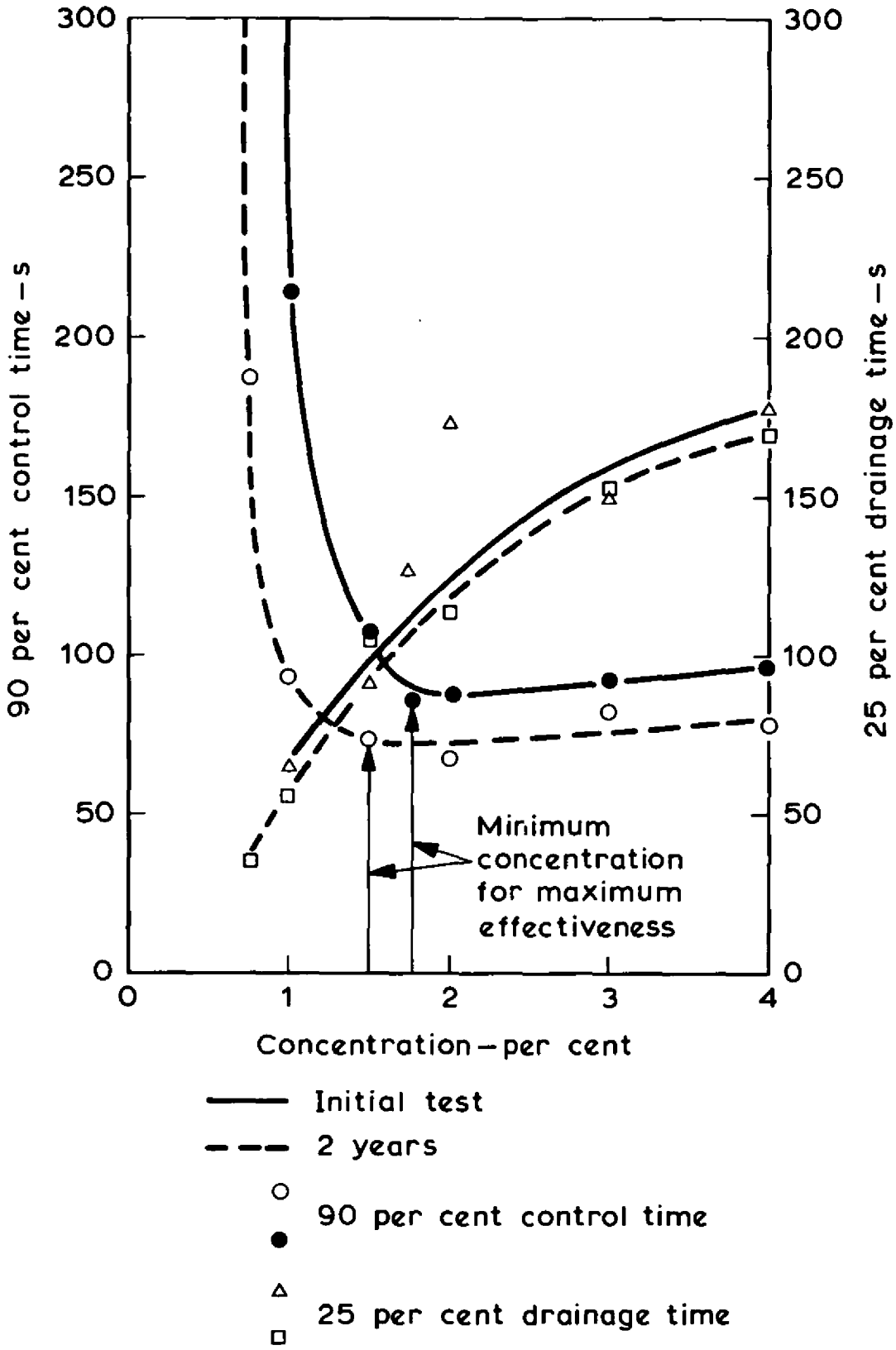

Figure 3 Fluoroprotein 'A' concentrate stored for 2 years at room temperature

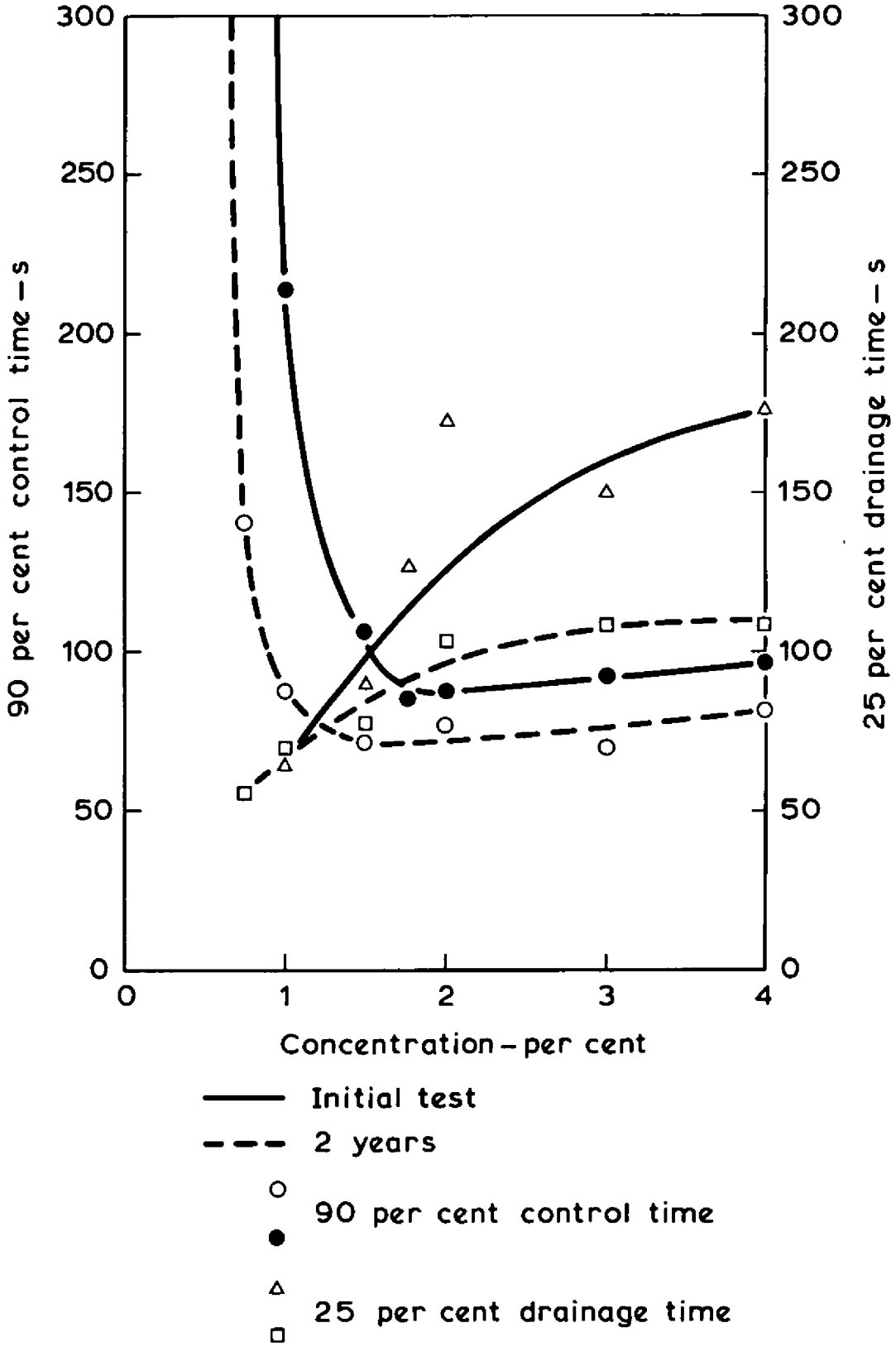

Figure 4 Fluoroprotein 'A' concentrate stored for 2 years at 38°C

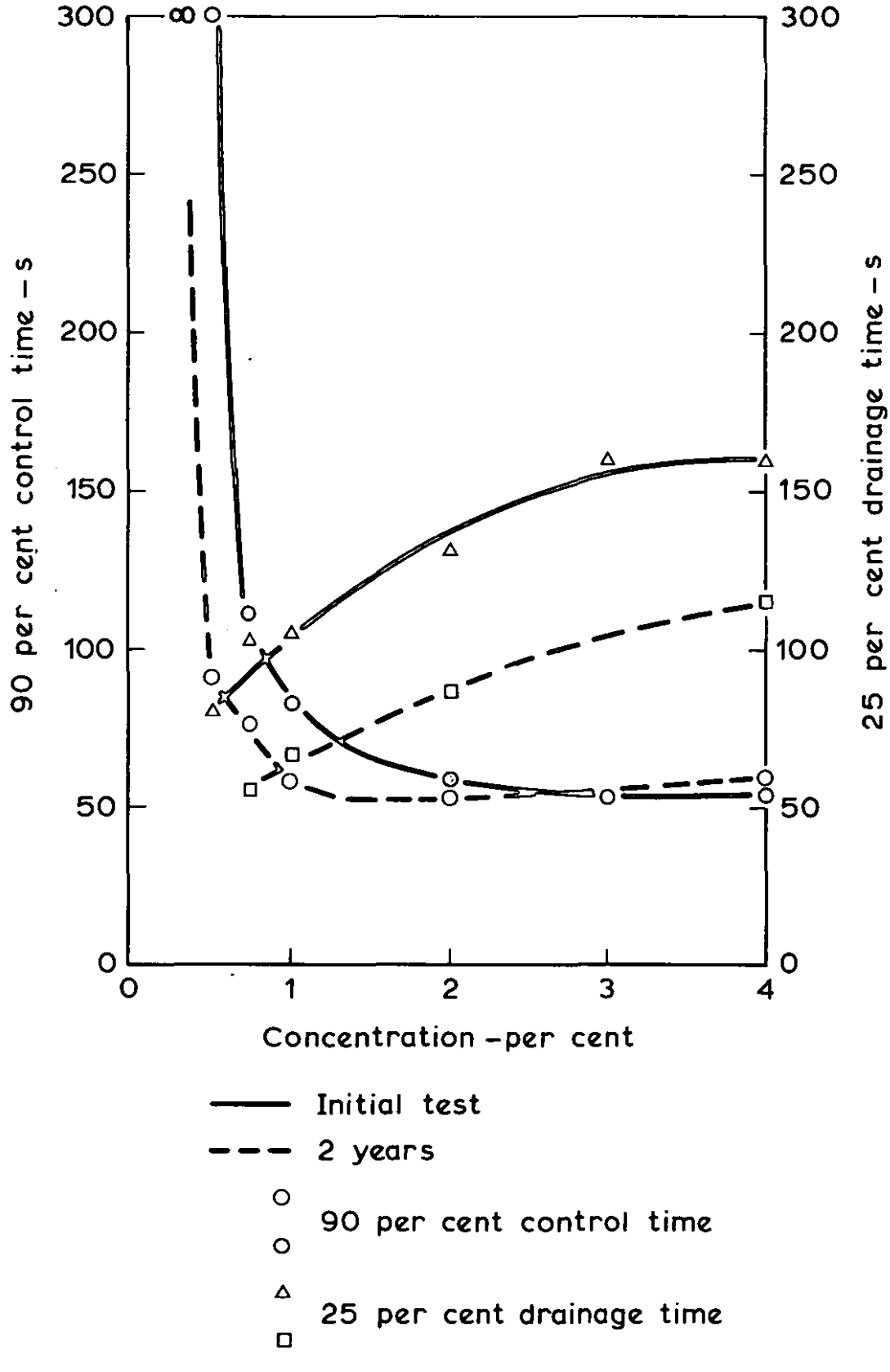

Figure 5 Fluoroprotein 'B' concentrate stored for 2 years at room temperature

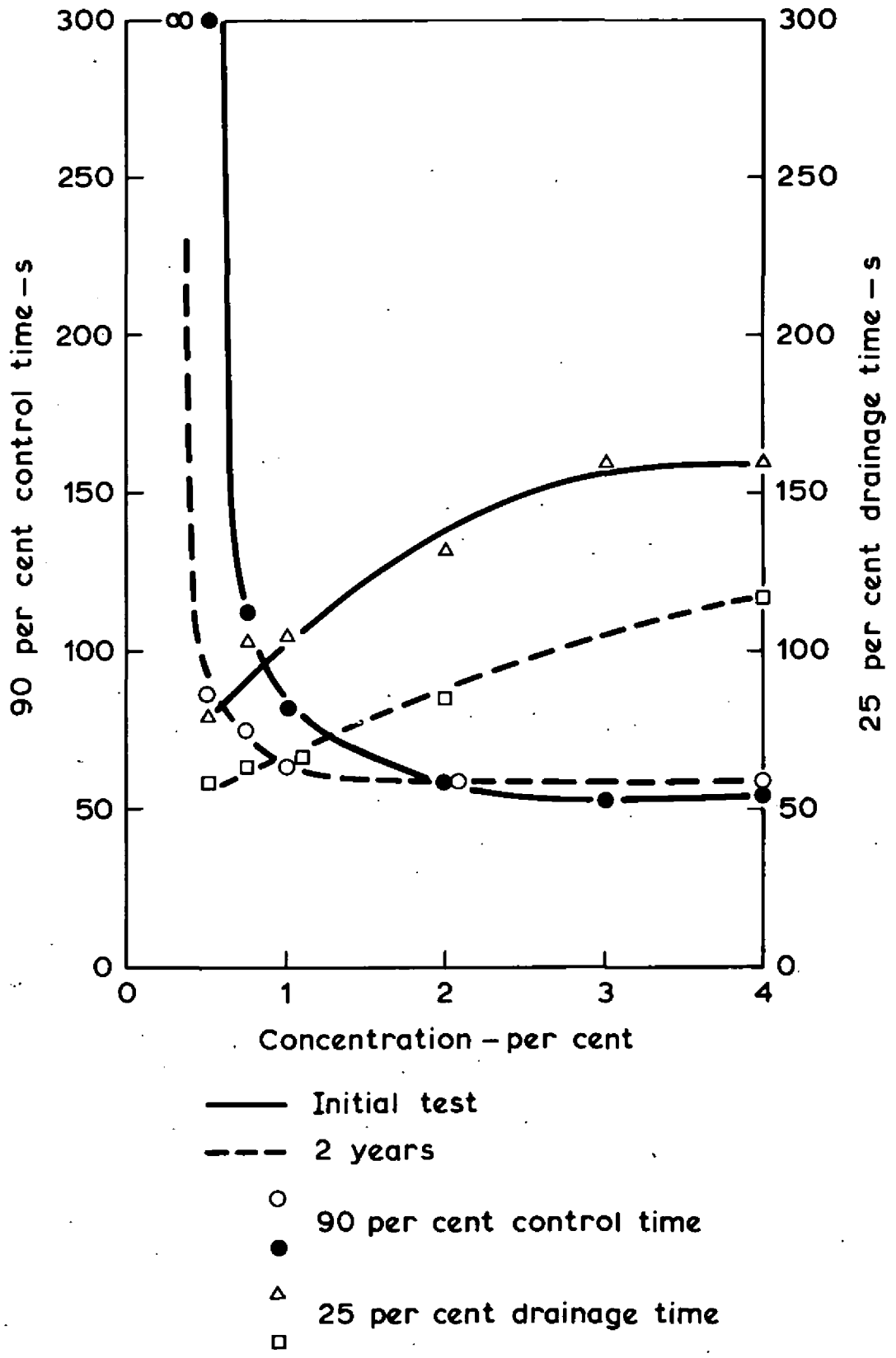

Figure 6 Fluoroprotein 'B' concentrate stored for 2 years at 38°C

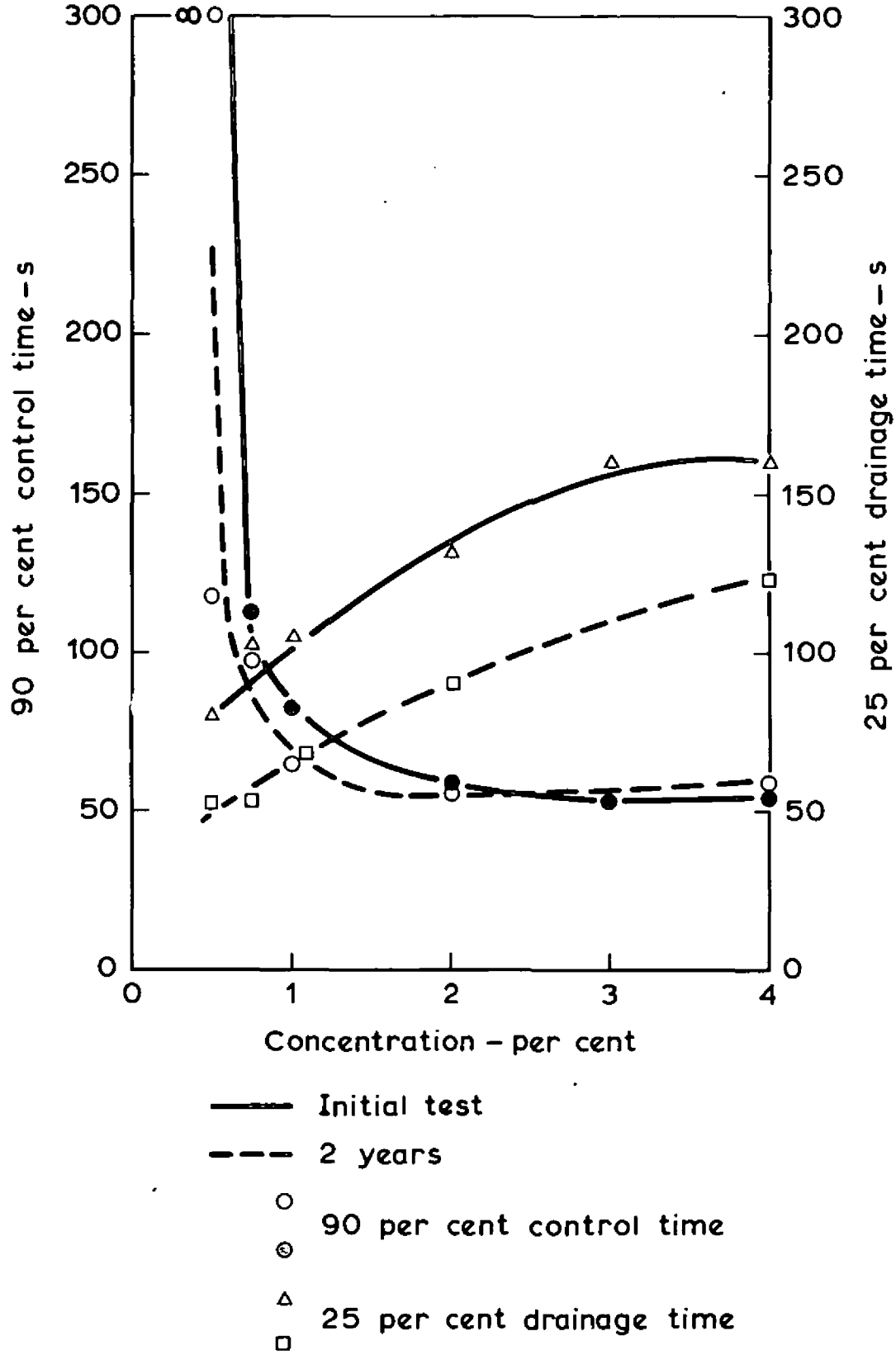

Figure 7 Fluoroprotein 'B' – 4 per cent solution stored for 2 years at room temperature

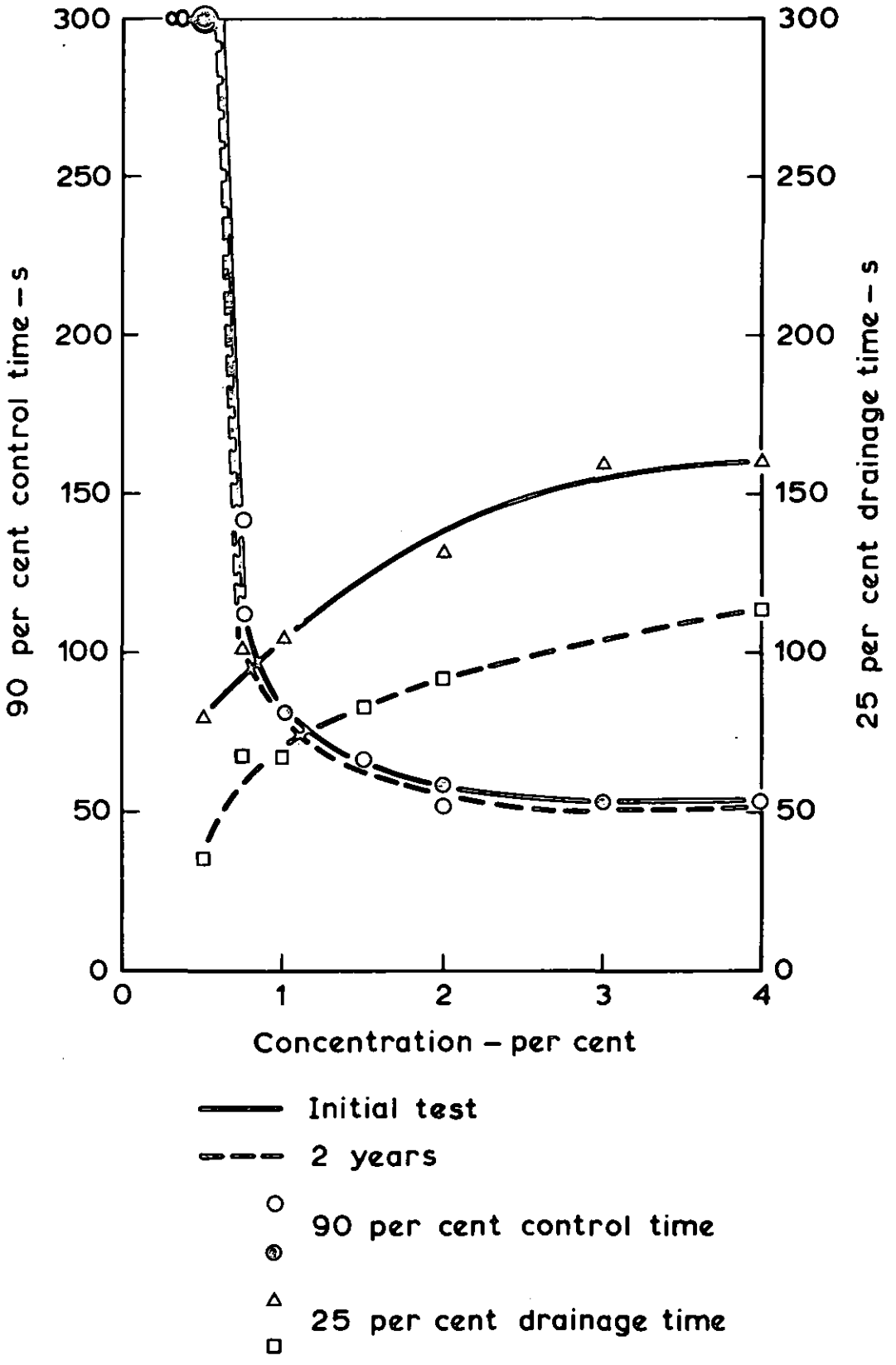

Figure 8 Fluoroprotein 'B' – 4 per cent solution stored for 2 years at 38°C

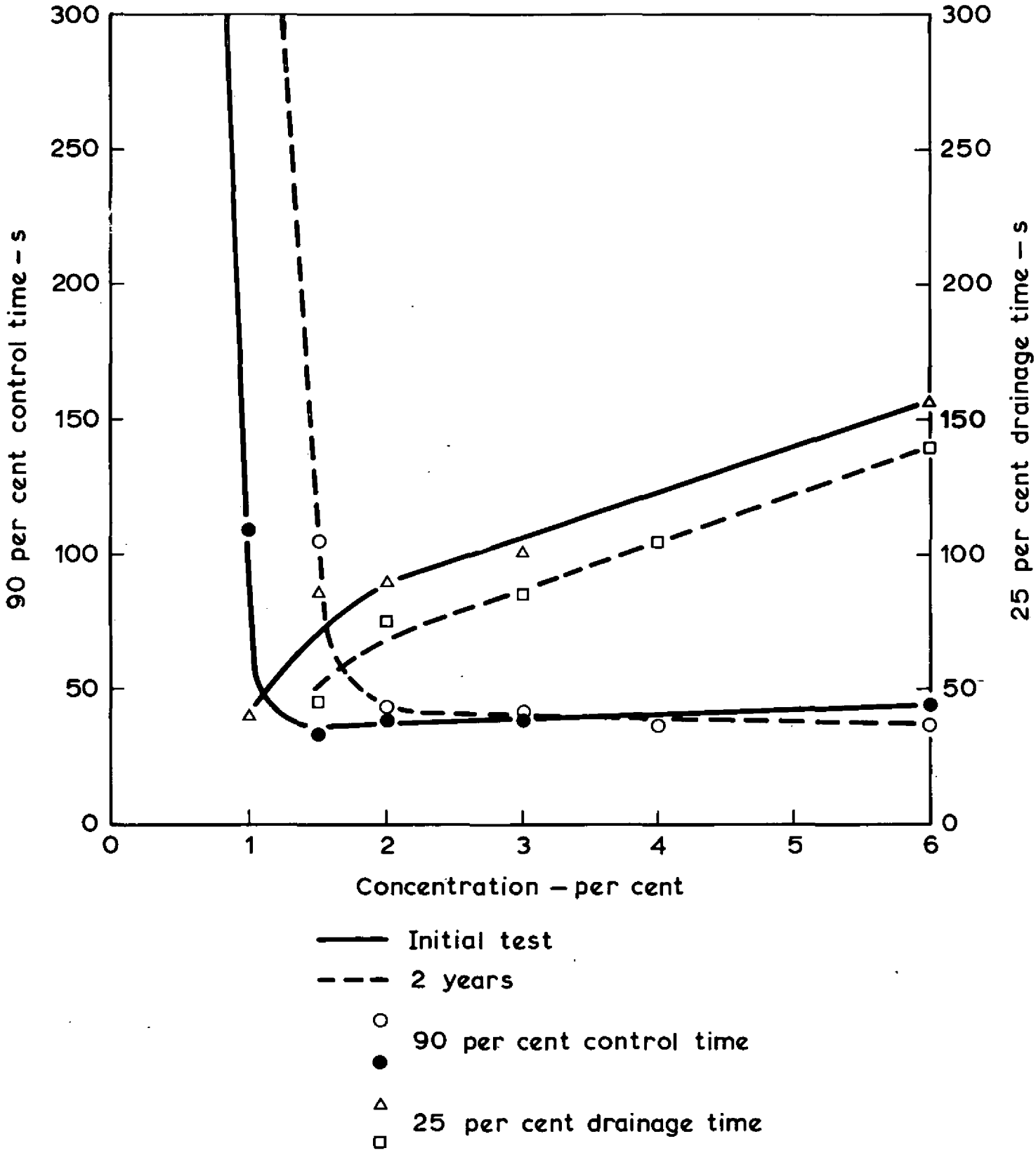

Figure 9 Fluorochemical concentrate stored for 2 years at room temperature

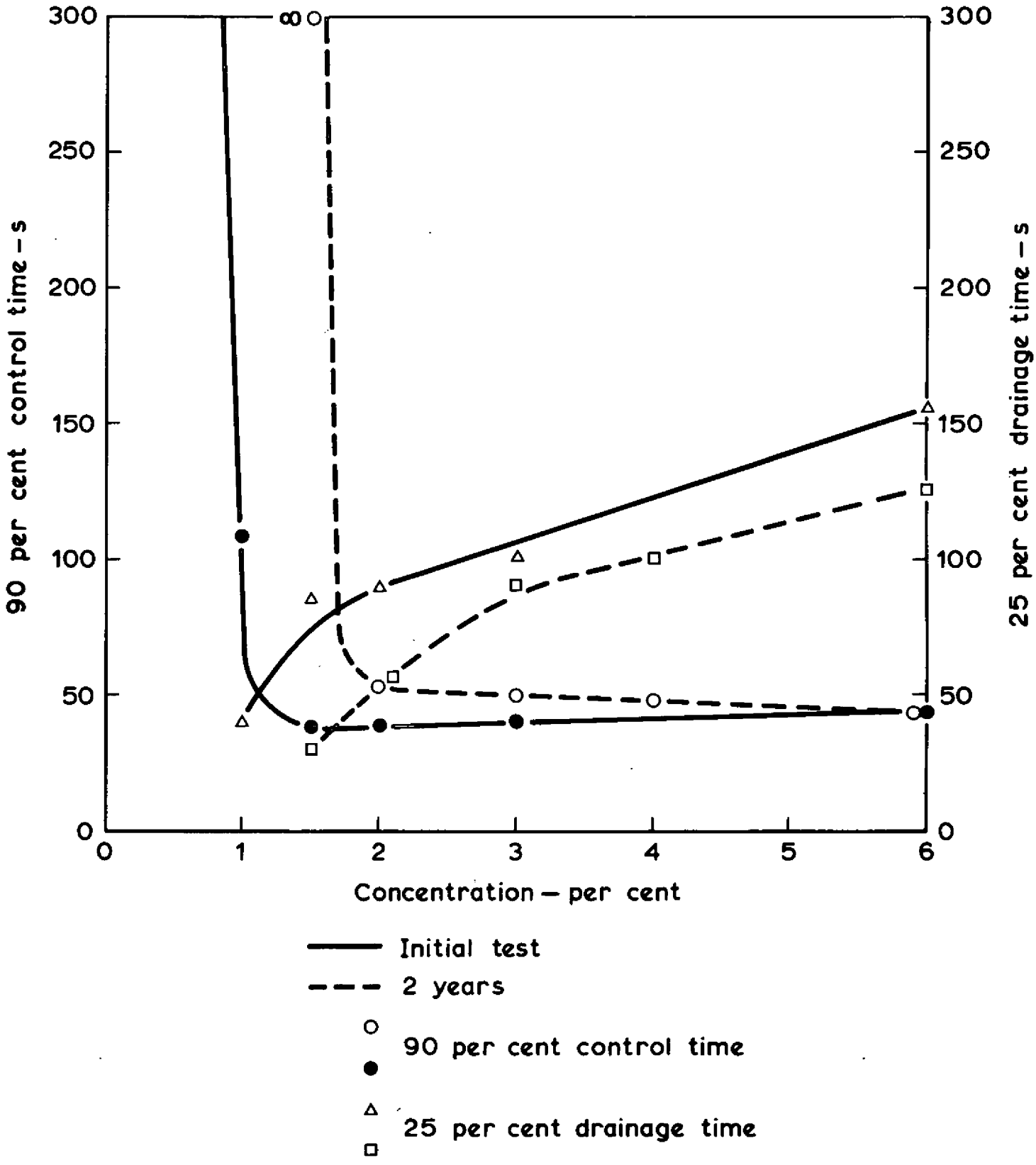

Figure 10 Fluorochemical concentrate stored for 2 years at 38°C

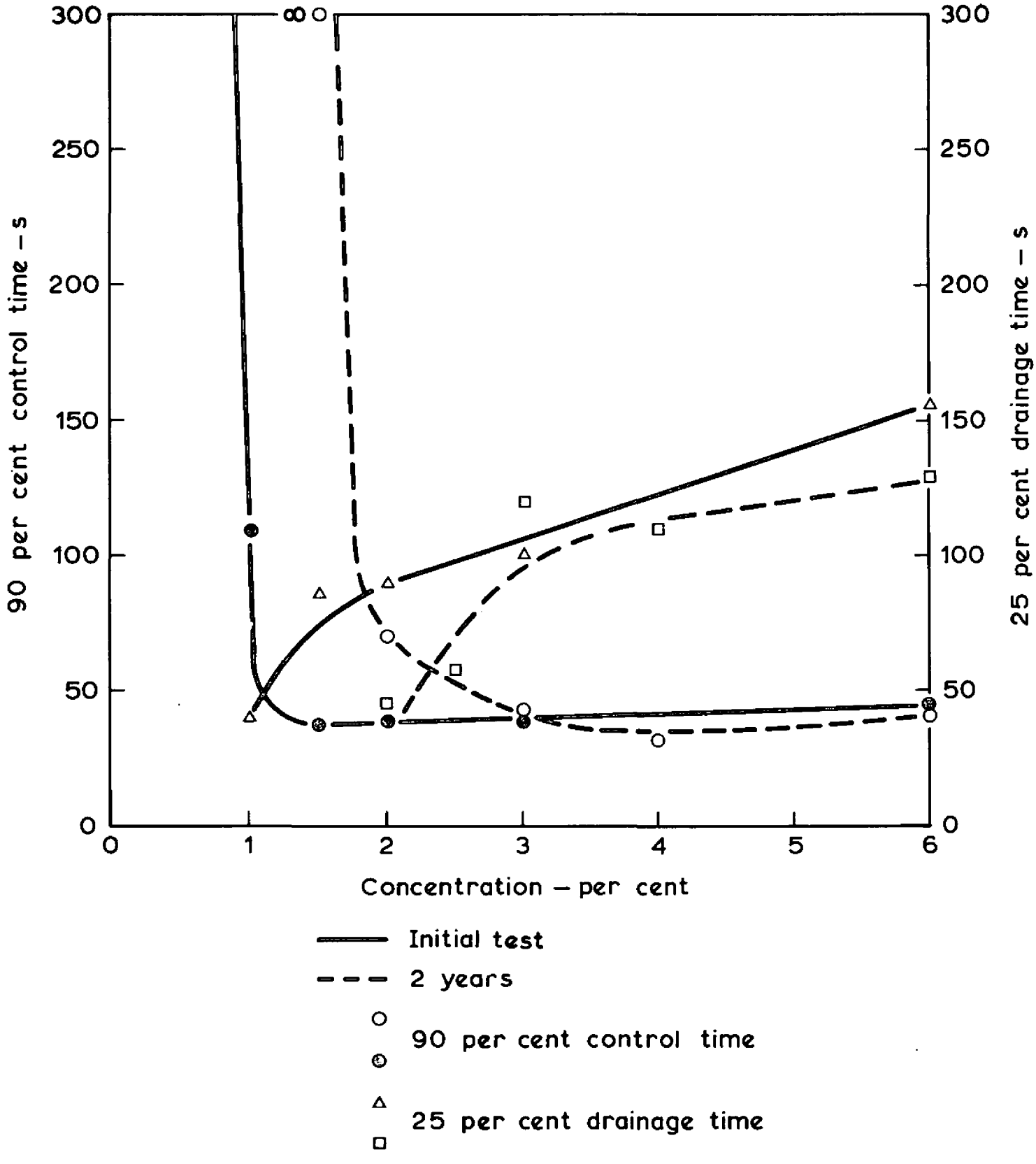

Figure 11 Fluorochemical – 6 per cent solution stored for 2 years at room temperature

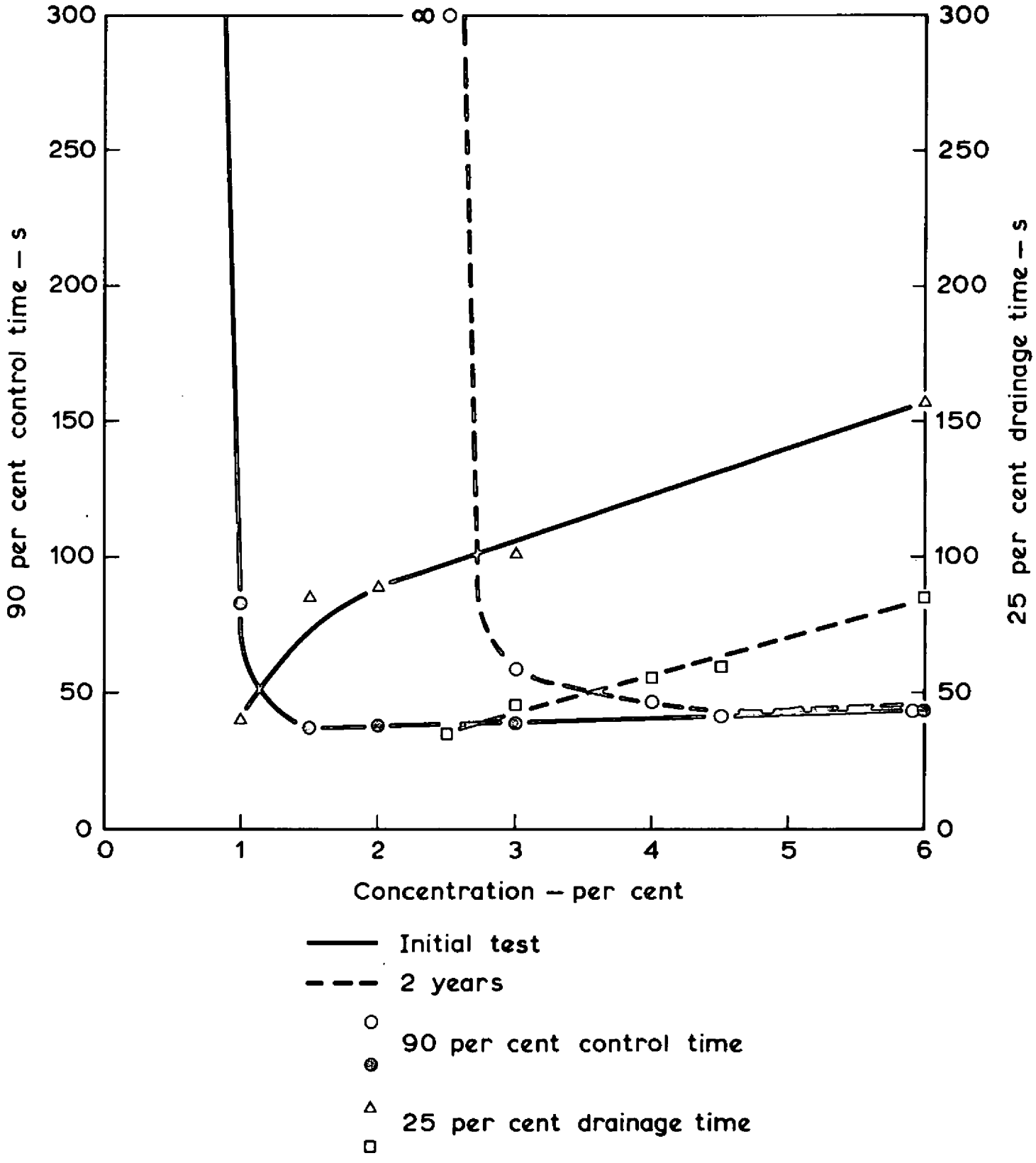

Figure 12 Fluorochemical – 6 per cent solution stored for 2 years at 38° C

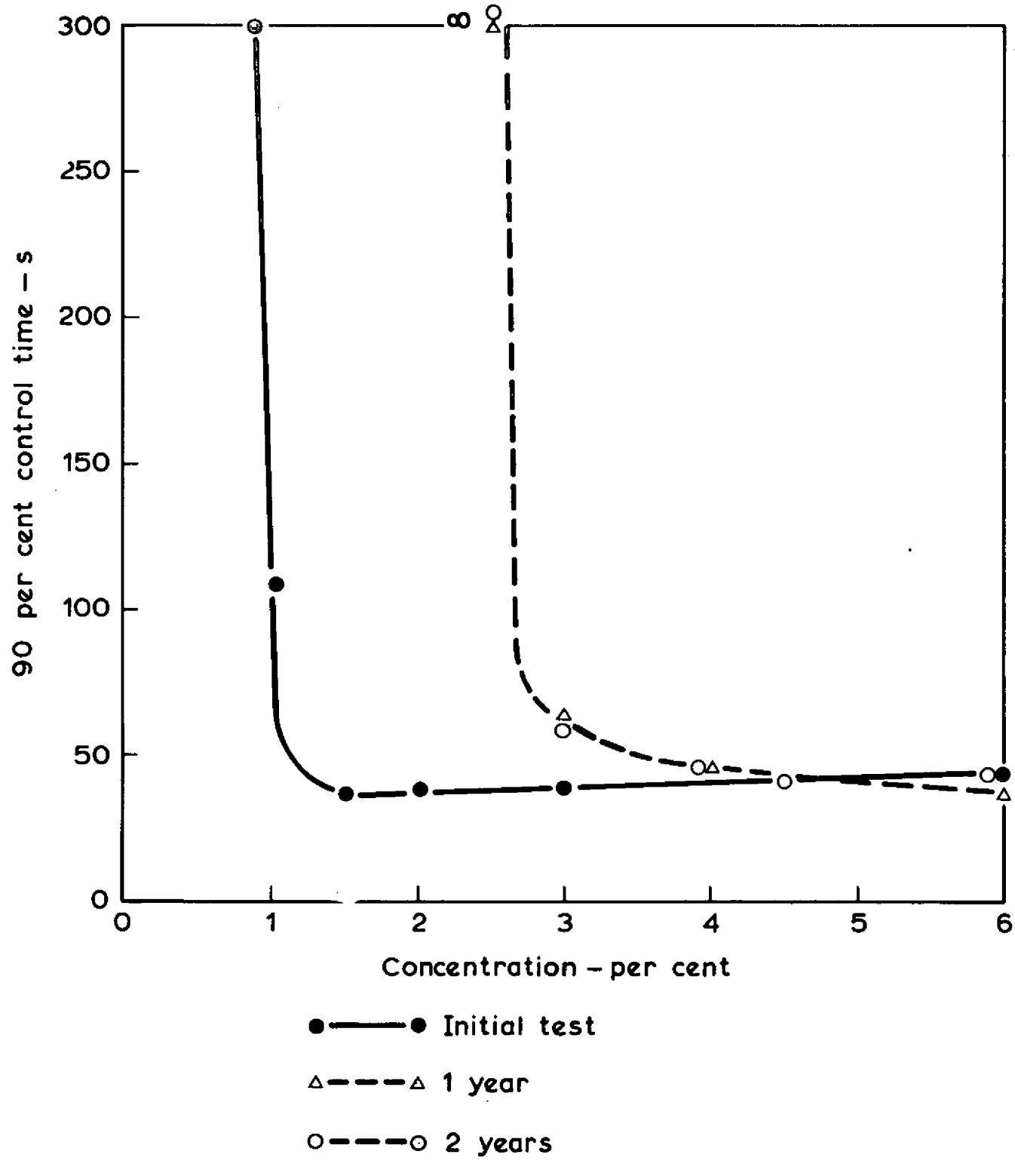

Figure 13 Fluorochemical – 6 per cent solution stored for 1 year and 2 years at 38°C

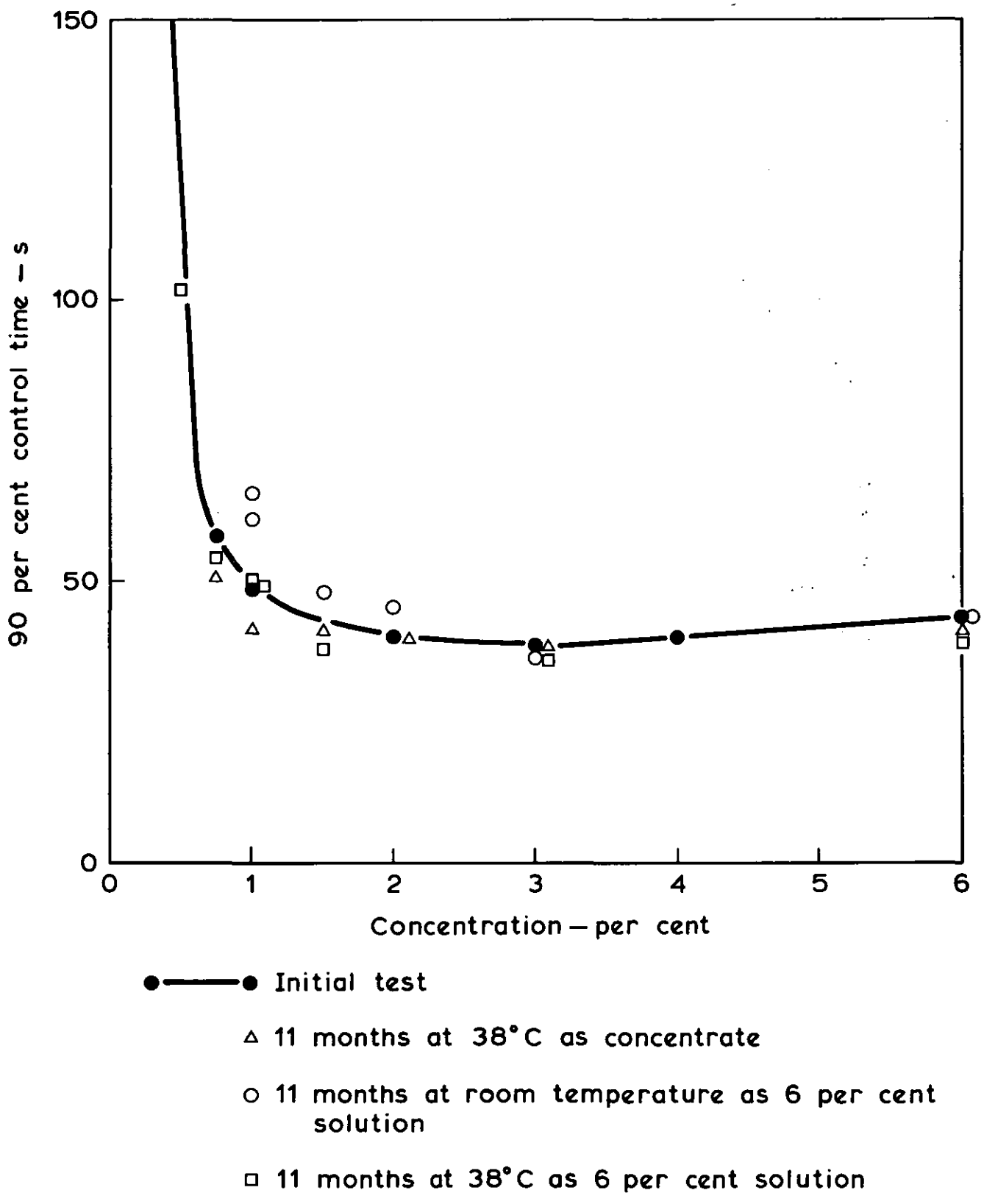

Figure 14 Flurochemical – grade 196 stored for 11 months

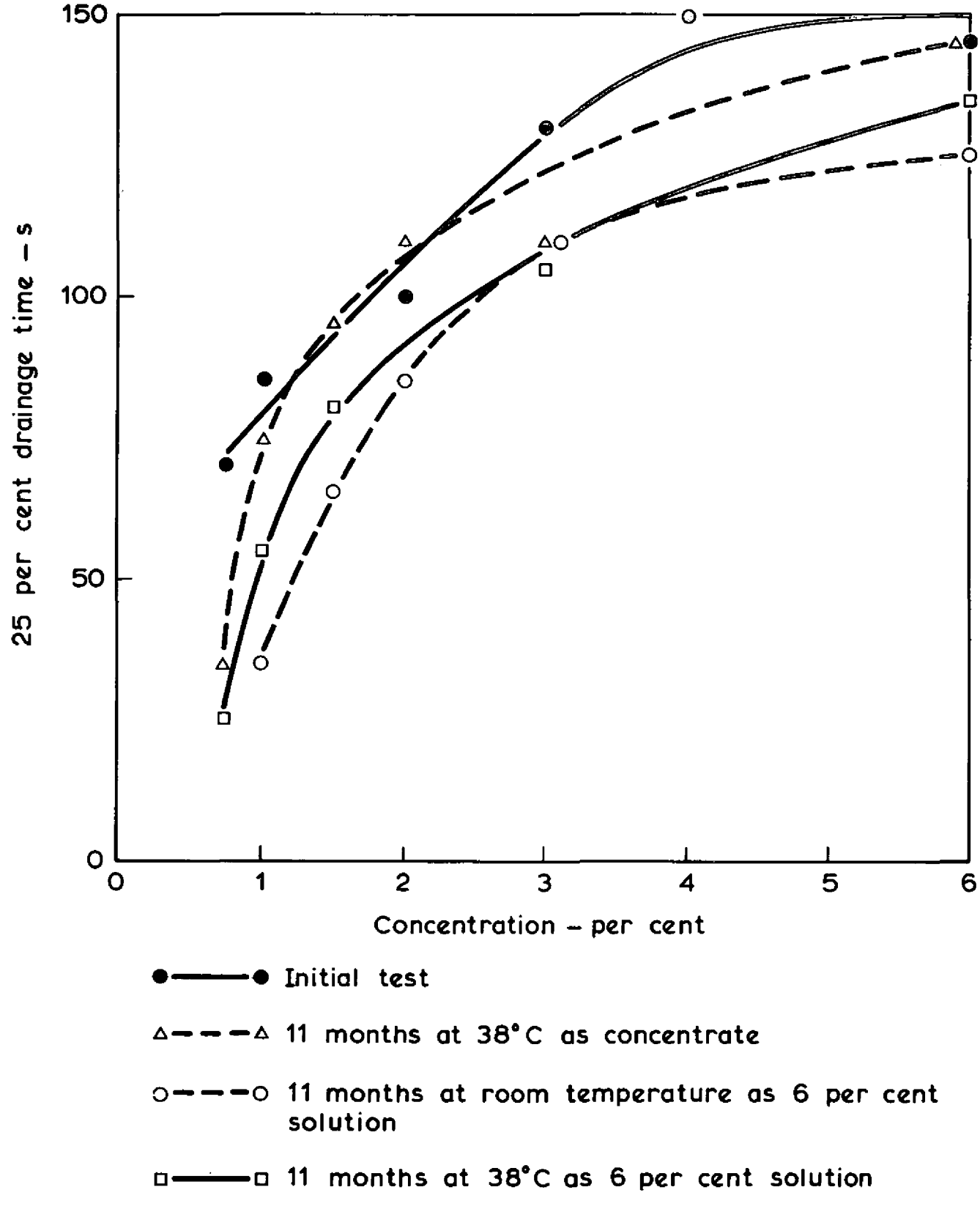

Figure 15 Fluorochemical-grade 196 stored for 11 months

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