



Project Summary

Evaluation of Foams for Mitigating Air Pollution from Hazardous Spills

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Water-based foam is investigated and evaluated as a means of mitigating vapor hazards posed by spills of hazardous materials. The study examines the use of foams on both individual chemicals and classes of these. Characteristics of foams that influence chemical compatibility and vapor control are also studied.

Results indicate that foam is an effective mechanism for mitigating the vapor hazard from most volatile hazardous materials. Different chemical classes require different types of foam. For long-term control of vapor, a high-expansion foam is desirable, whereas a low-expansion foam is best for short-term situations. Expansion is the ratio of the volume of foam to the volume of foam-forming fluid. For low-expansion foam, this ratio is about 10:1; for high-expansion foam, 100:1.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

In the last few years, significant advances have been made in the control and containment of hazardous material spills. These advances minimize damage to the land and water, but they do

not address the significant air pollution problem that can be caused by such spills. This problem is particularly acute for the personnel assigned to clean up and dispose of the spilled material, but it can also pose a serious threat to all life and property in the spill area.

Water-based foams have been known for some time to be effective in controlling the vapor released from some volatile chemicals. Foam blankets retard evaporation by insulating the bulk material from heat sources (air, solar radiation) and further act as barriers between flammable materials and ignition sources. Vapor release is further reduced because of the limited permeability of the foam, its capacity to absorb the chemical, and by dilution of the surface layer. For materials that boil below 0°C and whose gas density is less than air, foam actually assists in vapor dispersion since the temperature of the vapors increase as they permeate the foam layer and thus disperse better. Problems posed by water-reactive chemical spills can also be mitigated by foams. Foams allow the gentle application of water to the surface to effect dilution and/or conversion to less hazardous chemical species without violent reaction.

At the time this study was initiated, some data already existed to show that foam could be effectively used with spills of hydrocarbon fuels. Limited information was also available on the use of foam with liquefied natural gas,

vinyl chloride monomer, ammonia, chlorine, and sulfur trioxide. This program aimed to better define the capabilities of foam as a mechanism of vapor mitigation. Three separate tasks were identified. The first task investigated and evaluated the use of foams to mitigate air pollution from spills of hazardous materials as a general class. The second task assessed the use of foams and foam-generating equipment against individual chemicals. The third task defined the characteristics of foams that influenced chemical compatibility and vapor control.

Results and Conclusions

Results of the program show that application of foam is an effective mechanism for mitigating the vapor hazard from most volatile hazardous materials. Different chemical classes require different foam types, with the foam expansion ratio as an additional variable. Table 1 provides a basic selection guide for a range of chemical classes. As a basic rule, the better the water retention of the foam (i.e., low drainage rate), the better its performance, regardless of other factors. Thus drainage (the rate at which the foam releases water) should be a primary consideration when selecting a foam concentrate for spill use.

As indicated in the table, certain generalizations can be drawn. For nonpolar liquids that are not water reactive, any high quality foam cover, regardless of its chemical type, can provide mitigation of the vapor hazard. Only those foams designed for use with polar liquids are applicable to that class of chemicals. Other types of foam rapidly collapse. For vapor mitigation, polar solvent foams based on metal stearates are superior to those that use a gelling polysaccharide. For liquids that are extremely water reactive (such as sulfur trioxide), only high-expansion foam should be used because of the high heat of reaction. Low-expansion foams contain too much water to gently dilute these water-reactive liquids. For liquefied gases that are lighter than air at ambient temperatures, high-expansion foam provides a heat source. Vapors passing through the foam are warmed, and upon release, they tend to rise rather than drift downwind at ground level. For those that are heavier than air, no foam could effectively mitigate the vapor hazard, since warming does not result in a positive buoyancy. For reactive liquefied gases (such as NH_3), high-expansion foam pro-

vides a reasonable vapor mitigation. High-expansion foam warms and scrubs the vapors as they pass through the foam layer. Low-expansion foams add too much water to the liquefied gas, resulting in large vapor clouds.

The program has shown further that laboratory tests can predict the behavior of foams for spill control under field conditions. Atmospheric conditions, wind, and rain can be a factor in selecting the correct expansion ratio for optimum vapor control.

For long-term control, a high-expansion foam is the better selection. High-expansion foam mitigates the hazard by containing the vapors and reducing the vaporization driving force. Low-expansion foam operates by acting as a barrier to vapor release, and it is best suited to short-term situations.

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Table 1. Preliminary Matrix of Foam Capabilities on the Spilled Hazardous Chemicals Listed

		Recommend 1*	2	3	4	5	6	
Organics-Aliphatic Acids	- Acetic Acid	ND*	ND	ND	ND	ND	ND	ND
	- Caproic Acid	ND	U	ND	ND	ND	ND	ND
Alcohols	- Amyl Alcohol	ND	U	U	ND	ND	ND	ND
	- Butanol	R	E-	E-	E-	E-	A+	E-
	- Butyl Cellosolve	ND	ND	ND	U	ND	ND	ND
	- Methanol	R	E-	E-	E-	E-	A+	E-
	- Octanol	R	U	U	U	U	U	ND
	- Propanol	R	E-	E-	E-	E-	A+	E-
Aldehydes & Ketones	- Acetone	R	E-	E-	E-	E-	A+	E-
	- Methyl Butyl Ketone	R	E-	E-	U	ND	A+	ND
	- Methyl Ethyl Ketone	R	U	U	U	ND	A+	ND
Esters	- Butyl Acetate	ND	U	U	U	U	ND	ND
	- Ethyl Acetate	ND	U	U	U	U	ND	ND
	- Methyl Acrylate	ND	U	U	ND	U	ND	ND
	- Methyl Methacrylate	ND	U	U	ND	U	ND	ND
	- Propyl Acetate	ND	U	U	U	U	ND	ND
Halogenated	- Butyl Bromide	ND	U	U	ND	ND	ND	ND
	- Methyl Bromide	ND	U	U	ND	ND	ND	ND
	- Tetrachloroethane	ND	U	U	ND	ND	ND	ND
Hydrocarbons	- Heptane	R	C+	B+	B+	B+	A+	C+
	- Hexane	R	C+	B+	B+	B+	A+	C+
	- Octane	R	C+	B+	B+	B+	A+	C+
Nitrogen Bearing	- Dimethyl Formamide	ND	U	E-	ND	ND	ND	ND
Organics-Aromatic Hydrocarbons	- Benzene	R	C+	B+	B+	B+	A+	C+
	- Tetrahydronaphthalene	R	U	U	U	ND	ND	U
	- Toluene	R	C+	B+	B+	B+	A+	C+
Organics-Alicyclics	- Cyclohexane	R	B+	A+	B+	B+	C+	C+
Organics-Industrial	- Gasoline	R	C+	B+	B+	B+	A+	C+
	- Kerosene	R	C+	B+	B+	B+	A+	C+
	- Naptha	R	C+	B+	B+	B+	A+	C+
	- Paint Thinner	R	C+	B+	B+	B+	A+	C+
Organics-Cryogens	- Liquefied Natural Gas	R	C-	A+	E-	E-	E-	E-
Inorganics	- Silicon Tetrachloride	R	E-	A+	E-	E-	E-	E-
	- Sulfur Trioxide	R	E-	A+	E-	E-	E-	E-
Inorganics-Cryogens	- Ammonia	R	C+	A+	C+	C+	E-	C+
	- Chlorine	R	C+	C+	C+	C+	E-	E-

*Type of Foam: 1, Surfactant Low Expansion; 2, Surfactant High Expansion; 3, Protein; 4, Fluoroprotein; 5, Alcohol; 6, Aqueous Film-Forming Foam

*U Limited data available - capabilities uncertain
 ND No data
 R Foam use recommended over spill
 A+ Best foam formulation
 B+ Next best foam formulation
 C+ Acceptable in some situations
 E- Unsuitable foam formulation

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John E. Brugger is the EPA Project Officer (see below).

The complete report, entitled "Evaluation of Foams for Mitigating Air Pollution from Hazardous Spills," (Order No. PB 82-227 117; Cost: \$10.50, subject to change) will be available only from:

National Technical Information Service

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The EPA Project Officer can be contacted at:

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