Fire Research Note

NO. 608

PERFORMANCE OF PROTEIN-BASED FOAMS ON VARIOUS FUELS

by

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FIRE RESEARCH STATION

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SUMMARY

This note describes an investigation of the performance of approved fire-fighting foams on fires in various aviation and motor fuels. It shows that fires in aviation kerosine (AVTUR) are more readily controlled than fires in other aviation and motor fuels, and that motor fuel fires are generally more difficult to control than fires in aviation fuels. The rate of breakdown of the foam blanket on most of the fuels used was not found to be unduly rapid.

MINISTRY OF TECHNOLOGY AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

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Introduction

At the request of the Ministry of Aviation (Fire Service) a study has been made of the performance of representative protein-based foams in the extinction of fires on various flammable liquid fuels. On a number of occasions in recent years, there have been reports from the Ministry of Aviation (Fire Service), of unduly rapid foam breakdown when fighting fires in aviation fuels, particularly AVTUR and AVTAG. Examination of the specifications for these fuels, issued by the Ministry of Aviation, did not show any components likely to cause excessive foam breakdown. A number of motor fuels was also examined in the investigation, but the specifications of these fuels were not available.

Foams

Two foam liquids, designated A and B, which were just within the opposite limits of the acceptance range of the Ministry of Public Building and Works specification for foam liquids were used in the experiments. A third foam liquid (C), known to have a middle-range performance in fire tests,[1] was used for reference purposes. A laboratory foam generator was used to make foam from a non-premixed 4 per cent vol/vol solution of foam liquid C. The setting of the generator gave a foam expansion of 7, and a critical shear stress and 25 per cent drainage time similar to that given by a 4 per cent solution of C when used in the standard branchpipe used for Ministry of Public Building and Works Foam Liquid Acceptance Tests. The same setting was then used with the other foam liquids throughout most of the programme of experiments. The resulting physical characteristics of foams made from the three foam liquids were as follows:

Table 1

Physical characteristics of foams

	Foam liquid A	Foam liquid B	Foam liquid C
Expansion	7	7	7
Critical shear stress (dyn/cm^2)	200	500	280
25 per cent drainage time (min)	5.0	7.0	4.9

Fuels.

The fuels used in the investigation are shown in Table 2.

Table 2

Description of fuels

Fuel	Description	Spec. No. (where applicable)
N.B.P.	Narrow boiling point range motor fuel (Reference fuel)	-
AVTUR	Aviation kerosine. Minus 50 freeze point	D. Eng. RD 2494
AVTAG	'Wide cut' aviation fuel	D. Eng. RD 2486
AVGAS	Aviation gasoline (100/130 anti-knock rating)	D. Eng. RD 2485
AVPIN	Iso-propyl nitrate (Starter fuel, gas turbine engines)	D. Eng. RD 2492
Petroleum X	Regular grade motor fuel	-
Petroleum Y	Regular grade motor fuel	-
Petroleum Z	Super grade motor fuel	-

Experimental Method

In the test apparatus (Fig.1) the flammable liquid was contained in a circular tank giving a free liquid surface area of 3 sq. ft. The tank was constructed of 18 S.W.G. brass sheet, the upper section being cylindrical and 4 in. in depth; the lower section was a truncated cone fitted at the bottom with a $2\frac{1}{2}$ in. internal diameter x 24 in. long glass measuring cylinder, in which the foam solution draining from the foam was collected.

Each of the foams was first applied in the following manner to each of the fuels, without these being ignited. The rate of application of foaming solution was 0.15 gal/min, and application was continued for a period of 4 minutes. The foam was directed into the centre of the fuel surface through a jet of 5/32 in. diameter, placed 24 in. from the centre of the fire tank and 15 in. above the fuel surface. The stability of the foam blanket was determined by measuring the quantity of liquid drained from the foam at various times after the commencement of foam application.

Each of the foams was then applied in the same manner to each of the fuels after these had been ignited and allowed to burn for ½ min. or 1 min., depending on the fuel used. The radiant intensity of the fire was measured by four radiometers connected in series and arranged symmetrically around the fire, as shown in Figure 1. The time to reduce the radiant intensity of the fire to one-tenth of the mean value during the 5 seconds before foam application was taken as the '9/10 control time'. The stability of the foam blanket was determined by the same method as that used in the tests with no fire.

Experimental results

The quantity of foaming solution drained from the foam blanket at various times after the commencement of foam application to the fuels is shown in Figures 2 and 3, for the aviation fuels, and in Figs. 4 and 5 for the motor fuels.

The '9/10 control times' and liquid drainages 10 minutes after commencement of foam application, in tests with and without fire, are shown in Tables 3 and 4 for tests with aviation and motor fuels respectively.

Discussion of results

Figures 2 to 5 show that the fluid foam (A) generally drained more rapidly on the fuels than the stiffer foam (B), as would be expected. The difference in drainage was less marked, however, with the second batches of the foams (Figures 4 and 5).

Both foams were more effective against fires in AVTUR than against fires in the reference fuel, i.e., N.B.P. petroleum (Table 2) but the rate of drainage was very similar. Fires in AVTAG and AVGAS were controlled less readily than fires in the N.B.P. fuel by the fluid foam (A), but slightly more readily by the stiffer foam (B). Drainage with each of these fuels was generally slightly greater than with N.B.P. fuel. The control time of the fluid foam (A) on the starter fuel (AVPIN), was about 3 times as great as on the N.B.P. fuel, but the stiffer foam (B) controlled the AVPIN fire more readily than the N.B.P. fire.

The performance of both foams on typical motor fuels is shown in Table 4, in which second batches of each of the foam liquids were used. In experiments with no fire, liquid drainage with the motor fuels, when compared with the drainage on the N.B.P. fuel, was less with foam (A) and generally similar with foam (B). In experiments with fire, drainage was generally greater with the motor fuels than with the N.B.P. fuel, and fires in these fuels were usually more difficult to control than those in the N.B.P. fuel.

A comparison of the performance of the first and second batches of the foams on the N.B.P. fuels (Tables 3 and 4) shows that the second batch of foam (A) was significantly more stable and more effective in fire control than the first batch. A comparison of the control times given in Tables 3 and 4, for both foam (A) and foam (B), shows that fires in motor fuels were generally more difficult to control than fires in aviation fuels.

While these variations in foam performance are of significance, it is not considered that they would explain away gross changes in foam performance in the field, and some other factor, possibly in the foam-making equipment, would need to be sought for an overall consideration of the problem.

Conclusions

(1) Fires in aviation kerosine (AVTUR) are more readily controlled than fires in AVTAG, AVGAS, AVPIN and motor fuels.

(2) A stiff foam will control fires in aviation starter fuel (AVPIN) more readily than a more fluid foam.

(3) Fires in motor fuels are generally more difficult to control than fires in aviation fuels.

(4) Some fuels, especially when burning, may cause accelerated foam breakdown, but the results show that this is generally not more than 1.35 times the breakdown with N.B.P. fuel.

(5) Serious deterioration in foam performance in the field is unlikely to be due only to the effect of the fuel and other sources of variation need to be considered.

Reference

(1) FRY, J. F. and FRENCH, R. J. J. appl. Chem., 1951, 1, 425-9.
"A mechanical foam generator for use in laboratories."

Table 3

Performance of foam on aviation fuels

Fuel	Drainage at 10 min (ml) No fire		9/10 Control time (s)		Drainage at 10 min (ml) Fire	
	Foam Liquid A Batch 1	Foam Liquid B Batch 1	Foam Liquid A Batch 1	Foam Liquid B Batch 1	Foam Liquid A Batch 1	Foam Liquid B Batch 1
NBP	1,200	800	65	100	1,850	1,100
AVTUR	1,150	800	35	55	1,900	1,000
AVTAG	1,250	750	95	75	2,300	1,150
AVGAS	1,350	950	75	100	2,050	1,300
AVPIN	≁	≁	190	45	≁	≁

≁ No meniscus as fuel is miscible with water

Table 4

Performance of foam on motor fuels.

Fuel	Drainage at 10 min (ml) No fire		9/10 Control time (s)		Drainage at 10 min (ml) Fire	
	Foam Liquid A Batch 2	Foam Liquid B Batch 2	Foam Liquid A Batch 2	Foam Liquid B Batch 2	Foam Liquid A Batch 2	Foam Liquid B Batch 2
NBP	1,100	850	45	105	1,300	1,150
Petroleum X (regular grade)	1,000	900	140	145	1,550	1,450
Petroleum Y (regular grade)	900	800	130	100	1,600	1,150
Petroleum Z (super grade)	950	900	160	155	1,750	1,350

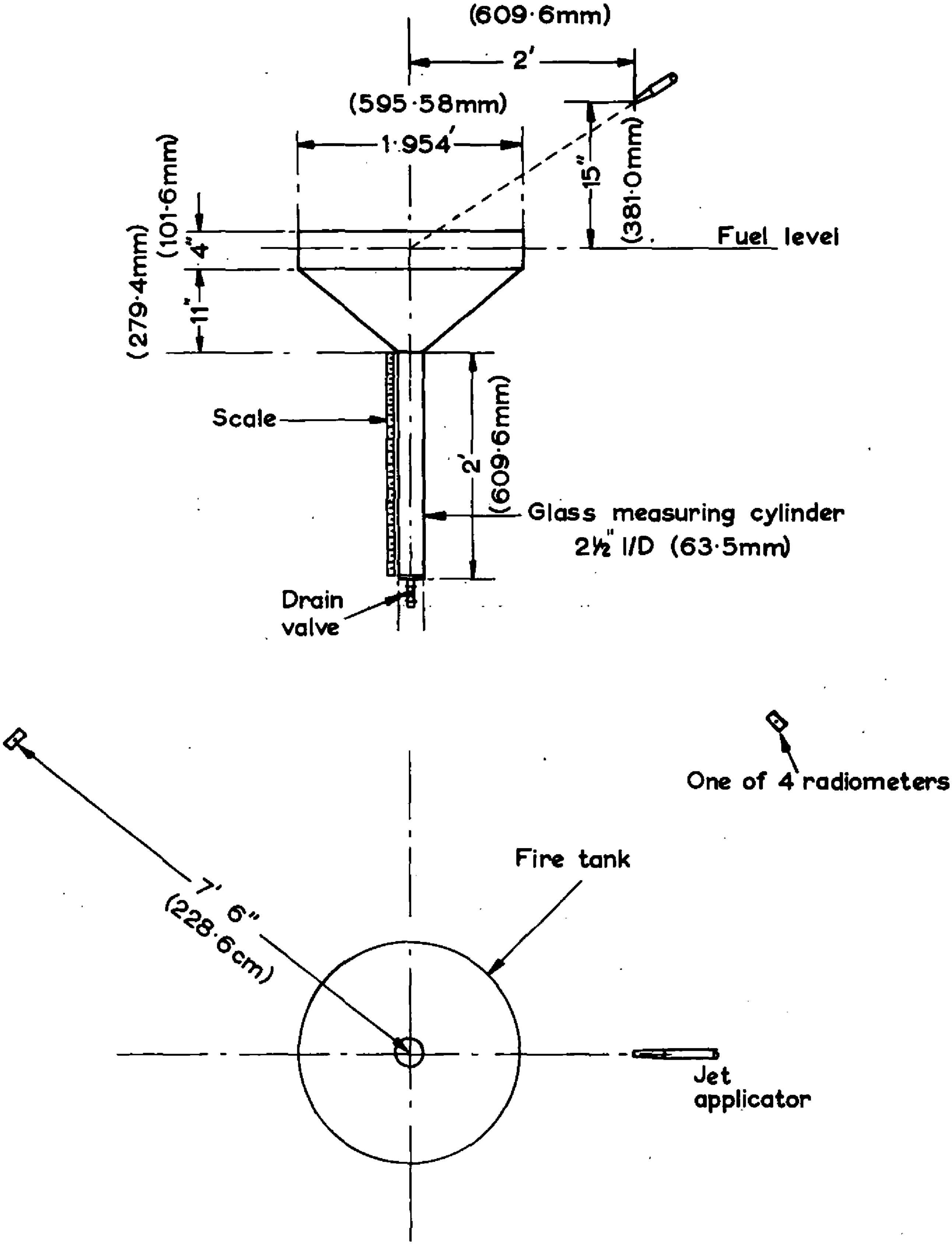

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FIG. 1 ARRANGEMENT OF APPARATUS

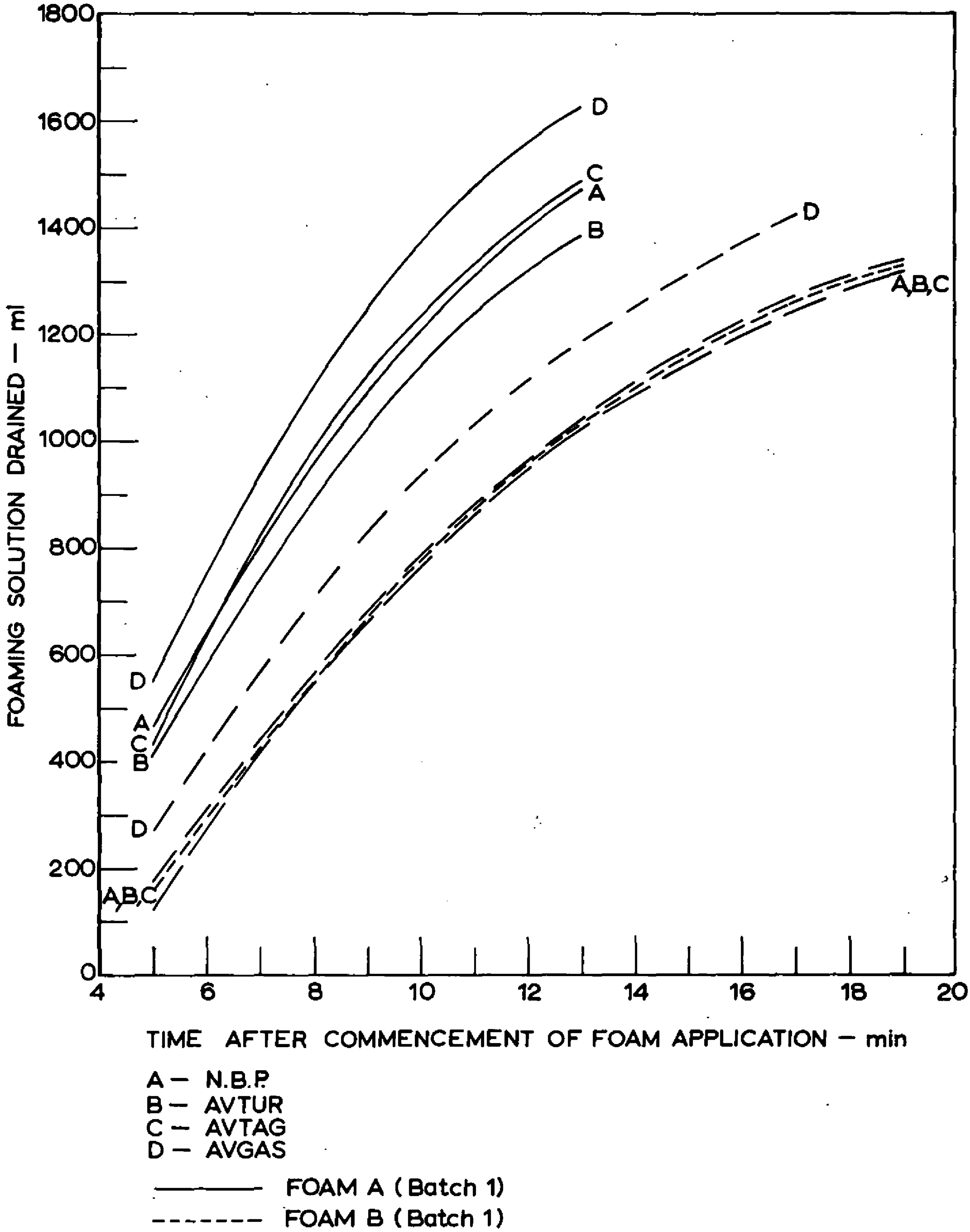

FIG. 2 FOAM DRAINAGE ON AVIATION FUELS (NO FIRE)

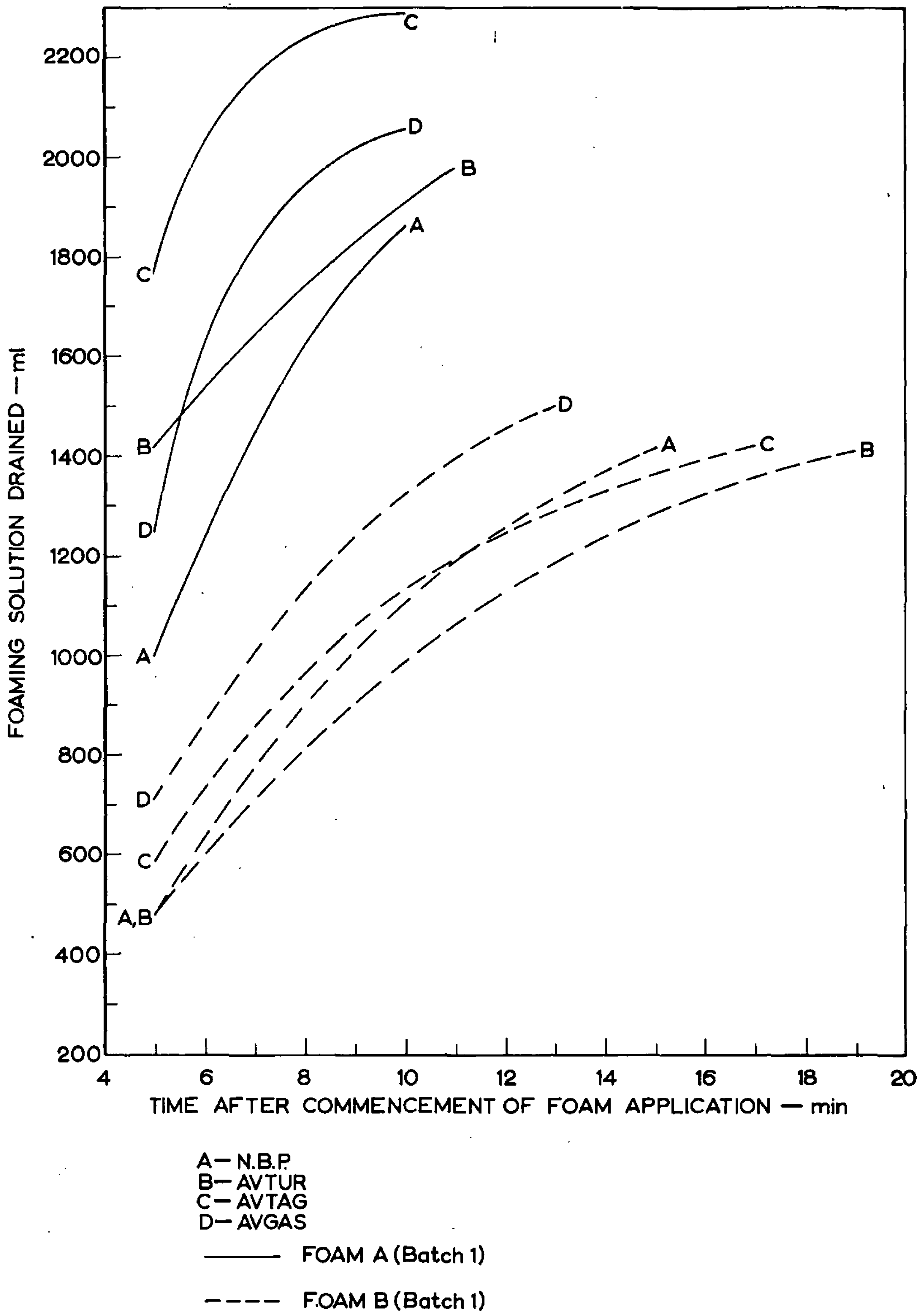

FIG. 3 FOAM DRAINAGE ON AVIATION FUELS (FIRE)

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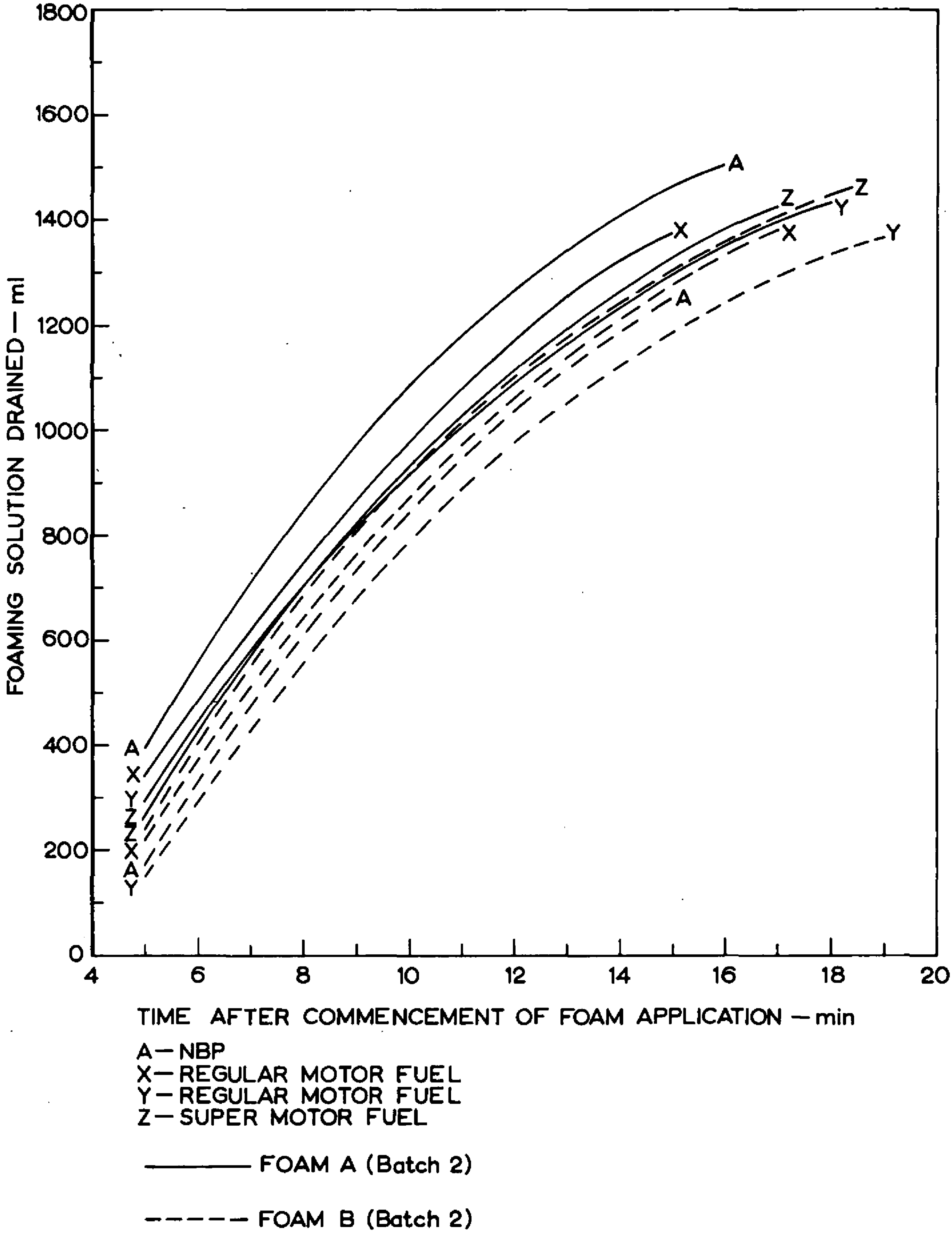

FIG. 4 FOAM DRAINAGE ON MOTOR FUELS (NO FIRE)

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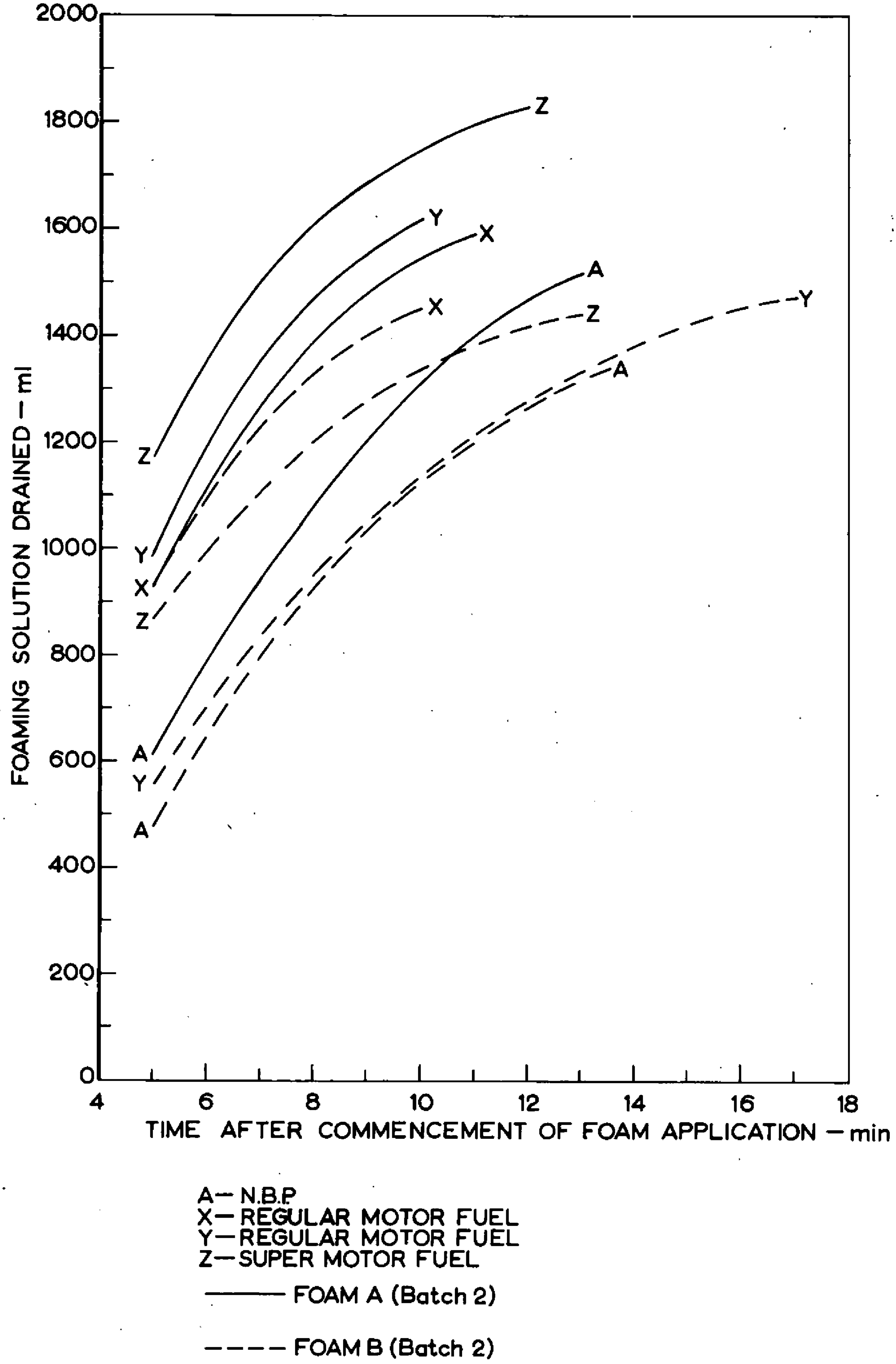

FIG. 5 FOAM DRAINAGE ON MOTOR FUELS (FIRE)

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