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Standard Guide for Using Aqueous Foams to Control the Vapor Hazard from Immiscible Volatile Liquids[1]

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INTRODUCTION

The vapor released by spills of volatile hazardous substances (either flammable or toxic) can present a significant hazard to life and property in the spill area and for some measurable distance downwind. Such spills may also cause natural resource damage by penetration into the ground or by movement into groundwater.

Aqueous foam blankets have been shown to be an effective technique to reduce the hazard arising from vapor release of volatile chemicals and to reduce the chance of accidental ignition of flammable liquids. Because they are a common tool of the fire services, they are available early in the spill response effort. Foams can be used to control spill vapors to extend evacuation time and may offer a control for the life of the incident.

Effective actions have been demonstrated for a wide variety of chemical classes—volatile organics, some water reactive inorganics, and certain classes of liquefied gases.

The water reactive compounds and liquefied gases require special considerations peculiar to each chemical grouping. Although foam solutions are not considered to be dispersants, foam treatment may enhance the penetration of water soluble materials into the ground, or transport into the groundwater, or both. Adequate information is not available to generalize on such questions.

1. Scope

1.1 This guide restricts itself to addressing the application of foam to water immiscible liquid and some water reactive compounds with boiling points above 15°C for vapor control or fire suppression of land spill or contained spills on water.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For hazard statements, see Section 10.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F716 Test Methods for Sorbent Performance of Absorbents

F726 Test Method for Sorbent Performance of Adsorbents

2.2 *NFPA Standards:*

NFPA 11 Standard for Low-, Medium-, and High-Expansion Foam[3]

3. Terminology

3.1 *alcohol or polar solvent foam*—This is one type of foam that is resistant to destruction by water miscible polar compounds. It is usually termed polar solvent resistant, and contains a water soluble polymer. When this polymer contacts a water miscible polar fuel, it gels and forms a membrane which floats on the fuel and serves as a barrier to protect the foam from destruction by the fuel. Polar solvent resistant foams may be either surfactant or AFFF based. They behave like a conventional foam on hydrocarbons. They may be

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

applied by nozzle or by any other low expansion foam-making equipment on either hydrocarbons or polar fuels. Alcohol or polar solvent resistant foams produce surface tensions in water ranging from 15 to 50 dyne/cm.

3.2 *aqueous film forming foam (AFFF, pronounced "A triple F")*—AFFF is a mixture of fluorocarbon and hydrocarbon surfactants. It is usually used at low expansion. The very low surface tension of AFFF solution permits the formation of an aqueous film on top of most hydrocarbon fuels and alcohol-compatible material is resistant to destruction by miscible or immiscible water-reactive or strong polar compounds, or both. Because maintenance of this film requires drainage of solution from the foam, AFFF is fast draining and the foam is not persistent. The film is easily disrupted and should not be relied upon for vapor sealing unless a visible foam blanket is present. The surface tension of AFFF solutions in water is 15 to 19 dyne/cm.

3.3 *aqueous foam*—a mixture of water and a foaming agent.

3.4 *fluoroprotein foam*—conventional protein foam modified by the addition of fluorocarbon surfactants. Fluoroprotein foams are similar to protein foams except that they produce foam with greater fluidity, dry chemical resistance (for clarification see NFPA 11) and greater resistance to fuel pick-up. They are used only at low expansion. The surface tension of fluoroprotein foam solution (FP) is 27 to 30 dyne/cm. Film-forming fluoroprotein agents (FFFP) are being marketed with aqueous surface tensions in the 16 to 17 dyne/cm range.

3.5 *foam*—a mass of bubbles formed by the mechanical agitation of foam solution with air.

3.6 *foam expansion*—the ratio of air to water in the foam. A measure of the volume of foam produced for each volume of foam solution used.

3.7 *foaming agent*—an organic compound or mixture of compounds which lowers the surface tension of water and imparts a foaming capability to it. Five major types of foam liquid concentrates are in general use by the fire service.

3.8 *high expansion foam*—a volumetric ratio of greater than 200:1. (See foam equipment for practical ranges of expansion.)

3.9 *low expansion foam*—a volumetric ratio of typically 6:1 or 12:1 but less than 20:1.

3.10 *medium expansion foam*—a volumetric ratio of 20:1 to 200:1. (See foam-making equipment.)

3.11 *protein foam*—a mixture of hydrolyzed animal protein with various stabilizing materials. Protein foam may be used only at low expansion. The surface tension of protein foam solutions in water is 40 to 50 dyne/cm. Protein foams are subject to bacterial and fungal attack which can limit shelf life. When released to the environment, they contribute to biological oxygen demand (BOD). If a biocide is included, see 9.5.

3.12 *surfactant foam*—also known as syndet or detergent foam. These foams are based on high-foaming synthetic surface active agents. While these foams are normally used at high expansion, they may also be applied through low expansion foam-making devices. Surface tensions in water are in the range 23 to 30 dyne/cm.

4. Significance and Use

4.1 This guide is intended as a general guide to the correct use of foams. Specific decisions on when or if foam should be used will depend on the circumstances and conditions of each spill situation.

4.2 Polar solvent resistant AFFF can be applied to some water reactive chemicals with a medium expansion foam nozzle to extinguish a fire and to reduce toxic vapor release to the environment.

5. Film Forming Foam

5.1 Film forming foam develops a thin film of aqueous solution over the surface of a non-aqueous liquid chemical in response to a surface tension differential. Since water is denser than many liquid organic compounds, it will normally sink through such compounds. Foam agents reduce the surface tension of water. If the surface tension of the foaming solution is less than that of the organic compound, the drainage coming from the foam will tend to form a water film between the foam and the organic compound. The term "film forming" has been applied customarily to those foaming systems with low surface tensions, normally below 24 dyne/cm. Film forming may occur, however, whenever the ratio of surface tensions is appropriate.

5.2 Use of polar solvent foam on some water reactive chemical compounds, such as silanes, will reduce the amount of water that comes in contact with the compound-reducing toxic vapor release. Water reactive vapors are scrubbed or reacted by the foam to lessen the vapor release to the environment.

6. Stability

6.1 Stability is used in two senses, as a foam collapse rate and as a resistance to chemicals. Foam collapse rates are measured only for high expansion foams. They will range from 8 to 20 in. [20 to 50 cm] per h in laboratory tests, but can be higher in the field due to sun, wind, and precipitation.

6.2 Stability of foam in contact with water reactive chemical compounds is unique to each foam type. However, the rate that the water drains from the foam blanket, represented by the quarter (or 25 %) drain-down time, is thought to be the primary factor in this regard. For example, when foam is applied to a chlorosilane compound, water draining from the foam reacts with the chlorosilane chemical forming a layer of hydrolysis products on the surface. It is this layer of hydrolysis products that, when a sufficient thickness and consistency is established, affects the fire extinguishing capability or vapor suppression, or both, by excluding oxygen and limiting vapor evolution. However, the hydrolysis layer shall be formed relatively slowly for extinguishing capability or suppression of vapors to take place. If the drainage rate is too fast (that is, quarter drain-down time is short), the hydrolysis reaction takes place too quickly, producing a large amount of heat, which in turn produces more vapors. In addition, the rapid reaction causes turbulence on the water reactive chemical surface, preventing the formation of a stable layer of hydrolysis products. If the drainage rate is too slow (that is, quarter drain-down time is too long), the