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

2. Referenced Documents

2.1 *ASTM Standards:*

F 716 Methods of Testing Sorbent Performance of Absorbents[2]

F 726 Method of Testing Sorbent Performance of Adsorbents[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *absorption*—a process where the material taken up is distributed throughout the body of the absorbing material. (The body of the absorbing material must swell.)

3.1.2 *adsorption*—a process where the material taken up is distributed over the surface of the adsorbing material.

3.1.3 *gellant*—material that exists for both aqueous and organic materials.

3.1.4 *sorbent*—a material used to recover liquids (or fluids) through the mechanism of absorption or adsorption or both.

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.

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, etc.). 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 can be fastened over a damaged area with "T'' bolts, 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 plastic sheeting, 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, etc.). 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, etc. Wood, plastic, or metal reinforcements may be required.

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[2] *Annual Book of ASTM Standards*, Vol 11.04.

6.1.5 *Formed Plug*—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 (0.0025 in.) sheet of steel foil may be strapped over the damaged area.

6.1.9 *Mechanical Patch*—Neoprene 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, or banding/strapping material.

6.1.12 *Split Clamp Pipe Patch*—A split, sleeve-type coupling with a bolted flange assembly can be used to cover a rusted or damaged pipe section.

6.1.13 *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 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 equipment. Employ a grounded system so that static electric buildup cannot occur at discharge ports or nozzles.

8.3.1.2 *Sorbents*—Sorbent is a general term applied to both adsorbents and absorbents. 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 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 8.3.1.6, 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 Methods F 716 and F 726 are included in Section 3 of this guide.

8.3.1.3 *Adsorbents*—Adsorbent materials are those that are 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. The criteria is that if the fiber does not swell greater than 10 % or the carbon granule 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, etc.,

(2) Vaporization loss is often increased by increasing exposed surface area,

(3) The adsorbent may lead fluid causing secondary spill problems, and

(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, etc.

8.3.1.4 *Absorbents*—Absorbent materials are those that are 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 mean a stopping of 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 *Miscellaneous*—This category includes the "universal 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.

8.3.1.7 *Dikes, Dams, and Trenches*—Artificial containment barriers can be created to confine liquid spills by forming a wall of sandbags, water-inflated bags, or earth (by shovelling 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.

8.3.1.8 *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), and imbibing-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