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**THE PERFORMANCE OF WATER-TYPE EXTINGUISHERS  
ON EXPERIMENTAL CLASS A FIRES**

by

**M. J. O'DOGHERTY, R. A. YOUNG and A. LANGE.**

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THE PERFORMANCE OF WATER-TYPE EXTINGUISHERS ON  
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SUMMARY

The work described in this report was carried out on wood fires using water jet extinguishers of capacity 5.7 and 9.1 l (1 $\frac{1}{4}$  and 2 gal). The report describes tests carried out to the requirements of French and West German standards and experiments conducted with an experimental crib, of constant cross-sectional dimensions, to study the effect of increasing the length on the extinction time and the quantity of water used to extinguish the flames. A study was also made of the effect of the pre-burn time of a German standard crib on the extinction time and the re-ignition time.

KEY WORDS: Extinguisher (hand operated), water, jets, tests, wood fire, extinguishing.

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MEMORANDUM FOR THE RECORD

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# THE PERFORMANCE OF WATER-TYPE EXTINGUISHERS ON EXPERIMENTAL CLASS A FIRES

by

M. J. O'Dogherty, R. A. Young and A. Lange

## 1. INTRODUCTION

The first tripartite meeting of the standards organisations of France, West Germany and the United Kingdom (CENTRI 2 Committee) was held on 18-20th October 1967, under the aegis of CEN (Comité Européen de Coordination des Normes). The meeting was held to discuss requirements for standards for hand fire extinguishers to be agreed between the three countries, and which would be suitable for further consideration as International Standards by I.S.O. It was agreed that a programme of work be undertaken by the appropriate laboratories of the three countries to develop suitable fire tests for the various types and sizes of hand extinguishers<sup>1</sup>. The principle of testing to be adopted was that there should be a series of fires of increasing size, against which the performance of any given size and type of extinguisher could be measured.

This note describes an investigation of a number of types of Class A fires to establish a type suitable for the testing of water extinguishers. A wood crib fire was used which had constant cross-sectional dimensions, and the size of fire was increased by an increase in the length of the crib. Experiments were conducted with extinguishers of 5.7 and 9.1 l ( $1\frac{1}{4}$  and 2 gal) capacity to determine how increases in length affected the extinction of the crib.

## 2. EXPERIMENTAL

### (a) French and West German standard tests

Tests were made on the sizes of fire specified in French standard NF S 61-912<sup>2</sup> appropriate to extinguishers having capacities of 5.7 and 9.1 l. The form of fire used in the French tests is detailed in NF S 61-902<sup>3</sup>. The fires consist of a wire mesh basket, in the form of a rectangular parallelepiped, containing 10 cm lengths of wood sticks. The length of the basket and the weight of wood increases in a regular series, and extinguishers in a particular size range are required to extinguish a fire of a specified size. Plate 1a shows a general view of a fire at the beginning of a test.

Tests were also made using a 9.1 l extinguisher on the size of fire appropriate to a 10 l capacity which is specified in DIN 14 406<sup>4</sup>. This test

fire is a wood crib made of 4 cm square sticks each 60 cm long, with a 4 cm spacing between sticks. The crib contains approximately 45 kg (99 lb) of wood.

(b) Experimental test fire

Following the tests described in 2(a) above, it was decided that a crib type of fire should be used for test purposes. The crib would have constant cross-sectional dimensions, the length being varied to alter the difficulty of extinction. The specification of the crib used was as follows:

Type of wood : Pinus Sylvestris (Scots pine or Baltic redwood)  
Stick size : 2 cm square  
Spacing : 6 cm between adjacent sticks  
Cross-section :  $\frac{1}{2}$  m x  $\frac{1}{2}$  m  
Number of sticks per layer,  $n = \frac{L + 6}{8}$  where L is the crib dimension in cm.  
Pre-burn time : 3 min (including 2 min ignition by petrol)

Generally, for a particular value of L, the number of sticks is not integral, and the nearest integer was taken which gave the spacing nearest to 6 cm. In some cases, e.g. for L = 1.5 m, there were two alternative values for n (19 or 20), and in such a case the number of sticks was chosen so as to give the larger spacing, i.e. 19 in the example given.

In most of the experiments the mean moisture content was in the range 10 to 14 per cent, which was found to be applicable to bundles of wood which had been stored for a period of 2 to 3 weeks in a centrally-heated storeroom.

The length of the crib was increased by  $\frac{1}{4}$  m increments from a minimum of  $\frac{1}{2}$  m (crib in the form of  $\frac{1}{2}$  m cube), up to a maximum length of  $1\frac{3}{4}$  m.

Ignition of the fire was by petrol contained in a tray equal in area to the base area of the crib which was supported at 28 cm above floor level on steel cross members supported on bricks. Plate 1b shows an experimental crib, 1 m long, before a test.

For each length of crib, the fire was extinguished by applying water from a distance of 5 m until the flames were beaten down to the level of the top of the crib, after which the operator was free to move closer to the crib to extinguish flaming within it. At least three replications were made for each crib length.

The criterion for extinction was as follows. It was required that there should be no visible flaming within the crib at the conclusion of the extinguisher discharge (which was aimed into the crib until the contents were

exhausted), and that there should be no re-ignition of flames within five minutes of completion of discharge.

The extinguishers used were of the jet type, and their discharge characteristics are shown in Figure 1.

(c) Effect of pre-burn time (West German test crib)

The length of time for which the crib was allowed to burn freely before application of the water (the "pre-burn time"), was thought to be likely to influence the difficulty of extinction of the crib, and the chances of re-ignition. Some experiments were made using the German crib specified for a 10 l extinguisher. Instead of the specified 12 minutes pre-burn, with 2 minutes petrol ignition, the following pre-burn times were used, including a petrol ignition time of 1 minute in each case: 3, 6,  $7\frac{1}{2}$ , 9,  $12\frac{1}{2}$  and  $14\frac{1}{2}$  minutes. The fire was attacked in the manner specified in DIN 14 406.

### 3. RESULTS

(a) French and West German standard fires.

In the tests on the French fires for extinguishers of capacities 5.7 and 9.1 l, the fires were extinguished in times well within the capacities of the extinguishers (see Table 1). For example, for the 9.1 l size, the mean extinction time was  $12\frac{1}{2}$  s, compared with a total effective discharge time of 60-65s. It was found that the sticks constituting the fire did not burn uniformly within the fuel bed, and at the conclusion of the extinction, a number of sticks were virtually unburnt. The fire burned largely on the surface of the fuel bed, with isolated areas of intense burning. The water jet from the extinguisher was able to extinguish this type of fire with ease. A point noted during extinction was that the jet was able to penetrate the thickness of the fuel bed and emerge on the opposite side so that water was wasted from an extinction point of view.

The French fires were of a complex form, and involved a good deal of effort in removing the shields and trays before extinction could begin. It was judged that a minimum of four people were required to carry out a test effectively with the larger sizes of fires, which are constituted of a number of separate baskets, each with its side shields and ignition trays. The quantity of metal (mild steel) in the fires is high, with a weight equal to several times that of the wood involved, as can be seen from Table 2 for the first four sizes of fire.

It should be noted that the French standard NF S 61-902, while specifying sticks of 1 cm square and 2 cm square section (both 10 cm long), does not specify the relative proportions to be employed. It was decided to use 1 cm square sticks for half the total weight of wood, and 2 cm square for the remainder.

The tests on the West German standard fire with a 9.1 l extinguisher, showed that the fire could be extinguished in an average time of 21s. In all three tests however, flaming recurred within the 3 min period specified for non-reignition, and the fire eventually became re-established. The German standard (DIN 14 406) does not specify a time for ignition, merely stating that the crib should be ignited by petrol until it is well alight. In the experiments, an ignition time of 5 min was used in the first test, but this was reduced to 2 min in the other tests. The pre-burn time of 12 min appears to be unnecessarily long, and could be reduced without appreciably affecting the rate of burning of the crib, which was totally involved after about 3 to 4 minutes. The effect of varying the pre-burn time is described in section 3(c). The large stick size (4 cm square) made the crib easy and quick to construct. The cribs contained 43 to 45 kg (95 to 101 lb) of wood.

(b) Experimental test fire

The results of the experiments are given in Table 3, and in Figures 2 and 3 the times for the flames to be knocked down and the extinction times are plotted against the crib length, for the 5.7 and 9.1 l sizes of extinguisher. The graphs show the range of times observed at each crib length. Figure 1 used in conjunction with Figures 2 and 3 enables the quantity of water required to extinguish a particular crib length to be determined.

The results given in Figures 2 and 3 show that both the time required to knock down the flames and the extinction time are linearly related to the crib length. The time to knock down the flames forms a smaller proportion of the extinction time as the crib is lengthened, because the longer cribs take relatively longer to extinguish after the operator moves in. Thus for the 9.1 l extinguisher used on the  $\frac{1}{2}$  m crib, the knock-down time was about 51 per cent of the extinction time, and for the same extinguisher used on the  $1\frac{1}{4}$  m crib, it was 44 per cent.

The results for the 5.7 and 9.1 l extinguishers show increases in extinction time with crib length which are linear and practically parallel, the 5.7 l extinguisher having extinction times approximately 4 s longer than those for the 9.1 l extinguisher. The total quantity of water used to extinguish flaming is given in Figure 4, which shows that there was no practical difference in the

quantities for the two extinguisher sizes. The relationship between the total quantity of water for extinction and crib length is a proportionate one, approximately 5 l of water being required per metre of crib length.

(c) Effect of pre-burn time

The results of the experiments using the West German standard test fire are given in Table 4, and the re-ignition times and extinction times are plotted against pre-burn time in Figures 5 and 6 respectively.

Figure 5 shows that for pre-burn times less than  $7\frac{1}{2}$  min there is unlikely to be any re-ignition. The re-ignition time falls very rapidly with increasing pre-burn to only about 25 s for a pre-burn time of  $14\frac{1}{2}$  min. The extinction time increases linearly with pre-burn time from 5 s for a 5 min pre-burn to  $36\frac{1}{2}$  s for a  $14\frac{1}{2}$  min pre-burn. The extinction times for the 12 min pre-burn are lower than would be expected.

The pre-burn time affects both extinction and re-ignition and therefore a criterion for extinction must take both factors into account for a given fire configuration and size, such as that in the German standard. The specified pre-burn time of 12 min results in rapid re-ignition (unless the crib is knocked down, which is understood to be the German practice), and a criterion of about 50 s would have to be adopted to ensure successful extinction. If the pre-burn were reduced to 9 min, extinction would be achieved about 7 s earlier (in about 78 per cent of the time appropriate to the 12 min pre-burn) and re-ignition is unlikely in less than 3 min. For short pre-burn times (less than  $7\frac{1}{2}$  min), the curve of Figure 5 shows that the crib is unlikely to re-ignite, and will be extinguished fairly rapidly, so that the fire will not represent an adequate test of the extinguisher.

#### 4. DISCUSSION AND CONCLUSIONS

(a) French and West German test fires

The French test fires did not burn uniformly and most of the burning was on the outside surfaces of the fuel bed. The fire was very easily extinguished and did not test adequately the capability of the extinguisher sizes used. The fuel bed was narrow and allowed penetration of a water jet through it. The fire was a complex structure of baskets, shields and ignition trays, and contained a high proportion of metal to fuel. The principle of increasing the length of the fire in relation to extinguisher capacity, however, is a good basis for establishing the appropriate size of test fire.



The German standard crib fire for a 10 l extinguisher was extinguished well within the capacity of a 9.1 l extinguisher, but re-ignition occurred within the 3 min period required in all three tests made. No period for ignition by petrol is specified in the German standard. The pre-burn period of 12 min is a long one, but the 4 cm square stick size makes for rapid construction of the crib.

(b) Experimental crib fire

The configuration of fire used in the experiments was such that an increase in crib length had a significant effect on the difficulty of extinction. The results indicate that the use of a crib of constant cross-sectional dimensions, but of variable length, is a convenient means of specifying a test fire for hand extinguishers. The experiments showed that for water extinguishers, the total quantity of water required for extinction was proportional to the crib length, and was equal to approximately 5 l per metre of crib length for the two sizes of extinguisher examined.

The selection of a size of fire which provides an adequate test for an extinguisher of given capacity will depend on the margin chosen in relation to the expected scatter of results, so that the probability of failure to extinguish the test fire is low. Other factors which may be considered in determining an appropriate size of fire are differences in technique between operators, and the fact that in service the extinguisher may be used by an inexperienced person.

(c) Pre-burn time

For a fire of given size and configuration, the extinction time and re-ignition time are not independent. As the pre-burn time increases, the extinction times increases almost linearly, but above a particular pre-burn time the re-ignition times decrease very rapidly from very high values which represent no re-ignition in practical terms. The pre-burn time has to be chosen so as to represent an adequate task of extinction, in terms of extinguisher capacity, and the re-ignition time should then be specified so that the probability of re-ignition is low.

5. REFERENCES

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2. French Standard NF S 61-912, Fire fighting equipment : water extinguishers. Association Francaise de Normalisation (AFNOR), Feb. 1966.

3. French Standard NF S 61-902, Fire fighting equipment : fire types for testing portable fire extinguishers. Association Francaise de Normalisation (AFNOR), Aug. 1965.
4. DIN 14 406 (Sheet 2), Fire extinguishers. Portable extinguishers : tests for portable appliances. Deutschen Normenausschuss (DNA), May 1967.

Table 1

Results of French and German tests

French standard tests

Ignition time =  $3\frac{1}{2}$  min

Total pre-burn time = 4 min

No re-ignition within 5 min

Equal weights of 1 cm square and 2 cm square sticks in 10 cm lengths.

| Fire length<br>(dm) | Weight of<br>wood<br>(kg) | Extinguisher<br>size<br>(l) | Flame<br>knockdown<br>time<br>(s) | Extinction<br>time<br>(s) | Re-ignition<br>time<br>(s) |
|---------------------|---------------------------|-----------------------------|-----------------------------------|---------------------------|----------------------------|
| 13 <sup>(1)</sup>   | 13 <sup>(1)</sup>         | 5.7                         | 10                                | 20                        | No re-ignition observed    |
| 21 <sup>(2)</sup>   | 21 <sup>(2)</sup>         | 9.1                         | -                                 | 10                        | "                          |
| 21 <sup>(2)</sup>   | 21 <sup>(2)</sup>         | 9.1                         | 7                                 | 15                        | "                          |

(1) Appropriate to extinguisher capacities between 3 and 6 l.

(2) " " " " " 6 and 10 l.

German standard test (10 l water extinguisher)

Stick size = 4 cm square

Total pre-burn time = 12 min

Spacing = 1:1

Crib dimensions = 60 cm x 60 cm x 48 cm

No re-ignition within 3 min.

9.1 l water extinguisher

| Ignition<br>time<br>(min) | Flame<br>knockdown<br>time<br>(s) | Extinction<br>time<br>(s) | Re-ignition<br>time<br>(s) |
|---------------------------|-----------------------------------|---------------------------|----------------------------|
| 5                         | 11                                | 17                        | 87                         |
| 2                         | 11                                | 23                        | 60                         |
| 2                         | 12                                | 23                        | 157                        |

Table 2

Weight of wood and metal in French standard Class A fires

| Fire designation | Weight of wood (kg) | Weight of metal (kg) | Ratio of weight of metal to wood |
|------------------|---------------------|----------------------|----------------------------------|
| 3 A              | 3                   | 17.2                 | 5.73                             |
| 5 A              | 5                   | 22.2                 | 4.44                             |
| 8 A              | 8                   | 29.5                 | 3.68                             |
| 13 A             | 13                  | 41.3                 | 3.18                             |

Table 3

Results for experimental crib

Stick size = 2 cm square

Spacing = 3:1 (nominal)

Cross section =  $\frac{1}{2}$  m x  $\frac{1}{2}$  m

Ignition time = 2 min

Total pre-burn time = 3 min

No re-ignition within 5 min.

1 $\frac{1}{2}$  gal (5.7 l) water extinguisher

| Crib length<br>(m) | Flame<br>knockdown<br>time<br>(s) | Extinction<br>time<br>(s) | Re-ignition<br>time<br>(s) |
|--------------------|-----------------------------------|---------------------------|----------------------------|
| 0.5                | 8                                 | 16                        | No re-ignition observed    |
|                    | 12                                | 17                        | "                          |
| 0.75               | 9                                 | 25-30                     | "                          |
|                    | 17                                | 30                        | "                          |
|                    | 12                                | 22                        | "                          |
| 1                  | 16                                | 33                        | "                          |
|                    | 15                                | 28                        | "                          |
|                    | 13                                | Not extinguished          | -                          |
|                    | 16                                | 37                        | "                          |

2 gal (9.1 l) water extinguisher

| Crib length<br>(m) | Flame<br>knockdown<br>time<br>(s) | Extinction<br>time<br>(s) | Re-ignition<br>time<br>(s) |
|--------------------|-----------------------------------|---------------------------|----------------------------|
| 0.5                | 5-10                              | 10-15                     | No re-ignition observed    |
|                    | 7                                 | 15-17                     | "                          |
|                    | 7                                 | 17                        | "                          |
| 0.75               | 11                                | 20                        | "                          |
|                    | 9                                 | 17-20                     | "                          |
|                    | 10                                | 19                        | "                          |
| 1                  | 20                                | 40-45                     | "                          |
|                    | 15                                | 28                        | "                          |
|                    | 12                                | 45-47                     | "                          |
|                    | 10                                | 30                        | "                          |
|                    | 10                                | 25-30                     | "                          |
| 1.5                | 20                                | 35-40                     | "                          |
|                    | 23                                | 40                        | "                          |
|                    | 16                                | 44                        | "                          |
| 1.75               | 9                                 | Not extinguished          | -                          |
|                    | 11                                | 50                        | "                          |

Table 4

Results of study of effect of pre-burn time

Stick size = 4 cm square

Spacing = 1:1

Crib dimensions = 60 cm x 60 cm x 48 cm

Ignition time = 1 min.

| Total pre-burn time (min) | Flame knockdown time (s) | Extinction time (s) | Re-ignition time (s) <sup>(1)</sup> |
|---------------------------|--------------------------|---------------------|-------------------------------------|
| 3                         | 12                       | 20                  | -(2)                                |
| 6                         | 9                        | 15                  | -(2)                                |
|                           | 10                       | 16                  | -(2)                                |
| 7½                        | 11                       | 23                  | 899                                 |
|                           | 11                       | 22                  | -(2)                                |
|                           | 12                       | 20                  | -(2)                                |
| 9                         | 10                       | 21                  | 227                                 |
|                           | 9                        | 25                  | 206                                 |
|                           | 11                       | 25                  | 278                                 |
| 12½                       | 12                       | 45                  | 43                                  |
| 14½                       | 15                       | 36                  | 22                                  |
|                           | 15                       | 32                  | 27                                  |
|                           | 12                       | 42                  | 25                                  |

(1) Measured from end of effective discharge of extinguisher.

(2) No re-ignition observed.

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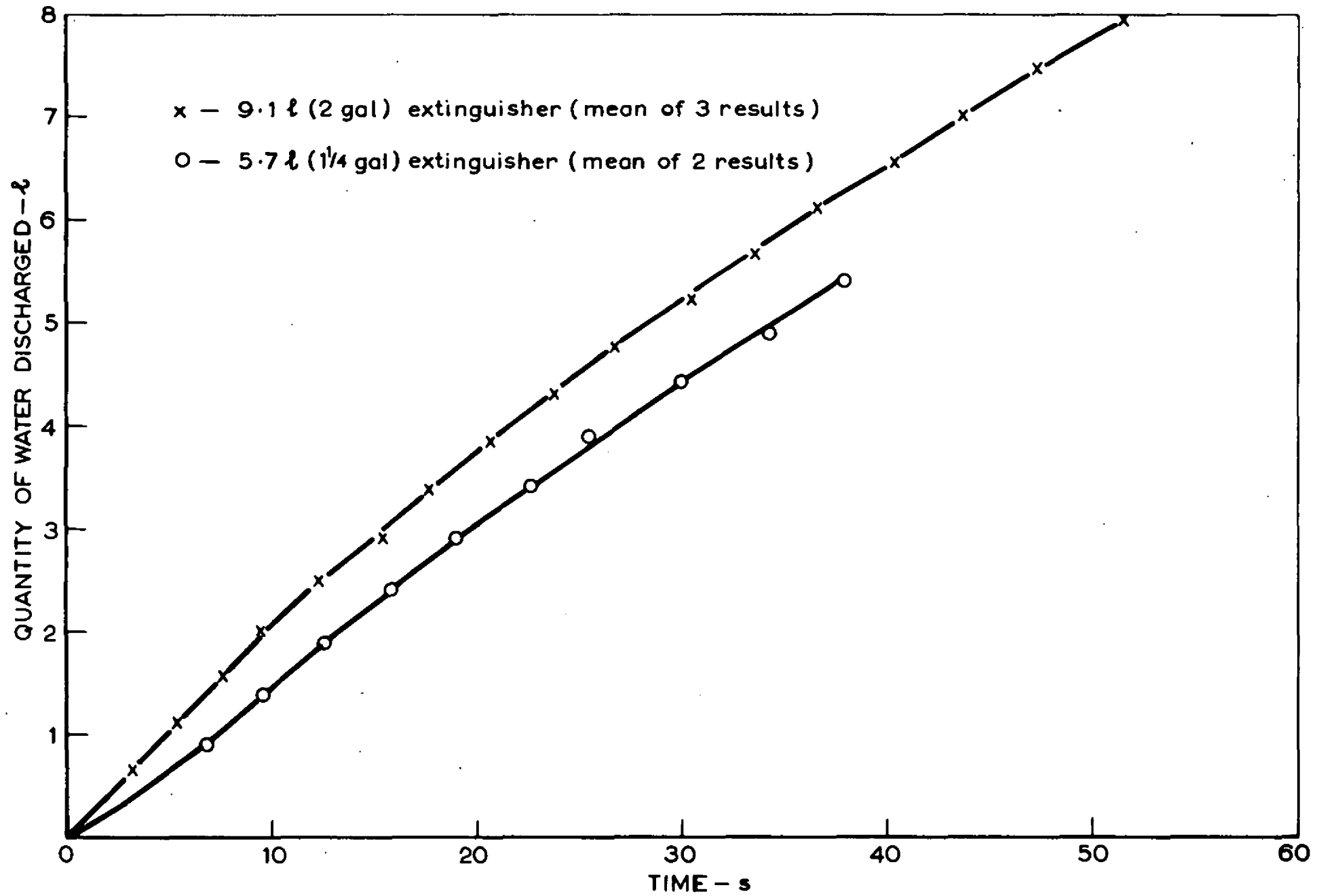
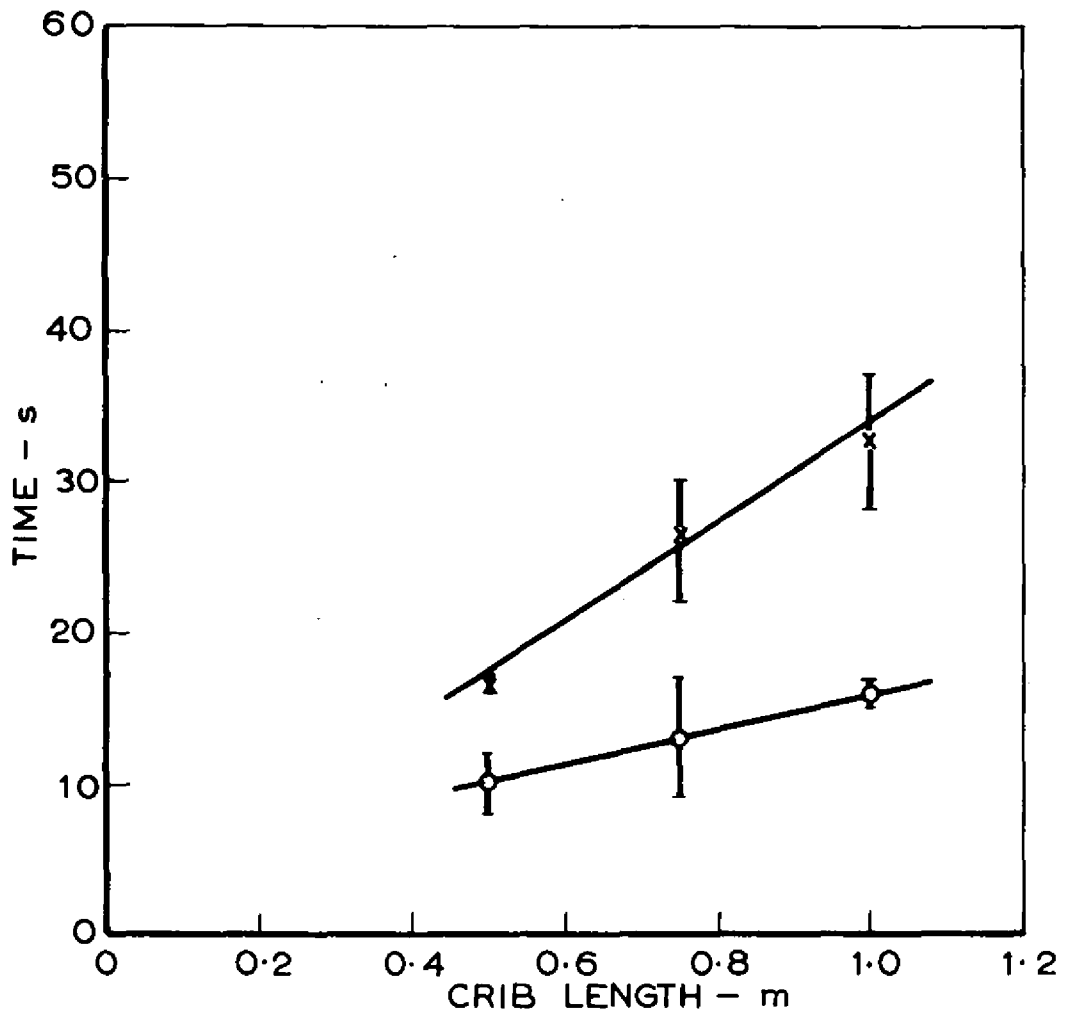


FIG.1. VARIATION IN QUANTITY OF WATER DISCHARGED WITH TIME

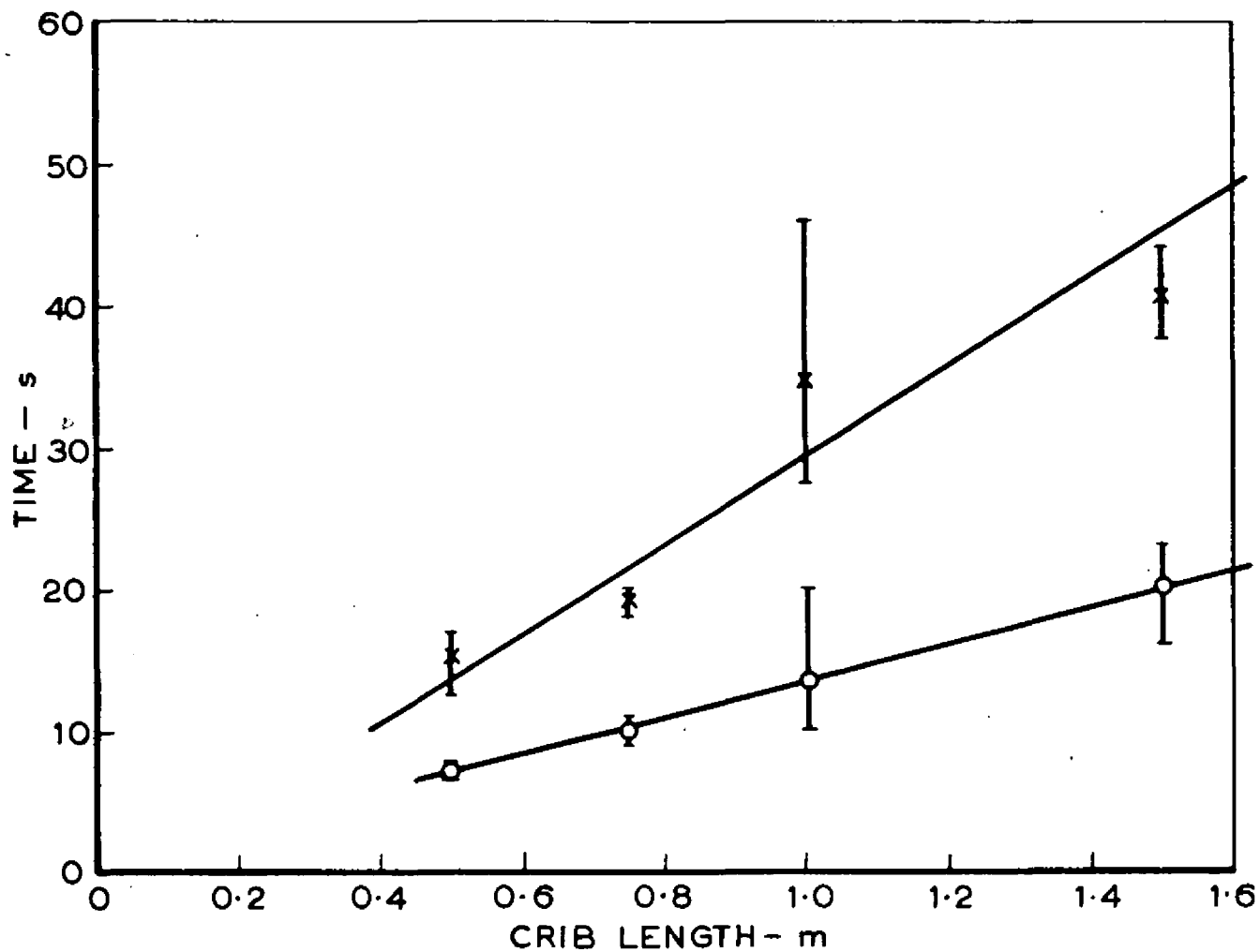




5.7ℓ (1¼ gal) water extinguisher  
 Crib section = ½m x ½m  
 2 cm square sticks  
 3:1 spacing  
 x - Extinction  
 o - Flame knockdown  
 I - Range of results

FIG. 2. VARIATION OF EXTINCTION TIME AND FLAME KNOCKDOWN TIME WITH CRIB LENGTH

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9.1 ℓ (2 gal) water extinguisher

Crib section = 1/2m x 1/2m

2 cm square sticks

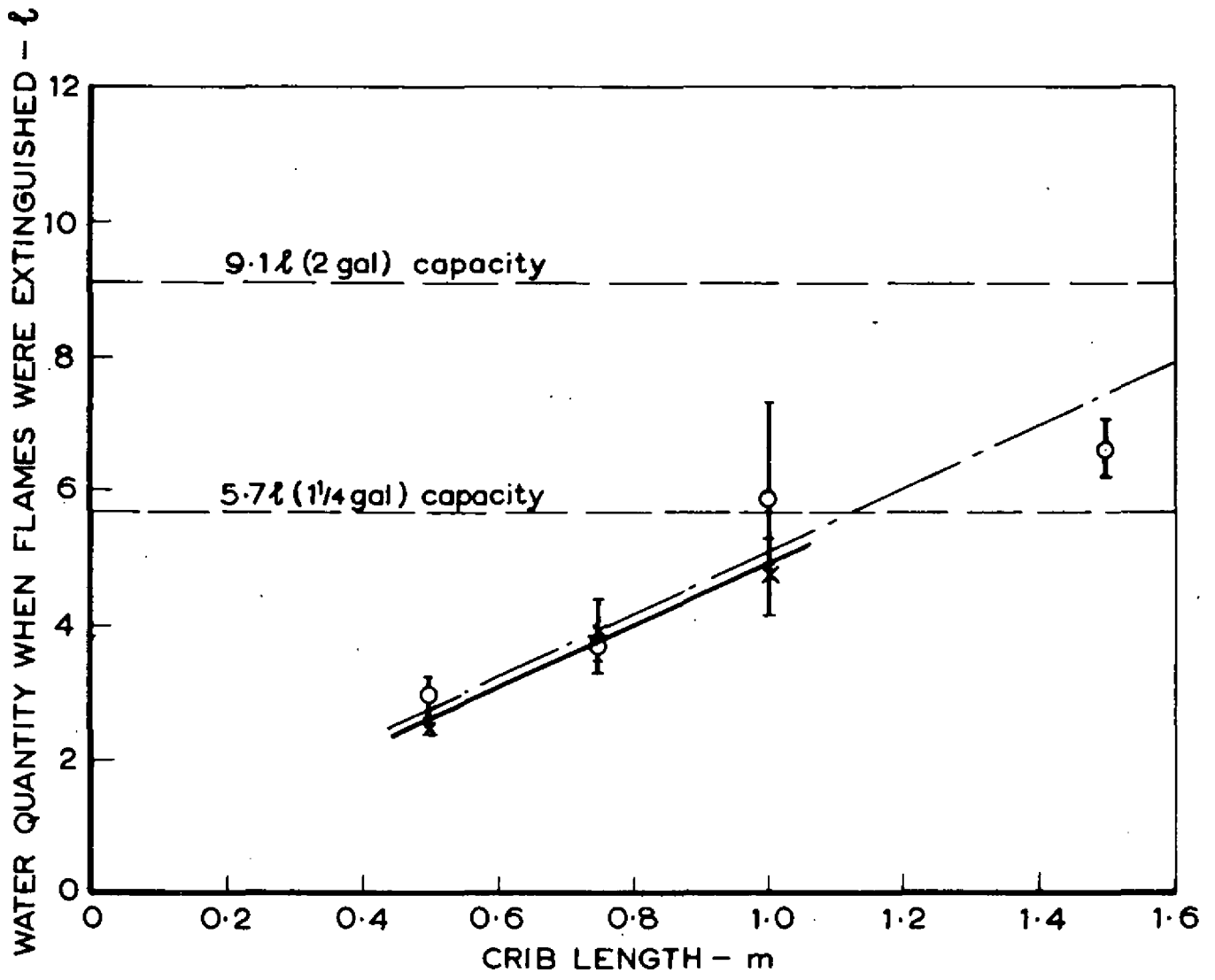
3:1 spacing

x - Extinction

o - Flame knockdown

I - Range of results

FIG. 3. VARIATION OF EXTINCTION TIME AND FLAME KNOCKDOWN TIME WITH CRIB LENGTH



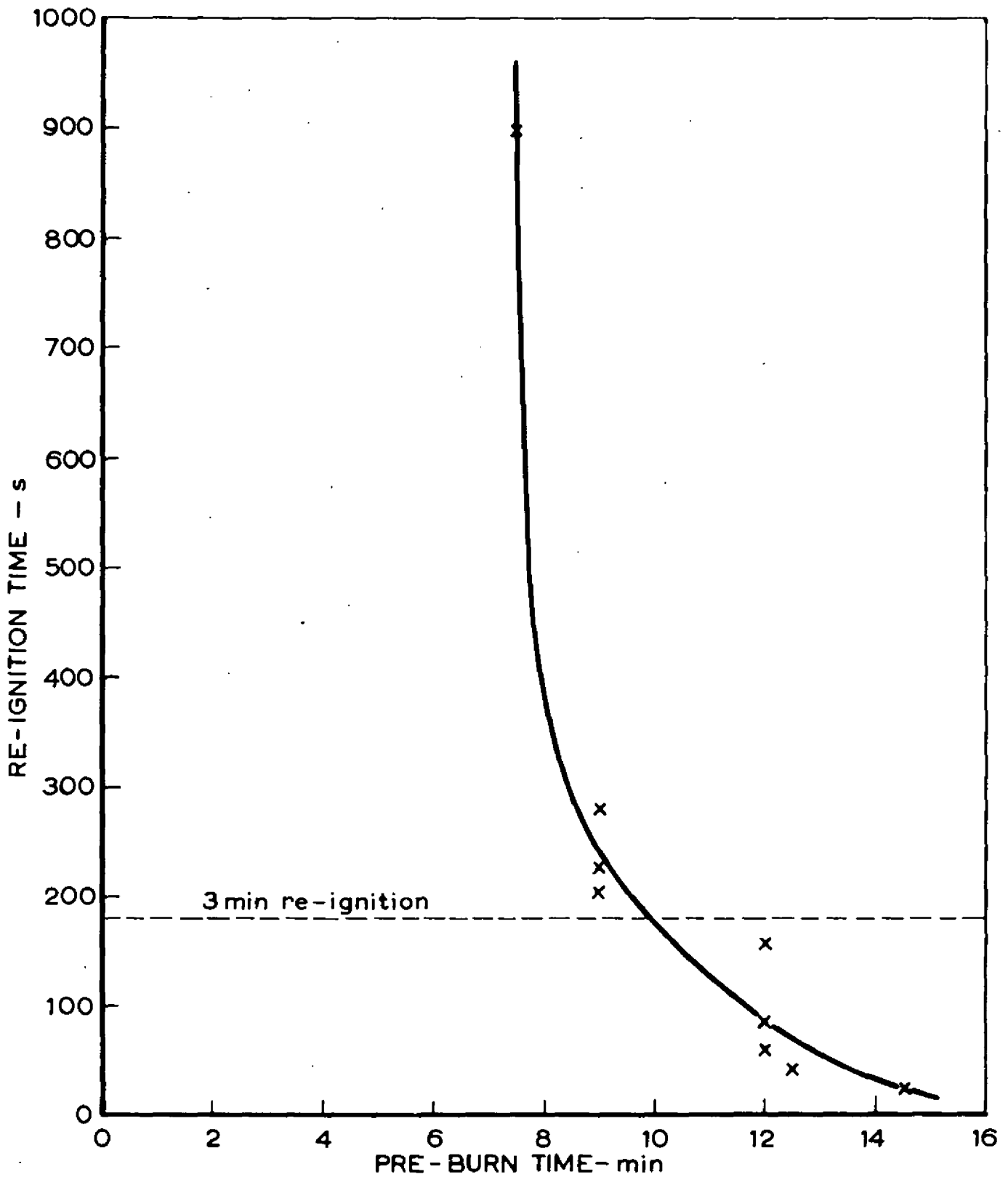
Crib section = 1/2 m x 1/2 m  
 2 cm square sticks  
 3:1 spacing

○ — ○ 9.1ℓ (2 gal)  
 × — × 5.7ℓ (1 1/4 gal)

┆ Range of results

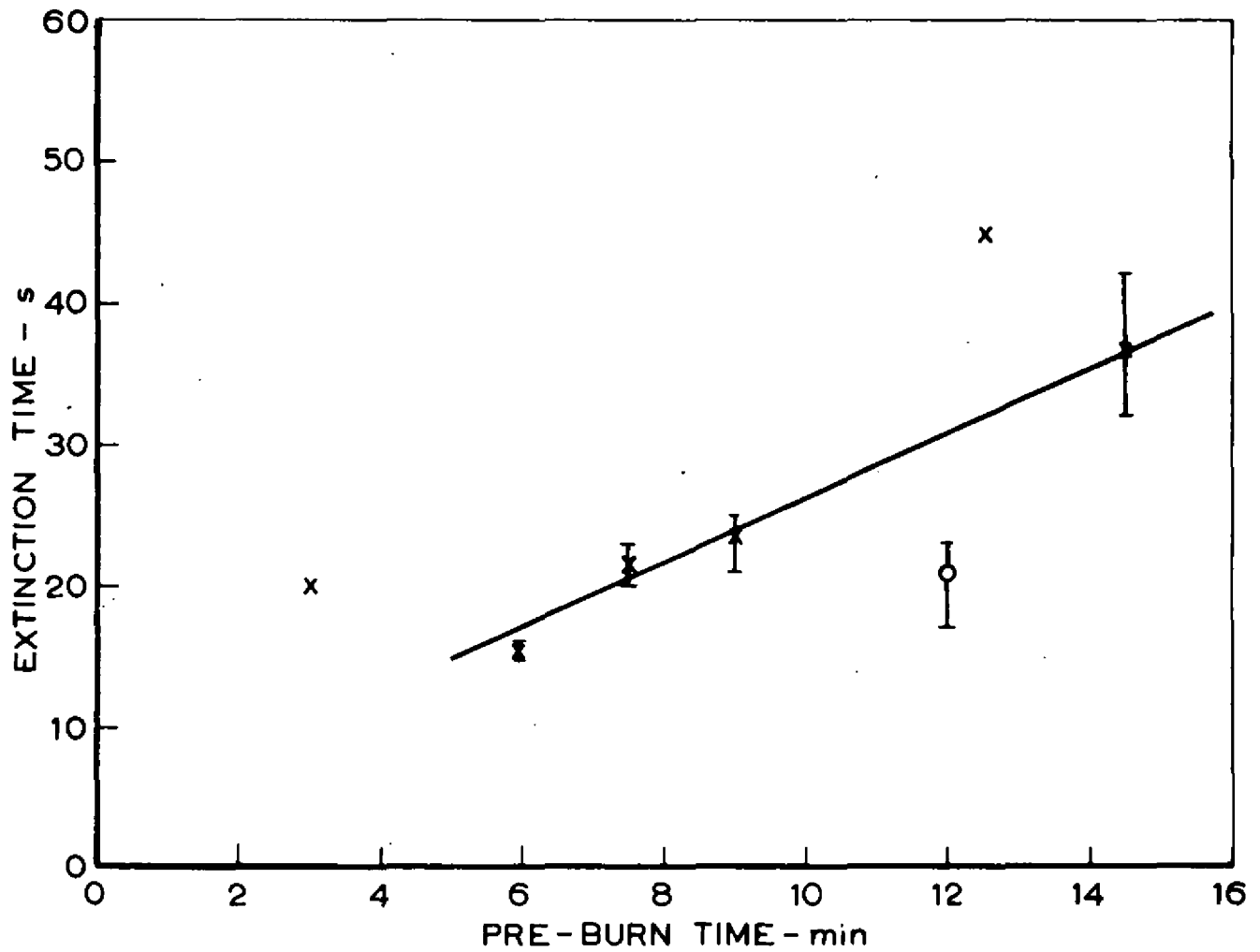
FIG. 4. VARIATION IN WATER QUANTITY REQUIRED FOR EXTINGUISHING WITH CRIB LENGTH

1/8609 F.R. 751.



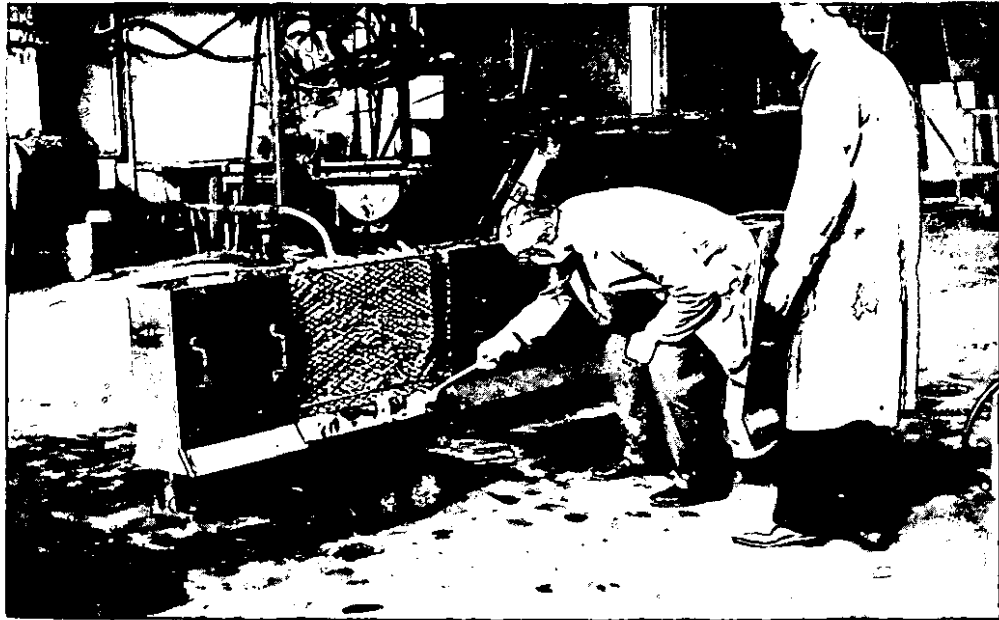
9.1ℓ (2gal) water extinguisher  
 German standard crib  
 4cm sticks, 1:1 spacing  
 60cm x 60cm x 48cm

FIG. 5. VARIATION OF RE-IGNITION TIME WITH PRE-BURN TIME

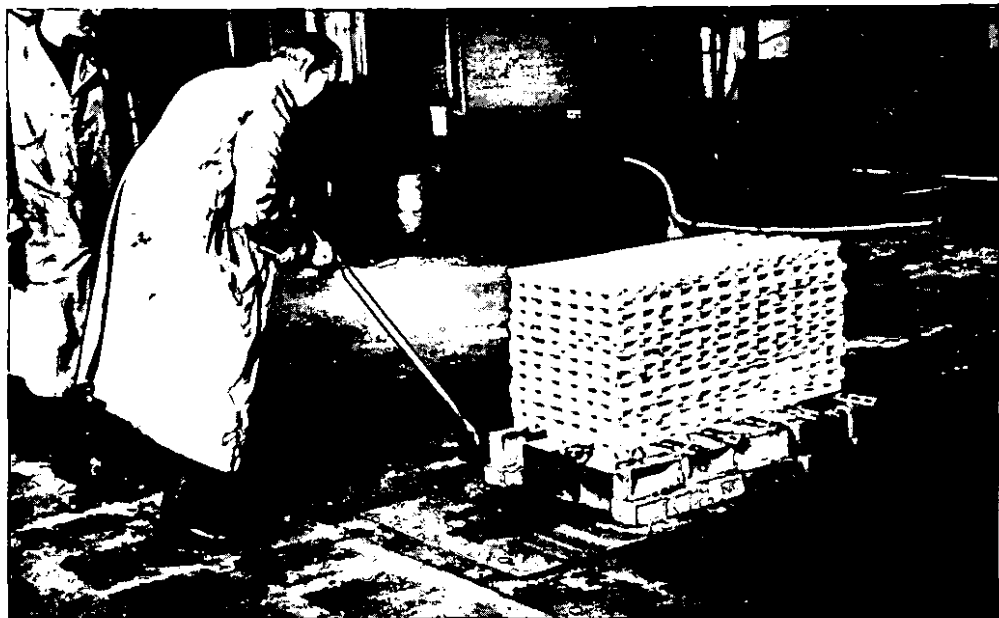


9.1ℓ (2gal) water extinguisher  
 German standard crib  
 4 cm sticks, 1:1 spacing  
 60 cm x 60 cm x 48 cm  
 x - 1 min ignition time  
 o - 2 and 5 min ignition time  
 | - Range of results

FIG. 6. VARIATION OF EXTINCTION TIME WITH PRE-BURN TIME



(a) French standard Class A Fire (21A)



(b) Experimental wood crib fire (1 m long)

