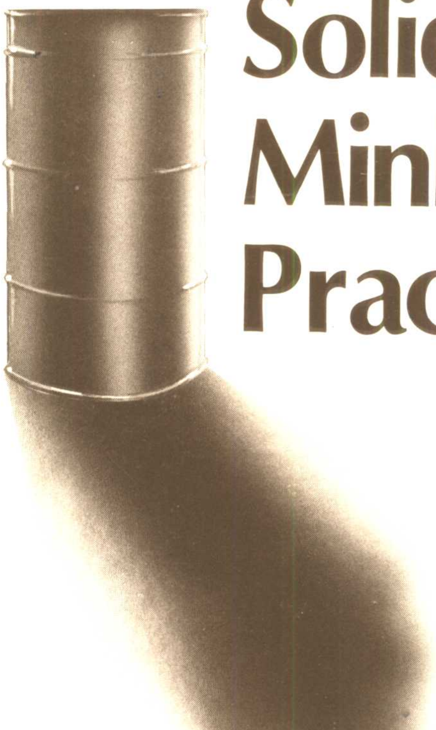
Hazardous and Industrial Solid Waste Minimization Practices



Conway / Frick / Warner / Wiles / Duckett
EDITORS

ASTM STP 1043

STP 1043

Hazardous and Industrial Solid Waste Minimization Practices

R. A. Conway, John H. Frick, David J. Warner, Carlton C. Wiles, and E. Joseph Duckett, editors

ASTM
1916 Race Street
Philadelphia, PA 19103

Library of Congress Cataloging-in-Publication Data

Hazardous and industrial solid waste minimization practices / R.A. Conway . . . [et al.], editors.
(STP ; 1043)
Papers presented at the 8th Symposium on Hazardous and Industrial Solid Waste Testing and Disposal, held in Clearwater, Fla., Nov. 12–13, 1987, sponsored by ASTM Committees D-34 on Waste Disposal and E-38 on Resource Recovery.
Includes bibliographies and index.
"ASTM publication code number (PCN) 04-010430-56"—T.p. verso.
ISBN 0-8031-1269-6
1. Waste minimization—Congresses. 2. Hazardous wastes—Congresses. 3. Factory and trade waste—Congresses. I. Conway, Richard A. II. ASTM Committee D-34 on Waste Disposal. III. ASTM Committee E-38 on Resource Recovery. IV. Symposium on Hazardous and Industrial Solid Waste Testing and Disposal (8th : 1987 : Clearwater, Fla.). V. Series: ASTM special technical publication ; 1043.
TD793.9.H39 1989 89-33965
628.4′2—dc20 CIP

NOTE

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

Peer Review Policy

Each paper published in this volume was evaluated by three peer reviewers. The authors addressed all of the reviewers' comments to the satisfaction of both the technical editor(s) and the ASTM Committee on Publications.

The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution of time and effort on behalf of ASTM.

Printed in Baltimore, MD
August 1989

Foreword

Waste Minimization Practice: The 8th Symposium on Hazardous and Industrial Solid Waste Testing and Disposal was held 12–13 November 1987 at Clearwater, FL. The symposium was sponsored by ASTM Committees D-34 on Waste Disposal and E-38 on Resource Recovery. R. A. Conway, Union Carbide Corporation, John H. Frick, Ph.D., Defense Logistics Agency, David J. Warner, Dynamic Corporation, Carlton C. Wiles, U.S. Environmental Protection Agency, E. Joseph Duckett, Schneider Engineers, served as chairmen of the symposium and are editors of the resulting publication.

Contents

Overview 1

GENERAL MANAGERIAL PRACTICES

Hazardous Waste Reduction Efforts in the Department of the Army—NANCY M. POMERLEAU, JEREMIAH J. MCCARTHY, AND JOHN T. BANDY 7

The Waste Minimization Program at the Feed Materials Production Center—JOHN E. BLASDEL, MILBURN E. CROTZER, ROBERT L. GARDNER, T. RAY KATO, AND C. N. SPRADLIN 17

Minimizing Waste by Charging the Generator—JEANETTE B. BERRY AND FRANKLIN J. HOMAN 29

WASTE MINIMIZATION AUDITS

Waste Reduction Audits: Matching Types to Stages—JOEL S. HIRSCHHORN AND KIRSTEN U. OLDENBURG 41

Waste Minimization Audits at Industrial and DOD Installations—MARVIN DRABKIN, EDWIN RISSMANN, PAUL SYLVESTRI, AND HARRY FREEMAN 48

Hazardous Waste Minimization Audits: Strategy and Methodology—MICHAEL E. RESCH 62

SOLVENT RECOVERY

Results of Field Sampling Programs Conducted at Waste Solvent Treatment and Recycling Facilities—DOUGLAS R. ROECK AND NICHOLAS PANGARO 73

Methods for Monitoring Solvent Condition and Maximizing Its Utilization—SURENDRA B. JOSHI, BERNARD A. DONAHUE, ARTHUR R. TARRER, JAMES A. GUIN, MAHMUD A. RAHMAN, AND BILL L. BRADY, JR. 80

The Application of a Mobile Solvent Recovery Process to Minimize Hazardous Waste—TIM C. KEENER 104

USED OIL RECOVERY

Minimizing Waste Oil Disposal—FRANCO E. GODOY AND MARY H. SAVAGE 115

Demetallation of Used Oil to Facilitate Its Utilization as a Fuel—J. H. KANG, ARTHUR R. TARRER, JOE KAMINSKI, JIM PARRISH, AND EDWARD R. BATES 123

Waste Oil Management for a Small Quantity Generator—THOMAS H. DEFOUW, BARRY VERDEGAN, AND ROGER ZOCH 143

MISCELLANEOUS SEPARATION AND UTILIZATION PRACTICES

Efficiencies in Waste Processing—RICHARD IAN STESSEL 153

Hazardous Waste Volume Reduction Research in the U.S. Environmental Protection Agency—JOHN F. MARTIN, MARK J. STUTSMAN, AND ERNST GROSSMAN, III 163

Magnetic Separation of Uranium from Waste Materials—JANET M. HOEGLER 172

Elimination of Precoat Filter Sludge Hazardous Waste—RICHARD J. KIEFFER 190

Utilization of Ash Products from Combustion of Shredded Solid Waste—PATRICK F. MAHONEY AND JOCELYN F. MULLEN 196

Index 205

Overview

In recent years, waste minimization has been growing in popularity. At the same time, the treatment and disposal of wastes has come under greater scrutiny. People realize that the volume of waste generated continues to increase while the availability of suitable treatment and disposal facilities continues to decrease. In fact, new technologies continue to bring about new and different types of wastes every day to be added to our growing disposal problems. Our country is clearly aware that our nation's wastes, especially hazardous wastes, pose a threat to human health and the environment when they are improperly handled or managed. In fact, proper handling and management of our land disposal facilities is still in question. Also, people are all too aware of our limited landfill capacity and the increasing difficulty of siting new treatment and disposal facilities. This drives up today's cost of disposal, which in turn results in the increased cost of goods and services, and it provides no assurances to the protection of our future generations.

Because of these circumstances facing our nation, waste minimization is now being approached as the last frontier of hope in dealing properly with the generation of waste today. In order to explore the benefits of standardization on this front, members of ASTM organized a new subcommittee on waste minimization. This subcommittee established a forum for exploring, developing, and expanding the coverage of voluntary consensus standards on waste minimization. In addition, a symposium was organized by Committees D34 on Waste Disposal and E38 on Resource Recovery to stimulate investigation into the standards development process and to encourage further dialogue and expanded implementation of waste minimization practices. This symposium, the Eighth Symposium on Hazardous and Industrial Solid Waste, presented information on managerial practices, auditing techniques, and specific practices used by industry and government activities.

The information presented can be useful to individuals who desire to put into practice those measures involving administrative or technological changes that diminish the overall amount or toxicity of waste generation for their company or activity, or it can be used in developing specific waste minimization strategies. To accommodate the reader, certain presentations are kept intentionally general in their approach while others are made specific.

The collection of 17 papers published in this volume has been grouped into five major categories. To accommodate the reader, these sections have been organized according to popular interest. These categories are general managerial practices, waste minimization audits, solvent recovery, used oil recovery, and miscellaneous separation and utilization practices.

General Managerial Practices

The papers in this section present several practices that can be used to initiate and improve a waste minimization program. The Department of the Army discusses its program from both a qualitative and a quantitative perspective. Here, studies are identified to refine the hazardous material tracking system used by the Army and the method used to economically evaluate and rank waste reduction options. The Department of Energy describes some of their programs to deal with radioactive waste streams at the Feed Materials Production Center operated by the Westinghouse Materials Company of Ohio. They stress the importance of training, communication, and incentives; and they discuss the progress they have made without the use of "high technology." The Oak Ridge National Laboratory operated by the Martin Marietta Energy Systems, Inc., explains its research on a program of waste generation accountability through charges to those responsible for waste production. Because of the types of hazardous wastes they handle and manage, these two activities of the Department of Energy are highly proactive and encouraged by the beneficial aspects of a sound waste minimization program.

Waste Minimization Audits

This section on waste minimization audits stresses the importance of conducting a survey of an activity's wastes through those who are closest to the problem. These are the people who often have the best ideas and solutions. Here, the Office of Technology Assessment reviews their four phases of waste reduction, that is, common sense waste reduction, information driven waste reduction, audit dependent waste reduction, and research and development based waste reduction. The first two stages can be accomplished with simple checklists, which in turn, can shift the thinking of production people from ordinary production work, conventional pollution control, and common waste management practices to more beneficial waste reduction efforts. The latter stages require a greater commitment of resources and time. The Environmental Protection Agency, too, encourages the development of waste minimization audits to reduce the generation of hazardous waste. A model hazardous waste minimization audit procedure was developed by Versar, Inc. through the Agency's Hazardous Waste Engineering Research Laboratory in Cincinnati, OH. A summary of this procedure is provided, and the results of two case studies are carried out on two electroplating operation studies to test the procedure. Also, a six-phase auditing strategy is presented to assist industrialized facilities in developing waste minimization programs. This paper cautions against conducting these audits in a vacuum and emphasizes that successfulness of the audit can be measured only when the facility acts on the recommendations and realizes the expected benefits.

Solvent Recovery

The third section on solvent recovery presents some of the problems and solutions of waste minimization associated with a major group of chemical materials, especially those that have been identified as candidates for the land-ban regulations. As described in the paper on field sampling programs conducted at waste solvent treatment and recycling facilities, high-quality distillate products suitable for a variety of uses can be delivered while virtually all metal contaminants detected in the waste feed streams are transferred to the still bottoms and disposed of by offsite fuel supplement users, that is, asphalt kilns and blast furnaces. In this section, three field sampling programs conducted by Alliance Technologies Corporation for the Environmental Protection Agency's Hazardous Waste Engineering Research Laboratory are presented. Another paper on the methods for monitoring solvent condition and maximizing its utilization evaluates simple tests to be used as criteria for determining the condition of cold dipping (stoddard solvent), vapor degreasing (chlorinated solvents), and precision cleaning solvents (freon-113 and isopropanol), and for identifying when a solvent should be changed, thereby extending its usable shelf life. Another interesting paper presents a novel mobile solvent recovery system, for reclaiming usable solvents on-site. The system has been designed to have the flexibility of reclaiming a wide variety of industrial solvents while still adhering to the regulations governing the quantities of wastes remaining within the system as residue, and minimizing the amount of cross-solvent contamination.

Used Oil Recovery

This section on used oil recovery identifies the regulatory restrictions, the types of waste oils involved, the options available for minimizing waste generation, and the process equipment needed to recover this material. One paper on minimizing waste oil disposal discusses minimization in terms of on-site recovery, on-site use as fuel, off-site disposal through fuel blending, off-site recycling, and hazardous waste fuels and the restrictions associated with these types of fuels. Case studies for utilizing waste oils as a fuel and for recycling waste machine coolants are also presented. Another paper presents a study on the demetallation of used oil before its burning, a method of facilitating compliance with the air pollution emission standards and the Resource Conservation and Recovery Act regulations. A novel approach for tanker cleaning operations is presented. A device used by the maritime industry for a number of years has been shown to be effective for use in the separation of oil from water at transportation service and repair facilities. Six field tests were made using different types of oil and oil mixtures, and the system required less capital investment and installation than the standard gravity separation systems.

Miscellaneous Separation and Utilization Practices

The last section on miscellaneous separation and utilization practices includes five papers. One paper discusses the efficiencies in waste processing. Here, the relationships between recovery efficiency and purity are explored. Criteria for an efficiency expression are discussed; current efficiency parameterization practices are discussed; and a current efficiency expression is presented. An alternative method of producing the efficiency distribution is developed. In another paper, the Environmental Protection Agency's Hazardous Waste Engineering Research Laboratory presents studies on three extramural projects in the area of waste concentration and resource recovery. In the area of magnetic separation, the Department of Energy, through their Oak Ridge National Laboratory, has developed criteria for selecting candidate wastes for testing the magnetic separation of uranium and other paramagnetic materials. Bench scale tests on the separation of uranium from magnesium fluoride waste indicate that a magnetic separation process could largely replace the expensive wet-chemistry process now being used at the Feed Materials Production Center in Fernald, OH. A paper on the elimination of precoat filter sludge hazardous waste presents a new liquid cyclone process, which can prevent further generation of ignitable hazardous waste, that is, sludge containing flammable solvent. The liquid cyclone system is designed to separate suspended solids from a polymer solution. Product and beneficial process changes resulting from the system change are discussed. On the topic of minimizing waste from municipal solid waste disposal facilities, studies have consistently found fly ash to contain levels of heavy metals, dioxins, acid gas constituents, and other pollutants in excess of regulatory standards, while the bottom ash stream is generally found to be within acceptable limits. A paper on the research and development activities of this waste has focused on the reuse of bottom ash as a lightweight aggregate. This process is showing very promising opportunities for recycling.

The papers briefly described here can provide a starting point for those who are becoming initially involved with waste minimization, or they can offer new and stimulating ideas to help improve an existing program. More importantly, however, this collection of waste minimization papers from the Eighth Symposium on Hazardous and Industrial Solid Waste represents the free spirit and enthusiasm of the participants on this subject and their willingness to share these creative ideas to help others. The symposium committee gratefully acknowledges the efforts of the authors and personnel of ASTM that have made this publication possible.

John H. Frick, Ph.D.
Defense Logistics Agency
Alexandria, VA 22304-6100;
symposium co-chairman and co-editor.

General Managerial Practices

Nancy M. Pomerleau,[1] *Jeremiah J. McCarthy,*[2] *and John T. Bandy*[3]

Hazardous Waste Reduction Efforts in the Department of the Army

REFERENCE: Pomerleau, N. M., McCarthy, J. J., and Bandy, J. T., "**Hazardous Waste Reduction Efforts in the Department of the Army,**" *Hazardous and Industrial Solid Waste Minimization Practices, ASTM STP 1043,* R. A. Conway, J. H. Frick, D. J. Warner, C. C. Wiles, and E. J. Duckett, Eds., American Society for Testing and Materials, Philadelphia, 1989, pp. 7–16.

ABSTRACT: The Department of the Army generates approximately 102 000 metric tons of hazardous waste each year. Nearly 90% of these wastes are produced by the Army's industrial activities. The typical method of treatment has been land disposal. Because of the costs associated with managing these wastes, both in terms of final disposal and corrective actions, and recent legislation emphasizing waste reduction, the Army began to strengthen its pollution prevention strategy. Beginning in 1984, the Army elevated the management of all wastes to the highest levels; previously, the Army had maintained a decentralized program by individual Army installations. Also, the Army established policy goals for reducing the disposal of solvents, a significant hazardous waste contributor. Similarly, in 1985, Army industrial activities developed waste reduction strategies for all other types of hazardous wastes that also emphasize front-end reduction, using methods such as materials substitution, recycling, and process changes to achieve specific process reduction goals. Hazardous waste audits and economic analyses are also required to identify and rank the appropriate type of reduction options that are economically practicable. Moreover, to develop a strategy for selecting waste management options and to measure progress in achieving program goals, formal committees were established. Committee members represent the various facets of Army activities responsible for the cradle-to-grave management of hazardous wastes.

To further facilitate the Army's hazardous waste reduction objectives, a study is being conducted to assess all hazardous waste reporting requirements, as provided by local, state, Federal, and international regulation and Army policy. The findings and recommendations from this study will support a concurrent study to identify and develop the most appropriate type of computer data base to record the necessary hazardous waste data. This data base will also serve as a useful tool in programming and budgeting for hazardous waste activities. Moreover, two additional studies are being conducted, in concert, to refine a hazardous materials tracking system and to economically evaluate and rank waste reduction options. These studies, in support of on-going waste reduction initiatives, and continuing waste reduction committee forums, will enhance the Army's efforts to meet its hazardous waste reduction objectives and goals.

KEY WORDS: hazardous materials, hazardous waste, mass balance, economic analyses, data management systems

[1] Department of the Army, Office of the Assistant Chief of Engineers, The Pentagon, Washington, DC 20310-2600.

[2] Department of Defense, Office of the Assistant Secretary of Defense, The Pentagon, Washington, DC 20310-8000.

[3] Department of the Army, Army Construction and Engineering Research Laboratory, Champaign, IL 61820-1305.

The U.S. Department of the Army engages in a variety of activities that use hazardous materials and that produce hazardous wastes in support of its military mission. Included in these activities are industrial and manufacturing operations to produce and repair equipment systems, production and testing of munitions, research and development for new equipment, and medical support for the soldier. Collectively, these activities produce a wide array of contaminated sludges, solvents, acids, bases, and heavy metal-type wastes.

The Army consists of several Major Commands (MACOM's) located worldwide, with different responsibilities, that contribute to the diversity of hazardous wastes generated. Similar activities within these MACOMs generate similar hazardous wastes. However, only three of the MACOMs generate the majority of hazardous wastes; namely, the U.S. Army Materiel Command (AMC), the U.S. Army Forces Command (FORSCOM), and the U.S. Army Training and Doctrine Command (TRADOC). In the United States alone, the hazardous waste generators within these MACOMs, consist of 108 active Army installations. More specifically, because of AMCs industrial mission to support the soldier in the active Army, the Army Reserve, and the National Guard Bureau, they contribute at least 90% of the hazardous wastes generated in the Army. In 1985, AMC generated over 69 000 metric tons of industrial wastewater treatment sludges, reactive wastes, solvents, and various heavy metal wastes.

Reducing the volume and toxicity of hazardous wastes in the Army presents significant challenges for all levels of management because of factors, such as the diversity of hazardous waste generating activities, the number of hazardous waste generators, the organizational structure, the size and location of the installations, and potential liabilities associated with waste management. Since 1985, the Army has gained considerable experience in developing and implementing a hazardous waste minimization (HAZMIN) program.

This paper presents the policies, case studies, and program developments that collectively contribute to reducing hazardous wastes in the Army.

Background

In 1984, at the direction of the Assistant Secretary of Defense for Manpower, Installations and Logistics, the Army and the other Military Services began to develop programs to eliminate the disposal of recyclable solvents by 1 Oct. 1987. Spent solvents are generally produced by cleaning, degreasing, and paint stripping operations. To date, the Army is working to meet the solvent reduction goal either by recycling its own solvents or by using specialized solvent recycling contractors. Because this effort is generally viewed as a subset of the Army's hazardous waste minimization program, solvent reduction is being measured both separately and collectively with other hazardous waste reduction efforts.

Following the enactment of the Hazardous and Solid Waste Amendments in 1984, providing a statutory requirement to minimize hazardous wastes, the Joint Logistics Commanders (JLC), which consist of the Commanders of the Army, Air Force, and Navy logistics activities, issued a policy in Dec. 1985, to develop a hazardous waste minimization program. This policy recommends methods of waste reduction and requires the following seven fundamental program elements: (1) accurate annual hazardous waste reporting, including type and quantity of wastes and disposal costs; (2) use of a hazardous materials control program for each generator; (3) review of existing technology as well as opportunities for improvement; (4) assessment of existing technology at activities and industries and research and development needs; (5) implementation of economically practicable minimization technologies; (6) consideration of waste minimization in all acquisition programs, and (7) development of command reduction goals, including monitoring progress in achieving these goals. Furthermore, the JLC required the Military Services to exchange information on technologies and to annually report all HAZMIN projects, studies, and

TABLE 1—*Hazardous waste reduction goals by process.*

Process, Operation or Condition	Percent Reduction Desired by 1992
Electroplating	50
Paint stripping, solvents	40
Paint stripping, plastic beads	60
Painting	50
Cleaning/degreasing	40
Vehicle maintenance	30
Electrical maintenance	60
Metalworking	15
Fueling operations	30
Battery shop operations	50
Munitions production	35
Munitions demilitarization	40
Load, assembly, and pack operations	15
Industrial wastewater treatment sludges	60
Other treatment-generated hazardous wastes	40
Other operations or processes	40

research and development to the Department of Defense. To support this program, the JLC authorized the use of funds from the Defense Environmental Restoration Account, supplemented by other Service resources.

While the JLC policy provides the foundation for the Army's waste reduction program, the MACOMs have also developed Command-specific reduction plans. The most comprehensive plan has been prepared by AMC; it establishes specific reduction goals for hazardous waste generation processes that are common to AMC. These process-specific goals are being used as a measure of waste minimization progress (Table 1). The Army is evaluating these goals for their relevance to similar activities Army-wide. Also, while the AMC plan has served as a model for other MACOMs in emphasizing source reduction, economic analyses of waste minimization options, and command support, the MACOM plans are tracking reviewing hazardous waste minimization initiatives and evaluating trends in waste generation.

Army Policy

In July 1987, the Army Secretariat established a formal hazardous waste minimization policy that requires the Army to achieve a 50% reduction of the quantity of hazardous wastes by the end of calendar year 1992, when compared to a baseline of calendar year 1985. Also, the policy requires all MACOMs to develop and maintain HAZMIN programs that (1) emphasize source reduction and recycling, (2) consider reducing the toxicity of hazardous wastes, (3) require routine audits of generating activities, (4) require an economic evaluation of HAZMIN alternatives, and (5) emphasize command support. To support the Army's goal, the Department of Defense has authorized the use of funds from the Defense Environmental Restoration Account. While aspects of this policy are already embodied in some of the MACOM HAZMIN plans, it nonetheless provides the Army's emphasis to minimize.

Command Emphasis

During the past few years, the Army has increasingly focused senior management attention on the issue of hazardous waste minimization. This emphasis is best exemplified by the Army's Hazardous Waste Minimization Workgroup, which was established in Aug. 1987, under the joint direction of the Deputy Assistant Secretary of the Army for Environment, Safety, and Occupational Health and the Assistant Chief of Engineers. The Workgroup affirms the Army's recognition of the need for an interdisciplinary approach to the cradle-to-grave management of hazardous wastes. It provides a "corporate-level" view to issues such as acquisition, budgeting, contracting, research, logistics, and health, by including key representatives of both the Army Secretariat and the Army Staff with functional responsibility for the management of all Army activities. The objective of the Workgroup is to formulate necessary policy and guidance to ensure progress in meeting the Army's hazardous waste minimization goals. To accomplish this objective, a 5-year strategy will be developed.

Waste Characterization

As stated previously, the most significant hazardous waste generating activities are in the AMC. To support the Army soldier in the active Army, the Army Reserve, and the NGB, AMC requisitions, overhauls, and repairs hundreds of thousands of pieces of equipment at its maintenance and repair depots every year. It also produces, tests, stores, distributes, and disposes of virtually all the ammunition for the Department of Defense. In 1985, 55 AMC installations generated 68 000 metric tons of hazardous wastes. These installations are responsible for the manufacture and repair of all Army weapons systems, including biological defense materiel and equipment maintenance.

By comparison, TRADOC and FORSCOM generated approximately 2600 metric tons and 4800 metric tons of hazardous waste, respectively, during 1985. These two MACOMs have relatively similar responsibilities in terms of training soldiers, and similar waste generating processes such as equipment maintenance and repair. Consequently, the most common hazardous wastes are cleaning and degreasing solvents, contaminated waste oil and fuels, battery acids, and paint stripping wastes.

Program Support

To support the MACOMs in identifying opportunities for waste reduction, the U.S. Army Environmental Hygiene Agency (USAEHA) developed a protocol to audit hazardous waste activities at Army installations. To date, 31 installations (AMC, TRADOC, and FORSCOM) have been surveyed. While USAEHA conducts an inventory of wastes by process and recommends specific technical modifications, and identify seven basic installation-wide type reduction efforts, such as accurate identification of hazardous wastes, technology transfer, and hazardous materials management, through implementation of initial USAEHA recommendations, hazardous waste generation can be reduced by 5 to 50% for each installation, resulting in an annual savings in the range of $14 000 to $600 000. Moreover, based on the minimization audits conducted, USAEHA recommends that implementation of some research and development proposals could reduce the hazardous waste generated by an additional 10 to 40%. The following examples illustrate these points.

Case Studies

Some of the findings of these audits include delisting of sludges for selected industrial wastewater treatment sludges. At Holston Army Ammunition Plant, TN, sludges from explosives wastewater treatment represented 95% of the reported total. Segregation of nonhazardous waste alum sludge from the explosives sludges, sludge dewatering, and replacement of hydraulic drive units with electric units, which do not require oil, have significantly decreased the quantities of these hazardous waste.

In 1985, 51% of the hazardous waste generated at Lake City Army Ammunition Plant, MO, or 689 metric tons, represented sludges from industrial wastewater treatment. The significant hazardous waste reduction efforts to date include a segregation of explosives wastewaters from other industrial wastewaters, design of a pyrotechnics chemical treatment facility, use of smaller ballistics bunkers to reduce the generation of hazardous sand, and treatment of mercurous wastes to facilitate recycling. Future efforts appear to include segregation of water treatment plant sludges from industrial sludges, recycling of spent solvents, and segregation of waste ammunition and components.

At Longhorn Army Ammunition Plant (LAAP), TX, a computerized hazardous materials tracking system has been developed to identify the types and quantities of hazardous materials stored by each generator to minimize the generation of hazardous wastes following the expiration of the shelf-life of the material. This system is designed to track containers or drums of hazardous materials throughout the installation from the point of issue to the point of ultimate disposition. Also, these containers and drums are numbered to provide accurate accountability for cradle-to-grave management. While the LAAP program does not currently inventory hazardous wastes from the point of generation in the same manner as for hazardous materials, the U.S. Army Construction and Engineering Research Laboratory is conducting a study to provide this type of comprehensive system for use Army-wide.

Pine Bluff Arsenal, AR, won the Department of Defense Environmental Quality Award for 1987, largely because of its efforts to reduce hazardous waste generation. HAZMIN initiatives included substitution of water for acetone in pyrotechnic mixes to reduce the number of off-specification batches and performance of experiments and pilot studies to minimize industrial wastewater treatment sludges. Experiments conducted at the wastewater treatment plant to minimize the amount of activated carbon that is being added to treat the total organic carbon in the wastewater has resulted in the selection of a more efficient carbon. Pine Bluff Arsenal has also developed a pilot process to use fixed-bed carbon adsorption in lieu of batch carbon treatment. Such a process change, which is programmed for 1989, would annually reduce the amount of sludge generated by 30%.

At Radford Army Ammunition Plant, VA, electroplating sludges and spent solvents represent approximately 83 and 10%, respectively, of the total amount of hazardous wastes generated. The significant HAZMIN reduction efforts to date include off-site recycling of stoddard solvent, use of battery electrolyte as a chemical additive at the industrial wastewater treatment plant, and separation of nonhazardous phosphate sludges from electroplating sludges. An economic analysis of off-site versus on-site distillation indicates that the volume of solvent could be reduced by 95% with a payback period of 24 months. In addition, the most important future HAZMIN efforts under consideration are treatment of corrosive electroplating wastes on-site, segregation of ash from the treatment of ordnance, elimination or reduction of electroplating rinse waters, and point source recovery of chromium and cadmium wastewaters.

Stratford Army Engine Plant, CT, where a variety of engines are manufactured, characteristically generates plating waste sludges, used oil, and spent solvents. In 1986, the installation constructed a new chemical waste treatment plant to segregate cyanide and chromium wastes, using mechanical dewatering and a filter press. Data are still being collected to determine the relative efficiency in waste reduction. Also, economic analyses to recycle Varsol, a medium to apply heavy oil to metal parts for short-term storage, and freon could result in a 95% reduction of these wastes.

Tobyhanna Army Depot (TOAD), PA, is largely a maintenance installation that repairs, fabricates, modifies, and assembles communications-electronics systems and supporting equipment. Industrial wastewater treatment plant sludges and paint wastes represented approximately 73 and 10%, respectively, of the hazardous waste generated. Significant