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HIGH EXPANSION FOAM FIRE PROTECTION SYSTEMS

By

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ABSTRACT

An investigation has been made regarding the suitability of high expansion foam fire protection systems for use in Naval shore facilities, and it is concluded that presently available high expansion foam equipment becomes cost-effective only in special situations. Certain types of storage facilities and remote buildings requiring self-contained systems are typical locations where high expansion foam should be considered for fire protection. New concepts in generator design and developments of improved foam concentrates should be examined as this work is anticipated to produce less expensive and more effective systems in the near future.

INTRODUCTION

The Naval Facilities Engineering Command (NAVFAC) initiated a program to obtain data on high expansion foam fire extinguishing systems for structural fire fighting in Naval shore facilities. High expansion foam is defined[1] as fire fighting foam having an expansion ratio (ratio of volume of solution of concentrate in water to volume of foam produced by the solution) at the outlet of the foam discharge equipment of not less than 100:1. Commercial high expansion foam generators produce foam in the range 500 to 1,000 to 1. The use of high expansion foam for fire fighting is a relatively new technique which has been developed since 1958 and is anticipated to have wide application for the protection of structures by supplementing or replacing present methods. Acceptance of this new concept must be based on a high degree of confidence in the capability and reliability of the system. At present, information is limited regarding its effectiveness for the variety of building and occupancy situations encountered in military facilities. This study has been undertaken to test and evaluate high expansion foam fire extinguishing equipment to establish a basis for engineering decisions concerning the use of this type of system.

The Factory Mutual Research Corporation under contract with the Naval Civil Engineering Laboratory (NCEL) evaluated high expansion foam on the basis of a literature survey, a test program and a cost effectiveness comparison between foam and sprinkler systems. The automatic sprinkler system may be considered the most generally used and important fire protection device in common use and such factors as capability, cost, equipment availability, damage and water consumption have been compared. Potential economic and technical advantages are illustrated. The study[2] concludes that at the present time, high expansion foam must be regarded as a specialized fire fighting system although there are applications where this system has distinct advantages over other systems such as sprinklers. Additional information collected by NCEL indicates that some of the major disadvantages of this type of system will be overcome in the near future by development work in progress at this time.

Principle of Operation

High expansion foam is essentially detergent bubbles of uniform size produced by large volumes of air and relatively small quantities of water and detergent solution. The foam is produced by blowing air through a nylon or perforated metal screen which is uniformly wetted by the water/foam concentrate solution. Expansion ratios may be obtained in excess of 1,000 to 1 although the foam becomes drier and less effective as the expansion ratio approaches and is increased beyond this figure. Due to the high expansion ratio, the foam may be generated in volumes which permit the total flooding of large areas in short periods of time. Foam generators in current production and commercially available for large permanent installations are able to produce 50,000 cfm of foam; portable units which may be carried by one or two men are available in the range 2,000 to 5,000 cfm, and mobile truck mounted units of intermediate sizes are also available.

The foam is an effective fire fighting agent for several reasons:

1. The formation of steam when the foam is driven onto a fire dilutes the oxygen content of the surrounding foam atmosphere to an approximate value of 7%, at which level combustion is not possible.

2. The formation of steam absorbs heat which cools the burning material.

3. The fire causes the breakdown of the surrounding foam and the resulting liquid cools and quenches the burning material.

4. The complete coverage of a fire reduces radiation and provides insulation as well as maintaining a smothering atmosphere by the exclusion of fresh air.

BACKGROUND

The concept of high expansion foam was developed in Great Britain for fire fighting purposes in coal mines. The foam was formed by erecting a net across the mine entry and using a water/detergent mixture to spray the net from a hand nozzle. The air was supplied from the mine ventilation system directed through the net and a number of experiments were conducted to evaluate the system and its components. The foam produced by this method could form foam to fill the mine roadways and extinguish timber fires, and this method of fire fighting was reccommended for situations where standard methods were ineffective or impossible to implement. The foam was shown to rapidly extinguish flaming combustion and hose streams were used to completely extinguish any smoldering.[3,4,5,6]

The U. S. Bureau of Mines conducted tests on coal mine fires using a variety of foam concentrates with different expansion ratios. Foam was found to be effective for control if the foam was wet and drainage had not removed most of the water. A minimum water content was specified for effectiveness of high expansion foam.[7,8,9] Further development work was carried out by Safety Development Company and the foam was used on two mine fires with considerable success.[10,11]

The concept of high expansion foam for general fire fighting purposes, other than mining, has been developed in the last 5 years. Extensive test programs have been conducted to demonstrate and effectiveness of high expansion foam on Class A and Class B fires.[12] In certain applications the nature of the foam demonstrated distinct advantages over other fire protection systems.[13,14,15,16,17] Several manufacturers have developed foam generating equipment and installations at large industrial facilities have been made. The Naval Applied Science Laboratory (NASL) has developed a generator for shipboard use[18] and has planned to test equipment for submarine use.[19]

High expansion foam is a relatively new concept and tests are still continuing to improve and optimize current foam generating equipment and foam characteristics. As these programs proceed, it may be expected that further developments will reveal additional applications and greater acceptability of the systems. In addition, new concepts in generator configuration are being made and improvement of foam characteristics sought.

This work was necessarily confined to the application of currently available equipment and foam concentrates for installation at fixed locations. Investigations by NCEL have found a new system not yet commercially available which shows exceptional promise when development is complete. There exist many problems associated with the characteristics of high expansion foam which are still to be resolved and are more in the nature of basic research than evaluation. Problems such as optimum expansion ratio, drainage rates and foam concentrate composition have been briefly examined but require further work.

SCOPE OF WORK AND TECHNICAL APPROACH

The contractors system evaluation has been based on a test program and previous experience with high expansion foam. The contractor submitted a review of information on commercially available high expansion foam generators and recommended suitable equipment for the tests.

The general aspects of high expansion foam have been covered in many test programs and have not been repeated in this work. Fire tests were conducted primarily to determine the effects of combustion products on the foam generating capability of the equipment. This area is of considerable importance as the requirement of using fresh air for foam generation markedly increases the initial cost of a high expansion foam system. A cost effectiveness study was made and standards for high expansion foams reviewed. In addition, methods of foam removal are discussed and a brief study made of the effect of adding Freon 1301 to the foam as an additional fire suppressant. This report also contains additional information collected at NCEL on recent developments in high expansion foam technology.

SELECTION OF TEST EQUIPMENT AND TEST PROGRAM

A study was made of commercially available high expansion foam components and systems to permit selection of the most suitable equipment for the test program. To obtain information from manufacturers of equipment, requests for quotations were sent out with specifications and conditions allowing competative design and bidding based on the quotations. It was decided to use two water powered generators of 2,000 cfm capacity. The foam concetrate is introduced into the water stream by an eductor and the generators were installed inside a test building 18'9" x 28'2" x 17'6" with an internal volume of 9242 ft^3.

The Class A fuel consisted of 4' x 4' panels of 3/4" plywood arranged vertically with 6-inch spaces, as shown in Figure 1. This fuel configuration was used instead of the hardwood pallets usually employed for fire tests as the panel arrangements permitted greater flexibility and reproducibility and were less costly than pallets. To check the results using the plywood, one fire test was carried out with pallets for comparison purposes. Class B fuels consisted of heptane or denatured alcohol.

The two generators were mounted near the ceiling of the building and for most tests one generator was used for foam production with the other generator on standby. The second generator was used when the first generator was inadequate for the test and also to ascertain that poor foam production rates were due to contamination by combustion products and not mechanical failure. Instrumentation included temperature measurement at several locations, fuel weight loss, water and concentrate flow rates and time for operation of two fire detectors.

The test procedure consisted of igniting the fuel and allowing it to burn for a measured period of time. The foam generator was manually activated and measurements made of rate of increase of foam height and drainage. Observations of foam generator performance and extinguishment of the fire were made.

A total of 24 fire tests were conducted using Class A or Class B fuels. The tests were, in general, of an exploratory nature and the data collected served to define each test rather than to form a definite conclusion from each fire and extinguishment. Some tests were used to obtain comparative data without a fire in the area. Data was collected to examine generator performance and foam characteristics with and without fire and combustion products. An attempt was made to introduce realistic conditions into the fire test program, using preburn times gauged to represent a probable actuation time for an automatic system.

TEST RESULTS

The tests were carried out with the prime objective of determining the effect of combustion products on the foam generating capabilities of the equipment under simulated realistic conditions for automated systems. It was proven by observation and evaluation of the data that under the conditions existing at the time of the tests, foam generation deteriorated due to combustion products from the fire contaminating the air used for foam production. Class B fires were extinguished although the foam produced using the air contaminated by the products of combustion from these fires was of inferior quality. The Class A fires were also mostly extinguished in spite of almost complete breakdown in the foam generating capabilities of the equipment once combustion products from the partially extinguished fire reached the generators. Only in the last test with pallets did the fire reach proportions where is was necessary to use a hose stream for complete extinguishment after failure of the generators due to excessive air contamination. No attempt was made to determine the exact constituent of the products of combustion which caused the foam breakdown. However, the tests indicated that it was only after the foam reached the fire and the combustion process was disturbed and the fire partially extinguished that there was no foam produced by the generators. Tests by manufacturers have been conducted taking the intake air for the generator from a well developed flammable liquid fire and have shown no deterioration in foam production capabilities. It is, therefore, apparent that the deterioration and eventual failure of high expansion foam equipment fed with contaminated air is due to the assorted products of partial combustion. The effect of air temperature has been shown to be insignificant in foam production in this work and in other tests by manufacturers of equipment.

The removal of foam from an enclosed area may be achieved in a number of ways. The simplest method is to permit the foam to naturally drain and breakdown. The removal may be speeded up by using a blower or heavy duty vacuum cleaner or, if increased damage is unimportant, a water spray may be used. The use of chemical defoaming agents is not recommended.

ADVANTAGES AND DISADVANTAGES OF HIGH EXPANSION FOAM

The nature of high expansion foam introduces several unique and distinct advantages over other fire fighting methods. These advantages have been reported frequently and are fully exploited in all equipment manufacturers literature. The main advantages are briefly listed below, where a comparison is made between high expansion foam and water as fire fighting media.

1. High expansion foam reaches inaccessible and shielded areas which are protected from water sprays.

2. High expansion foam acts as a shield against radiant heat from a fire where water sprays have little or no effect.

3. Damage and cleanup problems are minimized with high expansion foam.

4. High expansion foam tends to move towards fire by convection currents, accelerating extinguishment.

5. High expansion foam is suitable for Class A and B fires whereas water is only suitable for Class A fires.

6. Water requirements for high expansion foam production are small.

7. With portable high expansion foam equipment, firemen need not enter a building to extinguish a fire not directly accessible.

At this time, the primary disadvantages of high expansion foam systems are related to the quantity of equipment required for protection and the cost associated with this equipment. Sufficient foam generating equipment must be provided to totally flood the protected area with the maximum distance the foam must travel limited by the drainage rate. Excessive distances lead to ineffective, dry foam of poor extinguishing capabilities reaching the fire. The additional necessity of following recommendations to provide clean air for the production of the high expansion foam at the generators produces a system which is almost inevitably more expensive than a water sprinkler system for normal applications. The complexity of the generators reduces reliability although a new system recently developed has overcome this problem and is discussed in detail later in this report.

STANDARDS AND CODES

The design of high expansion foam fire protection systems for enclosed areas at fixed locations must be based on standards and codes relating to performance requirements and the application under consideration. The National Fire Protection Association has produced a tentative standard[20] for high expansion foam system design. Work at NASL has also been directed towards producing adequate standards for installation.[21] Although no firm procedures have been laid down for system design, the above work has produced guidelines which should be followed. A minimum rate of rise of foam within the enclosed area has been specified as 3 ft/min with allowances for foam breakdown in the vicinity of the fire, and drainage. Foam depth should be maintained at least 2 feet above the hazard for one hour. Foam generation must continue for this period of time as drainage, breakdown due to the fire and other factors will cause foam deterioration.

Foam Characteristics

Each manufacturer of equipment produces a foam concentrate recommended for their generator. The constituents in these concentrates vary but they all essentially conform to the basic requirements of producing a stable foam.[22]

The expansion ratio recommended as optimum has been shown to be of the order of 600:1.[21] The fluidity of the foam and its ability to penetrate confined spaces is an important feature and is related to foam concentrate constituents. The drainage of the foam must be kept to a minimum to ensure that the maximum quantity of water is carried to the fire and to ensure the foam remains stable. The damage caused by foam concentrates upon evaporation after the fire may be unacceptable if the residue is difficult to remove or has other undesirable features.

It may be seen that several essential characteristics must be combined into a single solution and this has proven difficult. Other characteristics which should be achieved are the development of a concentrate unaffected by combustion products and also usable in a variety of different generators - currently foam concentrate from one manufacturer has been shown unacceptable for generators from a different manufacturer.

Work by NASL has been carried out to evaluate the properties of several foam concentrates presently available[21] and differences in the characteristics have been found.

Work to develop improved foam concentrates is being undertaken by interested groups and results may be expected in the near future.

COST EFFECTIVENESS OF HIGH EXPANSION FOAM

The relationship between cost and effectiveness for a particular application of fire protection equipment does not rule out the use of high expansion foam for certain uses. The effectiveness of a system is a measure of its ability to produce the desired results in the most efficient manner. For each particular instance the cost of the system must be related to the required results and in some cases the advantages of high expansion foam outweight the cost considerations and provide a most cost effective system when compared to a water sprinkler system.

A cost effective study[2] revealed that under normal conditions when an adequate water supply is available, a high expansion foam system would cost approximately twice that of an automated water sprinkler system. However, for self-contained systems the costs of the two systems becomes comparable, as shown in Figure 2, which is based on typical cost figures. A review of the advantages of high expansion foam, as outlined above, has been used to determine in which application the foam becomes the most cost effective system.

1. The ability of high expansion foam to penetrate inaccessible and shielded areas makes foam well suited for such applications as high piled storage locations where sprinklers have little effect on deep seated fires at the lower storage levels, and areas full of equipment which are difficult to reach by fire fighters such as boiler rooms and ships compartments.

2. If damage and cleanup problems are a major consideration, then high expansion foam will be more effective in limiting these factors. Such application as record storage facilities, and facilities containing electronic equipment or high value stock would be considered as locations where sprinklers could cause serious damage to unburned material and foam would be easily removed with no deleterious effects.

3. Foam can provide protection in multi-hazard areas as it can be used on Class A and B fires with confidence, Class C fires where voltages are less than 500 volts, and with limited success on Class D fires. Sprinklers are effective on Class A fires only.

4. Self-contained foam systems have lower total water requirements than sprinkler systems, making them readily adaptable for such applications as remote facilities and advance bases.

The use of Freon 1301 (Halon 1301) to inert the air within the high expansion foam has been studied and found to be feasible. However, the cost of Freon 1301 and additional equipment required to introduce this additional fire suppressent indicate that a relatively small increase in effectiveness could be achieved only at a relatively high cost and, therefore, preclude the use of this system on a cost effective basis.

Evaluation of a high expansion foam system using Freon 1301 has previously been examined for remote building use but a sprinkler system was selected in preference for expediency at that time.[23]

The effectiveness of the system is also related to reliability and the complexity of commercially available high expansion foam generators leads to the conclusion that sprinkler systems are, by their nature, more reliable. Foam generators are, in general, powered by water, electrically or by gasoline engine and contain a number of moving parts and other critical items. Sprinklers, on the other hand, contain no moving parts and the design is extremely simple and almost foolproof. It would appear, therefore, that a high expansion foam system containing no moving parts would be a major step towards improving the reliability of this type of system. This approach has been taken by a small research and development organization in Los Angeles who have designed a high expansion foam system which has no moving parts. The principle of operation is that air is induced through the foam producing screen by the water/foam concentrate solution which is sprayed through nozzles. The generator consists of a water distribution pipe from which the water/foam concentrate solution is sprayed through the nozzles onto the perforated metal screen, as shown in Figure 3. Air is entrained in the water and foam of an expansion ratio of approximately 500-600 to 1 is produced to fight the fire.

As well as improved reliability due to less complexity, another advantage over other systems is that the generator is linear in nature, rather than being installed in a package at one location within the protected area. Thus, in a large area building, this type of foam producing equipment may be installed along the whole length or width with the desired spacing to give the required fill time.

A possible drawback, in contradiction to other manufacturers of equipment, lies in the fact that this generator uses air from within the enclosed area for foam production. The air may be contaminated with combustion products, and these have been shown to have a deleterious effect on the foam producing capabilities of equipment.[2,24] The philosophy behind this equipment is that provision of an adequate detection system installed with the foam equipment will be able to detect a fire, actuate the generator and, using the large volume of air within the enclosed area, extinguish the fire before sufficient air contamination has occurred to significantly effect the foam produced by the generator. In addition, the air supply for the generator is subjected to a scrubbing action as it passes through the foam already produced. The linear generator also will use air from the whole length (or width) of the building where it is installed and although there exists the possibility of foam generation being impared in the immediate vicinity of the fire, the remaining portions of the generator will still function. A new foam concentrate has been produced especially for this type of generator which is less susceptible to contamination breakdown. In has been shown that effective fire extinguishment can be achieved in practice by tests conducted to evaluate the total generator/detection system. However, it should be noted that this system has been designed specifically for the particular application of fire protection in large retail stores where constraints on design and fire situations are relatively clearly defined. Further developmental work will probably be required to ensure the system is suitable for a wide variety of conditions in different occupancy situations. Such a development would be a large step towards making high expansion foam competative with automatic sprinkler systems for general applications.

From the above discussion, it is clear that the increase in reliability in this instance has been achieved by using contaminated air for foam production. Although this procedure may be suitable for the particular application considered, it is not recommended for general use. The next step in the development of high expansion foam for general usage is to either develop a system, including detection devices, which would be applicable to all situations or produce a foam concentrate which is unaffected by the products of combustion and would, therefore, permit the use of inside air.

CONCLUSIONS

1. High expansion foam systems are more costly than sprinkler systems for normal fire protection problems.

2. High expansion foam systems become cost-effective and surpass sprinkler systems in certain special applications such as protection of high-piled storage facilities, facilities where contents may be damaged by large quantities of water, multi-hazard areas and for self-contained fire protection systems.

3. Currently available equipment requires an external supply of clean air to prevent combustion products within the enclosed area from degrading the foam.

4. New developments in generator design and foam concentrate improvement will reduce the cost and improve the effectiveness of high expansion foam systems.

5. Foam removal may be best achieved by natural decay, by drainage, assisted by a blower, or heavy duty vacuum cleaner.

6. The standards of NFPA are sufficient basis for design of high expansion foam systems.

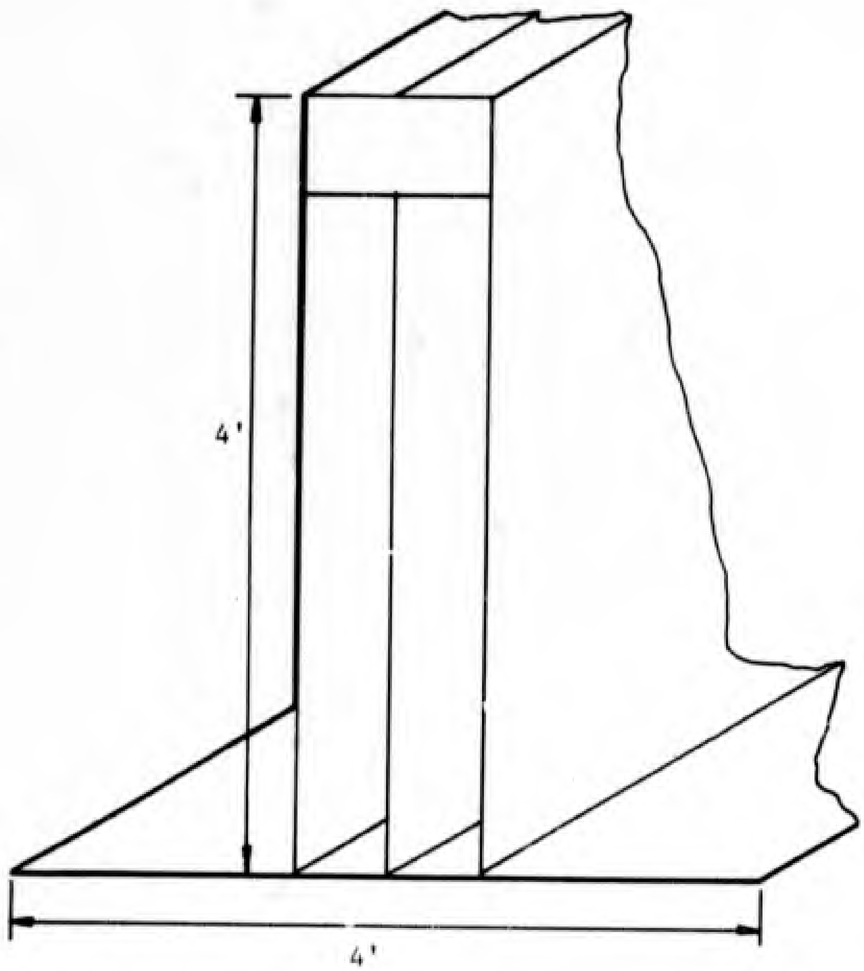
7. The use of Freon 1301 in the foam as an additional fire suppressent is considered impractical.

RECOMMENDATIONS

1. High expansion foam fire protection systems appear to be a promising alternative for water sprinklers for advance base facilities, as well as facilities containing electronic equipment, high value stock and important records. It is particularly suitable for multi-hazard and inaccessible high piled storage areas. The following extension of research and development effort is recommended for fiscal years 1969 and 1970.

(a) The development of a foam concentrate unaffected by combustion products should be undertaken, including tests to determine specific constituents of the combustion products which affect foam production.

(b) New concepts of foam generation and dispensing should be explored. This would include testing and evaluation of foam generators available on the market, and development of new and improved generators.



Material: 3/4" plywood

Figure 1. Class A fuel configuration.

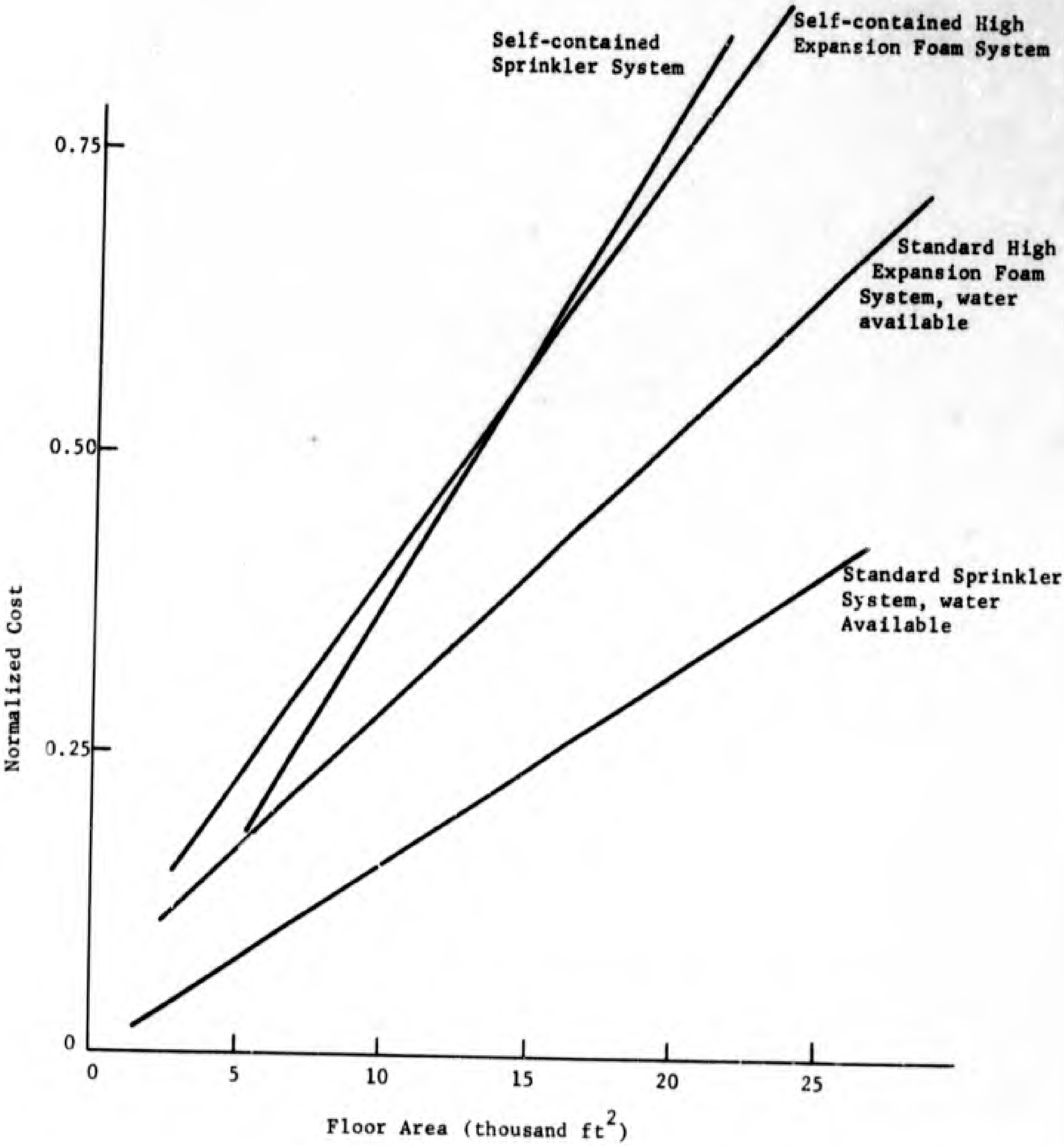


Figure 2. Typical cost data for high expansion foam and sprinkler systems.

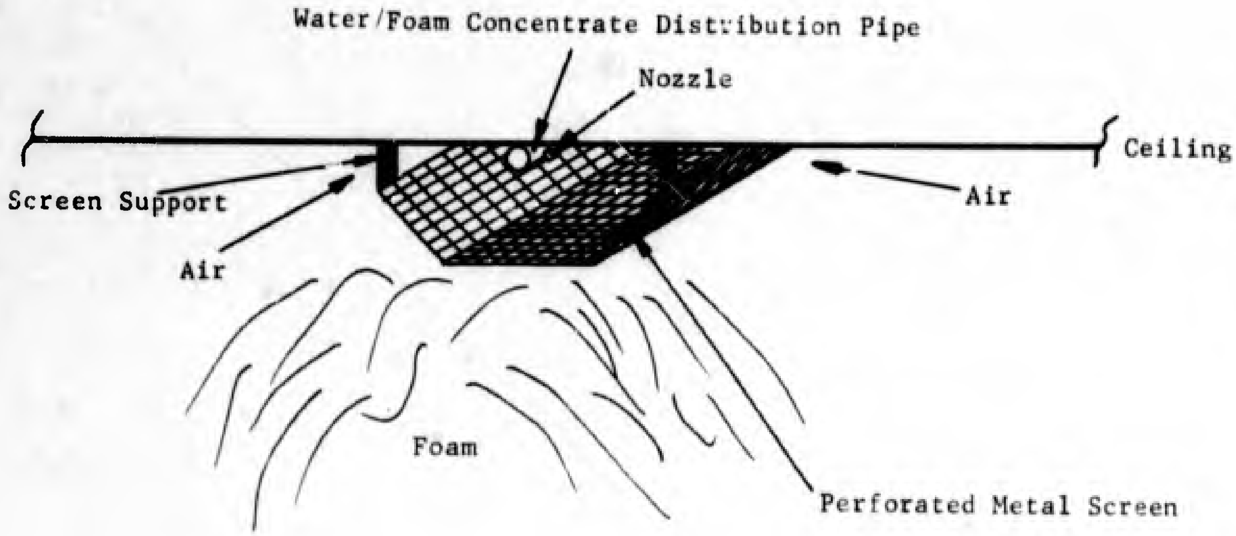


Figure 3. Schematic diagram of linear high expansion foam generator.

REFERENCES

1. Underwriters' Laboratories, Inc.,; Fire Protection Equipment List, January 1968.

2. Factory Mutual Research Corporation Report No. 18516: An evaluation of high expansion foam systems for protection of Naval Shore Facilities, by M. J. Miller and E. W. J. Troup, Norwood, Massachusetts. August 1968 (Contract No. NBy-89718).

3. Safety in Mines Research Establishment. Research Report 130: Fire fighting in underground roadways: experiments with foam plugs, by H. S. Eisner and P. B. Smith. Buxton, England, June 1956.

4. ________________. Research Report 171: Practical aspects of the foam-plug method of fighting large mine-airway fires, by E. T. Linacre, Buxton, England, February 1959.

5. ________________. Research Report 170: Materials and equipment for the foam-plug method of mine fire fighting, by E. T. Linacre and D. H. Jones. Buxton, England, August 1959.

6. ________________. Research Report 182: The formation and movement of foam-plugs for mine fire fighting, by E. T. Linacre. Buxton, England, August 1959.

7. U. S. Department of the Interior, Bureau of Mines, Report of Investigations 5418: Studies with high expansion foams for controlling experimental coal mine fires, by I. Hartmen, J. Nagy, R. W. Barnes and E. M. Murphy. Washington, D. C., 1958.

8. ________________. Report of Investigations 5632: Controlling mine fires with high expansion foam, by J. Nagy, E. M. Murphy and D. W. Mitchell. Washington, D. C., 1960.

9. ________________. Report of Investigations 5846: Practical aspects of controlling an underground fire on a mining machine, by D. W. Mitchell, E. M. Murphy, J. Nagy and F. P. Cristofel. Washington, D. C., 1961.

10. ________________. Information Circular 8019: Use of high expansion foam on a Pennsylvania coal-mine fire, by T. J. McDonald. Washington, D. C., 1961.

11. W. B. Jamison, Fighting mine fires with high expansion foam: Proceedings, West Virginia Coal Mining Institute. Morgantown, West Virginia, April 1963.

12. W. B. Jamison, High expansion foam, a new concept in fire fighting: Second International Fire Protection Seminar, Karlsruhe, Germany, October 1964.

13. USAEC Report UCRL - 7355: Hazards control, Quarterly Report No. 12 for Jan - Mar 1963. Lawrence Radiation Laboratory, Livermore, Calif.

14. USAEC Report UCRL - 7922: High expansion foam fire control system for gloved boxes, by C. L. Lindeken and R. D. Taylor. Lawrence Radiation Laboratory, Livermore, California. June 1964.

15. USAEC Report IDO - 12050: High expansion foam fire control for records-storage centers, by R. J. Beers. Idaho Operations Office, Idaho, 1966.

16. Factory Mutual Research Corporation. Laboratory Report Serial No. 17565: Application of high expansion foam on simulated maritime general cargo fires. Norwood, Massachusetts, November 1966.

17. Naval Research Laboratory. NRL Memorandum Report 1816: Toxicity and fire hazards associated with shipboard materials. Supplement #1, Section IV, Shipboard fire protection, by I. Wilder and L. Shapiro, Washington, D. C., February 1968.

18. U. S. Naval Applied Science Laboratory. Project 930-30. Technical Memorandum 5: NASL portable high expansion foam system for extinguishment of engine, boiler and machinery room compartment fires on Naval surface vessels, by M. M. Hunger. Brooklyn, New York, October 1967.

19. ____________________. Detailed test procedure for conducting NASL high expansion foam fire-fighting tests on board a decommissioned submarine. Brooklyn, New York, January 1968.

20. National Fire Protection Association. Tentative standards for high expansion foam systems (Expansion ratios over 100:1). NFPA No. 11 A-T, May 1968.

21. U. S. Naval Applied Science Laboratory. Project 930-30. Progress Report No. 1: Shipboard fire-fighting: Design criteria for fixed high expansion foam systems, by L. D. Shapiro, T. Ballas and C. Morales. Brooklyn, New York, April 1968.

22. G. V. W. Stark and P. S. Field, Suitable foam compounds for the production of high expansion foam for fire-fighting. Institution of Fire Engineers Quarterly. Vol. 27, No. 67, p. 280, 1967.

23. Naval Civil Engineering Laboratory. Technical Report R-520: Packaged automatic fire protection systems for remote buildings, by J. C. King. April 1967, Port Hueneme, California.

24. U. S. Naval Applied Science Laboratory. Project 930-30. Progress Report No. 2: Effectiveness of high expansion foam generated from air contaminated with combustion products, by M. M. Hunger. Brooklyn, New York, August 1968.

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13. ABSTRACT

An investigation has been made regarding the suitability of high expansion foam fire protection systems for use in Naval shore facilities, and it is concluded that presently available high expansion foam equipment becomes cost-effective only in special situations. Certain types of storage facilities and remote buildings requiring self-contained systems are typical locations where high expansion foam should be considered for fire protection. New concepts in generator design and developments of improved foam concentrates should be examined as this work is anticipated to produce less expensive and more effective systems in the near future.

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