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NOTES FOR SPECIFICATION OF HIGH EXPANSION FOAM LIQUID.

by

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Summary

Requirements for the specification of high expansion foam liquid are outlined. These include certain physical properties of the liquid itself, and the properties of the foam which the liquid is capable of making. It is important in devising tests for these properties and specifying acceptance criteria that more information is obtained on the performance of high expansion foam against fire, and certain fire performance tests are suggested for this purpose. Certain properties of the foam can only be conveniently measured when the foam liquid is used in conjunction with the foam making apparatus in which it is to be employed.

An indication is given on the extent to which a specification can be made at the present time to cover the stated requirements.

MINISTRY OF TECHNOLOGY AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

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INTRODUCTION

High expansion foam is becoming increasingly used by the Fire Service, and currently a number of Fire Services are carrying out investigations on its performance. Moreover, several manufacturers are offering different forms of apparatus and different liquids for making high expansion foam. Under these conditions it is important to devise a specification for high expansion foam and particularly for the foam liquid that is used to make foam. There are many factors which govern the production and performance of high expansion foam and there is not yet sufficient information available to allow a complete specification for high expansion foam liquid. However, sufficient is known to allow a useful step to be taken in this direction. In this note the major requirements necessary to specify high expansion foam liquid and high expansion foam are outlined and the extent to which it is possible to produce a specification at the present time is indicated.

REQUIREMENTS FOR SPECIFICATION

The main object of a specification of this kind is to ensure that under the practical conditions encountered by the firemen a sufficient quantity of high expansion foam of acceptable quality is produced. In addition to the foam liquid, the nature of the water used, and even of the atmospheric air, are important factors in controlling both quality and quantity of foam produced. The design of equipment used is also an important factor. It is therefore not possible to specify requirements for a foam liquid in isolation, and indeed many of these requirements can only be judged by performance tests on the high expansion foam produced, both by standardised laboratory apparatus, and the equipment in which the foam compound is to be used. For this reason the requirements have been sub-divided into four groups covering the physical properties of the foam liquid itself, the physical properties of the high expansion foam, certain essential requirements for the equipment producing the foam, and suggested performance tests of the high expansion foam on fires.

It should be noted that the term "high expansion" generally covers a range of expansion from 100 to 1,000, and this note will refer to foams within this range. However, the possibility should not be overlooked that the specification for foam liquids to produce foams within this range might also be extended to cover the whole range of expansions, so as to encourage the development of single foam liquids, to produce foams over the whole range of purposes required by the Brigades, i.e. for expansions between 5 and 1,000.

Physical properties of the foam liquid

Viscosity

The viscosity of the foam liquid is important because this governs the ability of the liquid to be conveyed either by pumping or induction into the water to give a foam-making solution. If pumping is used, a high viscosity may be tolerated in the foam-making liquid, but available evidence indicates that the viscosity should not be greater than 1,000 centistokes if the liquid is to be pumped. On the other hand, if the foam liquid is induced into the water the viscosity must be considerably less. A viscosity of 25 centistokes should allow the induction of the foam-making agent into simple inductors.

Solubility

The foam compound should be capable of forming a solution with water at the required strength of active material. Water temperatures likely to be encountered will vary between 5 to 30°C. Generally, insofar as mains water in town areas is concerned, the water is likely to be quite soft, or to have a hardness of approximately 300 parts per million. On the other hand, it is also desirable to use the liquid with sea water, which, of course, has a very much greater hardness.

Storage and ageing

The material should not undergo chemical or physical change when stored under temperature conditions existing in this country. Requirements of the Ministry of Public Building and Works for protein foam liquid may be taken as a guide in this. These requirements are that there shall be no precipitation within two years when the storage temperature has any value between 0 and 37°C, and at the end of two years it should retain its fire-fighting properties.

Corrosion

Foaming liquid should not be unduly corrosive to the materials of the containers in which they are shipped or stored. The material should not be highly flammable (flash point less than 150°F) or cause any physiological hazard.

Specifications for the foam produced

Conversion to foam

It is important that the foam liquid should allow the adequate conversion of water and air to high expansion foam with the minimum wastage of either of these constituents. A good performance is often obtainable when water and/or air temperatures are average, but might fall off badly when extremes of air or water temperatures are reached. Generally air temperatures might vary between -10 and +37°C and water temperatures between 5 and 30°C.

Foam stability

When the foam has covered a source of fire or filled a volume it acts as an obstacle for ventilation currents of air to the fire area which can rekindle the fire. It is important, therefore, that the foam should have a substantial life.

Water drainage test

Available information on performance of high expansion foam suggests that the rapidity of drainage of water from the foam is the most important property governing its performance. Thus, if a 2 ft thick layer of the foam allows 50 per cent of its water to drain in two minutes, its performance in extinguishing fires is comparatively poor. Although the foam can usually cover such fires a rapid breakdown and reignition usually follows fairly quickly. In fact there is a tendency for flammable liquids to burn under quite substantial thicknesses of such foams. On the other hand, if the drainage time is ten minutes the foam can cover and even extinguish a wide range of flammable liquids and solids fires. These figures apply for foams with an expansion of 1,000. There is no available information on the effect of drainage time on performance for foams of much lower expansion, and it is necessary to carry out performance tests on fire to define required drainage rates.

Breakdown of foam by heat

The predominant mechanisms of action of high expansion foam are to cover the fuel completely and cut off the source of fuel vapour to the fire, and to cut off all openings to prevent the movement of air towards the fire. If before reaching either of these two places the foam is exposed to excessive heat, it will be liable to breakdown, probably with a release of air which will help feed the fire. It has often been stated that in the breakdown of the foam by heat, the steam that would be produced would be sufficient to reduce the oxygen concentration below ten per cent, and thus extinguish the flames. A number of performance tests on high expansion foam indicate

this to be rather the exception than the rule. It is likely that exposure of the foam to heat increases the drainage rate as well as causing evaporation of the water in the bubbles. It would be desirable to include in a specification a test on the breakdown of high expansion foam by radiation and possibly even conduction from hot metal surfaces, although it would be difficult to specify requirements in simple laboratory apparatus without much more information on the performance of high expansion foam against actual fires.

Breakdown by movement

The movement of foam through a duct, along a corridor or through a nest of passages tends to break down the foam. Available data does not provide consistent information on the amount of breakdown that takes place under these conditions, and some research is necessary here.

Breakdown by chemical and physical agents

The presence of certain substances might accelerate the breakdown process. Thus experience in tests carried out in a basement indicated that the presence of fine grain dust accelerated the breakdown[4]. Experiments at the Fire Research Station have shown that china clay may actually be used to help the breakdown of foam when it is necessary to clear foam away quickly. However, it is impracticable that specific tests should be devised to cover the wide range of substances with which high expansion foams might come into contact.

Performance of foam-producing apparatus

Ability to produce foam

It is important that the apparatus should produce high expansion foam without undue wastage of air or water solution over the range of water and air conditions that it could encounter. It might be difficult, however, to produce artificially extremes of conditions on the full-scale, particularly sub-zero temperatures in the atmospheric air and reliance may need to be placed on laboratory-sized equipment, as indicated above. The presence of certain contaminants in the air might reduce the efficiency of foam production. Thus, it has been stated that products of combustion of polyvinyl chloride and particularly the hydrogen chloride, can seriously affect foam production[2]. Indeed, the presence of great acidity in the water whatever the cause might seriously worsen the properties of the foam. Thus[3], the drainage performance of ammonium lauryl sulphate high expansion foams was found to deteriorate catastrophically when the PH of the water used was reduced to a value lower than 2. However, to produce such an acidity in the water as a result of the presence of hydrogen chloride in the gas would require of the order of 300 parts per million of hydrogen chloride vapour. Such an atmosphere would be quite irrespirable.

Back pressure of foam

It is necessary that high expansion foam be delivered through a length of ducting into premises. A decision will be needed on a reasonable length of ducting and there should be a specification that the high expansion foam should be capable of delivery through this ducting within the range of pressure drop available from the appliance and without any significant reduction in the water content of the foam. The specification may also cover the breakdown of the foam that would occur.

Fire performance tests

In order to obtain criteria which might be inserted in performance tests for the foam compound and the high expansion foam it is necessary to know a great deal more of performance of foams of a variety of expansions against different typical standard fires. It is suggested that the following standard fires be used as a basis for obtaining this information and also as a basis for obtaining a direct measure of the efficacy of the high expansion foam itself:-

a) Liquid fire on the ground. This could be a simple tray fire, such as is used for testing the efficacy of extinguishers. The fire should be placed within a bounded area so that the ratio of fire area to bounding area is constant. The high expansion foam might then be tested by finding the rate of filling of the bounding area which would bring about control of the fire, and also the minimum thickness of foam required to bring about complete extinction. It has been found[4] that a petrol fire of 20 sq. ft within a boundary area of 200 sq. ft can be controlled with a rate of filling of 6 in to 1 ft per minute, with foam of expansion of 800 to 1,000, and may be extinguished when the thickness of the foam layer is 1 to 2 ft in depth.

b) A crib fire. This is similar to a) except that a burning crib is used instead of burning liquid. Again, the rate of filling of the bounded area can be measured, and the height of build-up of foam required to bring about complete extinction. Experience indicates that such fires are more difficult to extinguish by high expansion foam than petrol fires.

c) A fire with flames under the ceiling. During the development of the fire, after flames have reached the ceiling they spread extensively under the ceilings. This state of the fire is commonly encountered in buildings and is the state which leads to flashover. It is important in testing high expansion foam, since during the advance of foam to the source of the fire, the foam becomes exposed to a great deal of radiation from the flames under the ceiling and under these conditions the foam breaks down readily. It has been found[4] that the burning of a tray of petrol under a concrete ceiling produces extensive flames of this kind which could be used to similate this type of fire.

d) A running oil fire over hot metalwork. High expansion foam is coming to be increasingly used for fires in engine rooms, turbines, etc. The most difficult situation which the foam would need to face under these conditions is a fire stabilized on a network of hot metal, particularly in the form of tubes, girders, etc. In this situation the foam would tend to break down by heat transfer from the conducting metalwork as well as from the flame, and the foam might have difficulty in covering such a fire. A fire of this kind was used as the basis for acceptance tests for water sprays in similar risk conditions[5], but no information is available on acceptance tests of this kind with high expansion foam. Experiments are due to be carried out on this type of fire at the Joint Fire Research Organization.

The prime reason for the fire performance tests is to define criteria of acceptability for tests on the properties of the foam, particularly drainage rate and breakdown by heat. It is possible, however, that such properties might not be capable of measurement in simple laboratory tests and a fire performance test may be needed as a direct measure of the relevant property of the foam. For example, it has been found[4] in work on test (c) above that the breakdown of foam in a practical test occurs at several times the rate that would be expected from the radiation that the foam has to encounter. It is possible that the combined effect on breakdown of movement and radiation together is greater than either singly. It may be added that it has been found that a petrol fire 20 sq. ft under a ceiling of 200 sq. ft area requires a flow of high expansion foam about eight times the rate to a similar size fire on the ground referred to under "a".

REQUIREMENTS CAPABLE OF IMMEDIATE SPECIFICATION

The above paragraphs indicate the wide range of factors that would need to be specified before a full specification for high expansion foam may be defined. At the present time enough information is available to define some of the basic requirements for the foam liquid, as follows:-

(i) Viscosity and solubility. These can be easily measured.

(ii) Storage, ageing. The procedure as laid down by the M.P.B.W. requirements can be followed here.

(iii) Corrosion, flammability and physiological hazard. This can usually be assessed if the composition of the foaming liquid is known. If necessary, tests can be devised to meet special cases.

(v) Drainage. An investigation has been in progress at the Fire Research Station to devise a satisfactory drainage test for high expansion foam. In a previous paper[6] an apparatus was described for measuring the drainage of high expansion foams. However, in the present context this apparatus has the disadvantages of being able to produce only foams within a narrow range of expansion and not allowing independent checks on the expansion and water content of the foam.

A new apparatus is being devised at the J.F.R.O. with which it is aimed to rectify these defects. The appliance can produce foam within a range of 200 to 800 and it delivers samples of foam to a cylindrical transparent container, which may then be weighed continuously. This allows a complete record of both the expansion and the extent of drainage to be obtained.

Results so far indicate that half drainage times of the foam depends very markedly on the expansion, but that a foam liquid which produces a good foam at one expansion also produces a good foam over the whole range. It is suggested, therefore, in the first instance that the expansion of foam tested should be between 500 and 600. The sample of foam tested should be 4 ft high and 2 ft 4 in diameter, and the half time for drainage of this sample of foam should not be less than 16 minutes. As more experience on a wider range of foam compounds is obtained and on the results of performance tests on fires, it may be necessary to modify this figure, but in the first instance, foams which pass this test should be capable of giving a good fire extinguishing performance of fires near ground level.

Apart from the above, there is little testing which can be usefully carried out at the present time, and a great deal more information on actual performance against fire is necessary to devise further tests. However, a test which should be developed in the near future, is one on the ability of the foam compound to convert water and air into high expansion foam under extremities of conditions encountered by the Fire Service. This should be capable of being done using the foaming apparatus used above to test foam lifetime and drainage.

Conclusions

(1) Requirements for a specification for high expansion foam liquid should cover performance requirements on the foaming properties as well as the physical properties of the liquid and also of the apparatus in which the liquid is to be used.

(2) Further information on the performance of high expansion foams against fire is required before the foam liquid can be fully specified. It may be necessary to include performance tests on fires to specify the quality of the foam made by the liquid.

(3) At present it is possible to draw up a specification covering the physical properties of the liquid and the drainage and stability of the foam.

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