Fire Research Note No 957

THE PERFORMANCE OF SOME PORTABLE GAS DETECTORS WITH AVIATION FUEL VAPOURS AT ELEVATED TEMPERATURES

PART 2 TESTS WITH 'AVCAT', 'KERO B' AND 'AVTUR' VAPOURS

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SUMMARY

The results of further tests on portable flammable gas detectors are given. The response of these detectors was low when they were operated at 65°C ambient temperature and at moderate humidity levels with the aviation fuels 'Avcat', 'Avtur' and 'Kero B'.

KEY WORDS: Flammable gas, detector, tests

DEPARTMENT OF THE ENVIRONMENT AND FIRE OFFICES COMMITTEE

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1. INTRODUCTION

Part 1 of this report[1] gave the test results for some portable gas detectors when used at 65°C with the fuel vapours of 'Avtag' and 'Civgas' and at 65°C and 25°C with n-hexane vapour, all tests being carried out under moderate humidity conditions. For these materials at the lower explosion limit (LEL) concentration of the vapour in air, there was no evidence of the vapour condensing out. Thus to obtain various fractions of the LEL concentrations, in order to test the meters, it was only necessary to reduce the fuel delivery rate into the test apparatus by a calculated amount.

In the tests described here, the fuels used ('Avcat', 'Avtur' and 'Kero B') comprised both a vapour and a liquid phase at the LEL concentration at 65°C making it impossible to calculate directly the exact vapour concentration from the known liquid fuel delivery rate. The contribution to the vapour phase from the condensate could have been determined by vapour pressure measurements, but these would have been relatively prolonged and it was decided to measure the mass rate of condensate formation directly and subtract this from the known total liquid fuel delivery rate to give the rate of vapour formation and hence the true vapour concentration in air.

2. EXPERIMENTAL

(i) Test apparatus and procedure

This was fully described in Part 1 and only a brief outline will be given here.

The fuel to be tested was metered by a calibrated pump from a reservoir to a heated cylindrical vessel. The temperature of this vessel was adjusted to ensure complete vaporisation of the fuel. A metered air flow also passed into the vessel and the mixture of fuel vapour and air passed through a heated tube into a thermostatted oven, and finally either into a standard explosion limits tube or the detector under test, both of which were inside the oven. Various concentrations of fuel vapour in air were passed into the explosion limits tube and subjected to an electrical spark. When a vapour concentration was found which, when exceeded, gave rise to a self-propagating flame, this was taken as the lower explosion limit concentration, after correcting for the condensate production. The LEL mixture and various known fractions of it were then passed through the detector and the reading checked in each case.

(ii) Measurement of rate of formation of condensate

Figure 1 shows the apparatus used to determine the rate of condensate formation. The coiled tube acted as a condenser and the condensate was allowed to drip into a burette; the uncondensed vapour passing on via a side arm. The volume rate of formation of condensate was measured (after reaching a steady state condition) for a number of fuel delivery rates, and the density of the condensate measured with an SG bottle in each case, allowing the mass rate of condensate formation to be calculated.

(iii) Tests carried out

The detectors used in these tests were the same as described in Part 1 and are given the same designation here. A summary of the instruments appears in Table 1.

Table 1. Some details of the tested detectors

Detector	Sampling mode	Calibration gas	Scale ranges (LEL)	Power source	Other features
A	Aspiration	Methane*	0–100%) 0– 10%))	Replaceable leak proof cells	
B	"	Leaded petrol	0–100%))		
C	Diffusion	Methane	0–100%	Rechargeable battery	)) Pre-set) audible) and visual) alarm)
D	Diffusion or Aspiration	n-pentane	0–100%	"	

*Methane test kit supplied but original calibration with pentane

They were all tested with the fuels 'Avcat', 'Kero B' and two samples of 'Avtur', at 65°C and moderate humidity levels. Table 2 gives some details of the fuels.

Table 2. Fuels used for tests

Fuel	Description	Source
Avcat	Aviation turbine fuel: high flash type. (Min. of Aviation Supply Ref No D.ENG.RD. 2498) N.A.T.O. Ref.F-44	R.A.F. Machrihanish
Avtur	Aviation turbine fuel: kerosine type. Min. of Aviation Supply Ref No D.ENG.RD. 2494 N.A.T.O. Ref.F-35	R.A.F. Marham
Avtur	As above	R.A.F. Leuchars Fife
Kero B	Kerosine	R.A.F. Coltishall

Detector 'E' was not available for these tests and
Detector 'D' was not tested with one 'Avtur' sample.

3. RESULTS

Figures 2 - 4 show the plots obtained from the rate of condensate production measurements. A regression line was calculated for Kero B and Avcat (Figs 2 and 3). The two Avtur samples were found to give virtually identical rates and in Fig. 4 both the points and the curve represent both samples. Table 3 below gives the lower explosion limit concentrations as determined for this report together with those obtained for Part 1, for comparison. Figures 5 - 8 give the response curves for each detector tested.

Table 3

LEL concentrations for aviation fuels

Fuel	LEL at 65°C (% by mass)
n-hexane	3.56* (Part 1)
'Civgas'	3.41 (" ")
'Avtag'	3.49 (" ")
'Avcat'	4.01 (Part 2)
'Avtur' (Fife)	3.74 (" ")
'Avtur' (Marham)	3.74 (" ")
'Kero B'	3.75 (" ")

* at 25°C

4. DISCUSSION

The values of the LEL concentration obtained for the fuels in this report were higher (on a mass per cent basis) than those described in Part 1. For pure paraffin hydrocarbon compounds, the LEL concentration on a mass basis should be similar.

The technique used to measure and allow for the condensate production was subject to certain errors. The density of the condensate was determined at a lower temperature than 65° C,giving a corrected vapour concentration, slightly higher than was actually the case.

A further error would arise from the spread of the points used to plot the graph of rate of condensate production v. total fuel flow. The straight line of best fit was drawn through the points by themethod of least squares, giving a minimum correlation coefficient of 0.98. This error was thus not significant.

The spread of the LEL concentration values, and their difference from the fuels used in Part 1 of this report can therefore be ascribed to differences in the composition of the fuels. The presence of mist in the sampling lines of the detector, which was observed, with high nominal fuel concentrations, should not have affected the condensate correction. The mist can be counted as vapour in the sense that it burns, and thus would contribute to the observed LEL concentration.

The results presented here show similar trends to those in Part 1 – a marked depression of response from the true value, throughout the range of concentration 0 – 100 per cent LEL.

It should be possible to find a particular vapour, which when used to calibrate the detectors will ensure correct or high (and thus erring on the side of safety) readings with these fuels, and this point is currently under investigation.

5. REFERENCE

1. FARDELL, P J The performance of some portable gas detectors with aviation fuel vapours at elevated temperatures. Part 1. Tests with n-hexane, 'Avtag' and 'Civgas' vapours. JFRO FR Note 938 July 1972.

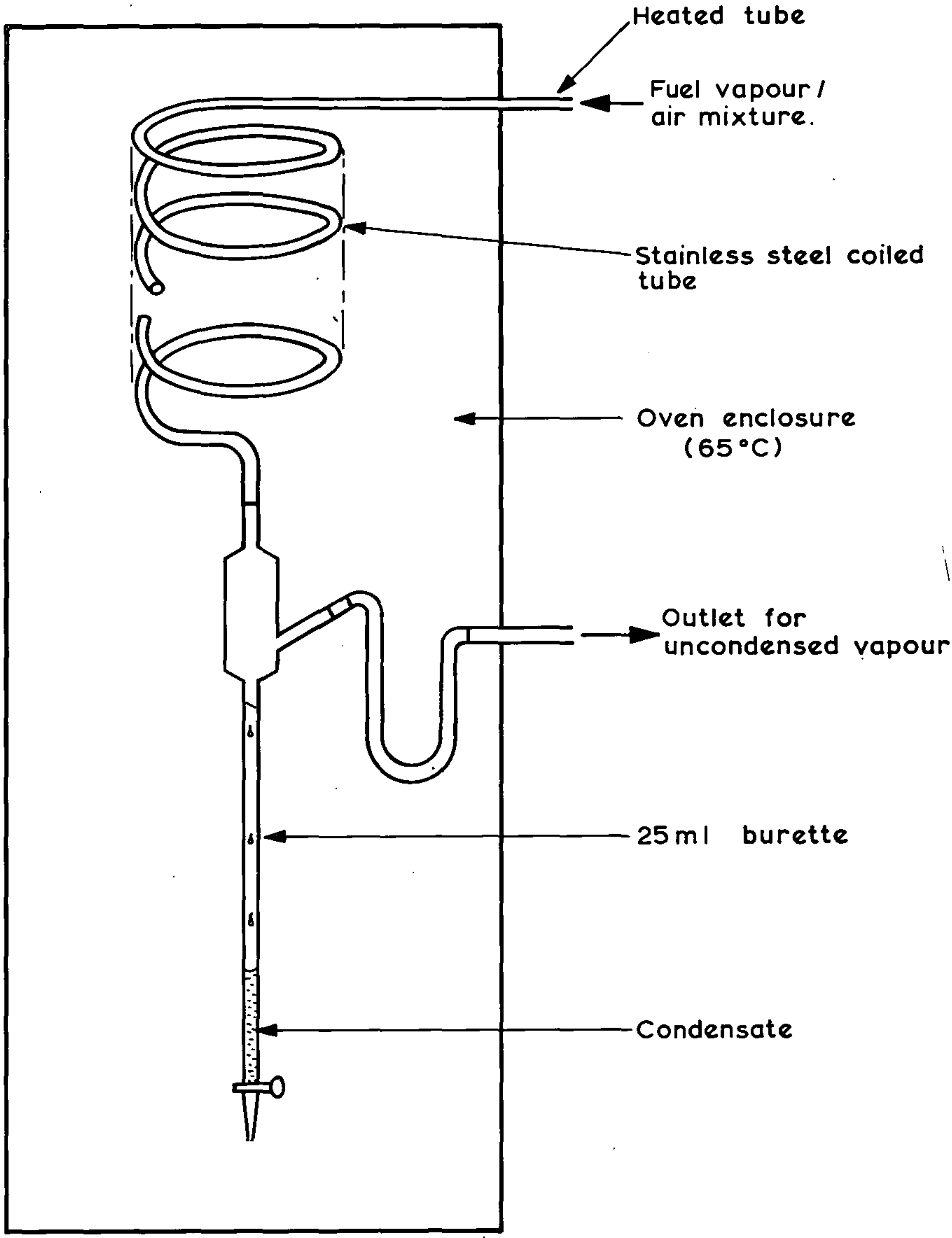

FIG. 1. APPARATUS FOR MEASUREMENT OF RATE OF CONDENSATE FORMATION.

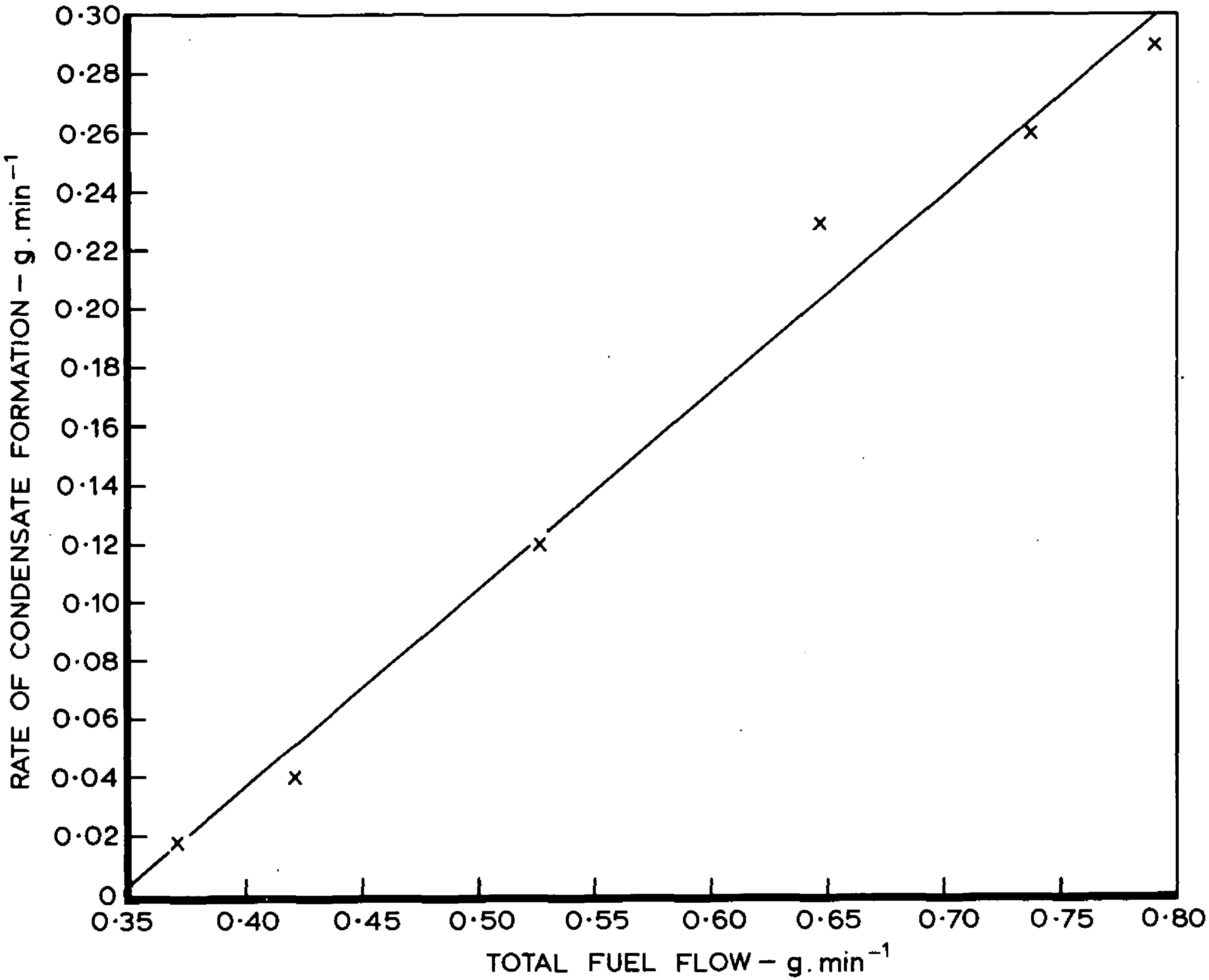

FIG. 2 RATE OF CONDENSATE FORMATION FOR KERO 'B' FUEL

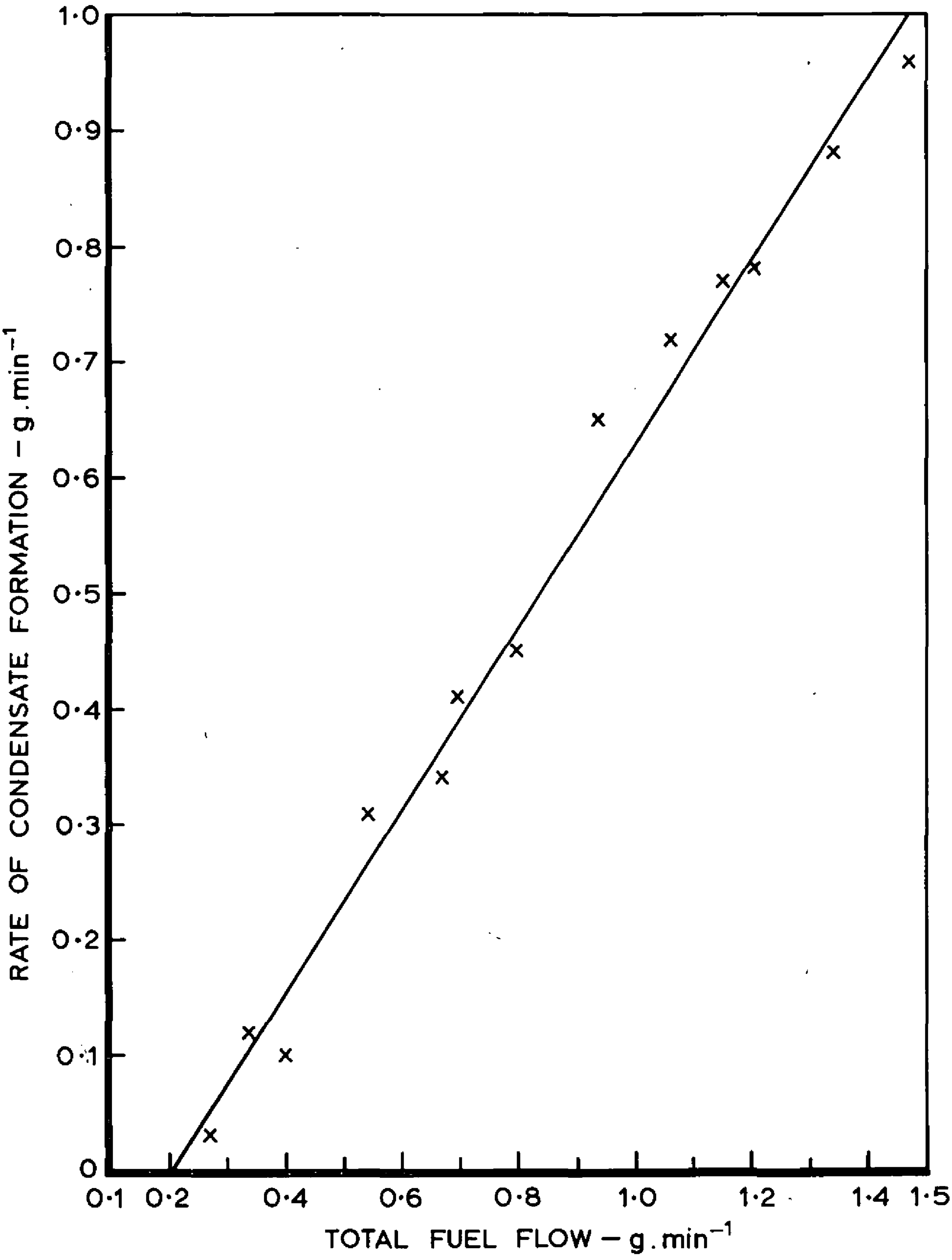

FIG. 3 RATE OF CONDENSATE FORMATION FOR AVCAT FUEL

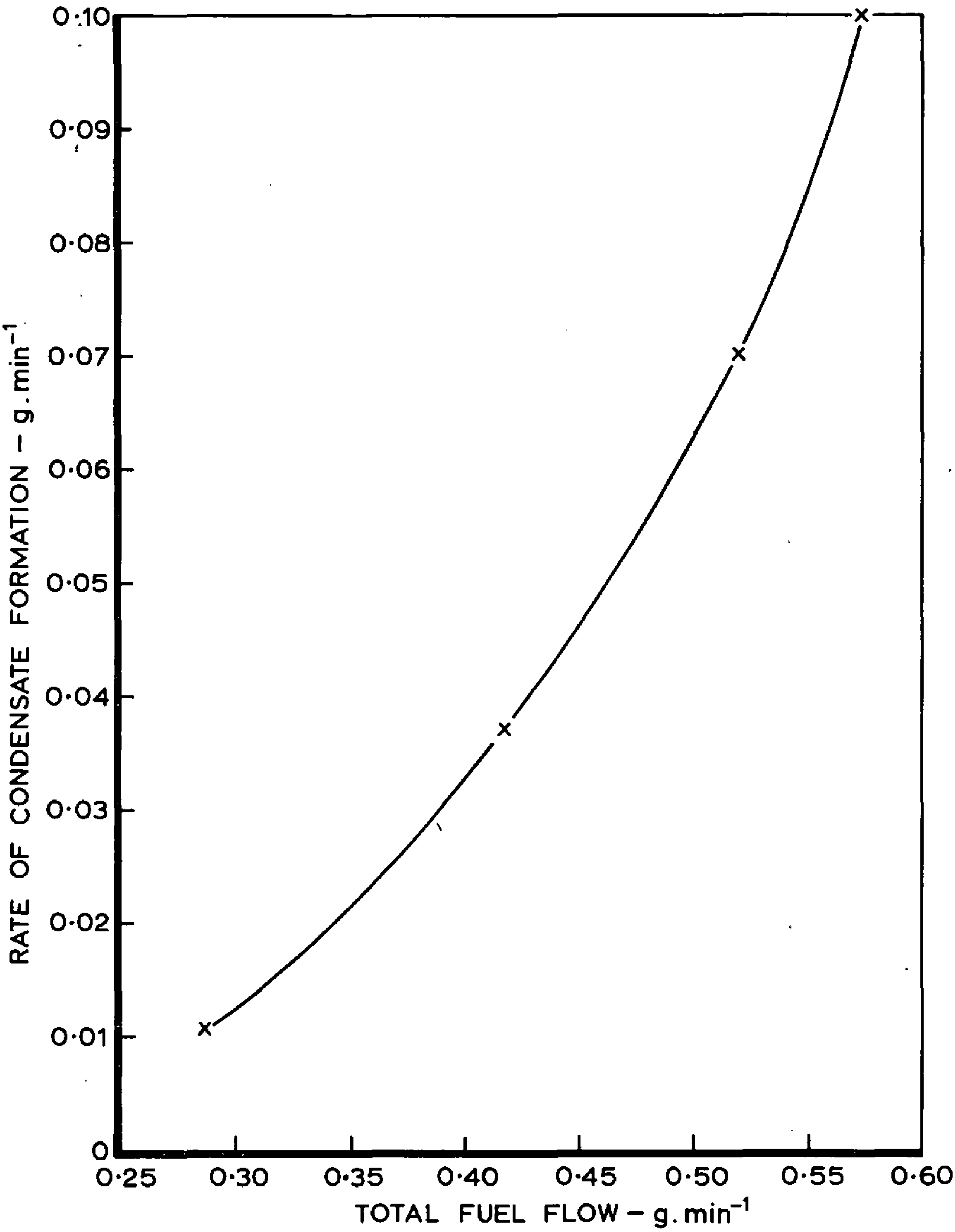

FIG. 4 RATE OF CONDENSATE FORMATION FOR THE AVTUR FUELS

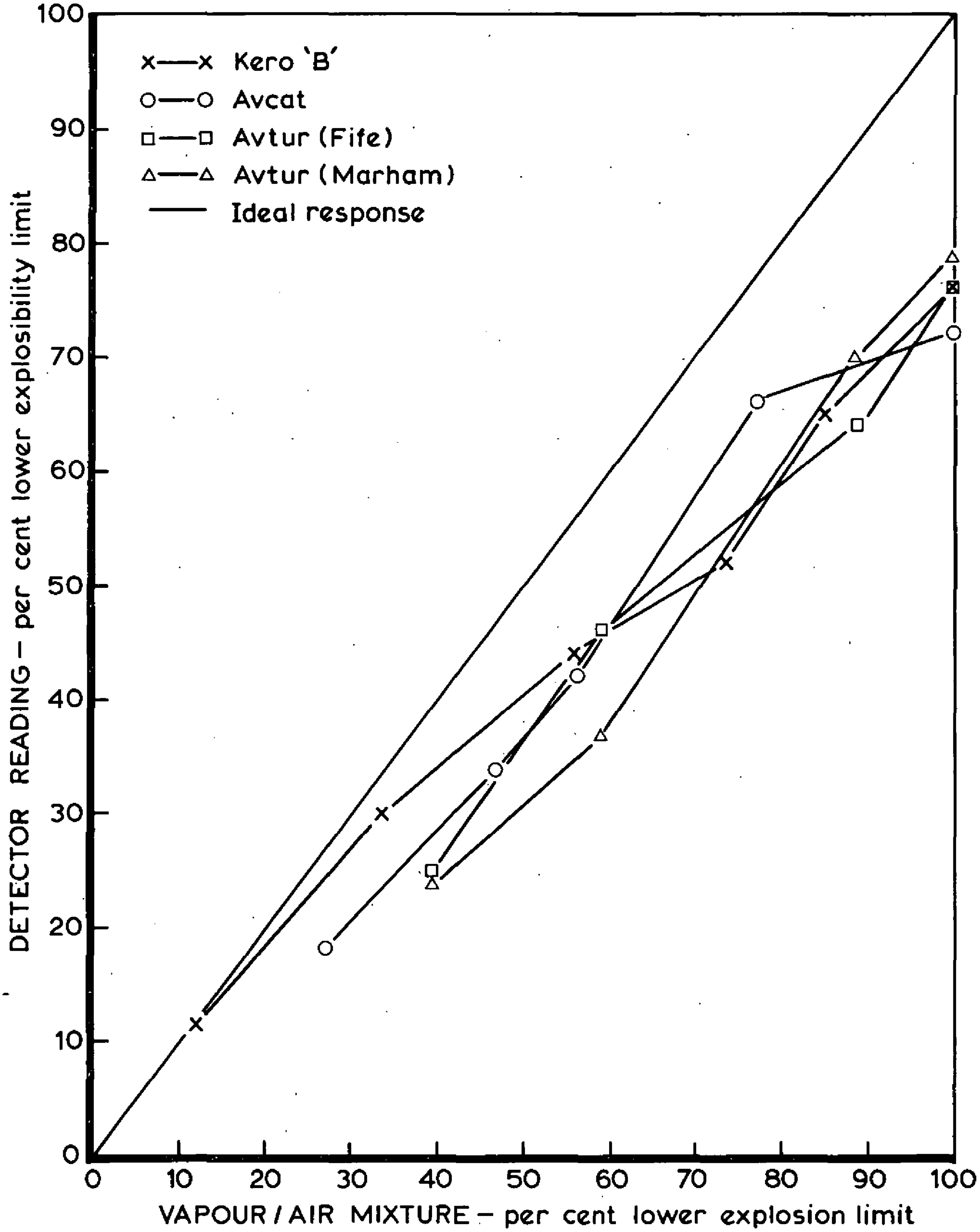

FIG. 5 RESPONSE CURVES FOR DETECTOR 'A'

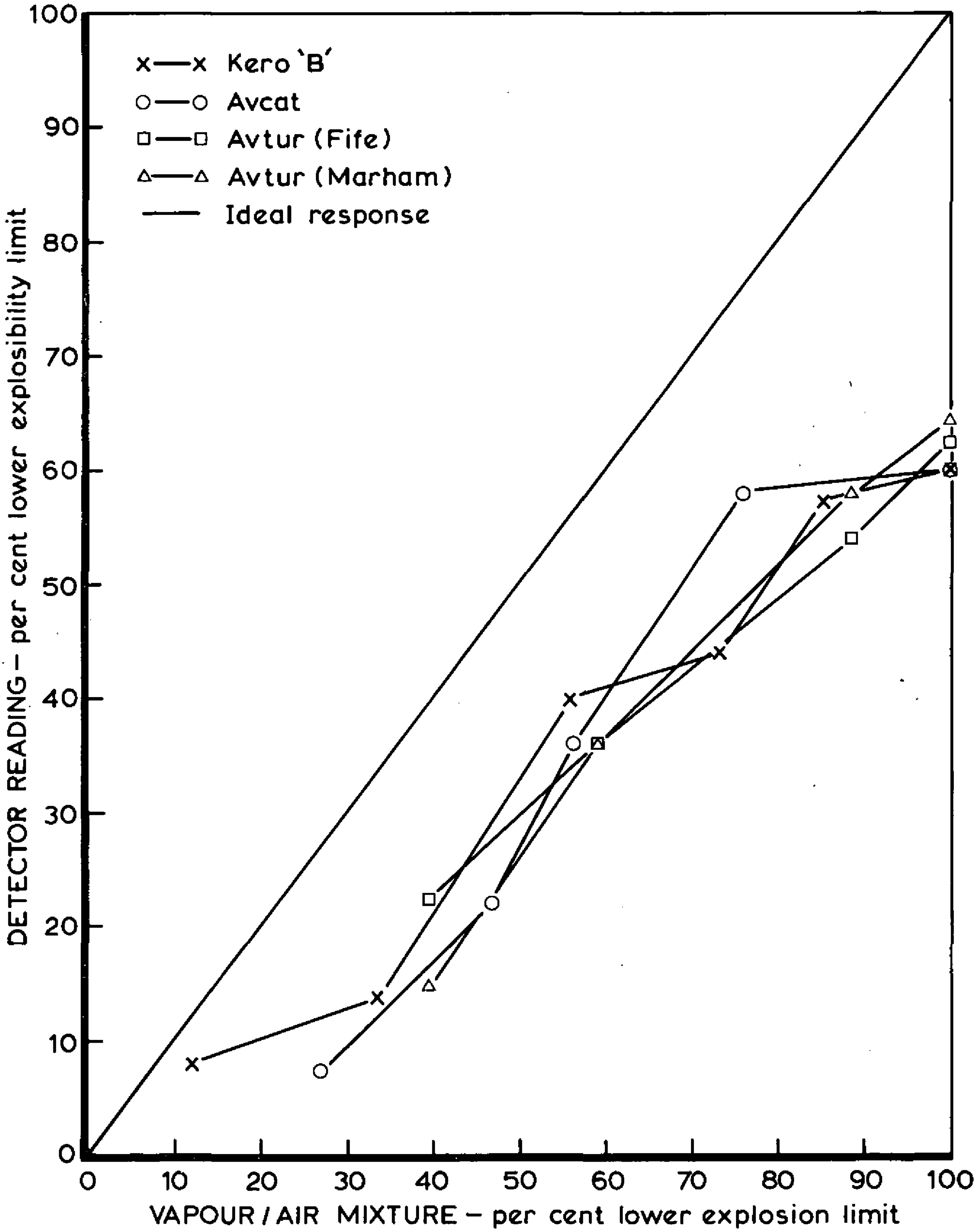

FIG. 6 RESPONSE CURVES FOR DETECTOR 'B'

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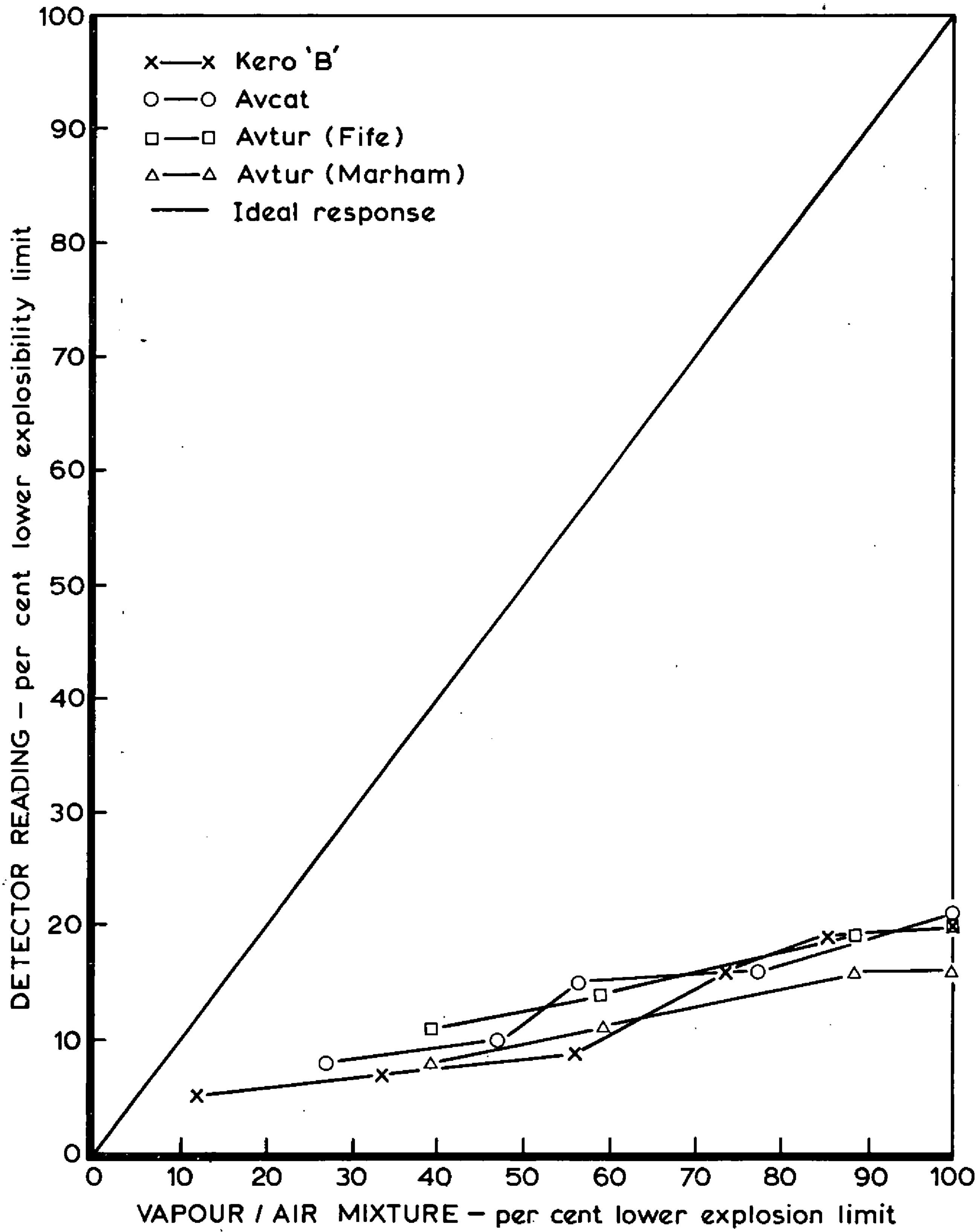

FIG. 7 RESPONSE CURVES FOR DETECTOR 'C'

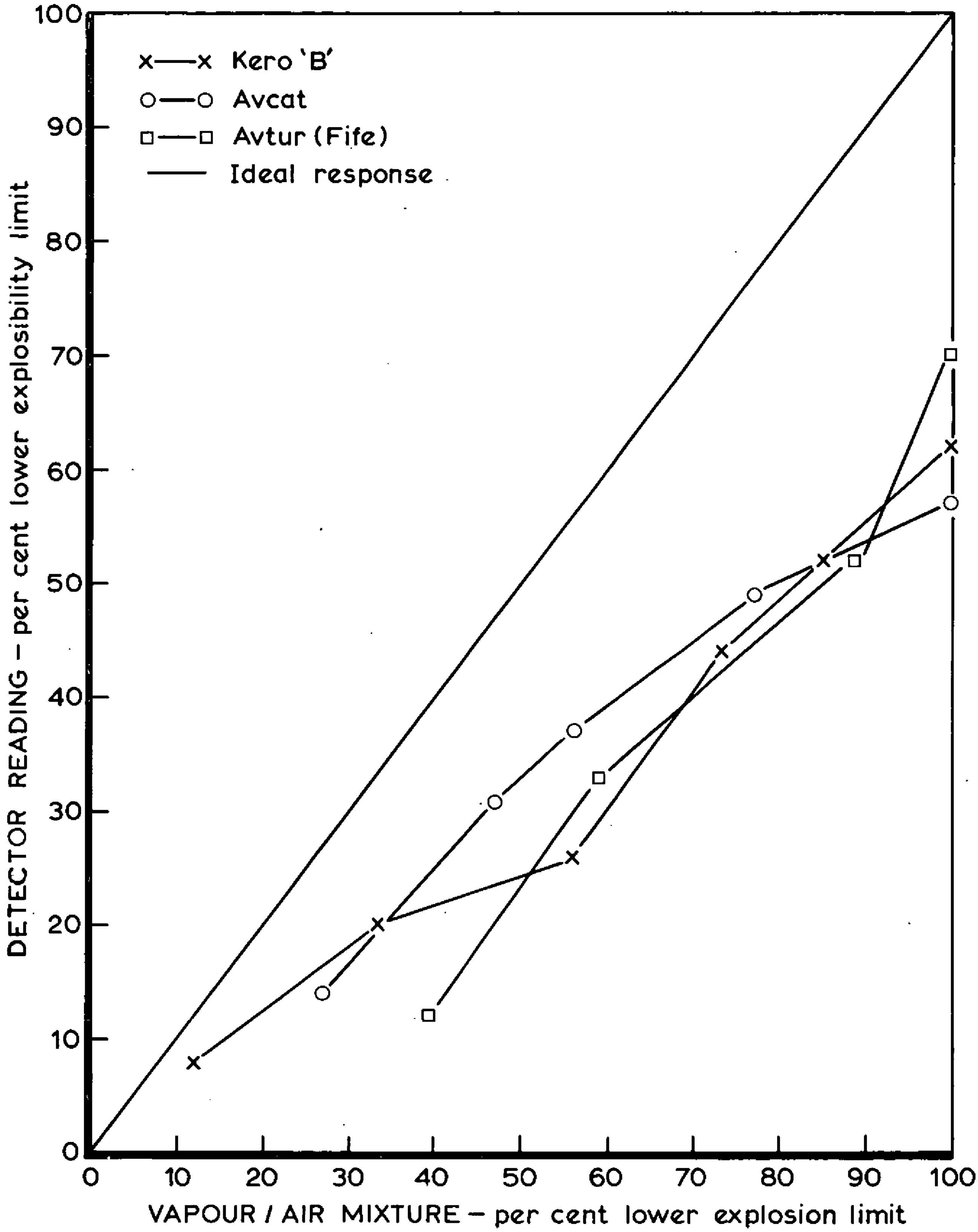

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FIG. 8 RESPONSE CURVES FOR DETECTOR 'D'