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THE EXTINCTION OF POOL FIRES BY WATER SPRAY WITH HAND-CONTROLLED NOZZLES

by

D. J. Rasbash and G. W. V. Stark

Summary

An account is presented of tests on the extinction of 8 ft diameter pool fires of oils by water sprays applied by an operator from spray nozzles on a hand line. The mechanism of extinction is similar to that of a fixed nozzle installation, the cooling of the oil by the spray predominating. The improvement in the performance of the operator with the number of fires tackled is of the same form as that observed in learning and training in other fields.

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Fire Research Station,
Boreham Wood,
Herts.

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Introduction

The effect of the properties of water sprays from fixed nozzles on the extinction of pool fires in the open air has been recorded elsewhere (1). The present note describes tests on the extinction of 8 ft diameter pool fires of oils with water spray applied by hand. The object of the tests was to investigate whether such fires could be readily extinguished by hand application of spray, and to examine the effects of spray properties, fuel properties and the experience of the operator upon the efficiency of extinction.

Experimental

The tests were conducted on an open site with the nearest obstructions (trees, buildings etc.) about 50 yards away. The pool fire consisted of a layer of oil, floating on water, with an ullage of 8 - 11 cm in a combustion vessel 8 ft diameter and 6 in. deep constructed of 16 S.W.G. sheet steel. The fire was started by priming the surface of the oil with a small amount of petrol and igniting with a taper. The main programme of tests was made with transformer oil, but a number of tests were made with other oils to examine the effect of fuel properties on extinction. Properties of the oils used and the amounts of priming petrol are given in Table 1. The fire was allowed to burn for a specified time, the preburn time, before applying water spray. The spray was applied to fires from one, or two, nozzles on a 2 ft long extension pipe, $\frac{3}{4}$ in. internal diameter with a pressure gauge fitted close to the nozzle, connected to a 1 in. reinforced rubber hose line. Some properties of the nozzles used are given in Table 2. With the object of studying the effect of increasing experience, one operator applied the water spray throughout the main programme.

The effect of pressure was studied by comparing the performance of a single nozzle at one pressure with that of two nozzles at a quarter of that pressure. To investigate the effect of fuel depth and preburn time, depths of oil of from 1 to 6 cm, and preburn times of from $\frac{1}{4}$ to 5 minutes were used.

After each extinction, the temperature of the surface layers of oil was measured at three positions, one of which was in the area in which the last flames were present prior to extinction.

Results

Preliminary tests. The operator, who had had no previous experience of extinguishing pool fires, was instructed on the way to deal with such fires, and allowed to tackle four fires before starting the main programme of tests. He wore light protective clothing, his face being protected by a transparent plastic visor.

The most successful method for extinguishing and controlling a fire, which was used in the main programme of tests, was for the operator to approach closely to the fire from the windward side, directing the spray downward onto the rim of the vessel and that part of the fire nearest him. As the area of the fire extinguished increased, he advanced to the edge of the combustion vessel, moving the spray to tackle residual tongues and pockets of fire, progressively reducing the angle between the spray and the fuel surface until all the fire was extinguished or control was lost. If control was lost, the procedure was repeated until total extinction was obtained or until a time of not less than one minute had passed.

The progress of an extinction is shown in the Plate.

Main test programme. The results of tests with transformer oil, kerosine, gas oil, turbine oil and heavy fuel oil are given in Table 3 - 7 respectively. The order of performance of the tests (test number, L) is included in the Tables; missing numbers in this order refer to tests which failed to fulfil test requirements, due to factors outside experimental control.

Transformer oil tests. The extinction times, t, for tests with some of the single nozzles in Table 3 have been plotted against the test number L in Fig. 1. This figure shows an inverse relation between test number and extinction time and also between flow rate, R, and extinction time.

✓ The extinction times obtained with nozzles A and J were substantially constant after the 15th Test. Thereafter blocks of tests were performed to examine the effect of pressure P (test 16-29), oil depth H (tests 30-39) and preburn time Y (tests 40-65).

The results of these tests on transformer oil fires indicated that preburn time, drop size, and flow rate influenced extinction time in a similar way to that found for fixed spray nozzles installations(2).

Extinction time was not found to be significantly affected by variations in pressure, or in depth of oil when this was greater than a value between 1 and 3 cm.

The tests on other fuels (Tables 4 - 7) were made over ranges of values of the above factors and the results were later used in a regression analysis.

Splash fires. It was observed that splash fires occurred more readily with the lighter oils, kerosine and gas oil, than with the heavier oils, and that splash fires occurred more readily both as the depth of the oil and as the drop size of the spray increased.

Reignition and oil temperature. In all tests in Tables 4 - 7 and from test 37 on, in Table 3, a lighted taper was held 1 cm above the surface of the fuel within 5 seconds of extinction. In only one test (kerosine, Table 4, test 55) did the oil reignite, and in no test was the maximum measured temperature of the surface oil after test above its fire point.

Discussion

Comparison with fixed spray installation

The relation below was derived for the extinction time of pool fires by fixed nozzle installations spraying downwards, where the mechanism is the cooling of the fuel to its fire point.

$$t = 6900\, DYM^{-1}\, \Delta T^{-1\cdot 75} \qquad \ldots\ldots (1)$$

Symbols

D = Mass median drop size, mm.
K = Constant.
L = Consecutive number of attempts to extinguish fire.
M = Flow rate of spray to unit area of fire, gal ft^{-2} min^{-1}
R = Flow rate from nozzle, gal/min.
Y = Preburn time, min.
Δ T = Difference between ambient temperature and fire point of oil, °C.
t = Extinction time, seconds.
c = (Subscript) critical.
l = (") limiting.

A regression analysis on the results in Tables 3 to 7 for depths of oil greater than 2 cm gave the following relation, the effect of pressure on extinction time not being found significant.

$$t = 1216000\, D^{0\cdot 85}\, Y^{0\cdot 39}\, R^{-0\cdot 68} \Delta T^{-1\cdot 67}\, L^{-0\cdot 33} \qquad \ldots\ldots (2)$$

The ranges of the parameters and the 95 per cent confidence limits of their exponents were:-

t = 3 - 90 secs.
D = 0·36 - 1·2 mm; ± 0·38
Y = 0·5 - 5·0 min; ± 0·20
R = 1·4 - 38·0 gal/min; ± 0·16
ΔT = 41° - 208°C; ± 0·31
L = 1 - 107; ± 0·35

This relation accounted for 70 per cent of the total variance. The confidence limits given above show that the exponents of D and ΔT in equations (1) and (2) are not significantly different. The exponent Y is however much smaller in equation (2) than in equation (1); also the exponents of R and M are different, the form of the terms differing also. The term L represents the effect of learning, the "learning factor", which will be discussed later. The similarity of the form of equations (1) and (2), coupled with the observation that in all but one of the present tests the fuel did not ignite on application of a lighted taper, support the conclusion that the mechanism of extinction is the same in each case, the cooling of the fuel to its fire point predominating.

Effect of preburn time, Y

The lower value of Y in equation (2) than in equation (1) may be due to the different direction of attack. Spray applied downwards from fixed nozzle systems must first pass through the uprising flames before reaching the liquid to be cooled; these flames are enlarged by upsurge on the initial application of spray, the enlargement increasing with increasing preburn time (3) and thus increasing the difficulty, and reducing the quantity, of spray reaching the liquid surface. This effect would not greatly influence hand applied spray, which is directed at the base of the flames. Also downward applied spray is less effective in cooling the rim of a combustion vessel than spray applied at an angle, and the temperature of the rim would also increase with increasing preburn time (4). Both these effects would reduce the dependence on preburn time of hand applied spray compared with that of downward spray from fixed nozzles.

Effect of flow rate, R. A comparison of the effect of flow rate between fixed and hand controlled nozzles may be made if R can be expressed as the flow rate per unit area of pool fire, M. In the present tests it was observed that, in the process of extinction, much of the spray was projected beyond the pool fire. Some spray was lost in this way because of the shape and dimensions of the spray cloud, and some because the operator applied the core of the spray cloud to the flames, which were present only at the rim of the combustion vessel for much of the extinction period. The amount of spray lost in this way increased as flow rate increased, and it was estimated that, for spray nozzles of flow rate 15 - 20 gal/min, about one-third of the total flow was lost in this way.

The equations (1) and (2) above for spray from a fixed installation and for spray applied by hand may be directly compared if equation (2) is written:-

$$t = K D Y^{0\cdot 30} M^{-n} \Delta T^{-1\cdot 75} L^{-0\cdot 33} \qquad \ldots\ldots (3)$$

in which K is a numerical constant and the exponents of D and ΔT have been given the same values as in equation (1) (the values are not significantly different in equations (1) and (2)). A precise value cannot be assigned to exponent n since the relation between the quantity of spray lost and the flow rate of the nozzle is not known. For the value of n to have the same value as in equation (2), the quantity of spray lost would need to increase with increasing flow rate; its value would not be expected to differ from that in equation (2) if the proportion of spray lost did not vary with the flow rate of a nozzle. The value of the numerical constant K, (64,200 for $n = 0\cdot 68$), does not however vary greatly with variations of n.

Equations (1) and (3) thus allow the performance of the present operator to be compared with that of a fixed installation. The present relation however would not necessarily apply to another operator, since the value of the constant K, and the exponent of L in equation (3) might differ. The present results suggest however that the extinction of a pool fire by a fixed installation would be somewhat faster than extinction by a hand nozzle delivering spray at the same rate to the fire area, even if the operator were skilled,* and provided that the flow rate was well above the limiting flow rate.

Limiting flow rate M_1

It has been shown elsewhere (2) that the critical flow rate, M_c gal ft^{-2} min^{-1} (the flow rate below which extinction cannot take place) for a fixed spray installation and kerosine fires $4\frac{1}{2}$ in. and 12 in. diameter, is given by:-

$$M_c = 0\cdot 32\, D \qquad \ldots\ldots (4)$$

The form of equations (1) and (2) also suggests intuitively that M_c would vary inversely with ΔT. A limiting flow rate, M_1, i.e. a flow rate at which extinction can be achieved in a minute or so, has about twice the value of M_c.

The results of the present tests suggest that the limiting nozzle flow rate R_1, used by a skilled operator, was about 19 gal/min with nozzle J for kerosine fires (Table 4) and 1·4 gal/min with nozzle D for transformer oil fires (Table 3). From these values it may be deduced that the limiting flow rate, M_1 in the present series of tests is proportional to $D/\Delta T$ and they have been so plotted in Fig. 2. This curve may be used to estimate the limits of effective use of a given spray nozzle, in the hands of the present operator, for the extinction of a pool fire.

Although equations (2) and (3) show the extinction times to be greater for hand applied spray than for sprays from a fixed installation, Fig. 2 indicates that the values of M_1 obtained in the present work is less than that of M_1 for pool fires and fixed spray installations, from equation (4).

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*The operator was considered skilled when he had tackled 30 fires.

This difference may be related to differences in the way spray is applied to the fire. For example, whereas spray from a fixed installation must cover and be effective over the whole of the area of the pool fire during extinction, spray from a hand nozzle is applied on part of the fire area only, and when this has been extinguished is advanced to cover adjacent burning areas of the pool, the part already extinguished being shielded from radiation by the spray projected over it. Extinction by hand spray may thus possibly require less water than by a fixed installation under critical conditions. It is however also possible that the smaller critical flow rate for the larger pool fire is due to a scale effect, the value of M_c and hence M_1 decreasing as the area of the pool fire increases. Some evidence of such an effect was observed between tests with $4\frac{1}{2}$ in. and 12 in. diameter fires (5).

The curves in Fig. 3 show the relation between limiting flow rate and drop size for different values of Δ T, obtained from Fig. 2, extrapolated when necessary. From these curves the value of M_1 for spray of a given drop size against a pool of fire of a given oil may be found. The drop size of the spray produced by a nozzle may be estimated from the data given elsewhere (6, 7). However, these curves apply strictly to the present operator, and since also an operator with limited experience would be expected to use spray less efficiently than a skilled operator the values of limiting flow rate obtained from Fig. 3 should be at least doubled to give an adequate safety factor.

The curves in Fig. 3 do not of course apply when the drop size of the spray is such that splash fires occur. Although the present and other work has indicated that there is a limiting drop size, for a given condition of application of spray to a fire, above which splash fires are stabilised, further work is necessary to determine the relation rigorously. Results so far obtained suggest that it is inadvisable to use sprays with a drop size greater than 0·7 mm to extinguish fires of kerosine or gas oil.

The learning process

The tests reported herein have shown how the performance of a given operator improved as he gained experience. The constant, and the exponent of L in equation (2) may either or both be dependent on attributes of the operator, and part at least of the 30 per cent residual variable unaccounted for by equation (2) is likely to be due to variations in his performance. A similar improvement in performance of operators has already been observed in trials on the extinction of room fires by water sprays and jets (8). The effect of learning ($L^{-0.33}$, equation (2)) is not unlike that found in the experimental study of the learning process in other fields (9, 10). Most equations representing the learning process include a constant to allow for the minimum times of an operation. Such a minimum time would be expected in the present trials, since a finite time would be required for a given spray to traverse the surface of a pool fire in the course of its extinction. However such a minimum time was not included in order to simplify the derivation of equation (2), but observations suggested that, under the majority of the conditions tested, the minimum time was about 2 or 3 seconds for transformer oil fires.

Conclusions

(1) Pool fires of oils of fire points above 60°C (140°F) of large area may be extinguished with comparative ease by a skilled operator using a spray nozzle on a hand line, provided splash fires are not established.

Conclusions (contd.)

(2) Splash fires occur readily with the less viscid oils of low fire point. The use of hand spray nozzles for the extinction of fires of oils with fire points less than 66°C - 93°C (150°F - 200°F) is not therefore recommended if other means of extinction, such as foam, are available. If sprays are used, the drop-size should be less than 0·7 mm.

(3) There is a critical flow rate below which a given fire cannot be extinguished by hand applied sprays.

(4) The relation between the time for extinction, and spray and fuel properties, indicates that the principal mechanism of extinction is the cooling of the liquid to the fire point.

(5) The efficiency of an operator in extinguishing pool fires by hand applied spray increases with the number of attempts made to extinguish such fires. About 30 attempts by the present operator were necessary before a consistent level of performance was achieved, and it is therefore concluded that a similar degree of training would be desirable for other operators.

Acknowledgements

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References

(1) D. J. Rasbash and Z. W. Rogowski. F.R. Note No. 204/1955.
(2) D. J. Rasbash and Z. W. Rogowski. "Extinction of fires in liquids by cooling with water sprays". Combustion and Flame Vol. 1, No. 4, Dec. 1957.
(3) D. J. Rasbash, Z. W. Rogowski and G. W. V. Stark. "The extinction of oil fires by water spray" (in preparation).
(4) D. J. Rasbash and G. W. V. Stark. F.R. Note No. 303.
(5) D. J. Rasbash. F.R. Note No. 290.
(6) R. P. Fraser, P. Eisenklam and N. Dumbrowski. Brit. Chem. Eng. Vol. 2. No. 10, October, 1957.
(7) D. J. Rasbash. F.R. Note No. 181/1955.
(8) P. H. Thomas and P. M. T. Smart. F.R. Note No. 121/1954.
(9) Carl I. Hovland. "Human learning and retention". Chapter 17. "Handbook of Experimental Psychology". Edited by S. S. Stevens. Chapman & Hall, Ltd., London, 1951.
(10) J. A. C. Williams. "'Learning curves' in production planning". Time and Motion Study, 6, No. 5, May, 1957.

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TABLE 1

Properties of fuels

Type	Flash point °C	Fire point °C	Distillation		Priming petrol (pints)
			First drop °C	50 per cent (vol) °C	
Kerosine	58	61	158	198	0.5
Gas oil	91	98	190	270	1.5
Transformer oil	167	180	220	350	3
Turbine oil	213	228	210	369	3
Heavy fuel oil	149	207	N.D.	N.D.	3

TABLE 2

Properties of sprays

Pressure = 100 lb/in^2

Code	Type	Spray pattern	Cone or plate angle °	Flow rate R gal/min	Estimated drop size mm*
A	Multi-Impinging jet	Radial	≏ 270	14.2	0.41
B	" "	Cone	≏ 90	29	0.5
C	Single pair of impinging jets	Elliptic cone	≏ 80	0.9	0.3
D	" "	" "	≏ 80	1.4	0.36
E	$\frac{1}{8}$" Fan	Plate	≏ 100	2.8	0.7
F	3/16" Fan	"	≏ 100	6.3	0.9
G	$\frac{1}{4}$" Fan	"	≏ 100	11.2	1.0
H	Swirl	Cone	48	20.8	1.0
J	Swirl	"	65	19.0	1.0

Note: *All drop sizes referred to in this note are mass median drop sizes.

TABLE 3

Transformer oil fires

Test No.	Nozzle data			Pool fire data		Ambient conditions		Extinction data		
	Type	No.	Pressure lb/in^2	Depth H cm	Preburn Y min	Wind speed ft/sec	Air temperature °C	Control time sec	Extinction time* sec	Oil temperature after test °C
1	A	1	100	3	1	N.D.	27	N.D.	7.6	83
2	E	1	100	3	1	N.D.	27	N.D.	N.E.	-
3	J	1	100	3	1	N.D.	24	N.D.	20.2	98
4	G	1	100	3	1	5-10	24	> 5	21.7	87
5	H	1	100	3	1	N.D.	24	5	19.4	80
6	D	1	100	3	1	5	24	15	N.E.	-
7	F	1	100	3	1	N.D.	23	15	37	97
8	E	1	100	3	1	5	23	>40	N.E.	-
9	J	1	100	3	1	N.D.	23	3	12.9	74
10	A	1	100	3	1	5	23	5-10	16.8	90
11	E	1	100	3	1	N.D.	23	15	58	81
12	G	1	100	3	1	5	22	<5	18.2	76
13	F	1	100	3	1	N.D.	21	5	25.2	77
14	D	1	100	3	1	N.D.	21	10-15	38.0	123
15	H	1	100	3	1	N.D.	19	5	12.0	61
16	A	2	25	3	1	N.D.	17	5	7.6	93
17	G	1	100	3	1	N.D.	16	10	13.5	56
18	J	1	100	3	1	N.D.	16	10	15.2	68
19	F	1	100	3	1	N.D.	16	10	19.5	79
20	H	1	100	3	1	5	20	12	14.0	50
21	H	2	25	3	1	5	18	10	14.0	70
22	F	2	25	3	1	5	16	10	19.0	72
23	G	2	25	3	1	5	16	10	26.7	56
24	E	2	25	3	1	5	16	12	25.0	99
25	E	1	100	3	1	5	15	11	22.8	87
26	D	1	100	3	1	5	16	20	59.5	94
27	J	2	25	3	1	5	15	5	11.2	82
28	C	1	100	3	1	N.D.	16	40	N.E.	-
29	A	1	100	3	1	N.D.	20	P	4.8	90
30	J	1	100	6	1	5	19	5	10.2	54
31	J	1	100	6	1	N.D.	16	8	13.0	58
32	J	1	100	1	1	5	16	8	13.7	61
33	J	1	100	3	1	5-10	15	7	13.9	69
34	J	1	100	3	1	N.D.	20	5	9.5	83
35	J	1	100	6	1	N.D.	20	5	10.7	55
36	J	1	100	3	1	N.D.	20	5	11.0	55
37	J	1	100	1	1	N.D.	21	4	8.4	91
38	J	1	100	1	1	N.D.	21	5	9.5	67
39	J	1	100	6	1	N.D.	21	5	13.3	49
40	A	1	100	3	5	N.D.	21	N.D.	10.2	93
41	J	1	100	3	5	N.D.	20	7	15.4	57
42	J	1	100	3	3	N.D.	19	7	13.0	49
43	J	1	100	3	5	5	22	7	17.0	57
45	J	1	80	3	3	5	22	10-12	14.2	59
58	D	1	100	3	3	2-5	20	8	58	150
59	A	1	100	3	3	0-2	21	P	6.4	110
60	J	1	100	3	1	N.D.	20	5	10.0	65
61	A	1	100	3	1	0-2	20	3	8.0	91
62	D	1	100	3	5	3-5	9	10-20	22.2	150
63	D	1	100	3	1	2-3	20	10-20	21.5	145
64	B	1	100	2	1	5-10	20	P	3.4	110
65	B	1	100	2	3	5-10	20	P	4.5	85

SYMBOLS AND ABBREVIATIONS

Tables 3 - 7

● = Nozzle on boom, 6 ft long.
* = Severe splash fire.
N.C. = Not controlled.
N.D. = Not determined.
N.E. = Not extinguished in less than 1 minute.
P. = Immediate progressive control and extinction.

Note: Control time = time taken to remove flame from 75 per cent of surface of pool fire.

TABLE 4

Kerosine fires

Test No.	Nozzle data			Pool fire data		Ambient conditions		Extinction data		
	Type	No.	Pressure lb/in^2	Depth H cm	Preburn time Y min.	Estimated wind speed ft/sec	Air temp. °C	Control time sec	Ext'n time sec	Oil temp. after test °C
46	J	1	100	1.4	1.0	5	23	25	81.0	32
47	A	1	100	1.4	1.0	5	21	8	82.0	44
48	D	1	100	1.4	1.0	5	20	N.C.	N.E.	-
49	A	1	100	1.4	1.0	5	19	7	59.4	49
50	J	1	100	1.4	1.0	5	19	7	60.0	38
51	J	2	100	1.3	1.0	5-10	17	4-5	16.0	43
52	J	2	100	3.1	1.0	5-10	20	5-6	90.0*	30
54	A	2	100	3.0	0.5	5-10	24	3	19.0	41
55	A	2	100	2.9	1.0	5-10	24	4	49.3	50
56	A	2	100	2.9	3.0	5	24	5	65.0	57
80	B	1	100	1.1	1.0	15	17	<7	40.0	35
81	B	1	100	3.2	3.0	15-20	18	5	60.0	43
82	B	1	100	3.0	1.0	15-20	17	<7	41.2	45
83	A@	1	100	1.0	1.0	15-20	17	7	54.6	45
84	A	2	25	1.0	1.0	15-20	17	12	N.E.	-
86	A	1	200	1.0	1.0	1-2	13	7	30.0	40
88	A	2	50	0.65	1.0	5-10	15	4	28.0	42

TABLE 5

Gas oil fires

Test No.	Nozzle data			Pool fire data		Ambient conditions		Extinction data		
	Type	No.	Pressure lb/in^2	Depth H cm	Preburn time Y min.	Estimated wind speed ft/sec	Air temp. °C	Control time sec	Ext'n time sec	Oil temp. after test °C
66	J	1	100	1.0	1.0	1-3	20	5	20.0	50
67	A	1	100	1.0	1.0	1-3	18	5	36.4	69
68	D	1	100	1.0	1.0	2-7	17	N.C.	N.E.	-
69	J	1	100	3.0	3.0	5-10	15	5	40.0	42
70	J	1	100	3.0	0.5	5-10	16	5	10.2	36
71	A	1	100	3.0	0.5	5-10	16	6	21.1	62
72	A	1	100	3.0	3.0	5-10	16	5	29.4	85
73	A	1	100	2.3	1.0	5-10	15	5	23.2	80
74	J	1	100	2.05	1.0	5-10	14	5	25.8	50
75	A@	1	100	1.75	1.0	5-10	14	4	12.0	N.D.
77	A	2	25	1.4	1.0	10-15	17	5	32.0	58
78	B	1	100	1.3	1.0	10-15	17	<5	12.6	80
79	B	1	100	1.0	0.5	10-15	18	P	4.0	45

TABLE 6

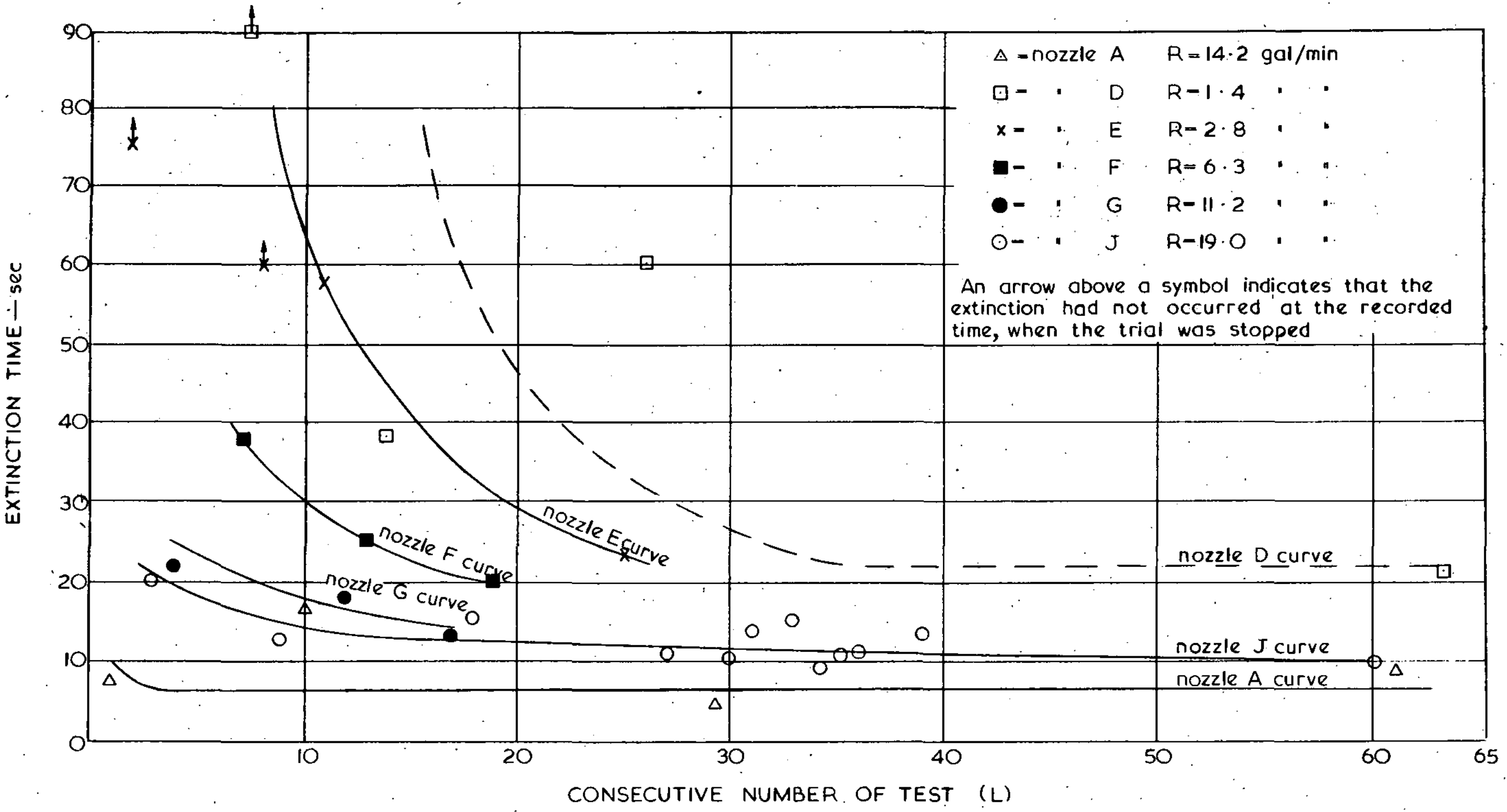
Turbine oil fires

Test No.	Nozzle data			Pool fire data		Ambient conditions		Extinction data		
	Type	No.	Pressure lb/in^2	Depth H cm	Preburn time Y min.	Estimated wind speed ft/sec	Air temp. °C	Control time sec	Ext'n time sec	Oil temp. after test °C
90	J	1	100	3.0	5	15	15	8	18.8	84
91	J	1	100	1.8	3	15	15	5	12.0	69
92	J	1	100	1.4	1	5-10	15	3	10.0	64
93	D	1	100	0.8	1	5-10	15	5	15.2	90

TABLE 7

Heavy fuel oil fires

Test No.	Nozzle data			Pool fire data		Ambient conditions		Extinction data		
	Type	No.	Pressure lb/in^2	Depth H cm	Preburn time Y min.	Estimated wind speed ft/sec	Air temp. °C	Control time sec	Ext'n time sec	Oil temp. after test °C
100	B	1	100	3.0	1.0	15	13	P	4	98
101	J	1	100	3.0	1.0	10-15	9	P	7	88
102	A	1	100	2.6	1.0	1-3	12	P	3-4	92
103	D	1	100	2.8	1.0	1-3	12	5	16	80
104	A	1	100	2.9	5.0	0-2	12	P	6	151
105	J	1	100	3.5	5.0	0-1	12	5	11.5	155
106	D	1	100	3.1	5.0	0-2	12	15	26	162
107	D	1	100	3.0	3.0	1-3	12	10	20.6	150
108	J	1	100	<2.0	1.0	0-2	15	3	7.2	159
109	A	1	100	<2.0	1.0	0-2	15	P	4.5	124
110	D	1	100	<2.0	1.0	0-2	15	7	10.0	148
111	B	1	100	<2.0	3.0	0-2	15	P	3.2	104



An arrow above a symbol indicates that the extinction had not occurred at the recorded time, when the trial was stopped

FIG.1. EFFECT OF EXPERIENCE ON EXTINCTION TIME
TRANSFORMER OIL FIRES AT 1min PREBURN

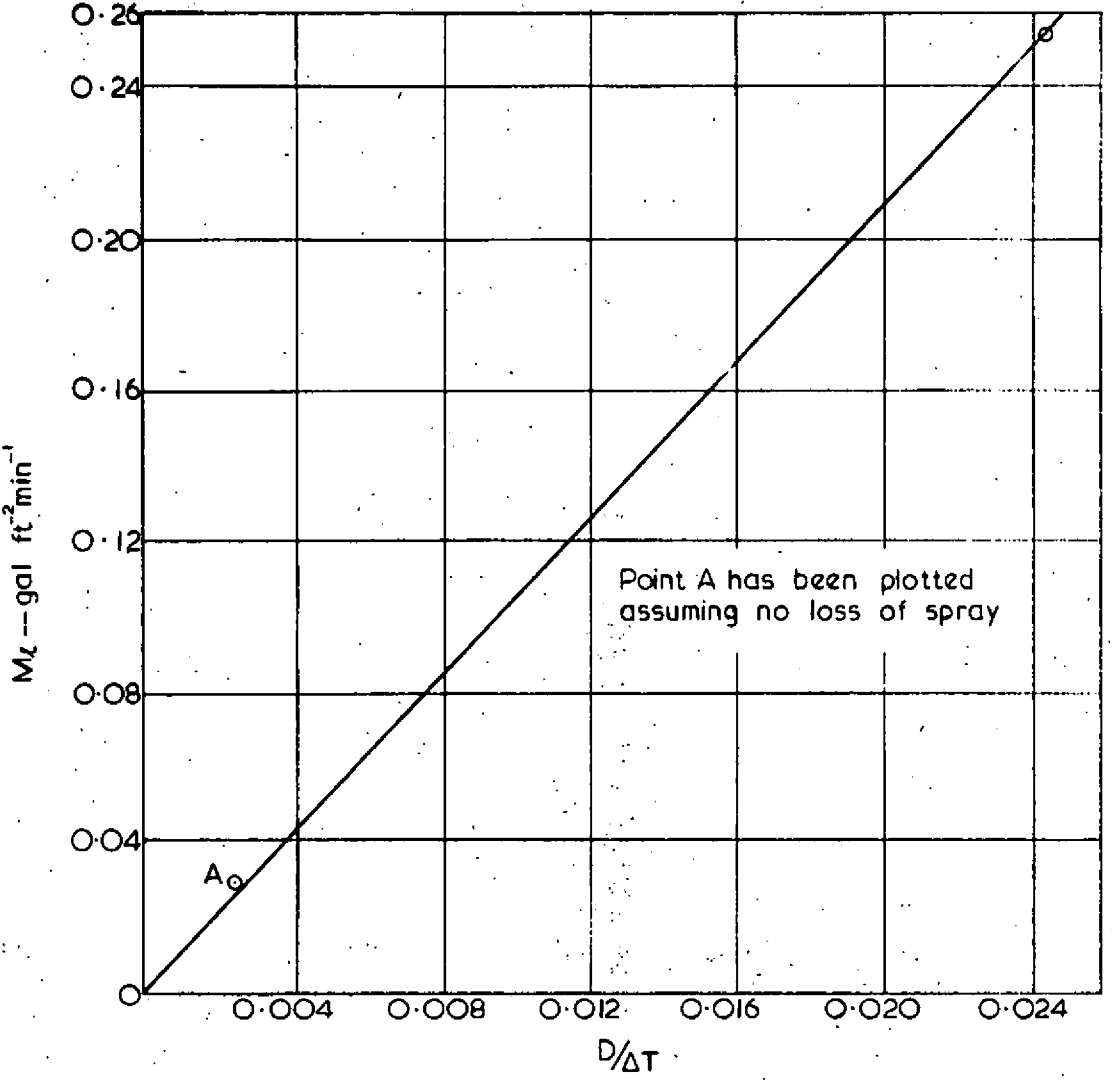


FIG 2 RELATION BETWEEN LIMITING FLOW RATE AND $\frac{D}{\Delta T}$

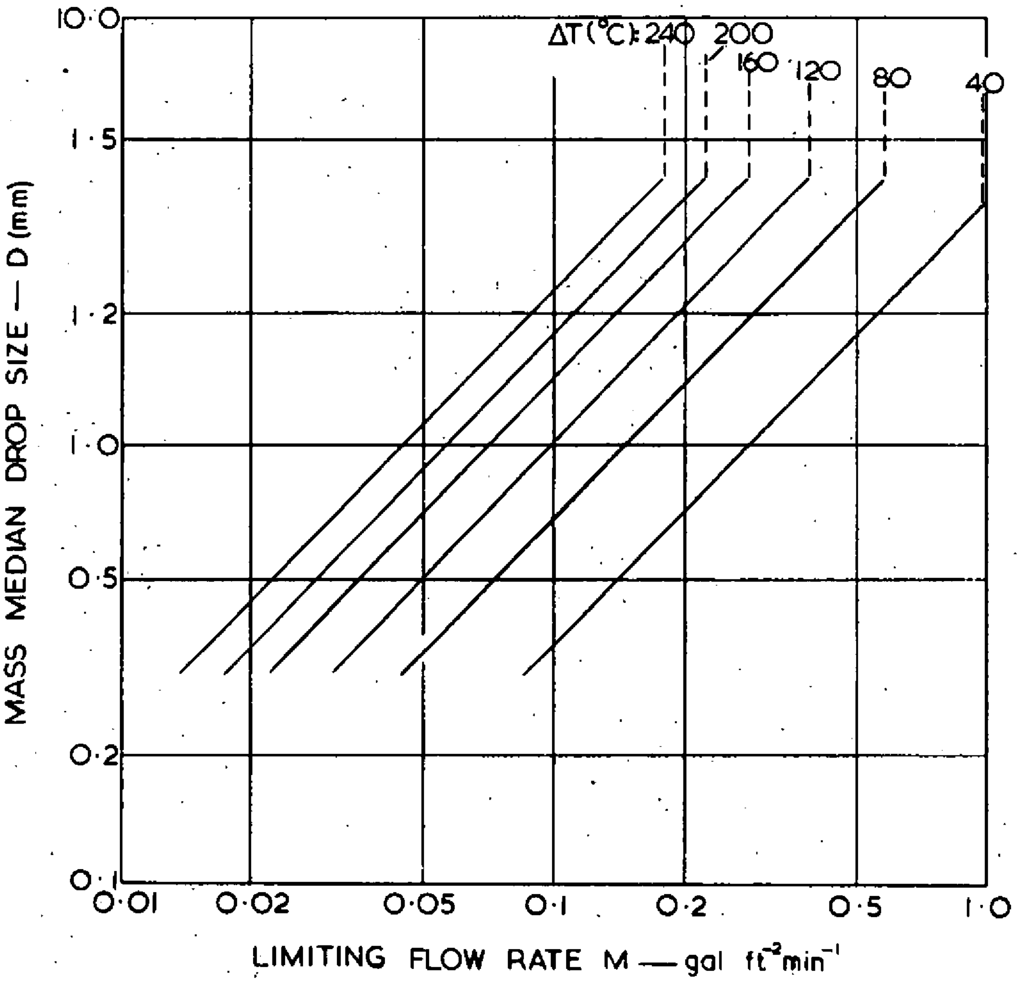
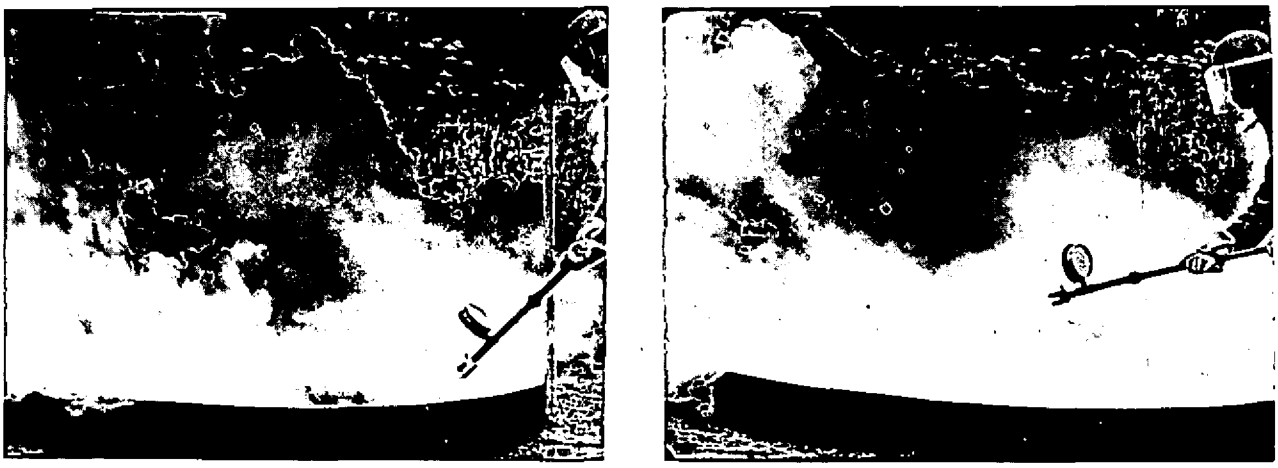


FIG. 3. RELATION BETWEEN DROP SIZE AND LIMITING FLOW RATE

i. FIRE BEFORE APPLYING WATER SPRAY

ii. FIRST STAGE: EXTINCTION AT NEARSIDE OF RIM



iii. FIRE UNDER CONTROL. EXTINCTION OF FLAMES AT RIM

iv. FIRE JUST BEFORE EXTINCTION

PLATE

EXTINCTION OF HEAVY FUEL OIL FIRE BY HAND SPRAY
NOZZLE D, TEST N°. 110