Fire Research Note
No.668

SOME NOTES ON THE PROPERTIES OF FOAMS PRODUCED BY A GAS TURBINE OPERATED FOAM GENERATOR

by

D. W. FITTES

FIRE
RESEARCH
STATION

JUNE, 1967.

Fire Research Station,
Borehamwood,
Herts.
ELStree 1341

F.R. Note No. 668
June 1967.

SOME NOTES ON THE PROPERTIES OF FOAMS PRODUCED BY A GAS TURBINE OPERATED FOAM GENERATOR

by

D. W. Fittes

SUMMARY

This report gives details of the physical properties of the protein-based foams produced by an experimental gas-turbine operated foam generator at different rates of delivery of foaming solution. The relation between critical shear stress and foam drainage is also shown.

Some experiments using a detergent-based foam are reported.

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

SOME NOTES ON THE PROPERTIES OF FOAMS PRODUCED BY A GAS TURBINE OPERATED FOAM GENERATOR

by

D. W. Fittes

Introduction

This note is concerned mainly with the physical characteristics of the foam produced by the gas turbine operated foam generator(1), which was used in the large scale simulated aircraft crash fire programme reported in F.R. Note No. 615(2). Only one make of foam liquid was used in these experiments, and measurements showed that this liquid did not vary unduly in quality throughout the programme.

It is well known that protein foam liquids may vary in quality depending on the type of protein material used, and its geographical source. These materials may include any suitable waste products such as hoof and horn meal, animal blood, fish scales, chicken feathers, soya bean etc. Quality can also be affected by variations in manufacturing technique, and differences can occur between successive batches of the same make of liquid. Recent experiments with the gas turbine operated foam generator and with the laboratory foam generator(3) have shown that some recent samples of proprietary foam liquids are of rather different quality from that used in these experiments.

Physical characteristics of protein foams produced by the gas turbine operated foam generator

The foam properties were measured by the methods usually used, as follows.

Expansion was determined by comparing the weight of a given volume of foam with the weight of the same volume of foaming solution. Critical shear stress was measured by a rotating vane viscometer(4), and foam drainage was determined by measuring the time for 25 per cent of the solution to drain from the foam contained in a dry pan(5).

In the programme of simulated aircraft fires, it was intended that certain chosen values of foam expansion should be used, the foam being made from a premixed 6 per cent solution and being applied at certain chosen rates of application of foaming solution. The values used for calibration were therefore:

Foaming solution rate	50, 125 and 200 gal/min
Expansion	6, 13 and 20 (± 10 per cent)

Critical shear stress was to be varied between the minimum and maximum obtainable with the apparatus, at each expansion and rate of application. Foam drainage or "25 per cent drainage time" was not varied independently of the critical shear stress in the experiments, the reasons for this being discussed later.

At the lowest rate of 50 gal/min (Figure 1a), the critical shear stress range for foams of expansion 6 was between 150 and 400 dyn/cm^2. At the higher expansions, a wider range was achieved, but it was not possible to make the very fluid foams which were obtained at the lowest expansion. The critical shear stress ranges at the higher rates of 125 and 200 gal/min showed a generally similar trend (Figures 1b and 1c).

In the fire test programme, foams covering the whole range of critical shear stress at each of the three expansions were used at the lowest rate of 50 gal/min, but at the higher rates, only part of the ranges were used and are shown "hatched" in Figures 1b and 1c.

Relationship between critical shear stress and 25 per cent drainage time

In the small-scale production of foam in the laboratory foam generator, foam drainage can be varied independent of critical shear stress to a limited extent. Independent variation of these properties was difficult to achieve with the gas turbine operated foam generator, however, consistent with a reasonably economic usage of foam liquid. It was decided, therefore, to vary the rate, expansion and critical shear stress only in the large-scale fire experiments, provided a relation between critical shear stress and foam drainage could be established for the foams produced by the generator. The relation for the whole range of foams produced is shown in Figure 2. There is a considerable spread of the results at the upper end of the scale, for 25 per cent drainage times above about 50 or 60 min. The relation at the lower end of the scale is shown in Figure 3. There is a tendency for the relation between critical shear stress and 25 per cent drainage time to vary with foam expansion, and Figure 4 shows this relation for foams within different expansion ranges. It will be seen that "25 per cent drainage time" generally increases with expansion for a given value of critical shear stress, but for foams of expansion greater than about 11, it remains practically constant.

Variations in foam drainage for a given critical shear stress value will affect the durability of a foam blanket, but these variations are not likely to affect the fire control performance of the foam.

Standard acceptance fire test for foam liquids

The work on simulated aircraft crash fires reported in F.R. Note No. 615(2) showed that variation of foam expansion in the range 6 to 20 had no discernible effect on fire control time. Foams having a critical shear stress of about 500 dyn/cm^2 were found to be most effective in fire control. It will be seen from Figures 2, 3 and 4 that foams produced by the gas turbine foam generator having this critical shear stress had a 25 per cent drainage time of about 35 to 40 min.

Foam having an "intermediate" expansion of about 10 or 11, a critical shear stress of about 500 dyn/cm^2 and a 25 per cent drainage time of about 30 min was made on the laboratory foam generator and tested for its fire-fighting properties in the standard Ministry of Public Building and Works test for foam liquids(6), using narrow boiling point range petrol as fuel.

This foam gave an actual drainage on the fire test of 25 per cent of its liquid content in 20 minutes, as compared with the 30 minutes on the dry pan test. (Fig. 5).

By comparison, Ministry of Defence (A.M. Dept) specifications issued prior to 1966 for aircraft fire fighting foams have required that the foam drainage from a dry pan should not exceed 5 per cent in 15 minutes, and this figure is approximately equivalent to a 25 per cent drainage time of 30 minutes, as used in the foam tested in the Ministry of Public Building and Works test.

Experiments with detergent foam

Ammonium lauryl sulphate was selected for use in the present experiments as this material has been used widely at J.F.R.O. for other investigations(7) where a stable, slow-draining, air foam was required. When used in a proprietary 2 gal foam-making extinguisher, an 0.8 per cent active solution of the agent produced foam having an expansion of 5 or 6 and critical shear stress of 50 to 100 dyn/cm^2. This foam reduced a 3 ft by 3 ft petrol fire to a few flickers in 30 sec but did not completely extinguish the fire in 40 to 45 sec, the time required to discharge the contents of the extinguisher. In another experiment in which an active detergent solution of 1.6 per cent was used, the foam had an expansion of 5 or 6, and a critical shear stress of 100 to 150 dyn/cm^2. In this experiment the petrol fire was extinguished in 40 sec.

Some experiments with the gas turbine foam generator using a 1 per cent active solution of ammonium lauryl sulphate have been made. The properties of the foams produced lay within the following ranges:

Expansion - Generally about 10 or 12
Critical shear stress - 100 to 180 dyn/cm^2
25 per cent drainage time - 7.5 to 20 min

Compared with protein foams, the detergent foams have a low critical shear stress and a low drainage rate, and it is hoped to examine the performance of some of these foams on fairly large fires (875 ft^2 area) as soon as it is possible to do so.

Conclusions

(1) The overall critical chear stress range of foams made by the foam generator at the three discharge rates and three expansion values of 50, 125 and 200 gal/min, and 6, 13 and 20 respectively, used in the experimental aircraft fire programme, was between 150 and 1,400 dyn/cm^2.

(2) Independent variation of foam drainage and critical shear stress could not readily be achieved with the generator, but there was a general relation between the two properties over the whole expansion range examined. This relation might also be interpreted as a series of straight relations at the various expansions.

(3) The drainage from foam of the "optimum" properties for aircraft fires, viz, an intermediate expansion of 10 to 11, a critical shear stress of about 500 dyn/cm^2 and a 25 per cent (dry pan) drainage of about 30 minutes, has been shown on the Ministry of Public Building and Works Standard Test for Foam Liquids to give an actual fire drainage rate of 25 per cent in 20 minutes. This drainage rate would be within the maximum acceptable to the Ministry of Defence (AM) specification.

(4) Experiments with the generator using ammonium lauryl sulphate, a detergent normally used to make "high expansion" foam, have shown that this agent may also be suitable for the manufacture of "low expansion" foam (about 10 or 12) for fire fighting.

References

(1) FITTES, D. W. and NASH, P. "The design and development of an experimental gas turbine operated foam generator". F.R. Note No.583.

(2) NASH, P., FITTES, D. W. and RICHARDSON, D. D. "Foam for aircraft crash fires (3)". F.R. Note No.615.

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

(4) FRENCH, R. J. "Foam viscometer". J. scient. Instrum. August, 1960, Vol.37. pp.307-8.

(5) TUVE, R. L. and PETERSON, M. B. "A study of some mechanical foams and their use for extinguishing tank fires". Naval Research Laboratory, U.S.A. N.R.L. Report 3725.

(6) Foam liquid, fire extinguishing. Ministry of Public Building and Works Specification No.MW/CS/439/3.

(7) LANGFORD, B. and STARK, G. W. V. "Control of Fires in Large Spaces with Inert Gas and Foam Produced by a Turbo-Jet Engine. (VII) – The selection of foaming agents for the production of high expansion foam". F.R. Note No.519.

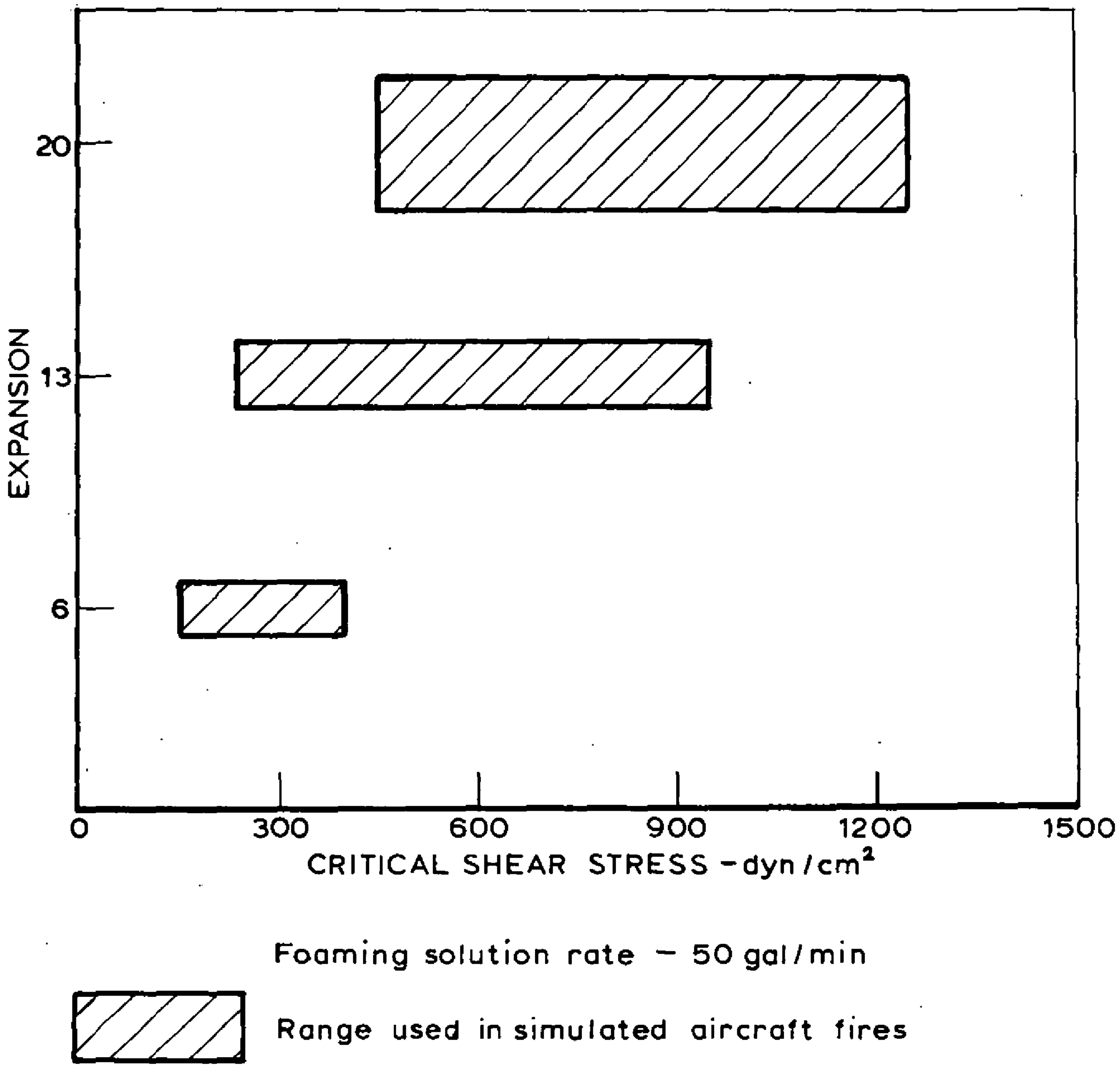
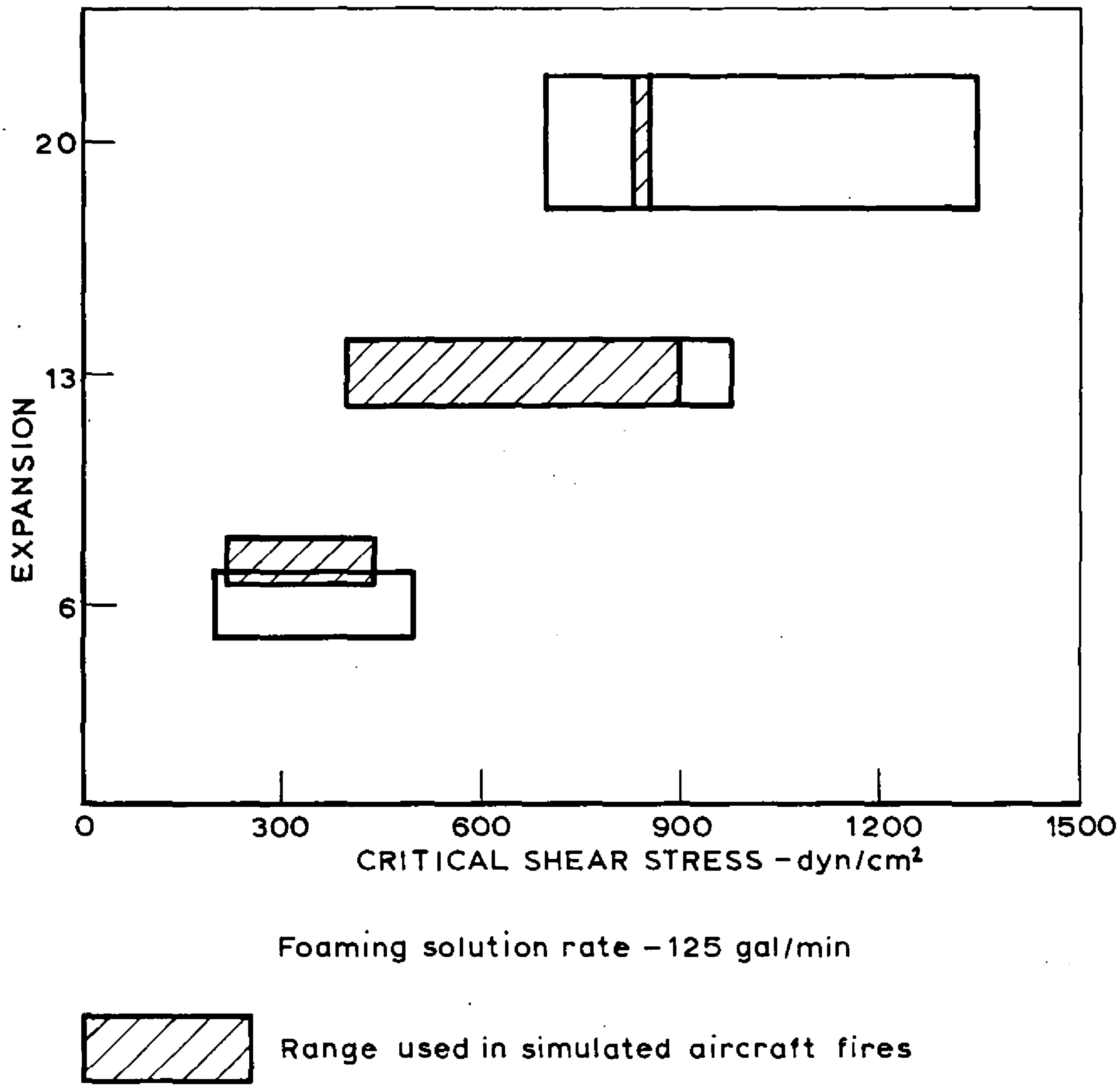


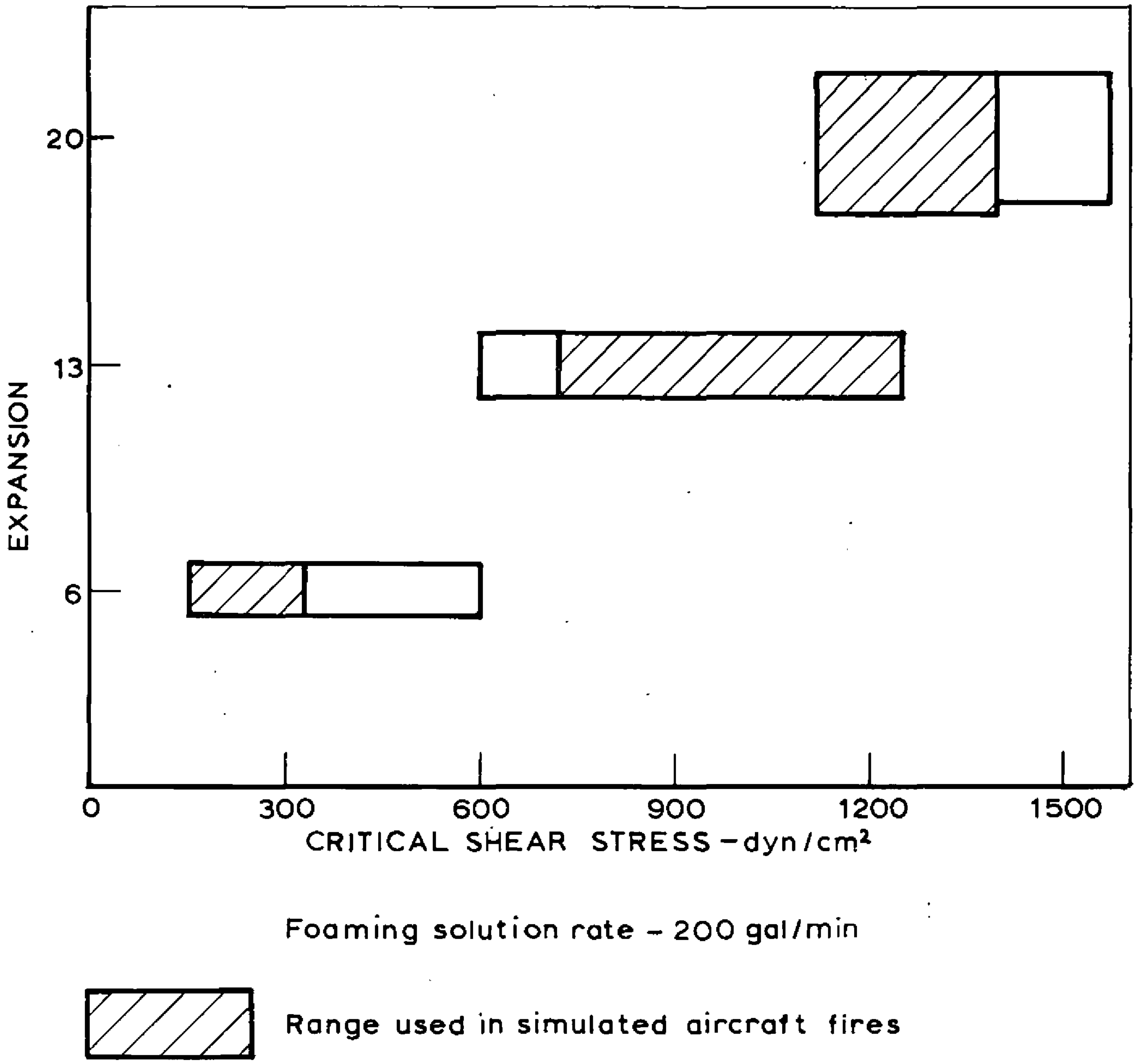
FIG. 1a. RANGE OF CRITICAL SHEAR STRESS AT VARIOUS EXPANSIONS



Foaming solution rate - 125 gal/min

FIG.1 b. RANGE OF CRITICAL SHEAR STRESS AT VARIOUS EXPANSIONS

1/7593 F.R. 668



Foaming solution rate – 200 gal/min

FIG.1c. RANGE OF CRITICAL SHEAR STRESS AT VARIOUS EXPANSIONS

1/7594 F.R. 668

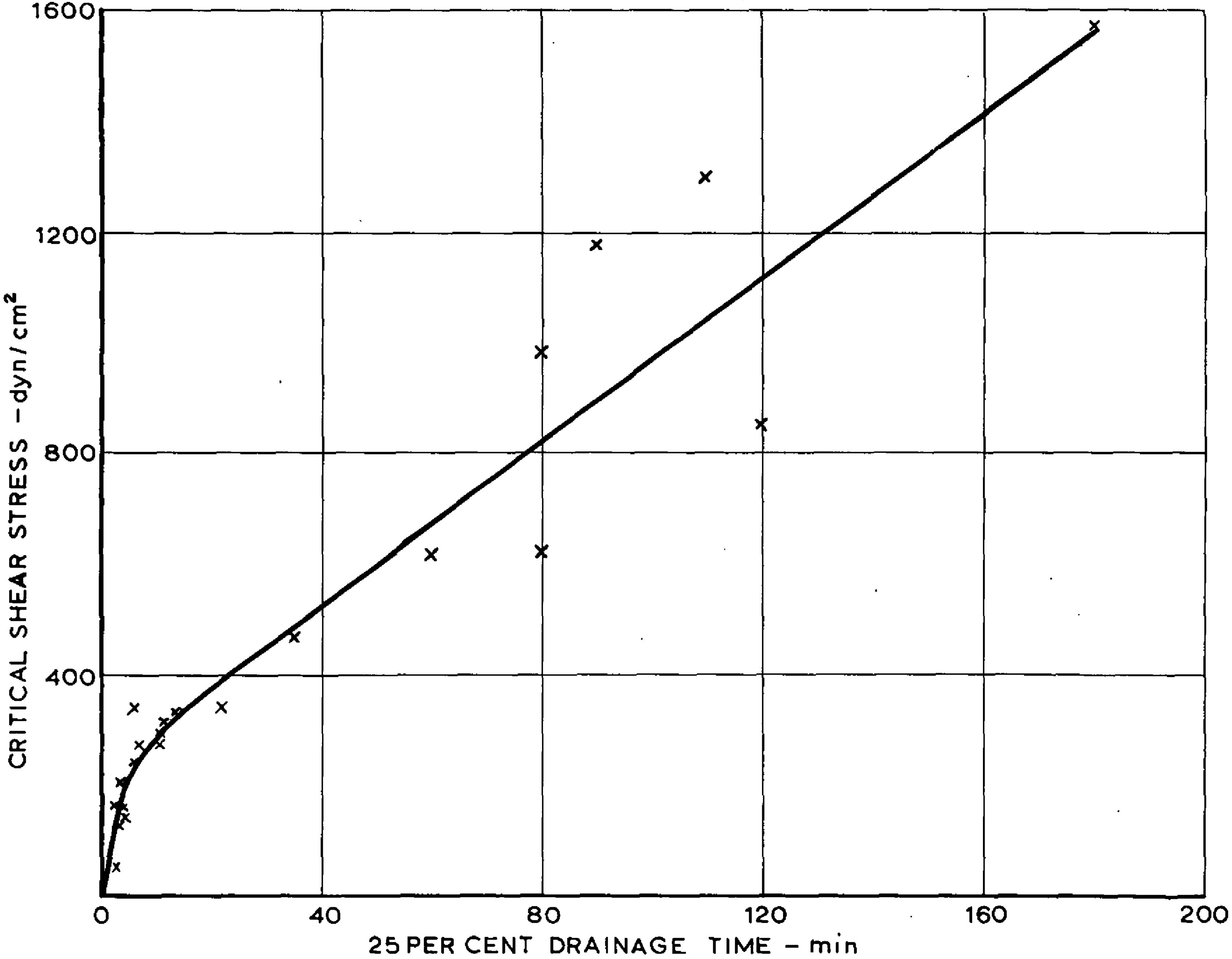


FIG.2 RELATION BETWEEN FOAM STIFFNESS AND DRAINAGE

1/7596 F.R. 668

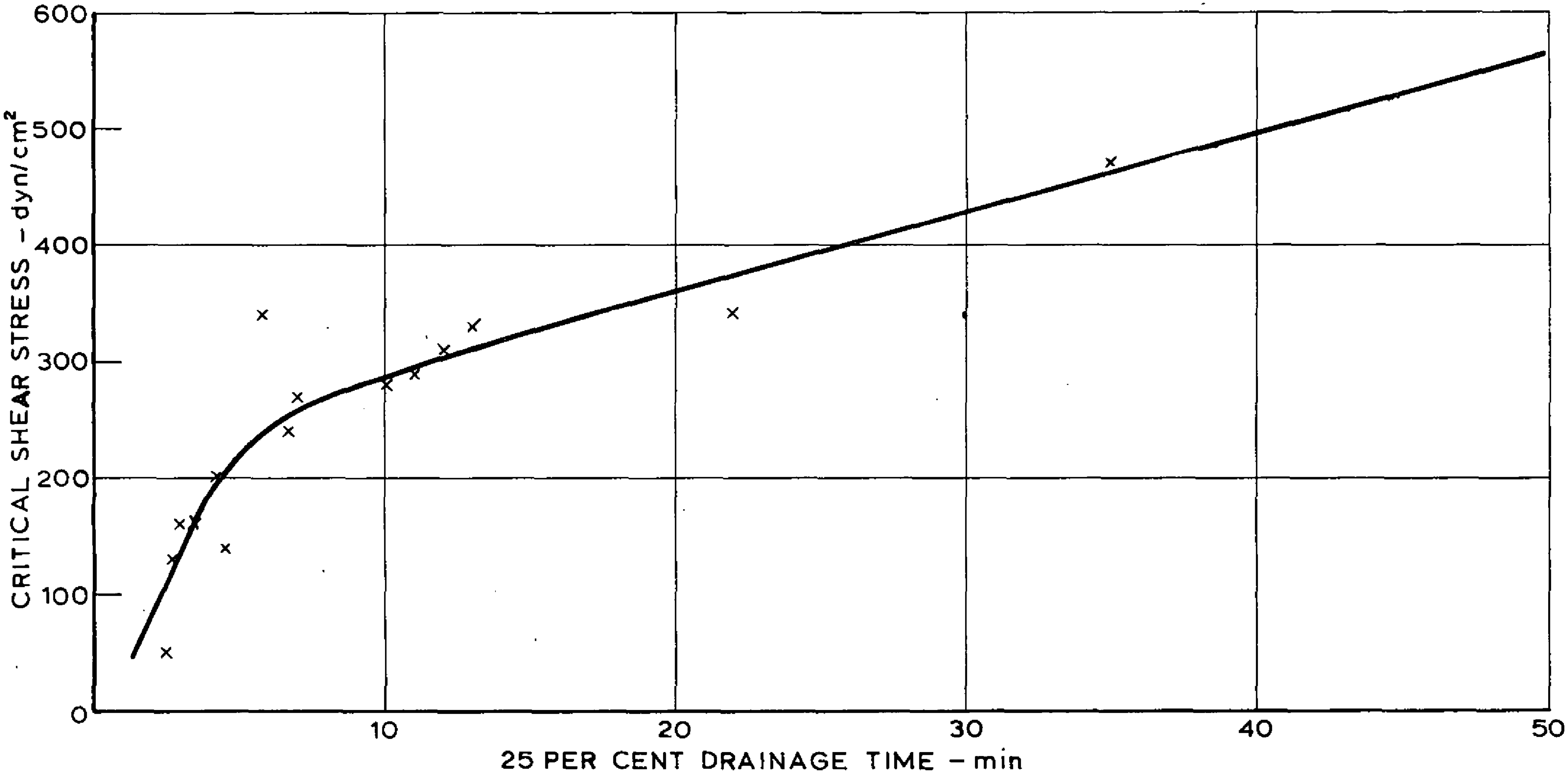


FIG.3. RELATION BETWEEN FOAM STIFFNESS AND DRAINAGE FOR THE MORE 'FLUID' FOAMS

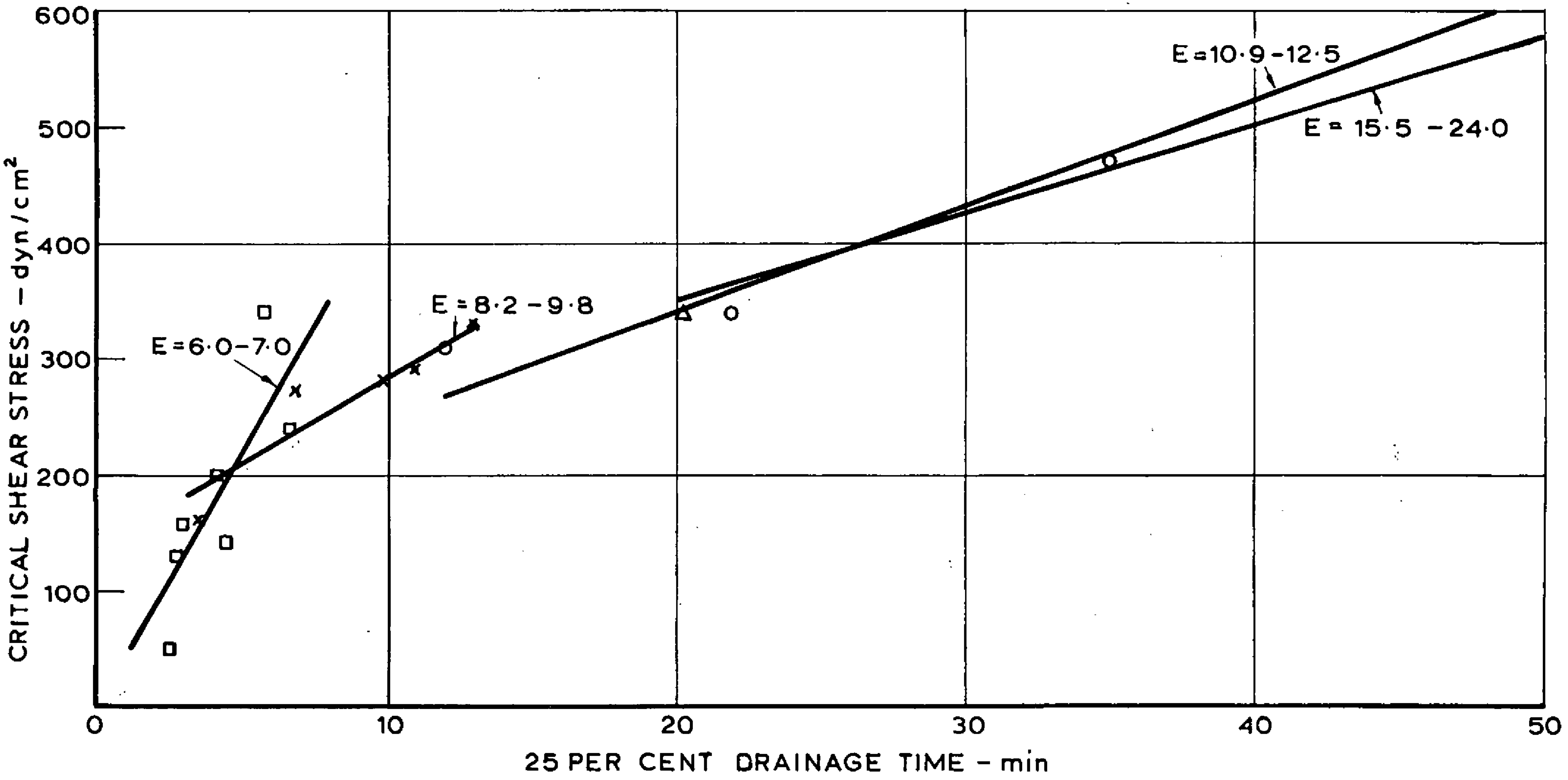


FIG.4. EFFECT OF EXPANSION
ON THE RELATION BETWEEN FOAM STIFFNESS AND DRAINAGE

1/7598 F.R. 668

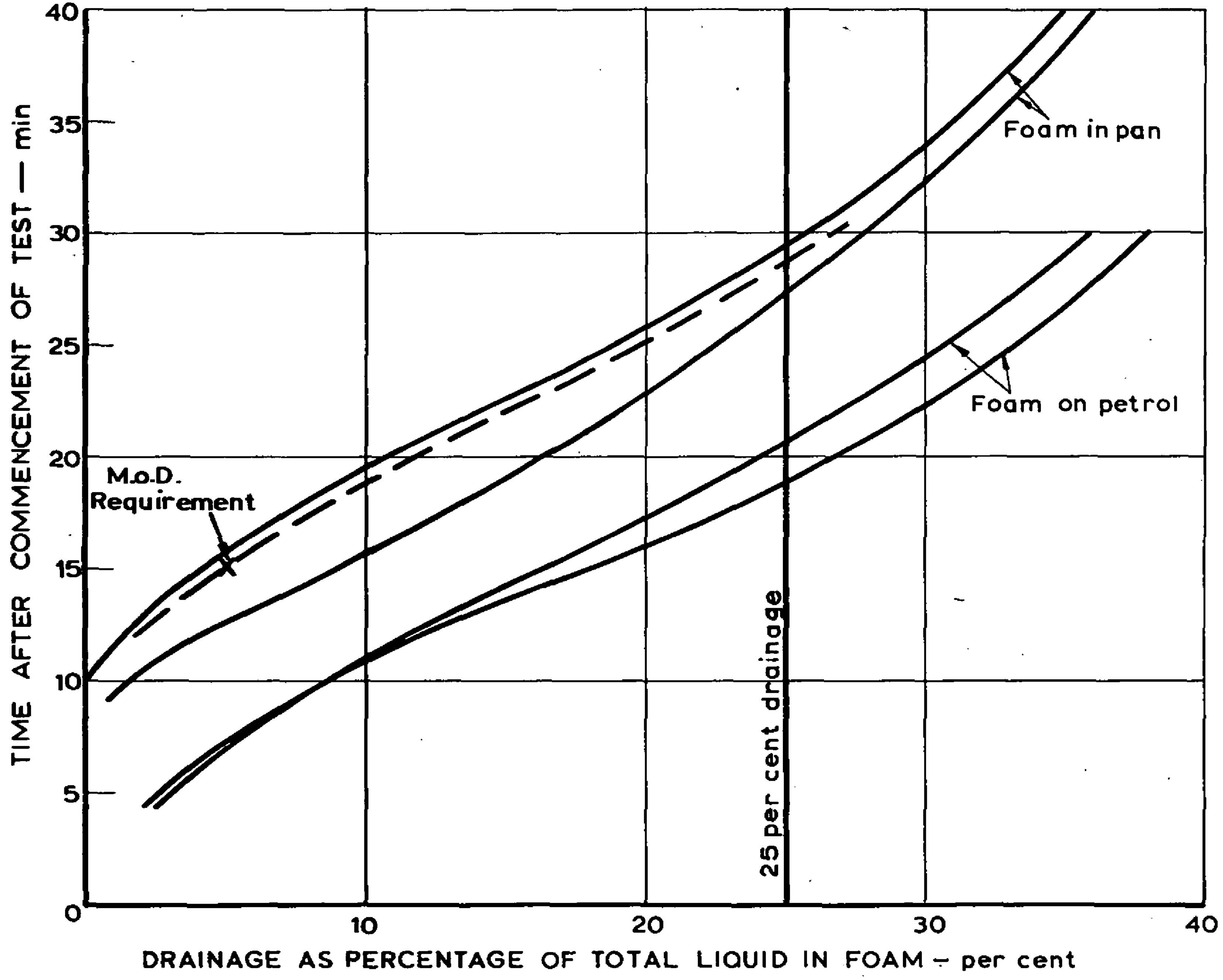


FIG.5. COMPARISON OF FOAM DRAINAGE ON PETROL WITH DRAINAGE FROM FOAM IN METAL PAN