Central Fire Brigades Advisory Council
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Summary Report

by Kirsty Bosley

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Water Additives for Fighting Class A Fires

The Fire Experimental Unit (FEU) was asked to investigate the efficiency of a number of additives for use with water against Class A fires. Preliminary fire trials were held in 1995 and more detailed trials commenced in 1996. Thirteen different Class A additives were tested. In both series of trials, no significant distinction could be drawn between the extinguishing performance of water with any of the additives, and water alone. This report summarises both series of trials.

INTRODUCTION

In recent years, a range of additives intended for use on Class A fires has been marketed. These additives were developed in the US for use, at very low concentrations, on brush fires. They are now also being recommended for use on structural fires. Although they are generically known as Class A foams, they are more accurately Class A additives, since they do not all produce foam as an end product.

The Fire Experimental Unit (FEU) was asked to investigate the effectiveness of Class A additives in normal firefighting operations. A series of fire tests was carried out in 1995, followed up by a further series of tests in 1996.

In 1995, each additive was tested once. Problems with the test fire meant that tests using some of the additives did not produce valid results. The results from the valid tests seemed to indicate that although some additives performed better than water alone, others performed worse. The changes in performance were so small that far-reaching conclusions could not be drawn using this data.

As a consequence of these tests a second series was carried out in 1996. The test method was kept broadly similar to that used in earlier tests, but each additive was tested at least twice. Some changes were made to the original test fire and procedures partly to reduce the variability in the burning characteristics of the fires, and partly to improve the discrimination between good and bad extinguishing performance. This report summarises both series of tests.

1995 TESTS

Test Fire and Experimental Procedure

The 1995 tests aimed to give a broad initial view of the performance of the Class A additives. The results of these tests would then be used to decide whether further, more closely controlled tests were justified.

All fire tests were carried out under the smoke hood in the FEU Still Air Facility at RAF Little Rissington. Each fire consisted of 56 wooden pallets, arranged in a square of 4 stacks of 14 pallets (see Figure 1). The pallets were ignited with a tray of heptane beneath each stack. The heptane was measured to burn out after 2 minutes. The pallets were allowed to burn until a steady fire was achieved (the preburn). Firefighting then commenced.

A total of 13 Class A additives were used during this series of tests. Water, a synthetic detergent based foam (Expandol) and an AFFF were also used for comparative purposes. Each of the Class A additives was premixed to the manufacturers' recommended concentration and was applied to the test fire, through a high pressure hosereel, at 50 litres per minute. Although 50 lpm is lower than would be used by working firefighters, it was selected in order to provide greater discrimination between tests.

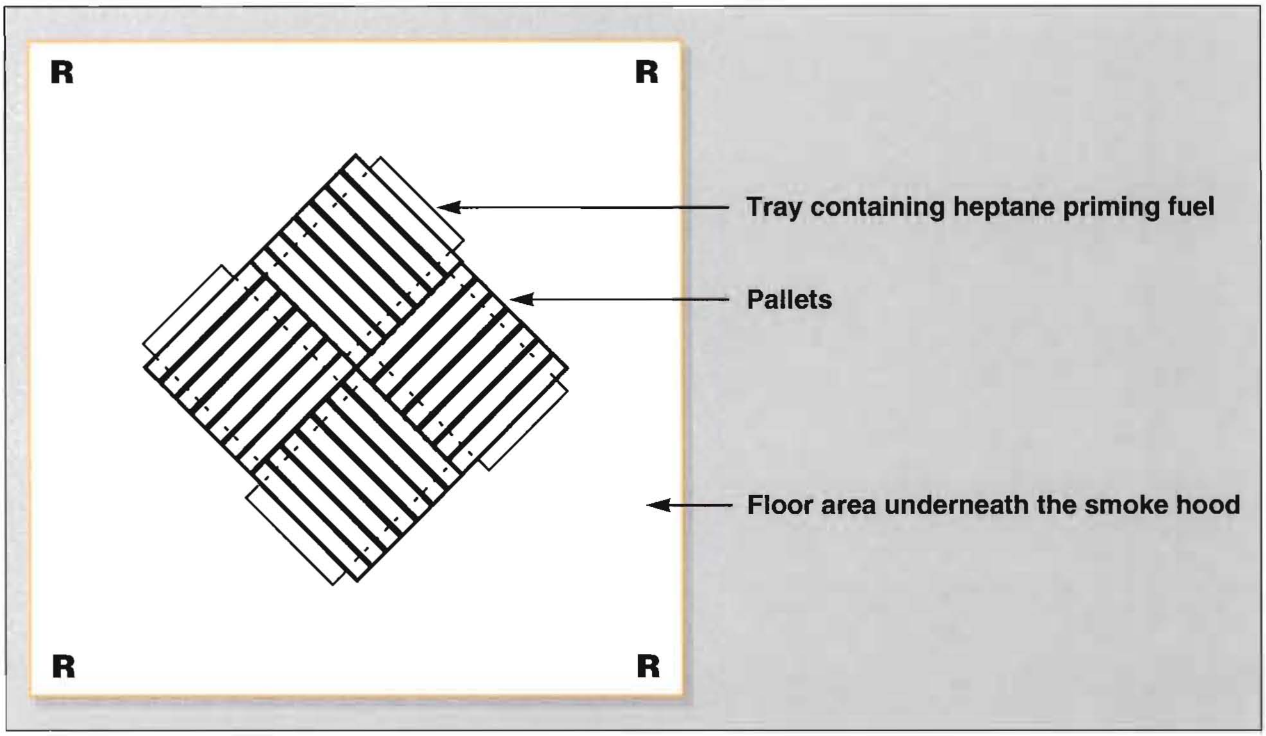

Figure 1: Plan view of the area under the smoke hood showing the orientation of the pallets and the position of the radiometers (marked R).

Firefighting was carried out by an experienced local authority firefighter who had free access all around the fire. The hosereel branch was switchable between a jet setting and a fixed spray with an included angle of approximately 60°. The first minute of firefighting was carried out with the jet in order to achieve an initial knockdown of the fire. After one minute the firefighter switched to spray and continued firefighting until he felt that he had achieved a consistent level of extinguishment. Usually however, some hot spots remained and reignition often occurred. The decision on when to cease firefighting rested solely with the firefighter. For this reason the same firefighter was used throughout the series of tests.

The progress of the fire was monitored using radiometers to measure the radiant heat flux. Video recordings were used to check the timings of the firefighter's activities (e.g. the time firefighting ceased).

Results

In early tests, a 5½ minute preburn was used; this was later reduced to 5 minutes in an attempt to prevent stack collapses. Stack collapses occurred when the horizontal members of the pallets burned through. Once the pallets collapsed, the results were invalidated since the characteristics of the test fire had changed. Of the 13 Class A additives tested, only 10 of these were successfully tested (stack collapses negated the other results).

The time at which firefighting stopped did not provide a reliable measure of the effectiveness of the test media. The final damping down stages of firefighting included locating and accessing hot spots. These steps could take significant time which was not related to the performance of the extinguishing media. A more reliable measure of performance was the radiant heat flux measured by the radiometers.

For each test, the radiated heat flux data was averaged and normalised so that the progress of the fire could be assessed. A typical graph is shown as Figure 2.

Most fire reduction was achieved in the first two minutes of firefighting. For this reason, the area under the graph over these two minutes was used as the primary measurement of firefighting progress. This area represents the rate of heat reduction of the test fire. As can be seen in Figure 2, the reduction in the fire during the first minute, using a jet, was considerably greater than over the

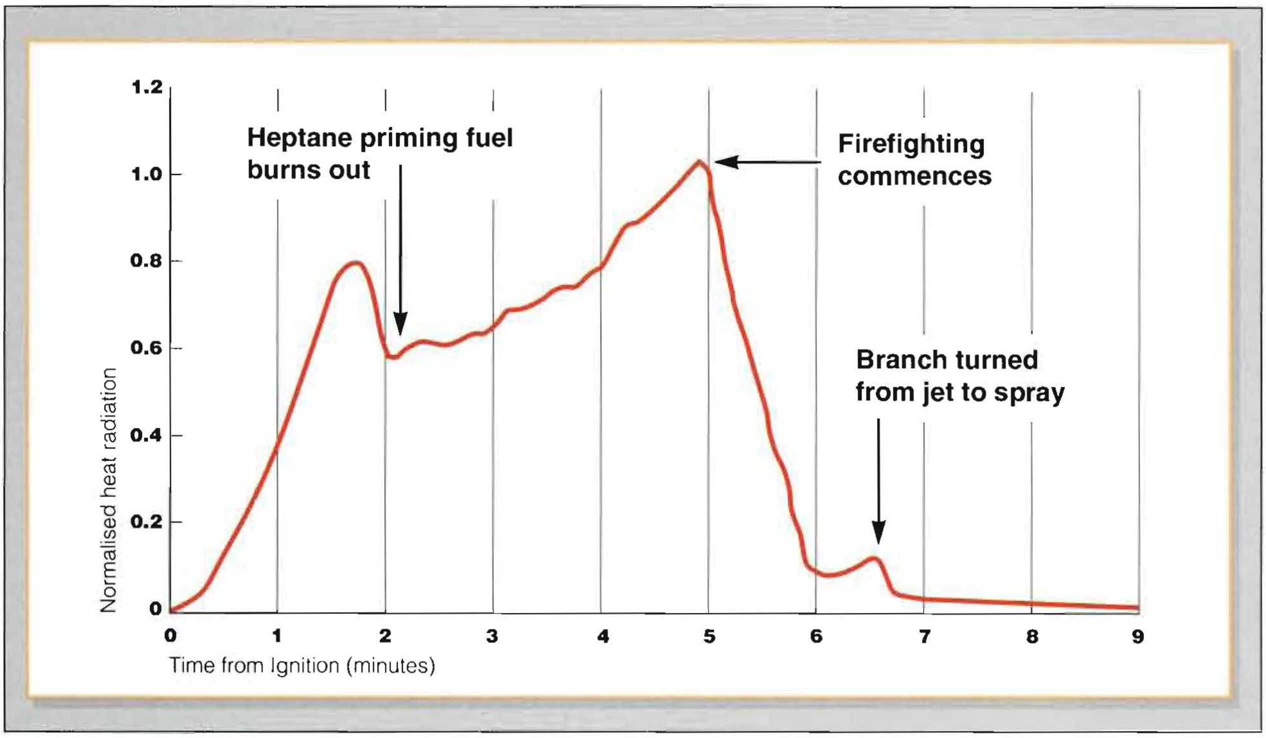

Figure 2: 1995 tests - the progress of a typical test fire (5 minute preburn)

second minute, using the spray. Table 1 lists the additives that were successfully tested and gives a summary of the results. Note that the lower the value for the area under the graph, the more quickly the heat of the fire has been reduced and the more effective the additives have been at suppressing it. Some additives that were tested are not listed here because no valid results were obtained from them due to problems with the test fire (e.g. stack collapses).

Figure 3 is a bar chart showing the result for each additive of the area under the graph during the first two minutes of firefighting.

The bar chart shows that, although there are differences between the results of the tests, they are not proportionally very great. Each additive type was only tested once and any variations were not sufficient to discount any of the additives from further testing. It was therefore decided that all of the additives tested should be subjected to further, more rigorous tests and the second series of tests was commissioned.

1996 TESTS

Test Fire and Experimental Methods

The test method for 1996 was a more strictly controlled version of the 1995 test method. All but one of the Class A additives used in 1995 were tested at least twice, as were water, AFFF and synthetic detergent (Expandol). The one additive that was not re-tested (Cold Fire) was not available at the time of this second series of tests.

The thickness of the horizontal members of the wooden pallets was increased to ensure that no stack collapses occurred. In addition, the moisture content of the wood was more closely controlled than in 1995 to help to ensure a more consistent fire and to prevent stack collapses.

All tests used a 5½ minute preburn. In order to extend the firefighting phase, and to improve the discrimination between the performances of the additives, all firefighting was carried out with the hosereel gun on a spray setting only. This limited the reach of the extinguishing media and resulted in longer firefighting times.

ADDITIVE TYPE	CONCENTRATION %	PREBURN TIME (mins)	AREA UNDER THE GRAPH		
			First minute	Second minute	First two minutes
Control A	0.5	5½	36	3.5	39.5
Phirex +	1	5½	35	8.4	43.4
Ecofoam	1	5½	38	12.5	50.5
Cold Fire	3	5½	34	3.7	37.7
Chemguard	0.5	5½	38	4.2	42.2
Phos-Chek	1	5½	38	4.0	42.0
Water		5½	39	8.8	47.8
JJD	0.025	5	32	2.8	34.8
Forexpan	0.5	5	33	12.4	45.4
1st Defense	1	5	30	7.0	37.0
Silv-ex	0.5	5	31	2.2	33.2
AFFF	3	5	32	2.6	34.6
Water		5	31	4.8	35.8

Table 1: 1995 tests - summary of the area under the graph results

(The lower the value, the better the additive performed)

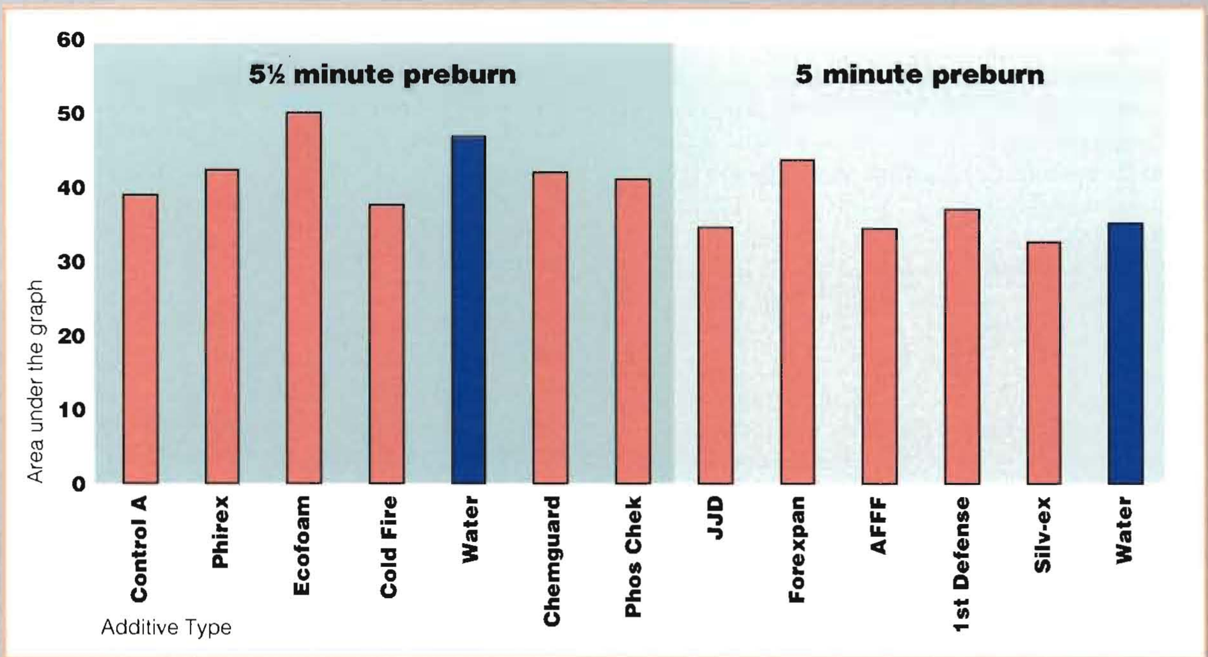

Figure 3: 1995 tests - summary of the area under the graph results over the first two minutes of firefighting

As in 1995, the flowrate used was 50 lpm. Firefighting continued until the fires were more thoroughly extinguished than in the 1995 tests with great care being taken to ensure, as far as possible, that all hot spots were extinguished; reignition during these tests was rare. Again the same firefighter was used for all tests.

Results

In the 1995 tests there was considerable spread of maximum heat flux from the fires (12 to 22 kW/m^2). In the 1996 tests the range varied from 8.5 to 11 kW/m^2. This represented a considerable improvement in the consistency of the fires and was mostly due to the close control of the moisture content of the wood.

The heat flux data from the radiometers was processed in the same way as it had been in 1995. Again the area under the graph was used as the primary indicator of additive performance. In 1996, the area under the graph was calculated over 4 minutes of firefighting, as opposed to two minutes used for the 1995 fires. The longer firefighting times were due to the use of spray application only during the 1996 fires.

A graph showing the typical progress of a 1996 fire is shown in Figure 4.

A summary of the area under the graph results of the 1996 tests is shown in Table 2. As with the 1995 results, the lower the value for the area under the graph, the more energy that has been removed from the fire and the more effective the additives have been at suppressing the fire.

Figure 5 is a bar chart showing the results for each additive of the areas under the graphs during the first four minutes of firefighting.

STATISTICAL ANALYSIS OF THE 1996 RESULTS

General Factors Affecting the Results

Although the results show some differences in the firefighting performances of additives during the tests, it was difficult to assess whether these could be assigned to the various additives themselves, or whether they were no more than unavoidable experimental variation. Statistical analysis was used to evaluate these differences.

Initially it was important to ensure that the results of the tests were not significantly affected by any factors except the extinguishing medium. Statistical checks were carried out on the following factors:

- maximum radiated preburn heat
- wood moisture content
- time to make the first firefighting sweep around the stack
- time to make the second firefighting sweep around the stack
- time to make the third firefighting sweep around the stack

Tests were carried out to find out whether these factors affected each other. These tests showed that the wood moisture content affected the maximum radiated preburn heat output of the fire; that is, as the wood moisture content increased, the heat output of the fire decreased. This was minimised as far as possible by conditioning the wood prior to testing.

The five factors were then checked against the result for the area under the graph to find out whether they affected that. None of the factors influenced the area under the graph.

These statistical checks give confidence that the only differences between the results of the fire tests were caused by the firefighting performances of the different extinguishing media.

The Effects of Additives

Statistical tests were carried out on groups of results. The aim of the tests was to show whether or not they could be from the same distribution, that is, whether the additives gave genuinely different results from water alone. To assess this, comparisons were made in two ways: First of all the results were assessed by comparing the water tests with all the other tests; secondly the water tests were compared with the tests on each individual additive type.

The results of the area under the graph over 4 minutes were tested to discover:

- whether there was any statistical difference between the results of the additive tests (taken together) and those of the water tests.

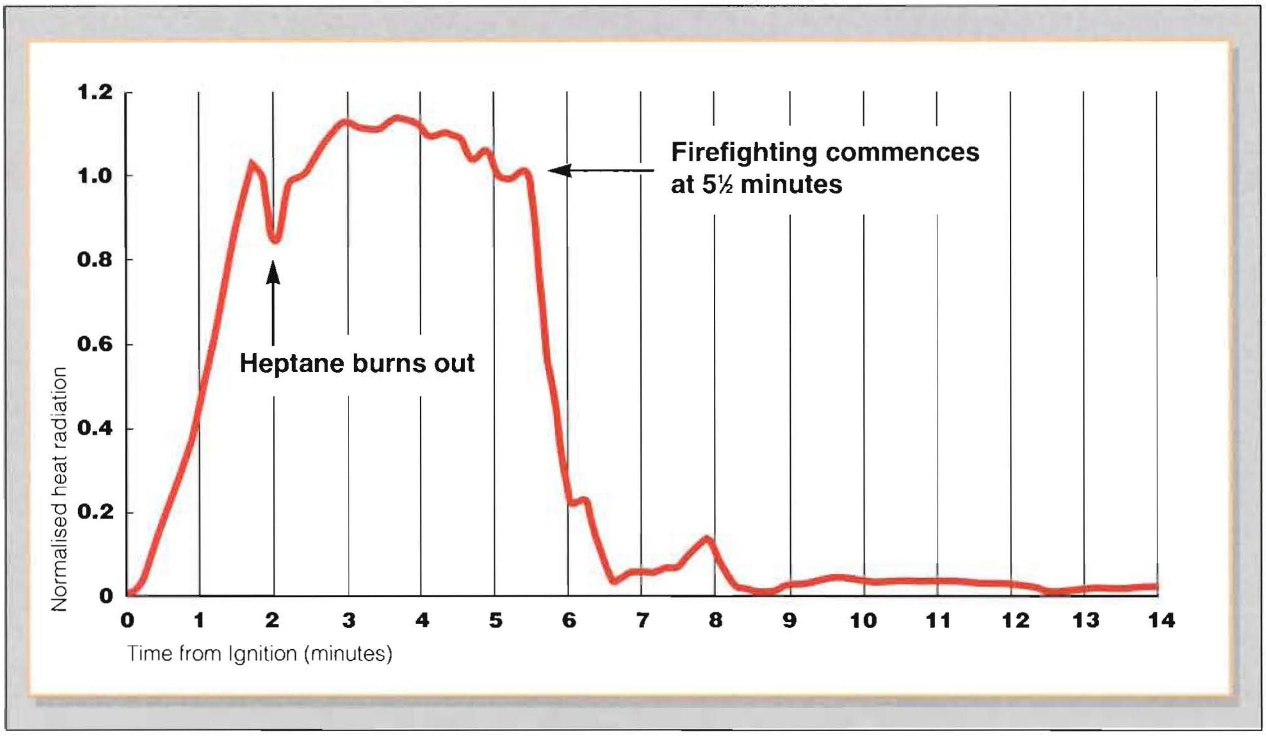

Figure 4: 1996 tests - the progress of a typical fire (5 ½ minute preburn)

- whether there was any statistical difference between the results of the individual additives and the results of the water tests.

Considering first of all the comparison of the 4 water test results with all 29 results of additive tests. The statistical tests give a value of 0.991. This indicates a 99% likelihood that the additive results came from the same group of results as the water ones. That means that there is no evidence to suggest any improvement in firefighting performance between Class A additives generically, and water.

The individual additive results were then compared, in turn, with the water results. Table 3 gives the results of these statistical tests. These values tell us the probability that the results for individual additives come from the same distribution as the results for water. For example, the results from 1st Defense additive have a slightly higher than one in ten chance of coming from the same distribution as the water results (i.e. producing the same results as water).

A figure of 5% or less would indicate a statistically significant change in the results (only a 1 in 20 chance of having the same performance as water). None of the results produced a significantly different performance to water alone.

There is a slight chance that the 1st Defense additive is better than water, but the difference is too small to be proved with this limited number of tests. If more tests were undertaken, the statistical confidence in the results might increase.

DISCUSSION

These tests, which were designed to represent a simplified household fire, failed to show any improvement due to the use of Class A additives in place of water alone.

It should be noted that the tests described above were rigorously controlled, with all other factors that may have affected the fire kept to a minimum. Under normal operational circumstances there are so many uncontrollable variables affecting the fire that any change in firefighting performance that may potentially result from the use of Class A additives would probably be rendered unnoticeable.

The manufacturers claim that Class A additives possess a number of characteristics that make them good at extinguishing Class A fires. Firstly, they are

ADDITIVE TYPE	CONCENTRATION %	AREA UNDER THE GRAPH CALCULATED OVER THE FIRST 4 MINUTES OF FIREFIGHTING			
		First minute	Second minute	Subsequent tests	
1st Defense	1	26.2	30.9		
AFFF	3	38.0	33.3		
Chemguard	0.5	36.3	43.5		
Chubb Class A	1	34.8	35.0		
Control A	0.5	33.9	32.9	32.3	
Ecofoam	1	29.5	40.3		
Expandol	3	27.0	42.0		
Fire out	0.3	36.2	26.7		
Forexpan	0.5	36.0	32.6		
Fuel buster	1	49.2	31.3		
JJD	0.025	33.2	31.0		
Phirex	1	30.5	34.4		
Phos-Chek	1	29.0	43.5		
Silv-ex	0.5	39.1	40.5		
Water		34.3	30.1	36.8	38.1

Table 2: Summary of the results of the 1996 tests

(The lower the value, the better the additive performed)

oleophilic and contain hydrocarbon surfactants. It is claimed that this makes them behave like super-detergents, forming a bond between carbon and water, causing the additive solution to stick better to solid fuels, making them wetter.

In their foam forms, Class A additives are said to adhere to vertical surfaces, allowing the water contained in the foam to make contact with the fuel. Additionally the foam is said to have a 'fragile bubble structure' which bursts easily, releasing the water on to the surface of the fuel.

These properties have not been investigated in depth during this project. At this stage of the research the only important property of the additive is its firefighting ability. If the addition of Class A additives does not improve firefighting performance over that of water, the other properties of the additives need not be considered further.

In fighting brush fires, Class A additives are claimed to improve the penetration of the solution into the fuel, increasing wetting and cooling and reducing the possibility of the fire relighting. Thus Class A additives could be claimed to increase the effectiveness of the limited water available to fight brush fires, maximising a valuable resource. Although these properties have not been directly investigated during this project, an improvement would be expected in these tests if there were to be any improvement against brush fires.

Most of the additives are recommended for use at a concentration of 1% or less in water. A small amount of additive will therefore produce a large amount of solution. The cost of the additive per unit volume of solution is therefore low. From the results of the tests described in this paper, even a low additive cost would not be justified by the benefits.

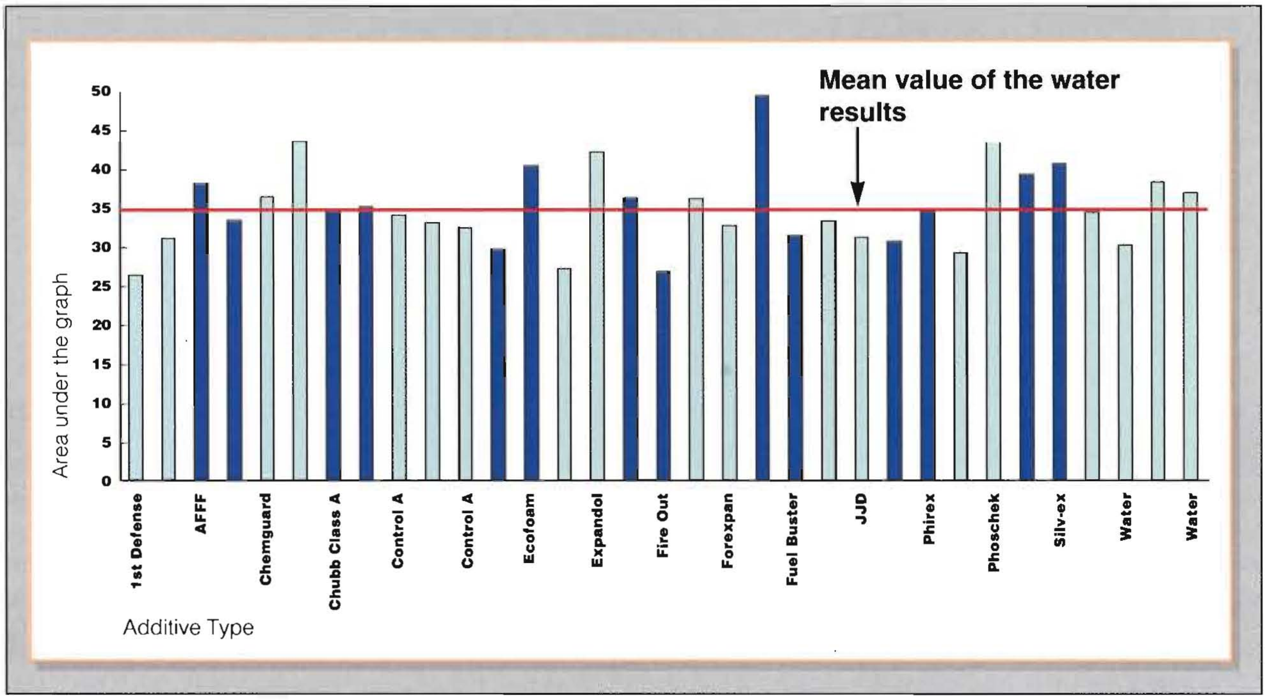

Figure 5: 1996 tests - summary of the area under the graph results over the first four minutes of firefighting

ADDITIVE TYPE	PROBABILITY THAT THE ADDITIVE IS MAKING NO DIFFERENCE TO THE PERFORMANCE OF WATER (%)
1st Defense	11
AFFF	80
Chemguard	22
Chubb Class A	98
Control A	44
Ecofoam	99
Expandol	97
Fire out	44
Forexpan	86
Fuel buster	65
JJD	37
Phirex	46
Phos-Chek	87
Silv-ex	14

Table 3: 1996 Tests - The results of statistical tests on the values for the area under the graph for the first 4 minutes of firefighting (the difference may represent an improvement or a reduction in performance)

CONCLUSIONS

In these trials, representing structural firefighting, there is no significant difference in firefighting performance due to the use of Class A additives, even under the closely controlled conditions of these trials. Under normal operational circumstances there are so many uncontrollable variables affecting the fire that any change in firefighting performance that may potentially result from the use of Class A additives would probably be rendered unnoticeable.

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