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

This standard is issued under the fixed designation F1127; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F716 Test Methods for Sorbent Performance of Absorbents for Use on Chemical and Light Hydrocarbon Spills
F726 Test Method for Sorbent Performance of Adsorbents for use on Crude Oil and Related Spills
~~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:~~Regulations:*[3]

29 CFR 1910.120 – Hazardous waste operations and emergency response
~~2001.3~~40 CFR 112 Protection of Environment, Part 112 Oil Pollution Prevention
~~2001.4~~40 CFR 300 Protection of Environment, Part 300 National Oil and Hazardous Substances Pollution Contingency Plan
~~2008.1~~

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

[1] This guide is under the jurisdiction of ASTM Committee F20 on Hazardous Substances and Oil Spill Responseand is the direct responsibility of Subcommittee F20.22 on Mitigation Actions.

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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.~~ Electronic Code of Federal Regulations e-CFR, https://www.ecfr.gov

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.~~liquid.

3.1.2 *adsorbent*—an insoluble material that is coated by a liquid on its surface including pores and ~~capillaries.~~ capillaries without the solid swelling more than 50 % in excess liquid.

3.1.3 *gellant*—a material such as a colloidal network or other aggregate network ~~which~~that 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.~~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. Initial hazard assessment should be performed before applying mitigation techniques.

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. See OSHA Hazardous Waste and Emergency Response Standard (HAZWOPER) requirements.

5. Containment Methodology

5.1 Containment equipment, procedures, and techniques can be categorized into three general functional classes: ~~(*a*~~*(a)*~~) patch/plug,~~ (patch/ plug, ~~*b*~~*(b)*~~)~~ enclosure, and ~~(*c*~~*(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.

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~~25 mm to ~~2-in. (25~~50 mm (1 in. to ~~50-mm)~~2 in.) thick can be fastened over a damaged area with “T” bolts, ~~tie-down~~tiedown 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:*~~ *Liquids*—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:

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

8.2.2 Immobilize the liquid by use of an adsorbent, absorbent, or a gelling agent (see ~~8.3.1.2~~8.3.2 through 8.3.5).

8.2.3 Pump to a suitable container or lined pit.

8.2.4 Erect physical barriers.

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

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

8.2.7 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.

8.2.8 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.

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

8.2.10 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.

8.2.11 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:~~ Spills*—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 *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 non-sparking or explosion-proof equipment. Employ a grounded system so that static electric buildup cannot occur at discharge ports or nozzles.

8.3.2 *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. So-called "universal or broad range" sorbents are covered in 8.3.7, 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.

8.3.3 *Adsorbents*—~~Typical methods~~ 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 and fibres (melt blown polypropylene, polyurethane), 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*~~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.~~ 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:

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(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.

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~~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.~~

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~~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.~~

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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~~8.3.3) 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 8.3.2)*:*

8.4.5 *Adsorbents* (see 8.3.3)—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