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Standard Guide for Containment of Hazardous Material Spills by Emergency Response Personnel[1]

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1. Scope

1.1 This guide describes methods to contain the spread of hazardous materials that have been discharged into the environment. It is directed toward those emergency response personnel who have had adequate hazardous material response training.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F716 Test Methods for Sorbent Performance of Absorbents

F726 Test Method for Sorbent Performance of Adsorbents

F1129 Guide for Using Aqueous Foams to Control the Vapor Hazard from Immiscible Volatile Liquids

F1525 Guide for Use of Membrane Technology in Mitigating Hazardous Chemical Spills

2.2 *Federal Schedules:*[3]

2001.3

2001.4

2008.1

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *absorbent*—a material that picks up and retains a liquid distributed throughout its molecular structure causing the solid to swell (50 % or more). The absorbent is at least 70 % insoluble in excess fluid.

3.1.2 *adsorbent*—an insoluble material that is coated by a liquid on its surface including pores and capillaries.

3.1.3 *gellant*—a material such as colloidal network or other aggregate network which pervades and holds a liquid in a highly viscous fragile structure. Many gels may rapidly liquefy with added heat or ionic/polar addition. These materials are soluble/flowable in excess liquid.

3.1.4 *sorbent*—an insoluble material or mixture of materials used to recover liquids through the mechanisms of absorption or adsorption, or both.

3.1.5 *thickener*—a material (usually of higher molecular weight) that is soluble in excess liquid. These materials go from dry to gummy (viscoelastic) to flowable and then soluble. The final viscosity depends only on the liquid to solid ratio.

3.1.6 *universal sorbent*—an insoluble material or mixture of materials that will sorb both hydrophobic and hydrophilic liquid spills.

4. Significance and Use

4.1 This guide contains information regarding the containment of a hazardous material that has escaped from its container. If a material can be contained, the impact on the environment and the threat it poses to responders and the general public is usually reduced. The techniques described in this guide are among those that may be used by emergency responders to lessen the impact of a discharge.

4.2 Emergency responders might include police, fire service personnel, government spill response personnel, industrial response personnel, or spill response contractors. In order to apply any of the techniques described in this guide, appropriate training is recommended.

5. Containment Methodology

5.1 Containment equipment, procedures, and techniques can be categorized into three general functional classes: (*a*) patch/plug, (*b*) enclosure, and (*c*) immobilization. The important advantage of containment is that it restricts the spreading of a spill and makes cleanup easier. Careful selection of techniques and materials is required. Errors in judgment can lead to worsening of the situation, deflagration or detonation, and increased hazard to personnel involved in the cleanup.

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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 U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.

6. Patches and Plugs (General)

6.1 Diminishing or stopping the flow of a leaking hazardous material is desirable in order to limit the size of the spill. The following techniques may be helpful in controlling leaks, provided response personnel can use them safely under existing conditions. Whichever method is used, it should be noted that the higher the pressure inside the container, the more difficult it is to plug the leak.

6.1.1 *Wood Plug*—Wooden cones and wedges may be hammered into leaking containers (drums, tanks, pipes, and so forth). Softwoods in particular are easily sawed or lathe-turned and conform well to irregular shapes. Additionally, softwood may absorb liquid and swell, enhancing its capacity to seal a leak. Wedges or cedar shingles are especially applicable to splits, gouges, rips, and tears. Rigid plywood sheets or compatible closed cell flexible plastic foam 1 to 2-in. (25 to 50-mm) thick can be fastened over a damaged area with "T" bolts, tie-down toggle, molly, butterfly bolts, straps, or by mechanical bracing and wedging. To minimize leakage between the plywood and the container, a gasket of rubber or flexible closed cell plastic foam, putty, butyl rubber caulk, lead wool, or oakum may be used.

6.1.2 *Metal Sheet*—Various sizes of steel or aluminum sheets can be fastened over damaged areas by mechanical methods ("T" bolts, toggle bolts, bracing, strapping, and so forth). Gasketing material between the metal and the container generally provides more positive sealing.

6.1.3 *Inflatable Plugs and Bags*—Reinforced rubber and coated-fabric plugs can be inserted into an opening and inflated with gas (air, nitrogen, carbon dioxide) or water to form a seal. Lead-sealing bags can be secured with straps, chains, cables, fire hoses, or bands to seal a leaking container.

6.1.4 *Fabric Patch*—Fabrics such as neoprene-coated nylon can be positioned over leaks and held in place by bands, chains, straps, and so forth. Wood, plastic, or metal reinforcements may be required.

6.1.5 *Formed Plug*—Closed–cell polymeric foam (for example, polyurethane or polyethylene), epoxy putty, or quick-setting hydraulic cement may be injected into a rigid concave form through a tubular handle or it may be troweled onto the form and placed against the damaged area. Once the patching material hardens, the support form may be removed.

6.1.6 *Caulking Patch*—Epoxy, plastic steel/aluminum, lead wool, clay-polymer mixtures, and oakum can be spread, troweled, or peened into cracks and small holes. Rapid-curing materials are available.

6.1.7 *Foam Plug (Self-Expanding)*—A package of polyethylene, polyurethane, or low-density neoprene rubber foam (all closed-cell) formed into a compact shape by compression and vacuum packing may be opened allowing the foam to expand and fill the leak area. These plugs may not be readily available.

6.1.8 *Magnetic Patch*—Magnetic sheets (rubber-bonded barium ferrite composite, with or without adhesive) backed by a thin sheet of steel foil may be strapped over the damaged area.

6.1.9 *Mechanical Patch*—Neoprene or rubber stoppers, rubber balls, and plywood or spring steel sheets with neoprene gaskets can be mechanically held in or on the damaged area. Toggle and "T" bolts, washers, and wing nuts are useful attachments.

6.1.10 *Adhesive Patch*—Adhesive patches sometimes work but usually require tedious surface preparation. Tape (duct, lead, aluminum, or stainless steel) is useful when applied over a wooden or rubber plug before application of epoxy to create a relatively permanent repair.

6.1.11 *Bladder Wrap*—Coated fabric or reinforced rubber pipe patches (similar to a clamp) with integral inflation bladder can be secured around a pipe or small round container with nylon self-adhesive fabric. Velcro, fire hoses, banding/strapping material, or automotive tie-downs may be used to secure the wrap.

6.1.12 *Pipe Pinch*—A "C"-shaped clamp device with hydraulically or explosively operated ram can flatten a section of pipe to pinch off the fluid flow.

7. Enclosure

7.1 Approved salvage drums (overpacks, recovery drums, waste drums, "open-head" drums) may be used to encapsulate leaking drums or other small containers. Contaminated materials (tools, clothing, soil) and plastic bags holding used sorbents or contaminated items also may be enclosed in salvage drums. Approved enclosure containers may be used for transport, storage, and disposal of many hazardous materials.

8. Immobilization

8.1 Once a hazardous material has escaped from its container, it may be possible to immobilize the material to prevent it from spreading. There are a number of methods that may be used to accomplish this task; these methods vary depending on whether the material is a liquid, a solid, or is volatile and escapes as a gas.

8.2 *Liquids:*

8.2.1 Spills of hazardous liquids (including slurries) are the most difficult of spill problems. Good management practice aims to contain the material and localize it in a concentrated form. Typical procedures that can be used to affect the spreading of a spilled liquid are as follows:

8.2.2 Change the physical properties of the liquid by modifying the viscosity or vapor pressure by temperature change (usually cooling).

8.2.3 Immobilize the liquid by use of an adsorbent, absorbent, or a gelling agent (see 8.3.1.2).

8.2.4 Pump to a suitable container or lined pit.

8.2.5 Erect physical barriers.

8.2.6 Form dikes from earth sandbags, water inflatable bags, weighted adsorbent foamed plastic, or absorbent sand mixture.

8.2.7 Assemble collapsible containers (for example, plastic swimming pools, if compatible) or use a plastic film-lined ground depression or pit for containment.

8.2.8 Deploy collection or containment devices such as boom curtains and portable dams. Suitable floating absorbents can help in preventing these booms from being made ineffective by stream current physically stripping liquid underneath.

8.2.9 A porous or wire mesh boom can be efficiently used with the proper floating absorbent material. A board boom is also effective in a ditch.

8.2.10 A reverse flow weir can be used to concentrate floating fluids.

8.2.11 Sewers or other types of drainage in the path of a spreading spill should be blocked. An absorbent/sand mixture can be used as a sealing dike or a soft closed-cell plastic foam can be used to cover the opening. Many impermeable systems can be used to seal the openings.

8.2.12 When a spilled material has a density greater than water, a weighted water insensitive sorbent can be placed at the bottom of a watercourse or sewer to pick up and immobilize a spill.

8.3 *Land Spills:*

8.3.1 Typical methods for handling spills on land are listed, including pumping, sorbents (adsorbents and absorbents), gellants, dikes, dams, trenches, soil and dike sealants and physical state modifications.

8.3.1.1 *Pumping*—If a pool of spilled liquid can be contained on land, the most direct mitigation is to pump it into a suitable container (or to use a vacuum truck). Compatibility of all equipment with the material being handled is necessary. Many of the typical materials widely used for oil containment and cleanup are not suitable for many hazardous materials. Gaskets and sealants for pumping units may be oil resistant but fail quickly with a hazardous material. For low-boiling-point liquids, the pump inlet will have to be below the level of the liquid. Otherwise, pump suction will cause the liquid to boil and the pump to cavitate. When pumping materials whose vapor is flammable, use nonsparking or explosion-proof equipment. Employ a grounded system so that static electric buildup cannot occur at discharge ports or nozzles.

8.3.1.2 *Sorbents*—Sorbent is an insoluble material and is a general term applied to both absorbents and adsorbents. The source of these products can be natural or synthetic. They can be organic, inorganic, or mixed in composition. Proper use of these materials depends on the compatibility with the type of spill, location, and type of sorbent to be used. The Federal Schedule 2008.1-1.1 and 2001.3 recommends the use of inert materials (that is, sorbents without reference to the size of a spill). It also gives the On-Scene Coordinator (OSC) the directive to use that material or method best suited to mitigate the spill. A separate part of this regulation (2001.4) prohibits adding any harmful substance in any quantity to water. For "hazardous materials," this prohibits the wringing out of sorbents (absorbents) for reuse. So-called "universal or broad range" sorbents are covered in 8.3.1.7, since they are often mixtures of the singly defined types. It is also true that the broad range of materials considered hazardous makes a truly universal material unlikely. Since these materials are totally different, the definitions developed in Test Methods F716 and F726 are included in Section 3 of this guide.

8.3.1.3 *Adsorbents*—Adsorbent materials are insoluble and inert to the spilled material and usually have a large surface area. Since adsorption is by definition only a surface coating process, high surface area is advantageous if the fluid has sufficiently low viscosity to cover it. An incomplete list of adsorbent materials includes plastic foams, plastic fibers, straw, peat, sand, porous clay, feathers, foamed glass and silicates, activated alumina, and soil. The surface can be external as in a fiber, or internal as inside a granule of activated carbon. If the solid matrix does not change size, then the sorption phenomenon is called *adsorption* and the material for the liquid intended is an adsorbent. Since the spilled fluid is available on the surface of an adsorbent, it may be removable. This can be an advantage if separation following recovery is important. It is detrimental to the extent that:

(1) The liquid can usually be removed by leaching (even by water used in clean up), rain, and so forth.

(2) Vaporization loss is often increased by increasing exposed surface area. If the vapor is toxic or hazardous, this could be a major consideration.

(3) The adsorbent may leak fluid, causing secondary spill problems.

(4) Since adsorbents can usually be wrung out, they easily contaminate personnel handling them. In the line of safety awareness, what is suitable for No. 6 fuel oil or even No. 2 fuel oil may be inadequate, if not hazard increasing, for gasoline, styrene, acrylonitrile, and so forth.

8.3.1.4 *Absorbents*—Absorbent materials are insoluble and inert to the spilled material but physically swell up in it. They often have a low surface area. They are also adsorbent by the nature of their surface area but since this area is small, they are not often used as adsorbents. Those absorbents useful in spill control do not dissolve in the spilled fluid but physically contain it in a form with minimum surface area. This reduction in surface area lowers the rate of evaporation and minimizes leaching. For many hazardous spills these are required properties. Absorbent materials also minimize human and secondary contamination since squeezing and contact may not be with a wetted surface as in the adsorbent. Use of an absorbent can also provide a method of reducing or stopping ground penetration, which can minimize cleanup. Also, fire, and the water used to extinguish it, or rain have a low tendency to leach spilled material. Absorbent materials for organic fluids include, among others, rubbers and cross-linked products like imbibing polymers. Absorbents for aqueous fluids include cellulosics (synthetic and natural), cross-linked proteins, cross-linked hydrolyzed synthetic polymers and cross-linked starches.

8.3.1.5 *Gellants*—Gellants are usually colloidal materials that, upon addition to a liquid with intimate mixing, form very high viscosity materials. Since these materials are not true absorbents, the network the fluid is held in can be broken by heat or other forces. The intimate mixing required is often difficult on a land spill. Gels usually have a delay time when congealing, therefore they may not be suitable for running spills.

8.3.1.6 *Thickness*—A material (usually of higher molecular weight) that is soluble in excess liquid. These materials go from dry, to gummy (viscoelastic), to flowable, and finally to soluble. The final viscosity depends only on the liquid to solid ratio. Many names have been created to describe these materials including solidifier, encapsulant, and so forth. Since they are soluble, they do not meet the USEPA description of sorbent.

8.3.1.7 *Miscellaneous*—This category includes the "universal or broad range sorbents" that are usually mixtures of other materials listed previously. These materials should be qualified for what type of spill they can be used on and their relative pick up of water and spill mixtures. This type of material can be especially valuable for small spills and quick on-site response. They are less important on larger spills where water sensitivity or the lack of water sensitivity is important.

8.3.1.8 *Dikes, Dams, and Trenches*—Artificial containment barriers can be created to confine liquid spills by forming a wall of sandbags, water-inflated bags, or soil by shoveling or using mechanized earth-moving equipment. The use of an absorbent/sand mixture offers the advantage of a sealing and diking material. Sometimes the spill can be confined on a prepared surface, such as concrete or blacktop, but the more typical situation involves earthen surfaces and dikes, which are prone to pass spilled liquids unless coated with a soil sealant to prevent percolation into the earth. Inorganic foams, such as foamed concrete, foamed gypsum, and sodium silicate foam, have been used to produce dikes and barriers. The basic problem in adapting these materials to a particular application is the difficulty in building these materials up without some form of constraint. A quick set has been achieved in using silicate additions to cement slurries. Polyurethane foams have also been used successfully as diking material on dry hard-packed soil for short-term containment. Liquid spills may penetrate into the soil and seep under the dike.

8.3.1.9 *Dike Sealants*—Several low-cost methods for sealing surface soil to prevent infiltration have been developed. These include plastic sheets and materials that can be sprayed on a site to form an impervious layer. Soil surface sealant candidates can be grouped into several classes: reactive, non-reactive, and surface chemical. This classification is based on how the sealant is formed chemically and the interaction of the sealant with the soil surface. Reactive sealants are usually two-component systems in which one material is either reacted or catalyzed with a second material to yield a polymer. Such materials include epoxy, unsaturated polyester, phenol-formaldehyde, urea-formaldehyde, and urethane. Nonreactive sealants are those that have been previously polymerized and are either dispersed or dissolved in either an aqueous or a solvent system. Such materials are primarily thermoplastic in nature and include such materials as bitumastic, rubber, acrylic, cellulosic, fluoroplastic, phenolic, polyester, polystyrene, poly-(vinyl chloride), silicone (RTV) room temperature vulcanizing products and also the and imbibing/absorbing type polymers. Certain of these imbibing types will swell and seal imperfections. Most of the others depend on a solid coherent layer of sealant. The third sealant type consists of repellant chemicals that, when applied to surfaces, modify the surface characteristics such that the surfaces are not penetrated. Extensive repellant technology has been developed for four classes of materials: textiles, paper, leather, and masonry. In each, there is a broad range of techniques and chemical systems.

8.3.1.10 *Physical State Modification (Freezing)*—Many hazardous chemicals have a freezing point that is higher than that for ordinary water and therefore, could be frozen. Some liquid cargos are heated and insulated for shipment as liquids, ordinarily being solids or near-solids at ambient temperatures. With respect to a relatively small spill of hazardous substance on land, immobilization by freezing is possible. A device for effectively crushing and distributing the coolant (possibly ice or dry ice) on a spill is required.

8.4 *Water Spills:*

8.4.1 When a spill of a hazardous substance occurs in such a way that the material (liquid or fluidized solid) enters a watercourse, the problem of containment in the most concentrated form is exceedingly difficult.

8.4.2 For insoluble floating hazardous substances, many of the techniques applicable to oil spills may be suitable. These include booms, flow guides, curtains, adsorbent booms, and so forth. When the spilled floating material is flammable (for example, benzene or gasoline), the danger of ignition and fire must be recognized. An absorbent boom and floating material can be advantageous since it immobilizes the spilled fluid (in case it is hit by a stream of water); it reduces the rate of vapor release (allowing a fire to be cooled by water fog and extinguished); and minimizes loss due to stream or tidal current. Recovery and removal are safer with respect to both personnel and environment. Adsorbents (as noted in 8.3.1.3) may increase vapor release, and so forth. Only vapors burn, not liquids. A reverse flow weir can be valuable if the water stream can be interrupted.

8.4.3 *Booms*—A sealed boom consisting of a plastic (resistant) curtain, a flotation device, and a tension device can be deployed around ships, oil rigs, at the mouth of harbors, and across streams. If the speed of the current (either stream or tidal) is more than 2 knots, then absolute retention is not always possible by use of boom alone. Use of the proper sorbent can alleviate this problem somewhat. Liquid entrapment behind a boom can aid in building a thicker layer of spilled product than can be pumped or removed by vacuum equipment. Point source control is most desirable. Use of particulate sorbents at the site of a spill allows collection of the contaminated units on a wire fence across a stream.

8.4.4 *Sorbents* (see 8.3.1.3)*:*

8.4.4.1 *Adsorbents* (see 8.3.1.3)—Certain adsorbents useful on land spills are less useful in spills on water. The main reason is preferential water wetting. Also, water may tend to weaken the structure of certain adsorbents useful on land. The nature of certain hazardous materials (for example, oxidizers) should be checked for compatibility with the sorbent. Strong oxidizers as a matter of practice should not be contacted with organic sorbents.

8.4.4.2 *Absorbents* (see 8.3.1.4)—Compatibility of absorbents with the spilled material should be checked. As a general practice, organic absorbents should not be used with strong oxidizers. Compatible absorbents in unitized packages can be weighted and used to pick up sinking materials (DNAPLS), that is, dense non-aqueous phase liquids, as well as establish bottom booms. The value of this as well as the ability to retrieve the spill from the bottom without loss during retrieval is very important.

8.4.4.3 *Gellants* (see 8.3.1.5)—Gellants in dry or water-dispersed form may have use in handling thin layer spills on quiet water. The ability to change viscosity allows separation techniques that would be impossible otherwise.

8.4.5 *Underwater Dikes, Dams, and Trenches*—Underwater dikes of sandbags or other materials can be constructed. Dredging of underwater ditches at angles to the flow may also be useful. If pits can be dug, then vacuuming can be considered.

8.4.6 *Membrane Technology* (see Guide F1525)—As applied to spills, membrane technology involves the use of a semipermeable membrane to concentrate a chemical, which has been spilled into the ground or surface water, for ease of recovery. Soluble, insoluble, and slightly soluble materials may be recovered by this technique. Because of time constraints, recovery may be limited to small bodies of water. The branches of technology involved are microfiltration (MF), ultrafiltration (UF), nano filtration (NF), and reverse osmosis (RO).

8.4.6.1 *Microfiltration (MF)*—Microfiltration is a pressure-driven process whereby suspended solids and macromolecules are removed on the basis of size. Pore size is normally 0.1 to 5.0 µm and operating pressures usually range from 3 to 50 psi (20 to 345 kPa). Membranes are typically constructed using polypropylene, teflon, and metal oxides. Microfiltration can be used alone or as a pre-treatment step for other technologies.

8.4.6.2 *Ultrafiltration (UF)*—Ultrafiltration is a form of very fine, cross-flow filtration. Suspended solids, immiscible liquids, and emulsions may be recovered by this technique, which involves low pressure (from 50 to 200 psi or from 345 to 1380 kPa). The material is to be treated and pumped, under pressure, across the surface of a finely porous membrane. Water passes through the pores leaving a more concentrated product stream. Use of turbulence promoters assists in preventing buildup of product on the surface of the membrane. By use of recirculation loops, recoveries of up to 99 % of the product at volume reductions from 95 to 99 % are frequently possible. Membranes are made of many synthetic materials (cellulose acetate, polyamide, polyimide, polysulphone, and so forth). Compatibility of the membrane and other components of the system to the chemical involved should be known before recovery is tried.

8.4.6.3 *Nanofiltration (NF)*—Nanofiltration is a pressure-driven process whereby a contaminated liquid stream is separated and purified by a process involving filtration, diffusion, and chemical potential across a compatible membrane. Divalent and multivalent species with a molecular weight above 80 can be removed, as are uncharged and univalent molecules with a molecular weight above 200. Operating pressures normally run between 200 to 400 psi (1380 to 2760 kPa).

8.4.6.4 *Reverse Osmosis (RO)*—Reverse osmosis involves a diffusion reaction in which the water passes through a semi-permeable membrane leaving behind a more concentrated product. Slightly soluble and soluble products may be recovered by this technique which requires high pressure (from 400 to 1000 psi or from 2760 to 6895 kPa). The material to be concentrated is pumped under high pressure across the surface of a membrane. Turbulence promoters decrease the buildup of product at the surface. By use of circulating pumps, volume reductions from 90 to 95 % are possible. Possible product recoveries vary with the size and type of molecule. Some examples include:

Inorganic Chemical, %		Organic Chemical, %	
Sodium chloride	99	Methanol	40
Potassium hydroxide	79	Ethylene dichloride	70
Ammonium nitrate	97	Benzene	90
Zinc sulphate	98	Malathion	99.9

At present, only dilute solutions may be handled by this technique (5 % for inorganics, 0.5 % for some organics). As with UF, RO membranes are made of many synthetic materials (cellulose acetate, polyamide, polysulphone, polyetherimide and so forth). These membranes are much more product specific in the application than are their UF counterparts. The capability of the membrane and the compatibility of the complete system to the chemical involved should be known before this technique is attempted.

8.5 *Volatiles:*

8.5.1 Many volatile materials are shipped in cylinders or containers under pressure. When these are vented through a hole, all except two of these volatile materials tend to cause a cooling effect. It is worth noting these two exceptions. One is helium, which is not hazardous except as a suffocating agent, and the other is hydrogen. A pressurized cylinder of either of these will heat up as the material is vented. Hydrogen in air has a low ignition point and burns with an almost invisible flame. (**Warning—**Use caution when the volatile is hydrogen.)

8.5.2 *Foam Covering*—(See Guide F1129) Water-based blankets applied to the surface of a volatile liquid spill can significantly reduce the vapor hazard. The foam blanketing is effective with water-immiscible flammable liquids, water-soluble flammable liquids (polar compounds), and certain classes of water reactive liquids. Some gaseous materials shipped and stored as refrigerated liquids such as methane, ethylene, ammonia, and chlorine can also be benefited by foam blankets. Not all foams are effective against all chemicals.[4,5,6] These references should be consulted along with foam manufacturer's literature before using foam for vapor control. Some foam/chemical combinations can exaggerate the hazard rather than mitigate it. Pre-planning is important.

8.5.3 *Water Spraying*—The use of water spray must be considered carefully. If the water warms the spill, it could cause increased vaporization. Water will raise the level of a contained spill and perhaps cause it to overflow. Sprays or mists may not be effective in scrubbing vapor from air, but can be used to guide a drifting vapor cloud or plume away from sensitive areas. The advantages of the water fog and spray are availability and short response time. The disadvantage is the potential for contaminated water runoff as well as spreading a spill.

8.5.4 *Chilling*—Cooling has been tested as a method to reduce the vaporization rate of hazardous substances involved

[4] "Evaluation Development of Foams for Mitigating Air Pollution from Hazardous Spills," EPA-600/2–82/029, National Technical Information Service, Springfield, VA, June 1982.

[5] "Handbook for Using Foams to Control Vapors from Hazardous Spill,'' EPA-600/8-8-019, National Technical Information Service, Springfield, VA.

[6] *Hazardous Materials Spills Handbook*, Chapter 10, McGraw-Hill, 1982.

in land spills or floating on water. Candidate coolants tested include the following: liquid nitrogen (LN_2), solid carbon dioxide (CO_2), and ice/water mixture. Only the latter two coolants are practical. Even these must be dispensed uniformly over the spill surface as a finely divided solid. Carbon dioxide extinguishers or snow horns are not effective since they yield less than 10 % solids and may cause a static electric problem. Solid CO_2 is the most effective and applicable to most materials with which it does not react and where the boiling point is greater than the sublimation temperature of the CO_2. But if the spill is on water, the CO_2 will sink and may increase vapor release. Wet ice has application to water-miscible materials; it both cools and dilutes. Special equipment is necessary to crush the ice to the correct particle size distribution and project it to the spill surface. Coolants appear to be restricted to in-plant use where quantities of dry or wet ice would normally be available. The effectiveness of cooling to mitigate spills of hazardous chemicals is dependent on many factors, such as delivery method, physical properties of the coolant, freezing point of the spilled material, and environmental factors. Wind and rain can have a significant impact on the effectiveness.

8.5.5 *Film Covering*—If a volatile spill could be covered with an inert film, the vapors could be contained and released to a treatment unit. When unrolling a plastic film, static generation of sparks should be considered.

8.5.6 *Scrubbing*—Capture of the vapor coming from a volatile spill should be considered. Scrubbing the vapors by drawing them through a neutralizing or absorbing material, water fog, or entraining foam may be possible. (**Warning—** Neutralization of acids or bases may be accompanied by the generation of heat in a quantity that may cause boiling, splashing, and serious personnel hazards—thermal and chemical exposure.)

8.6 *Solids*—In the absence of bad weather (rain or wind), fire, explosion, or contact with other spilled reactive materials, insoluble solids will usually be nonspreading. The lack of inherent mobility of solids improves the possibility of containment as opposed to fluids. Solids, especially those shipped in smaller containers such as bags and drums are usually easy to handle. However, certain solids, such as phenol, maleic anhydride, and so forth, are shipped as melted liquids in bulk but are solids at normal temperatures. When a solid is mixed with water, its containment is more difficult. In situations where solids are solubilized by contact with rain or with water used in fighting a fire, practical containment techniques used to contain spills of liquids should be employed (see 8.2). When the spill of a hazardous solid is accompanied by fire or water, or both, containment can be difficult. Reactions may give off particulate clouds, toxic vapor, and even explosions may occur. The reaction of solids with liquids should not be treated casually. There are chapters in Manual 10 that cover such hazards. Even the addition of a solid such as clay (a typical solid adsorbent) can cause a catalytic reaction with a monomer such as styrene and cause a fire where originally there was none.

9. Keywords

9.1 absorbent; adsorbent; DNAPL; emergency response; foam; gellant; hazardous materials; membranes; patches; plugs; spills; sorbents; thickener

RELATED MATERIAL

ASTM Guide F1011 for Developing a Hazardous Materials Training Curriculum for Initial Response Personnel

ASTM Guide F1644 for Health and Safety Training of Oil Spill Responders

ASTM Guide F1656 for Health and Safety Training of Oil Spill Responders in the United States

2004 Emergency Response Guidebook, USDOT, Transport Canada, and Secretariat of Transport and Communications of Mexico, http://hazmat.dot.gov/pubs/erg/gydebook.htm.

A Guide to the Safe Handling of Hazardous Materials Accidents, ASTM STP 825, ASTM, 1983.

Chemical Hazards Information System (CHRIS) Manual, U.S. Coast Guard, Washington, D.C.

Sorbent Material for Cleanup of Hazardous Spills, U.S. Department of Commerce, Washington, DC.