



Project Summary

A Guidance Manual for Selection and Use of Sorbents for Liquid Hazardous Substance Releases

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The document described herein is a guidance manual developed to provide information for the selection and use of sorbents for cleanup or control of liquid hazardous substances. Literature reviews, sorbent manufacturer data and experiences of Federal On-Scene Coordinators were reviewed in conjunction with laboratory studies to determine the compatibility and sorption capacity of selected representative hazardous liquid-sorbent pairs. The combined experimental and literature data were used to prepare the manual. On-scene coordinators and their technical support personnel are the primary target audience for the manual.

Before utilizing the manual, the user must first identify the spilled liquid. If it is one of the 212 liquid hazardous substances addressed in the manual, a reference is provided to one of 26 "Sorbent Selection and Use Guides." Each of the guides enables the user to rapidly identify the generic sorbent classes, physical forms, and methods for application and collection that are most suitable for each of three different chemical release-control scenarios: (1) a spill onto land; (2) a floating release into water; and (3) immobilization for landfilling.

The manual contains "Sorbent Data Sheets" for 13 generic classes of sorbents other than activated carbon. These data sheets contain information on manufacturers, acquisition costs, bulk density and sorbent limitations. The sorption capacity of 190 sorbent-

chemical pairs was determined and recorded in the manual. The manual also includes cost estimation procedures, test methods, hazardous liquid physical properties, and a description of the rationale for the release-control scenarios.

This Project Summary was developed by EPA's Hazardous Waste Engineering 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

Spills and releases of liquid hazardous substances can pose a severe threat to the public and the environment. Such substances may be released at fixed sites or during transportation accidents. Sorbents are potentially effective materials for cleaning up and controlling many such releases. The guidance manual is designed to facilitate the selection and use of appropriate sorbents for treating releases of hazardous liquids. While the manual is targeted primarily to Federal On-Scene Coordinators (OSC) and their technical support staffs, it is also meant to assist personnel who respond to releases of hazardous liquids and immobilize such substances prior to disposal, or who engage in emergency response for cleanup or control of industrial spills.

Development of the manual involved a review of the literature, sorbent manufacturers' data, OSC experiences,

and laboratory studies. The laboratory studies determined the compatibility and sorption capacity of selected hazardous liquid-sorbent pairs. To establish a framework for the manual, three liquid release-control scenarios were studied: (1) a spill onto land; (2) a floating release onto water; and (3) immobilization for landfilling. "Sorbent Selection and Use Guides" were developed which list sorbents for each release-control scenario. Sorbent Data Sheets were also prepared for each of 13 classes of sorbents. The manual also provides information on sorbent application, collection and disposal, cost estimation procedures, test methods, hazardous liquid physical properties, and a narrative to enable selection of appropriate sorbents. The manual is designed to provide information for both rapid decision making and for conducting thorough evaluations of alternative sorbent-use strategies.

Procedures

The manual development project was completed in three phases. The approach and results of each phase are described below.

Phase 1: Information Collection and Test Plan Development

Development of a List of Applicable Hazardous Liquids—A list of hazardous liquids for which the manual would be applicable was developed from the substances regulated by the Comprehensive Environmental Response, Compensation and Liability Act of 1980, PL96-150 (CERCLA). The CERCLA hazardous liquids of concern are 212 neat hazardous substances that meet the liquid criteria designation (i.e., that a substance possesses a melting point at or below 77°F (25°C) and a boiling point at or above 50°F (10°C)). Waste mixtures were not considered.

These CERCLA-regulated liquid hazardous substances were placed into 27 classes according to functional groups described by Herrick et al.¹ Since it was not possible to experimentally evaluate all of the CERCLA hazardous liquids, representative hazardous liquids were selected from each chemical class based

¹Herrick, E.D., D Carstea, and G. Goldgraben. Sorbent Materials for Cleanup of Hazardous Spills, EPA/600/2-82/030, U.S. Environmental Protection Agency, Environmental Research Center, Cincinnati, Ohio, 1982.

on aqueous solubility, specific gravity, liquid surface tension, and viscosity. Table 1 lists the chemical classes and guide numbers to which each hazardous liquid was assigned.

Collection of Information—To complete the Sorbent Selection and Use Guides and the Sorbent Data Sheets, pertinent data were collected. The physical data gathered for each liquid included specific gravity, aqueous solubility, surface tension, and viscosity. When physical data was unavailable from technical reference materials and journals, such data were solicited from chemical manufacturers of the liquids.

A literature review also was conducted to identify available sorbents and their manufacturers, and to obtain published data on sorbent properties and performance. Because information deficiencies were noted in the literature, data sheets were requested from sorbent producers. These data sheets provided limited sorbent property and procurement information, and sorbent-hazardous liquid pair data such as sorption capacity, retention capacity, sorbent compaction and expansion data, performance parameters and safety precautions.

Test Plan Formation—For each chemical class, a representative chemical was chosen. Similarly, a representative sorbent was chosen from each of the 13 generic sorbent classes. Those representative sorbent-hazardous liquid pairs for which no data were available became primary candidates for testing. The selection of a hazardous liquid for testing was based on the probability that a substance from one of the 27 chemical classes would be released and the degree of hazard that it presented to public health or the environment. Probability of

a release was based on the annual production volume, while the degree of hazard was based on the proposed reportable quantity (RQ) of the CERCLA liquid as promulgated by the Environmental Protection Agency in 48FR23552-23605 and subsequent revisions. The sorbents were assigned priority for testing based on (1) sorbent availability and (2) sorbent applicability for ameliorating a spill similar to one of more of the three cleanup scenarios. The following list presents the 13 generic sorbent categories identified by the project:

- Sorbent Clay
- Polyethylene
- Diatomite
- Polypropylene
- Wood Fiber
- Cross-Linked Polymer
- Treated Wood Fiber
- Feathers
- Expanded Mineral
- Treated Clay/Treated Natural Organic Foamed Glass
- Treated Expanded Mineral/Treated Wood Fiber
- Polyurethane

The sorbent-hazardous liquid pair chosen for testing were from the top priority groups, resulting in selection of a maximum of 250 pairs.

Phase 2: Compatibility and Sorption Capacity Testing

Laboratory experiments and estimation procedures were employed in Phase 2 to generate or estimate sorbent performance data that were not available from the literature. The Phase 2 work is described below.

Compatibility Testing—A standard operating procedure (SOP) was prepared

Table 1. CERCLA Liquid Chemical Classes

Chemical Class	Guide Number	Chemical Class	Guide Number
Acidic compounds, inorganic	1	Esters and ethers	15
Acidic compounds, organic	2	Ethers, halogenated	16
Alcohols and glycols	3	Halides, inorganic	17
Aldehydes	4	Heavy metals	18
Aliphatic hydrocarbons	5	Hydrazines and hydrazides	19
Aliphatics, halogenated	6	Ketones	20
Amides, anilides, and imides	7	Nitro/nitroso compounds	21
Amines, alkyl	8	Organophosphates	22
Amines, aryl	9	Oxides, alkylene	23
Aromatic hydrocarbons	10	Peroxides	24
Aromatics, halogenated	11	Phenols and cresols	25
Basic compounds	12	Sulfates and sulfites	26
Cyanates and isocyanates	13	Sulfides and mercaptans	27
Cyanides and nitriles	14		

to describe the procedures employed in conducting the compatibility tests. When a gross incompatibility is observed or degradation of the sorbent occurs, the sorbent-hazardous liquid pair is excluded from sorption capacity testing. Also, when the sorbent is not wetted by the hazardous liquid, the sorbent-liquid pair does not qualify for sorption capacity testing. The sorption capacity measurements of 190 sorbent-liquid pairs were conducted in Phase 2 of the project. The 10 sorbents tested for sorption capacity with the representative hazardous liquids were also tested for their sorption capacity with water. The data obtained were used to determine hazardous liquid/water preference indices for the sorbents.

Sorption Capacity Testing—The sorbent testing protocol consists of three procedures for three different sorbent forms: (1) a decanting procedure for particulate sorbents in which, after a 2-hour exposure in a graduated cylinder, the hazardous liquid is poured out through a stainless steel screen leaving behind the loaded sorbent for measurement; (2) A volume measurement procedure for finely-divided particulate sorbents, wherein the sorbent is allowed to settle and the volume of the sorbent layer (and the liquid contained therein) is determined; and (3) A pad/mat immersion procedure, in which a standardized sorbent specimen is immersed in and then removed from a hazardous liquid and weighed after dripping ceases.

Sorbent/Hazardous Liquid Data Estimation—Project funds did not permit experimental determination of all sorbent-hazardous liquid sorption capacity values of interest. Procedures were established for estimating sorption capacities in cases where the untested sorbent-chemical pair is sufficiently similar to pairs for which data are available. Although the estimation procedures are not rigorously defensible from a scientific standpoint, it was concluded that OSC and their technical support personnel would have to develop similar estimation procedures when faced with hazardous liquid releases for which sorption capacity data did not exist. Therefore, the estimates were made, included in the manual, and clearly marked as estimates.

Phase 3: Manual Preparation

This phase of the project involved the following elements:

- Development of the Sorbent Selection and Use Guides
- Preparation of the Sorbent Data Sheets
- Production of ancillary data tables:
 - sorption capacity
 - hazardous liquid/water preference
 - physical properties
 - test methods
 - equipment/sorbent costs
- Preparation of the handbook text

Each of these elements is described below.

Results and Discussion

The manual contains nine sections. The first three sections, "Sorbent Selection and Use," "Sorbent Data," and "Technical/Logistical Information," are essential to users who require a condensed source of sorbent selection and use guidance. The other six sections, "Cost Estimation Procedures and Data," "Test Methods," "Spill Scenario Rationale," "Sources of Information," "CERCLA Liquid Chemical Information," and "Sorbent Selection Rationale" explain the rationale used to develop the condensed guidance in the first three sections and also provide information that enables the user to acquire and use sorbent information for specific needs. A synopsis of each of the nine sections is provided below.

Section A—Sorbent Selection and Use

Two CERCLA Liquids Indexing Tables are an integral part of Section A. The first indexing table lists CERCLA designated hazardous liquids, the chemical class and guide number to which each liquid has been assigned, the CAS number for each liquid, the hazards in addition to toxicity, and the behavior of the liquid in water. The second indexing table lists the 4-digit DOT ID number used in commercial shipping, and supplemental information similar to that in the first indexing table. Information is provided for all 212 CERCLA liquids that were identified.

Section A of the guide also contains the Sorbent Selection and Use Guides. Each guide presents information on the use of sorbents relevant to the three scenarios: Landspill, Floating Spill, and Landfill. Chemical functional classes are generally regarded to be descriptive of the chemical reactivity of the CERCLA

liquids; consequently, one guide was prepared for each chemical class for which data were available. Each guide lists generic sorbents in recommended order for consideration for each of the scenarios. Application and collection procedures are listed in each guide based on assessment of the optimal procedures for use with each generic sorbent. For each sorbent listed in each guide, the page number of the Sorbent Data Sheet is also included.

Section B—Sorbent Data

This section contains (1) an index of sorbent manufacturers, trade names, and generic sorbent categories, (2) 13 Sorbent Data Sheets, (3) the sorption capacity data, and (4) the hazardous liquid/water preference indices.

A Sorbent Data Sheet was prepared for each generic class of sorbents. Each data sheet lists the generic sorbent class, commercial trade names, manufacturers' data on the types of sorbents, their cost, bulk density and storage requirements. The sorbent types generally available include: particulates, pillows, pads, mats, and booms. The data sheets also report limitations on the use of each generic sorbent for landspills and floating spills. Hazards relative to gross incompatibilities, and health, safety, and environmental concerns, are delineated and the sorbent density is also given. The format allows for updating of the Sorbent Data Sheets as additional sorbents become available. Sorption capacity data for the representative sorbent-hazardous liquid pairs are also tabled in the final document. Still another table in the final guidance manual contains hazardous liquid-water preference indices, which are the ratio of the grams of hazardous liquid absorbed to the grams of water absorbed by the same quantity of sorbent. The preference index provides an indication of a sorbent's performance in a waterspill scenario. The larger the hazardous liquid/water preference index, the greater the hydrophobic quality of the sorbent and the greater the likelihood that it will preferentially sorb hazardous liquids.

Section C—Technical/Logistical Information

This section presents guidance on equipment and techniques to use for (1) the application and collection of sorbents in a spill cleanup situation, (2) the immobilization by sorbents of hazardous

liquids for disposal in a landfill, (3) reuse of sorbents, and (4) the disposal of used sorbents. The text describes equipment and manpower requirements, limitations, and safety precautions for the application and collection of the three basic sorbent forms: (1) particulate, (2) pillow, pad, or mat, and (3) sorbent booms.

Section D—Cost Estimation Procedures and Data

This section provides data for estimating the cost of using a sorbent. A discussion of general cost categories for cleanup with sorbents is presented. The major categories are equipment, expendable materials, labor, disposal, and transportation. Cost data are given in 1983 dollars for estimation purposes. Guide Sections B and C should be consulted to determine specific equipment, materials, labor, disposal, and transportation requirements.

Section E—Test Methods

Section E describes test methods available for evaluating sorbent performance characteristics such as sorption capacity and release rates. Brief descriptions of the test methods, including purpose, applicability, limitations, and selection of an appropriate test method if required. Manufacturers data on sorption of hazardous liquids by sorbents generally do not cite test procedures. The absence of sorbent performance data derived from a common test method makes comparison of results difficult.

Section F—Spill Scenario Rationale

Section F presents the rationale for selecting and defining the cleanup scenarios considered in the manual. These scenarios represent situations where sorbents are most likely to be a viable method of spill treatment.

Section G—Sources of Information

Sources of information on CERCLA liquids and sorbents are presented in Section G. References such as reports, handbooks, publications, and vendors are identified.

Section H—CERCLA Liquid Chemical Information

Section H presents physical property data on specific gravity, solubility in

water, viscosity, and surface tension for the CERCLA liquids. The physical data tabulation enables identification of CERCLA liquids with similar physical properties, which is useful information for estimating sorption capacity for similar liquids. The hazardous liquid specific gravity, in conjunction with sorbent specific gravity and sorption capacity, can be used to calculate the volume of loaded sorbent that will be generated and subsequently require disposal. The data are organized alphabetically by chemical class followed by the hazardous liquid CERCLA name and the CAS Registry number.

Section I—Sorbent Selection Rationale

Section I presents the rationale and resultant procedures for developing the ranked lists of sorbents that are contained in the Guides.

Conclusions

A Guidance Manual for the Selection and Use of Sorbents for Liquid Hazardous Substance Releases provides a concise compilation of information and data pertaining to the selection, acquisition, application, collection, regeneration, and disposal of sorbents. The inclusion of a chemical index (by chemical name and DOT number), which is cross-referenced to Sorbent Selection and Use Guides and Sorbent Data Sheets, enables the user to quickly locate pertinent sorbent information for the liquid hazardous substances addressed in the manual. The manual includes 190 sorption capacity measurements taken as part of the project and which were unavailable in the literature prior to this effort. The availability of a condensed source of information on sorbents promotes their efficient use by assisting decision-makers to estimate and compare the effectiveness and cost of various sorbent-use strategies. Although the primary target audience for the manual is Federal On-Scene Coordinators and their technical support staffs, the manual is also applicable to the needs of spill clean-up managers representing State and local agencies as well as the private sector.

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The complete report entitled "A Guidance Manual for the Selection and Use of Sorbents for Liquid Hazardous Substance Releases," (Order No. PB 87-208 765/AS; Cost: \$18.95, subject to change) will be available only from:

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