DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

AND

FIRE OFFICES' COMMITTEE

JOINT FIRE RESEARCH ORGANIZATION

FIRE RESEARCH NOTE

NO. 560

THE EFFECT OF ETHYLENE GLYCOL ANTI-FREEZE ADDITIVE ON THE PERFORMANCE OF WATER EXTINGUISHERS

by

G. H. J. ELKINS

July, 1964.

Fire Research Station.
Boreham Wood.
Herts.
('phone ELStree 1341)

F.R. Note No. 560

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

THE EFFECT OF ETHYLENE GLYCOL ANTI-FREEZE ADDITIVE ON THE PERFORMANCE OF WATER EXTINGUISHERS

by

G. H. J. ELKINS

SUMMARY

Ethylene glycol/water solutions have been tested against a standard wood crib fire. It is concluded that such charges, when used in fire extinguishers, should not contain more than 30 per cent by volume of ethylene glycol.

THE EFFECT OF ETHYLENE GLYCOL ANTI-FREEZE ADDITIVE ON THE PERFORMANCE OF WATER EXTINGUISHERS

by

G. H. J. Elkins

Introduction

Water is the most widely used fire fighting agent against fires involving carbonaceous materials such as wood. A disadvantage to the use of water is its freezing point of 0°C (32°F), a normal winter temperature experienced in many parts of the British Isles and elsewhere (1). A reduction of the freezing point of the water in the extinguisher by the use of a simple additive would enable this type of extinguisher to be used more widely.

Reduction of the freezing point

A simple method of reducing the freezing point of water is to dissolve a suitable salt in the water. For example, an aqueous solution of sodium chloride (common salt) containing 23.6 per cent by weight of the salt has a eutectic freezing point of -22°C (7.6°F). Such a solution is corrosive to the common metals and consequently requires the use of specially protected extinguisher bodies. Another method makes use of solutions of ethylene glycol in water. Such solutions have been employed for many years as low temperature coolants for automobile engines, and, when properly inhibited, have very little corrosive effects.

The physical properties of ethylene glycol are shown in Table 1.

Table 1

Physical Properties of Ethylene Glycol

Chemical Formula	Mol Wt.	Boiling Point at 760 mm Hg.	Fire Point	Auto Ignition Temp.	Spec. Gravity 20°/20°C.
CH_2OH | CH_2OH	62.07	197 .2°C	120°C	417°C	1.1132

Ethylene glycol/water mixtures

Ethylene glycol and water are completely miscible in all proportions. The freezing points of ethylene glycol/water mixtures are shown in Table 2 and are plotted in Fig. 1. Fig. 1 shows the reduction of the freezing point with increasing ethylene glycol content to a minimum of -49°C (-56°F) when the solution contains 60% v/v of ethylene glycol. Any further increase in the ethylene glycol concentration results in a rise in the freezing points of the solutions.

Table 2

Freezing Points of Ethylene Glycol - Water Mixtures (2)

Ethylene Glycol per cent v/v	Freezing Point	
	°C	°F
10	-4	24.8
20	-9	15.8
30	-16	3.2
40	-25	-13.0
50	-36.5	-33.7
60	-49	-56.0
70	-44	-47.2
80	-43	-45.4
90	-27	116.6

Effect of ethylene glycol content on the properties of the aqueous solutions

Some extinguisher manufacturers are now recommending and providing low temperature fillings for water extinguishers using ethylene glycol/water solutions. One of these is stated to have a freezing point of -28°C (-18°F) and from Table 2 it will be seen that this would require a concentration of ethylene glycol slightly greater than 40% v/v. Since ethylene glycol is itself a flammable material, it seemed likely that at the high concentrations recommended, the performance of the extinguisher might be reduced, and in a preliminary examination, the flash points of ethylene glycol/water mixtures were investigated by the Cleveland Open Cup Method (3). It was found that each of the solutions boiled at a constant temperature for an initial period, the boiling points changing with an increase in ethylene glycol content, as shown in Table 3.

Table 3

Boiling Points of Ethylene Glycol/water Mixtures

Concentration Ethylene Glycol % v/v	Boiling Point °F
10	212
20	216
30	221
40	223
50	232
60	238
70	245
80	248
90	288

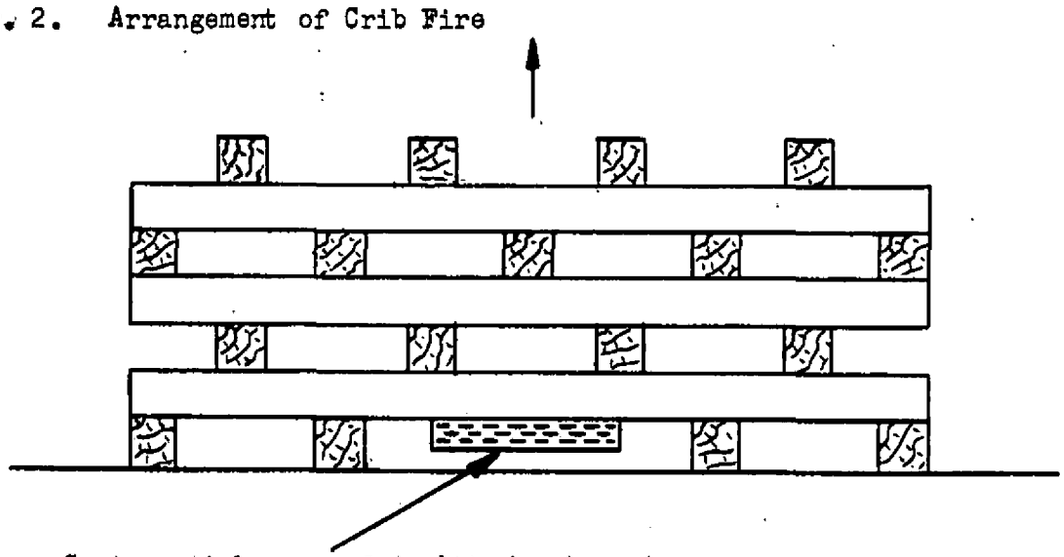
A true flash point was not exhibited by any of the solutions. It was observed that wisps of flame were produced in the vapours from solutions containing 60% or more of ethylene glycol. After approximately 5 mins heating, the vapours from the 90.0% ethylene glycol mixture ignited. The temperature of the residual solution had then risen to 300°F. Most of the water content of the solution appeared to have boiled off by this stage. If this were the case, it would mean that solutions of ethylene glycol/water, when applied to fires with a large thermal capacity, might initially lose water vapour, leaving a flammable constituent. Since it seemed improbable that the proportion of ethylene glycol used in practice would exceed 50% v/v, a solution of this strength was subjected to prolonged heating. When half the original volume of liquid had evaporated, the boiling point of the solution had risen to 295°F and the vapours above the solution ignited.

Use of ethylene glycol/water solutions for extinction of wood crib fires

It was apparent from the preliminary tests above, that the effectiveness of extinguishers using ethylene glycol/water mixtures instead of water might be reduced. As no standard fire extinction test for water extinguishers exists in Great Britain, a test fire was devised to measure variations in the performance of extinguishers charged with different solutions.

The fuel chosen was 100 lb of wood (Pinus Sylvestris) in 3 ft long x 1 in square battens. These were arranged in the form of a square section crib (Plate 1) every third and fourth layer being offset to increase the rate of burning (Fig. 2).

Fig. 2. Arrangement of Crib Fire



Note - Centre stick removed to insert primer tray

A tray containing 200 mls of petrol was placed at the centre of the base of the crib and was ignited. After 3 mins burning, the fire had enveloped most of the crib (Plate 2). The extinguishing solution was then applied from a B.S. 2-gallon water extinguisher charged to an initial air pressure of 125 lb/sq. in. Solutions containing 0, 10, 20, 30, 40 and 50 per cent by volume of ethylene glycol were tested. The test solutions were applied by one operator in the sequence 0, 50, 10, 40, 20, 30, 0% by volume, to reduce any possible effects of growth of experience by the operator on this particular fire. The operator for these experiments was generally experienced in the use of hand extinguishers for this type of fire.

Test Results

Test results are shown in Table 4.

Table 4

Times to extinguish test fires

Test No.	Conc. Ethylene Glycol % v/v.	Time to extinguish flames secs.	Remarks	Freezing Point Soln. °C	°F
1	0	15		0	32.
7	0	10		0	32
3	10	25		-4	24.8
5	20	35		-9	15.8
6	30	55		-16	3.2
4	40	NE	Flame increasing after 1 min.	-25	-13
2	50	NE		-49	-56

The solutions applied were at equilibrium room temperature (10-15°C)

Water began to control the fire immediately on application (Plate 3) and in both fires where water alone was used, all flaming combustion was extinguished in 15 secs or less (Plate 4). The remaining charge in the extinguisher was then used to extinguish all residual smouldering combustion (Plate 5). It was found possible to extinguish test fires using solutions containing 10, 20 and 30% v/v ethylene glycol respectively, the time taken to extinguish all flaming increasing with the increase in concentration of ethylene glycol. The residual charge was applied in all three cases and extinguished all smouldering. The test fire was not extinguished by the solution containing 40% v/v ethylene glycol. After 15 secs application a fairly large part of the crib was still burning. (Plate 6). After application for one minute flame still persisted and was increasing in intensity. The test was therefore abandoned. (Plate 7). When the 50% v/v ethylene glycol solution was applied, no reduction of the flame size was observed.

Discussion of test results

From Table 4, it is apparent that the maximum concentration of ethylene glycol in water which will give a solution capable of extinguishing the test fire was about 30% by volume. The time taken to extinguish the fire with this solution was some 3 - 4 times that required using water alone. Solutions containing more than this proportion of ethylene glycol did not extinguish the test fire. Table 4 also shows the freezing points of the solutions, and a 30% by volume mixture, capable of extinguishing the test fire, would have a freezing point of about -16°C (3.2°F).

Conclusions

It is recommended that where ethylene glycol is used as an anti freeze additive in water extinguishers, the concentration of ethylene glycol should not exceed 30% vol/vol. Such a solution has a freezing point of -16°C (3.2°F) which may, therefore, be regarded as the lower temperature limit for this

extinguishing agent. In the tests described above, the effect of temperature on the operating pressure available, and hence on the rate of ejection of the solution, was not examined.

Acknowledgement

Mr. B. K. Chandisingh assisted with the experimental work.

References

1. Temperature ranges for Great Britain and Northern Ireland and some other countries. Internal Note No. 193 G. H. J. Elkins.

2. Marsden, Solvents & Allied Substances Manual.

3. Standard Methods of Testing Petroleum and its products. Institute of Petroleum publication.

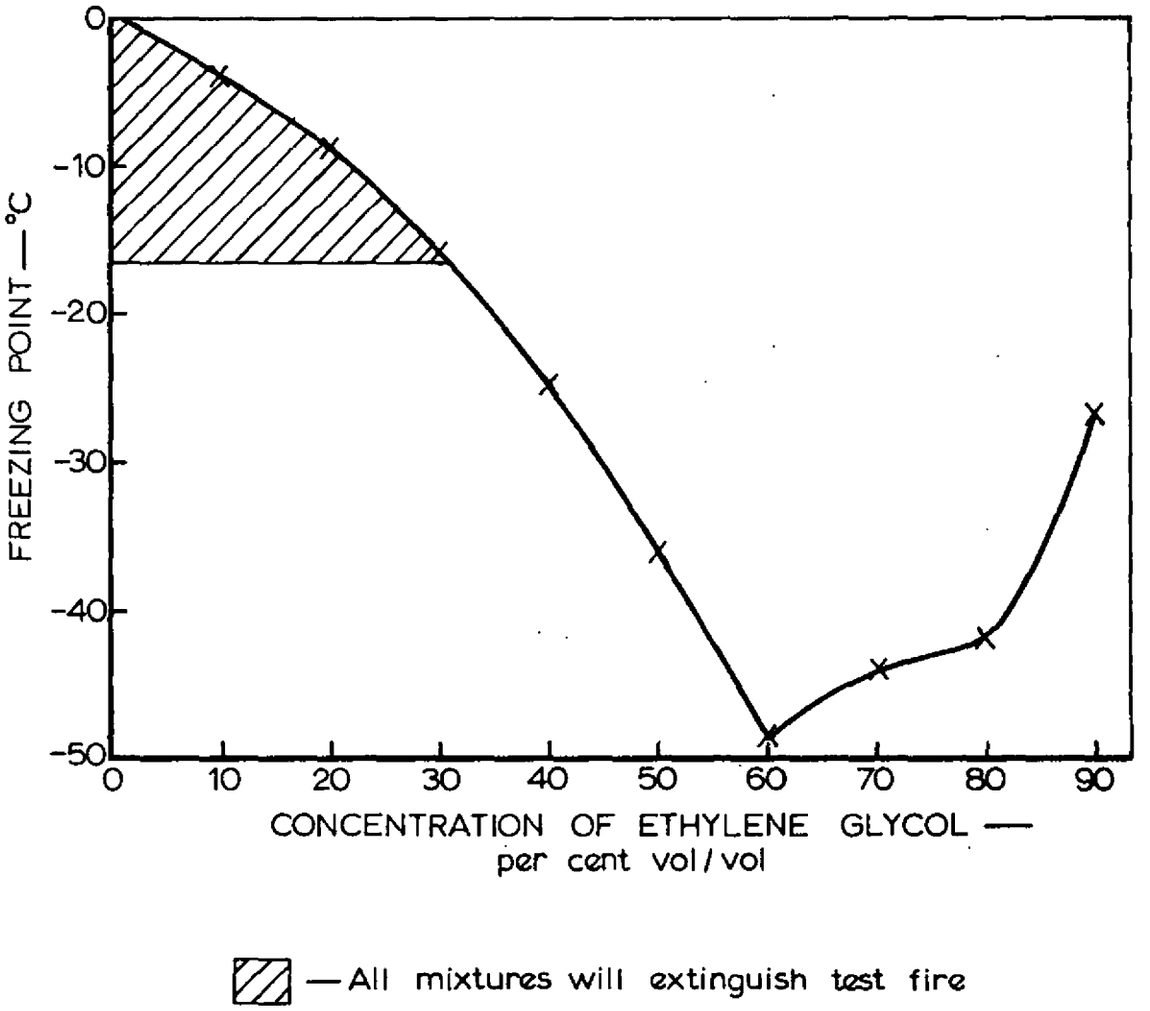
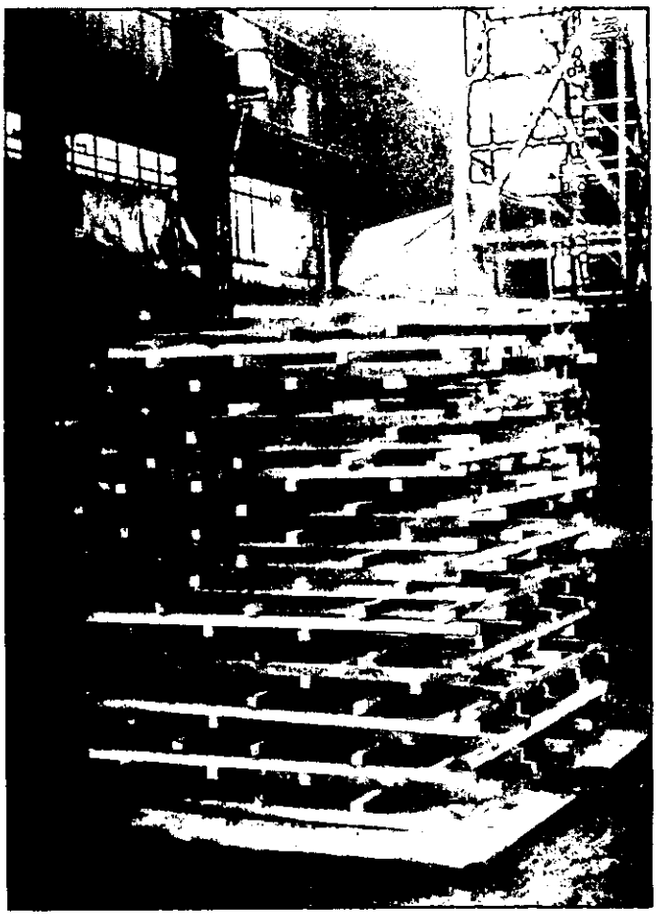


FIG. 1. FREEZING POINTS OF ETHYLENE GLYCOL/ WATER MIXTURES



Standard crib fire
PLATE 1

Fire after 3 minutes
PLATE 2

Fire immediately after water application
PLATE 3

Test 3 Flame extinguished after
15 seconds

PLATE 4

Test 3 Residual charge applied
PLATE 5

15 secs after initial application of
40 per cent ethylene glycol mixture

PLATE 6

One minute after application of
40 per cent ethylene glycol mixture

PLATE 7