QUALITY CONTROL PROCEDURES FOR FIRE-FIGhTING FOAMS

J.G.Corrie
Fire Research Station, Borehamwood, Hertfordshire

New United Kingdom Defence Standards for three types of fire-fighting foam are described. The quality control positions for other types of foam are given.

INTRODUCTION

All operations which include the use of flammable liquids introduce the risk of fire. Such fires are alarming in the rapidity of their growth and in their intensity, and plans must be made in advance to deal with them promptly and efficiently. No matter what safety precautions are taken the possibility of fire must be accepted; fires dc occur in industry, involving the manufacture, storage, or use of flammable liquids. In addition to accidental fires those caused by lightning, arsonists, or terrorists are gocd reasons for not relying entirely on prevention measures.

In most cases control and extinction by the application of fire-fighting foam is the method of choice and supplies of foam concentrate must be planned in advance. In a previous symposium, number five of this current series on Chemical Process Hazards, the importance of selecting the correct type of foam to be used, according to the flammable liquid at risk, was illustrated. In this paper the problems of ensuring that foam concentrate is of good quality when purchased and checking that it remains in good condition, are considered. It is appropriate to do so at this time because significant advances have recently been made in the United Kingdom in the quality control procedures, for the more important types of foam concentrate.

Difficulties of Assessing Foam Concentrate .Quality

Although fire-fighting foams have been the subject of much study in the past two decades a sufficient understanding of their mode of action to enable quality to be determined by a range of physical laboratory tests, such as viscosity and surface tensions, is not yet possible. Their precise chemical compositions are generally trade secrets, although we do know their principal constituents. They are complex mixtures such as hydrolysed proteins, synthetic detergents and fluoro-chemical surfactants the analysis of which is difficult and expensive. As with physical properties, chemical composition cannot be correlated with extinction performance. Thus quality assessment has to be based upon a fire extinction test. Experimental fire tests present problems. Large scale tests are expensive, pollute the environment, and are influenced by the vagaries of the weather. Considerable success has been achieved in designing small scale fire tests, and the new Defence Standard methods are a significant step forward in this field.

Another important limitation is that foam concentrates are complex formulations which may slowly change with time. Reaction with oxygen when exposed to the air, or with the material from which the containers are made may occur. Some concentrates are colloidal in nature and may form precipitates. Stocks of concentrate, which may remain unused for many years cannot be presumed to retain their special properties indefinitely, and checks of their quality are therefore required at appropriate intervals.

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CURRENT UNITED KINGDOM SPECIFICATIONS

The present position is as follows:

Protein foam	-	new Defence Standard (1)
Fluoroprotein foam	-	new Defence Standard (2)
Fluorochemical foam	-	new Defence Standard (3)
Synthetic foam		Home Office Specification (4)
Alcohol-resistant foam	-	no Specification

The three new Defence Standards were introduced in 1976. Previously there was only one Defence Standard, for protein foam, which is now superseded. There were no previous Standards for fluoroprotein and fluorochemical foam.

Before new Standards are described in detail, some aspects of the specifications of synthetic and alcohol resistant foams will he discussed.

Synthetic Foam

In the Home Office specification, in addition to a number of simple physical tests for the concentrate such as viscosity, pH, cloud point etc, the principal requirement is a minimum '50 per cent' drainage time of a sample of foam with expansion 1000 : 1. The foam is made at 20°C and this drainage time must not be less than 8 minutes. In UK the synthetic foams are mostly used in the form of high expansion foam for smothering fires by complete filling of enclosed spaces, such as stores or ship's holds. The specification drainage test assesses the suitability of the product to produce a stable high-expansion foam. A fire extinction test is not currently included.

The specification states that concentrates complying with the specification will also be suitable for the generation of medium expansion foam. If the use of medium expansion foam increases, which it probably will, it will be desirable to have a separate specification for this purpose, and it should include a fire extinction test. Similarly if the use of synthetic foam at low expansion increases in UK, as it has done in some continental countries, a separate specification will be desirable.

Alcohol-Resistant Foam

There is no UK specification for alcohol-resistant foam and one must rely upon information provided by the manufacturer. Because of the increased usage of flammable polar solvents by the chemical industry it is a problem of growing importance. The subject is difficult because solvents with a wide range of physical and chemical properties are used. The best advice is to ensure that the manufacturer provides specific experimental evidence of extinction performance with the solvent concerned. For many flammable liquids data already exist and the manufacturers of foam concentrates can usually co-operate in assessing their products against new liquids. It is difficult to visualize how a general specification for alcohol-resistant foams can be developed. A practical approach may be to prepare a standard test procedure for assessing foams against any flammable liquid. Because the Services have only small requirements for alcohol—resistant foam it is improbable that a Defence Standard will emerge and a Home Office or British Standards specification are possible alternatives.

THE NEW DEFENCE STANDARDS

General Points

Defence Standards are produced for the purpose of ensuring that equipment and materials purchased for the three Services conform to a defined quality. They are however freely available and can be used when alternatives such as British Standards Specifications are not available.

The old Defence Standard for protein foam had served well and, over many years ensured that in the United Kingdom a uniform, high quality was maintained. Problems encountered earlier, particularly sludge formation and batch to batch variation were effectively eliminated. With the advent of the newer foams the old Standard did not provide a good assessment of their fire control and extinction properties and improved methods were called for. The new Standards have been developed by the Ministry of Defence, through the Defence Engineering and Equipment Standardisation Committee, who enlist assistance and advice from other bodies such as Department of the Environment, Home Office, Civil Aviation Authority, foam manufacturers, and the Fire Research Station.

It is important to note that the new Standards all refer to foam suitable for use on liquid hydrocarbon fires, and their quality assessment may not be valid for other types of flammable liquid. A pertinent question therefore is why are there three new Standards and not a single performance Standard for all low expansion foams. It is because in some respects the new fluoroprotein and fluorochemical foams are superior to protein foam. For example fluorochemical

foams are notable for rapid fire control while fluoroprotein foams often provide particularly good post-extinction protection. Perhaps one day there will be a product which excels in all properties, hut meanwhile we must have a system which permits the use of products excelling in specific ways.

The new Standards should not he regarded as a hasis for predicting the application rates and extinction times for the large complex fires which occur in practice. Much study is still required before a reliable correlation with small lahoratory fires is estahlished. Rather must we regard the new Standards as effective means of ensuring that a batch of concentrate is of a satisfactory quality for its particular type.

Only a few companies manufacture foam concentrate and they justifiably have the reputation of being skilled in the art. If a new foam liquid appears, of a novel formulation, or from a completely new source, although it met the requirements of one of the new Standards, a variety of large scale practical tests would be necessary before it was generally accepted.

One disadvantage of standards is that they can inhibit innovation and this point is allowed for by including a clause that other liquids will be considered on a basis of their overall merits.

In the United Kingdom we have adopted the name 'fluorochemical' to describe the class of new foams which in the United States are called aqueous film-forming foams (AFFF). In some continental countries 'fluorosynthetic' is used to describe these foams. It is not established to what extent the film formation contributes to fire control and extinction properties of these foams, and methods of measuring film formation in the fire situation present difficulties. It is generally thought that any advantage from, film formation will he reflected in the fire extinction test.

The Defence Standard requires that the composition and a description of the manufacturing process are provided. Although this is acceptable when the government is the purchaser it would be an unreasonable disclosure in sales to private concerns. It would, however, he reasonable to ask for a general statement of the nature of the concentrate. With the Health and Safety at Work Act, and current concern with environmental pollution, some knowledge of the liquids handled is essential. The manufacturers generally provide adequate information in their product brochures.

Defence Standards usually provide details of packaging requirements. These have been omitted from the new foam Standards and will be regarded as an appendix to the purchase contract. Twenty litre plastic drums and 20 litre steel drums are both successfully used and the foam manufacturers ensure their suitability. One cautionary warning is that the plastic drums may fail if they are stacked too high, and a maximum of two deep is a useful guide to avoid this trouble.

CONTENTS OF THE NEW STANDARDS

The three new Standards are almost identical. Precisely the same test methods are used but different values are required for the foam properties, the fire control and extinction times, the burn-back time, and the pH value. The fluorochemical foam is tested as a 6 per cent solution while the other two foams are tested as 4 per cent solutions - these being the concentrations at which they are normally used.

In the fluorochemical Standard the test for sludge content after ageing, is omitted as it is inappropriate.

The tests for sludge content, viscosity and pH are prosaic and attention will now he given to the foam properties and the fire tests.

Foam Properties

Foam properties are determined on foam produced in a 5 litre per minute brass branchpipe which must he constructed carefully. Production drawings (5) are obtainable. A premixed solution is fed to the branchpipe at a pressure of 7 bar. A device on the branchpipe permits the discharge to be divided into a jet of 750 ml/min (which is to be used en the test fire) and a side stream of surplus foam. This discharge device requires slight adjustment for each foam. The foam from the jet is sampled. The expansion is determined by weighing a litre sample. The '25 per cent' drainage time is determined using a 20 cm deep pan. Tests are done using hoth fresh water and sea water to prepare the premix. Table 1 gives the requirements for the various types of foam.

It can be argued that the expansion and drainage properties of the foam need not he specified and that their effect will he revealed in the fire test results. There is some substance in this, hut these measurements are simple and require little time to make, and long experience has shown that they are useful indices of foam effectiveness.

The Fire Tests

Fire tests are required using gasoline and kerosine as fuel, and both fresh water and sea water to prepare the foam solution. The average of the best two from three tests can be selected. Thus a total of 8, or perhaps 12 fires is required. Only rarely is a third repeat required to allow for the chance persistence of a small flame against the tray side in one of the first two tests.

Nine litres of fuel are placed in a circular "brass fire tray with an area of 0.25 m . After ignition a preburn time of 1 minute is allowed and then foam is applied at 750 ml/min, ie 3 l/m^2-min, for a total time of 3 minutes. The time when the fire is reduced to 10 per cent of its original intensity is noted and also when extinction is achieved. The control time may be measured by radiometers or other suitable instrumentation, but direct observation is acceptable, and with a little experience different laboratories can obtain satisfactory agreement by this most simple method. The position of the branchpipe must be carefully adjusted so that its height above, and distance from, the fuel surface are as specified in the standard. Its position affects the force with which the foam stream hits the fuel surface and influences the extent of the contamination of the foam blanket with entrained fuel. This in turn affects the extinction time and the burn-back time.

After completion of the 3 minutes foam application, a brass pot containing gasoline is placed in the centre of the fire tray, so that it stands proud of the fuel, and ignited 1 minute later. The flames from the pot slowly destroy the foam in the fire tray and reignite the fuel. The time taken for the fire tray to be again fully covered with flames is noted, and is referred to as the burn-back time. Burn-back times vary between 10 and 30 minutes, and duplicate tests generally agree within ± 1 minute. It is important that the stated dimensions of the fire tray and burn-back pot are closely adhered to as any significant difference between the level of the 1 litre of gasoline in the burn-back pot and the fuel level in the fire tray will affect the result. Table 1 gives the fire test requirements for the various foams with gasoline and kerosine, fresh water and sea water.

From Table 1 it can be seen that the fluorochemical foams must have the shortest control and extinction times, followed by the fluoroproteins and then the proteins. The fluorochemical foams are permitted to have shorter burn—back times and shorter drainage times than the other two types of foam.

Testing Facilities

The apparatus required is described fully in the Standards. It is not available from laboratory suppliers and must be specially constructed, but many small engineering firms or engineering departments of large concerns would be able to do so. There is however one onerous requirement - a test room with an extraction hood of adequate size. A hood 2.25 m dia, 2.5 m above the ground, with a fan extracting 200 m3/min of free air is satisfactory. Experimental technique is not difficult to acquire but some reasonable amount of practice is necessary before reliable results are assured.

It is not therefore a practical proposition for the individual purchaser to arrange to test his own purchases and samples from stock, except in the few special cases of large regular purchasers, eg the Froperty Services Agency, who purchase on behalf of the Services. At present test rigs are operated by four manufacturers in the United Kingdom, one Continental manufacturer, the Property Services Agency and the Fire Research Station. Other purchasers must rely on the manufacturer's warranty, and they can also test foam stocks and advice on their replacement. The Fire Research Station have on many occasions checked their test results and found them completely reliable.

RECOMMENDATIONS

1. When purchasing protein, fluoroprotein, or fluorochemical foam concentrate, specify that it must conform to the relevant Defence Standard and ask the manufacturers to supply test results.

2. When purchasing synthetic foam concentrate for use as high expansion or medium expansion foam specify that it must conform to the Home Office specification, and ask the manufacturer to supply test results.

3. When purchasing alcohol resistant foam accept the manufacturers quality assurance and request supporting test data for the particular flammable liquid at risk.

4. At the time of purchase provide the manufacturer with details of storage conditions and ask for recommendations about frequency of quality checks.

5. Endeavour to plan regular fire practices for plant operators and works brigades (with extinguishers and branchpipes) so that stocks of foam concentrate are progressively used and replaced, and long—dated stocks are avoided.

REFERENCES

1. Defence Standard 42-21 Issue 1-27 July 1976. Foam Liquid-Fire Extinguishing. (Protein Type).

2. Defence Standard 42-22 Issue 1-23 July 1976. Foam Liquid-Fire Extinguishing. (Fluoroprotein Type).

3. Defence Standard 42-24 Issue 1-September 1976. Foam Liquid-Fire Extinguishing. (Fluorochemical Type).

Defence Standards are obtainable from: Ministry of Defence, Directorate of Standardization, First Avenue House, High Kolborn, London WC1 V—6HE.

4. Specification No.JCDD/28 High Expansion Foam Liquids. Home Office, Fire Department, Horseferry House, Dean Ryle Street, London SW1P 2AW.

5. Drawing No.MDG N0.96O. Department of the Environment, Southbridge House, Southbank Bridge, Londcn SE1.

TABLE 1 - Defence Standard test requirements

	Foam properties	Tests with AVTUR fuel	Tests with AVGAS fuel
PROTEIN			
Expansion	Not less than 7.0	-	-
25 per cent drainage time - min	Not less than 6.5	—	—
90 per cent control time — s	—	Not more than 100	Not more than 140
Extinction time - s	—	Not more than 130	Not more than 180
Burn-back time - s	-	Not less than 15	Not less than 10
FLUOROPROTEIN			
Expansion	Not less than 7.0	—	—
25 per cent drainage time - min	Not less than 6.5	—	—
90 per cent control time — s	—	Not more than 50	Not more than 75
Extinction time — s	—	Not more than 80	Not more than 110
Burn—back time - min	-	Not less than 15	Not less than 10
FLUOROCHEMICAL			
Expansion	Not less than 7.0	—	—
25 per cent drainage time - min	Not less than 3.5	—	—
90 per cent control time - s	—	Not more than 25	Not more than 40
Extinction time - s	—	Not more than 45	Not more than 60
Burn—back time - min	-	Not less than 10	Not less than 5