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

THE USE OF FIRE TESTS FOR GRADING EXTINGUISHERS

by

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SUMMARY

This report reviews the methods used for evaluating the relative effectiveness of different types of extinguisher, particularly with regard to flammable liquid fires.

July, 1961.

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Introduction

For practical purposes, fires are generally classified according to three main types:-

1) Class 'A' - fires in combustible, cellulosic materials, such as wood, paper etc.

2) Class 'B' - fires in flammable liquids, greases etc.

3) Class 'C' - fires involving electrical equipment.

Different types of extinguishing agent are used for dealing with these fires, including water, foam (chemical and mechanical), carbon dioxide, dry chemical and vaporizing liquids; and the efficiency of these varies according to the type of fire being attacked. Thus, Class 'A' fires are best extinguished using water, since the quenching and cooling effects are most important, whereas Class 'B' fires are most effectively tackled with either a blanketing agent such as foam, CO_2, or vaporizing liquid, which excludes air for combustion, or dry powder which acts largely by interrupting the chain mechanism in the propagation of the flame.

Since the effectiveness of the extinguishing agent depends to such a large degree on the type of fire being tackled, the relative efficiency of any particular agent has normally been assessed in relation to the class of fire for which it is most suitable.

Class 'A' fires are usually tackled with water or solutions containing large percentages of water, and, in this instance, the efficiency of an extinguisher on any one fire depends on the rate of application, total amount applied and the method of application.

In the case of Class 'B' fires, several extinguishing agents are available for use, all of the groups vaporizing liquid, carbon dioxide, dry chemical and foam being suitable to a lesser or greater extent.

Comparison of Extinguishers

A number of efforts have been made to estimate the relative merits of different types of extinguisher, but much has still to be done before the limits of the several types are fully understood.

A most useful study of methods for testing small extinguishers on flammable liquid fires was carried out by Shaub, Lee and Cameron[1]. A series of ten fires was devised consisting of a 4 ft^2 spill area, a cotton waste fire, a nominal 2 ft diameter tub, an open shallow pan, a leaking container, a spill flowing over a wide vertical surface, and four types representing fires in partially enclosed spaces, with or without an obstacle to free dispersal of the extinguishing agent. Fifteen extinguishers - eight of which were vaporizing liquid, 3 carbon dioxide type, 3 dry chemical and one foam - of varying capacities, were used on the above fires, and an arbitrary rating system, based on six levels of success, ranging from +3 to -3, was used to describe the relative degree of success.

Generally, the plus ratings were based on the amount of extinguishing agent unused, and the minus ratings were assigned on the basis of the operator's judgement.

Relative rankings of the performance of the 15 devices based on the percentage of success over the whole range of fires were then estimated, and also the fires were ranked in order of severity, the most difficult to extinguish being ranked 1. From this latter scale the performance of any one extinguisher can be estimated. Thus, if the item under test is shown to be successful on fire 9, its performance could be further tested on an intermediate fire such as 5, and then a difficult one, fire 1, the extinguisher passing the test if it is successful on a particular grade of fire four times out of five trials.

A number of trials were carried out, for demonstration purposes at the Fire Research Station for the Portable Fire Extinguishers Committee of the Fire Protection Association in which a two-gallon mechanical foam, a 10 lb carbon dioxide, a twenty pound dry chemical, a quart carbon tetrachloride (pump type) and a quart chlorobromomethane extinguisher were used against three different types of flammable liquid fire - a spill fire in which $\frac{1}{2}$ gallon of petrol was poured over 64 ft^2 area of concrete; a deep layer fire in which petrol was burnt in a 10 ft^2 circular pan; and a running fire in which petrol flowed from a spray bar over three horizontal pipes and into a collecting pan.

The spill fire was controlled or extinguished by all the agents, the dry chemical being the most effective; the deep layer was controlled by the foam and extinguished by the powder, and the running fire could only be extinguished by the dry powder. In all other cases, the extinguishers either became exhausted before the fires were extinguished, or else were not tested as it was known that they could not cope with the particular fire under investigation. In the case of carbon tetrachloride and chlorobromomethane, choking and unpleasant fumes were experienced.

The above series of trials were not controlled tests, but nevertheless served as a useful guide to the effectiveness of the various extinguishing agents.

A method of grading portable extinguishers developed by the Underwriters' Laboratories Inc. of America, is based upon the aforementioned letter classification of fires, and also upon the fire extinguishing potential, as measured using open trays of flammable liquid. Thus, in the case of Class 'B' extinguishers, the numeral is indicative both of the relative fire extinguishing potential of the appliance, and the approximate square foot area of deep-layer flammable liquid fire which an average operator can extinguish.

It is evident that, in all tests involving extinguishers, the experience of the operator will have a marked influence on the performance, and comparative tests should therefore be carried out either by the same operator, or operators of similar experience and aptitude.

Rasbash and Stark[2] included an investigation into the "learning process" in work on the extinction of pool fires with hand-controlled water sprays. They showed that the performance of an operator improved as he gained experience, until after about 30 attempts, a consistent level was achieved. Equations were derived relating extinction time with a "learning factor", with similar results to those obtained in the experimental study of learning processes in time and motion study, and other similar fields.

In the standard tests carried out at the Joint Fire Research Organization on extinguishers received from manufacturers, a fire test is included only on the dry powder type, and an attempt to standardise this test has been made in a draft British Standard, in which the extinguisher shall be capable of extinguishing a petrol-on-water fire in a square tray, the size of the tray being determined as follows:

$1\frac{1}{2}$ ft^2 of tray surface per lb of powder;
1 quart of petrol per ft^2 of tray surface,

the fire being allowed to burn for 30 seconds before commencing the attack.

Although dry powder is known to be effective in dealing with flammable liquid fires on open trays, its efficiency is impaired to a large degree if low fire-point liquids are involved where re-ignition can occur. Thus, if quantities of plant or pipework are involved in the fire, since the cooling effect of the dry powder stream is small, the heat retained by the metal will cause re-ignition at areas already extinguished, unless the rate of application is high enough to maintain a barrier until extinction is complete.

Little information is available regarding the efficiency of extinguishers containing the more recently developed and less toxic vaporizing liquids such as CF_3Br CF_2Br_2 and $C_2F_4Br_2$. However, work by Guise[3] on the application of these agents to fires from fixed installations gives some indication of their relative efficiency. Work by Coleman and Stark[4] on chlorobromomethane and carbon tetrachloride applied to fires ranging from 1 ft^2 to 100 ft^2 shows the great dependence of the extinction efficiency on the method of application, a wide angle flat spray, which covers the whole of the fire front, being most effective. They found chlorobromomethane to be about three times as effective as carbon tetrachloride.

In the case of Class 'C' fires, it is necessary to ascertain if the extinguisher can be used on live electrical equipment without danger.

This can be done by discharging the powder on to a copper plate charged to, say, 3 kilovolts and measuring the resistance of the jet between the plate and extinguisher.

The current passing should be considerably less than could be normally felt and no signs of flashover should be in evidence in the discharge stream.

Conclusion

Due to the large number of variables, it appears very difficult to arrange a satisfactory series of tests to grade the efficiency of extinguishers.

By statistical analysis, Shaub, Lee and Cameron[1] showed, from their results, that, providing reasonable care was taken regarding the ambient conditions such as temperature, humidity, pressure, these variables had no appreciable influence on their results. The wind speed showed some statistically significant effect on the scoring, the degree of sensitivity depending more on the fire type than on the type of extinguisher.

Accounting for these effects, along with operator efficiency, leaves only the characteristics of the fire to be investigated in a programme to determine the capabilities of different types of extinguisher. The approach of Shaub, Lee and Cameron appears to be a most promising method of evaluating the effect of the "shape" of the fire, and further work along these lines with a wider range of extinguishing agents, including the more recently developed halogenated hydrocarbons, would be most profitable.

The structures used in the investigation by Shaub were of non-combustible materials, since the programme was designed primarily for flammable liquid fires. If amounts of combustible material were added to the fire, the effectiveness of the extinguishers on mixed fires could be investigated, since this type is more usually met in practice.

Similarly, it would be well worth while studying the effect of the properties of the flammable liquid, particularly flash point, thermal properties and any physical interaction between the flammable liquid and the extinguishing media which might result in complete breakdown or partial failure of the agent.

References

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