STABILIZATION AND SOLIDIFICATION OF

Hazardous, Radioactive, AND Mixed Wastes

Gilliam/Wiles, editors

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Stabilization and Solidification of Hazardous, Radioactive, and Mixed Wastes, 2nd Volume

T. Michael Gilliam and Carlton C. Wiles

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Foreword

This publication, *Stabilization and Solidification of Hazardous, Radioactive, and Mixed Wastes, 2nd Volume,* contains papers presented at the Second International Symposium on Stabilization/Solidification of Hazardous, Radioactive, and Mixed Wastes, which was held in Williamsburg, Virginia, 29 May to 1 June 1990 The symposium was sponsored by ASTM Committee D-34 on Waste Disposal, Oak Ridge National Laboratory, U S Environmental Protection Agency, Hazardous Substance Management Research Center of the New Jersey Institute of Technology, Environment Canada, and Alberta Environmental Centre T Michael Gilliam, Oak Ridge National Laboratory, was symposium chairman The editors of this book, T Michael Gilliam and Carlton C Wiles, wish to express their appreciation to the symposium attendees, authors, and ASTM staff who have contributed to this publication A special note of gratitude is due to those individuals who served as peer reviewers for the papers presented in this publication

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Overview

Stabilization and solidification (S/S) technologies have been used for decades as a final treatment step prior to the disposal of both radioactive and chemically hazardous wastes. Stabilization refers to the alteration of waste contaminants to a more chemically stable form (i.e., a form which results in a greater difficulty of contaminant release to the environment), thereby resulting in a more environmentally acceptable waste form. Solidification refers to the physical alteration of the waste to restrict water release from or access to the waste and thereby resulting in a more environmentally acceptable waste form. Typically, stabilization processes also involve some form of physical solidification.

This Special Technical Publication contains 39 peer-reviewed papers out of the 70 that were presented at the Second International Symposium on Stabilization/Solidification of Hazardous, Radioactive, and Mixed Wastes, held in Williamsburg, Virginia, 29 May-1 June 1990. This symposium was sponsored by ASTM Committee D-34 on Waste Disposal, Oak Ridge National Laboratory, Risk Reduction Engineering Laboratory, Office of Research and Development of the U.S. Environmental Protection Agency (EPA), Hazardous Substance Management Research Center of the New Jersey Institute of Technology, Environment Canada, and Alberta Environmental Centre. Cooperating organizations include the Commission of the European Communities (CEC), Brussels, Belgium, ENEA (Comitato Nazionale per la Ricerca e per lo Sviluppo dell'Energia Nucleare e delle Energie Alternative), Rome, Italy, Netherlands Energy Research Foundation (ECN), Petten, The Netherlands, Imperial College of Science, Technology & Medicine, University of London, London, England; VKI (Water Quality Institute), Horsholm, Denmark, Studiecentrum voor Kernergie/Centre d'etude de l'Energie Nucleaire (SCK/CEN), Mol, Belgium; Korea Advanced Institute of Science and Technology (KAIST), Seoul, Korea, KAERI (Korea Atomic Energy Research Institute, Chung-Nam, Korea, Agence Nationale pour la Recuperation et l'Elimination des Dechets-Les Transformeurs, Angers, France; and RISO National Laboratory, Roskilde, Denmark.

This symposium series (scheduled once approximately every three years) provides a forum for technical exchange between researchers working with S/S technologies from both the low-level radioactive and chemically hazardous waste communities. Although the two scientific communities are faced with similar problems and basically work with the same technologies, this symposium series presents a unique forum for technical exchange between the two communities. This meeting is the second in the series. Papers from the first meeting in the series were published in STP 1033, *Environmental Aspects of Stabilization and Solidification of Hazardous and Radioactive Wastes*.

Land disposal restrictions are becoming ever increasingly stringent, driven by technical, regulatory, and political considerations. To the largest extent practicable, alternatives to land disposal are desirable, such as waste minimization, recycling, and destruction (e.g., incineration). In many instances, however, these alternatives are unrealistic due to the physical nature or location of the waste, the type and concentration of contaminants that it contains, or technical and economic issues. In such cases, S/S technology is a viable technical option which has historically proven to be cost effective.

A wide variety of both radioactive and chemically hazardous wastes are amenable to S/S. These include liquids, sludges, filter cakes, contaminated soils, and ash. S/S technologies are often used with chemically hazardous wastes contaminated with metals (e g , lead, nickel, chromium) and are routinely used with low-level radioactive wastes of all types Clearly, S/S is not the preferred technology for organic-rich wastes, but research is increasingly focusing on its application to wastes containing trace levels of organic contaminants

S/S technologies are often classified on the basis of the principal additives used to obtain a solid matrix Various systems based on organic and inorganic additives are listed below

Inorganic Based Systems	Organic Based Systems
portland cement	bitumen
soluble silicates-cement	urea formaldehyde
pozzolan-lime	polybutadiene
pozzolan-cement	polyester
clay-cement	epoxy
gypsum	polyethylene

The specific technology used is based on several factors including volume increase, performance requirements, economics, logistic constraints, and material availability

Inorganic-based systems may involve both stabilization and solidification They generally utilize a hydraulic binder which reacts with water to form a solid product Portland cement is the most commonly used binder. Cement-based systems are widely used due to the availability of raw materials, compatibility with existing process equipment, and adaptability to a variety of process configurations and waste-form performance requirements Pure cement systems are becoming increasingly rare Additives such as fly ash, granulated blast furnace slag, and specialty clays are used to improve waste-form performance and to minimize the cost Compared with a pure cement system, these additives can reduce the resulting volume increase, reduce porosity (and, thus, reduce leachability), and increase compressive strength

Organic-based systems consist of encapsulating the waste in a matrix that is essentially impervious to water As such, they are designated as solidification processes Many of these systems require water removal from the waste prior to solidification and thus result in an overall volume decrease Products from these systems require a container to provide the necessary structural integrity to support overburden pressure Use of such systems has been limited to special types of high-hazard, relatively low-volume, radioactive wastes due to the increased costs generally associated with these systems

The scientific community has been focusing attention on understanding and predicting the long-term containment prospects of waste treated with this technology Consequently, the majority of papers presented in this publication address to some degree one or both of the two principal issues associated with long-term containment, leachability and durability Leachability refers to the release of contaminants from the waste form upon exposure to an aqueous media Durability refers to the ability of the waste form to maintain its structural integrity upon exposure to expected environmental conditions

Attendees from 14 countries participated in this meeting, and the papers presented in this publication represent a cross section of research activities being conducted in this field worldwide The papers are grouped into six sections to deal with (1) Regulatory and Technical Guidance; (2) Speciality Wastes Organics, Ashes, and Resins, (3) Laboratory-Scale Leachability Studies, (4) Laboratory-Scale Process Development, (5) Test Method Development, and (6) Large-Scale Evaluation or Demonstration

Significant overlap among the papers is evident For example, papers grouped under Laboratory-Scale Process Development may well contain information pertinent to Laboratory-

Scale Leachability Studies. This is to be expected as the papers are grouped primarily based on the application of the data and conclusions as presented by the authors rather than on the data themselves. Moreover, the papers were purposely not grouped according to waste category (hazardous, radioactive, and mixed). The purpose of this meeting was to provide information exchange between the various technical communities. The presentations clearly showed that materials, processes, performance requirements, methods of experimentation, and subsequent data analyses were, for the most part, waste-category independent. Thus, only by reading papers from all represented technical communities can one get a true understanding of what this technology can and cannot do.

Regulatory and Technical Guidance

When contemplating the use of S/S technology for a particular application, the first questions asked are: What are the pertinent regulatory requirements? Has this technology been used successfully on similar wastes? What test methods can be used to assess the effectiveness of this technology? The four papers presented in this section deal directly with these questions. The first two papers address pertinent regulatory issues, the third addresses previous successes and failures; and the fourth addresses available examination techniques.

Specialty Wastes: Organics, Ashes, and Resins

S/S technology is used routinely in the nuclear industry for the treatment of low-level radioactive wastes. In addition, the EPA has specified S/S technology as the best demonstrated and available technology for a variety of wastes containing metals, such as cadmium, chromium, and lead. Clearly, one of the roles of the scientific community is to define the limits of existing technology and expand those limits where appropriate. Indeed, the majority of the papers presented in this publication could be viewed as contributing to this endeavor. Eight papers are presented in this section which directly address the application of this technology to three waste types of particular interest during the meeting: organics, combustion residues (e.g., ashes), and resins. The first three papers deal with the issue of organic-containing wastes and range from a review of existing literature to on-going experimental studies. Four of the papers deal with combustion residues such as incinerator ash, fly ash, and/or desulfurization sludges. One paper deals with anion exchange resins.

Laboratory-Scale Leachability Studies

Understanding the mechanisms involved in the leaching of a waste form is crucial to predicting its long-term performance in the environment. At present, the prediction of long-term behavior must rely on leaching studies and their associated leach-model development due to (1) a lack of understanding of the chemistry and morphology of the waste form, resulting in a limited ability to quantitatively predict its long-term performance and (2) both the lack of and difficulty in interpreting field-scale leach data, resulting in limited verification of laboratory-scale leach studies and derived models. Eight papers are presented in this section which deal with the development of leach models and/or determining parameters that affect waste-form leachability. Collectively, these papers indicate the similarity between the performance of waste forms containing hazardous and radioactive wastes. The editors believe that this subject more than any other shows the benefits and need for information exchange between the technical communities.

Laboratory-Scale Process Development

Numerous research and development efforts are being expended in formulating stabilization and solidification processes The eight papers presented in this section provide an excellent cross section of these development efforts The majority of the papers deal with cement-based systems (the most commonly used) and clearly show the benefits of the use of additives such as fly ash, granulated blast furnace slag, and slaked lime Four of the papers address alternatives to the cement-based systems including compaction (a form of solidification), sodium silicates, polyesters, and urea formaldehyde

Test Method Development

Test methods are useful tools in evaluating S/S technologies Appropriate test methods have the potential to increase one's knowledge of the process or product, decrease the time needed to acquire this knowledge, or improve the product/process The four papers presented in this section address all of these potential uses and range from laboratory-scale application to improved process control

Large-Scale Evaluation or Demonstration

The papers presented in this publication are predominantly related to laboratory-scale studies, which is an accurate representation of the level of effort applied in the scientific community Laboratory-scale studies are dominant for a variety of reasons including the ability to control variables of interest, which facilitates the determination of cause-and-effect relationships It is this control which necessitates the need for large-scale evaluation or demonstration Large-scale studies are needed to determine performance under less-controlled conditions that are inherent to field-scale operations, such as variability of the waste feed (both chemical and physical), variability in ability to control process parameters, and variability in environmental exposure conditions on the product The seven papers presented in this section address a variety of S/S techniques ranging from dynamic compaction to in situ stabilization Two of the papers provide case history studies which indicate the interrelationship between laboratory and full-scale studies The first paper in this section provides a summary of demonstrations conducted under the EPA's Superfund Innovative Technology Evaluation Program and can serve as a guide to information available on this subject from other sources

T. Michael Gilliam

Oak Ridge National Laboratory, Oak Ridge, TN 37831-7273, symposium chairman and editor

Carlton C. Wiles

Environmental Protection Agency, Cincinnati, OH, editor

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