MANAGING MIXED WASTES: TECHNICAL ISSUES[a]

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ABSTRACT

The U.S. Department of Energy manages wastes that are both chemically hazardous and radioactive. These mixed wastes are often unique and many have national security implications. Management practices have evolved over the more than forty years that the Department and its predecessor agencies have been managing these wastes, both in response to better understanding of the hazards involved and in response to external, regulatory influences. The Department has recently standardized its waste management practices and has initiated an R&D program to address priority issues identified by its operating contractor organizations. The R&D program is guided by a waste management strategy that emphasizes reduction of human exposure to hazardous wastes in the environment, reduction of the amount and toxicity of wastes generated, treatment of wastes that are generated to reduce volumes and toxicities, and identification of alternatives to land disposal of wastes that remain hazardous following maximum practicable treatment.

INTRODUCTION

The U.S. Department of Energy (DOE) manages wastes that are unique in their hazardous properties, history, and legal status. This paper reviews the properties of those wastes that make them unique and describes efforts that the Department is making to resolve technical issues that face waste managers of DOE facilities.

The defense facilities of the Department of Energy produce wastes that are both familiar and exotic. Liquid wastes that are treated and released under regulation by the Clean Water Act, air emissions that are regulated under the Clean Air Act, and solid wastes that are regulated under Subtitle D of the Solid Waste Act are examples of wastes that are common to other industries.

The Department's exotic wastes derive from the unique nature of its industry, nuclear weapons design and production. No other industry operating in the United States produces a comparable product; consequently, many of the waste streams produced are unique. In addition, the waste streams may contain information that can be used to reconstruct processes employed in the manufacture of weapons, information clearly related to national security. Yet, these considerations do not obviate the Department's responsibilities to human health and the environment, responsibilities that were defined in the legislation that created the Department and its predecessor agencies, the Atomic Energy Act of 1954.

The Department and its predecessor agencies have successfully managed radioactive wastes for over 40 years. Chemically hazardous wastes have also been managed, although the rules governing their management have changed radically within the last few years and Department facilities have come under close scrutiny from regulators, the public, and the press. The changing regulatory evnironment for hazardous wastes has impacted both DOE and private industry and has been a primary driver for change in waste management practices and technology development. Nevertheless, the Department's objectives of protecting human health and the environment remain the same while our strategy evolves with the changing requirements. Current DOE waste management strategy has four components: (1) to reduce exposures to hazardous materials, (2) to reduce the generation of hazardous wastes, (3) to improve our treatment capabilities for those wastes which must be generated, and (4) to improve disposal methods for wastes which remain hazardous following treatment. The following sections describe what we are doing to implement this strategy.

REDUCING EXPOSURE

The Department's waste management strategy seeks to prevent human exposure to hazardous wastes by preventing the wastes from entering the environment. However, because of earlier practices which were either poorly understood or ineffective, hazardous wastes already occur in the environment. Our exposure reduction efforts are aimed at better evaluation of the risks posed by hazardous wastes in the environment and at better detection and measurement of wastes in the environment.

Our top priority is to better understand the risks posed by hazardous wastes. The commonly employed risk methodologies do not adequately handle mixtures of hazardous constituents. They may either

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focus on the hazard posed by to one constituent and ignore others, or they may treat the hazards posed by different kinds of materials in different ways, thus producing hazard rankings that are difficult to explain and more difficult to defend. One example is the debate that has arisen over the interpretation of risks at the Rocky Flats Plant in Colorado. Work done at the Pacific Northwest Laboratory has examined the relative hazards of chemical toxicants and radioactive wastes. Our current effort, at Sandia National Laboratory, seeks to derive a methodology that will combine toxicity, probability of release, and environmental transport information into a defensible risk measure. That risk measure will then be used to set priorities for action in upgrading current waste facilities and in cleaning up contaminated and potentially contaminated sites.

Additional work is to progress to improve our ability to detect and monitor hazardous wastes in the environment. The Department is supporting work at Lawrence Livermore National Laboratory on the design, construction, and testing of instruments using fiber optics coupled with detectors to penetrate soils surrounding storage and disposal sites. Initial efforts center on the in situ detection of trichlorethylene (TCE), with future work planned for other chlorinated organics and for hydrocarbons. Parallel to our efforts at improved detection are efforts by Reynolds Electrical & Engineering Co., our prime contractor at the Nevada Test Site, to improve in situ monitoring by better understanding the movement of toxic materials in soils. This work involves the release and monitoring of nontoxic, highly mobile, organic tracers. These tracer studies will allow us to field calibrate the mathematical models used to predict the movement of underground plumes of hazardous wastes. Finally, the Department is supporting work to improve groundwater monitoring techniques. This effort, being carried out at Lawrence Livermore National Laboratory, seeks to reduce the costs of monitoring well installation and instrumentation by extending the current two-aquifer isolation technique to three or more aquifers and to evaluate commercially available instrumentation for cost effectiveness and efficacy.

REDUCING GENERATION

Generation of hazardous wastes can be reduced by recycling materials now released as waste and by changing processes, either by substituting feedstocks that result in less toxic waste being produced or by modifying the process such that different by-products are produced. The Department is supporting three such efforts.

The Pacific Northwest Laboratory is exploring ways of reclaiming and recycling the large volumes of acids used by DOE's Defense Programs. The objectives of the work are to develop a process and process equipment for treating acid waste streams to remove metallic ions such as uranium, copper, and zirconium, and to reclaim nitric, hydrochloric, and hydrofluoric acids by distillation with sulfuric acid. The Idaho National Engineering Laboratory (INEL) is examining current processes in which the substitution of one or more input materials would reduce or eliminate the generation of a hazardous waste. Individual process waste streams are being examined for materials which lead to the production of hazardous wastes and which may be replaced with alternative materials that would produce a less toxic waste. When such potential substitutions are found, the impact of substitution on the process and its economics will be evaluated before a recommendation is made.

Work being done at the Oak Ridge National Laboratory (ORNL) may greatly improve the efficiency of the work being done at INEL. An expert system (a computer program employing "artificial intelligence") exists for finding synthesis pathways for a specifed compound starting with commercially available materials and using known synthesis methods. ORNL is expanding the chemical knowledge base of this system and reversing the direction of the program. Starting with a specified waste compound, the program will search out pathways to possible products having less toxicity or perhaps commercial value.

IMPROVING TREATMENT

Although substitutions and recycling can significantly reduce the volumes and toxicity of wastes produced, large industrial operations will continue to generate large volumes of hazardous wastes. Treatment can reduce the toxicity and/or volume of wastes requiring disposal. The Department is supporting efforts to improve treatment capabilities and efficiencies and to reduce the costs of treatment. Work is proceeding in seven areas.

Los Alamos National Laboratory has operated an incinerator for radioactive, hazardous, and mixed wastes for some time. They will document their experience with that incinerator for the benefit of the rest of the Department. They will then build upon their extensive experience in processing various forms of hazardous wastes to design, construct, and test a self-contained, transportable hazardous waste incinerator for use at several DOE facilities. Such an incinerator will allow the Department to avoid shipping some hazardous wastes, which can be quite controversial.

Oak Ridge National Laboratory is investigating magnetic separation of paramagnetic components from hazardous waste mixtures. They will be attempting to separate heavy metals, such as mercury, lead, and uranium, from representative waste streams through differences in their magnetic susceptibility. Success will allow in-line separation of metals from organics which will allow for more efficient and cost-effective treatment of hazardous organic wastes.

Argonne National Laboratory is investigating the use of microwave heating to accelerate chemical processes for detoxifying polar waste streams. Such an externally-applied heat source could prove to be both an efficient and maintenance-free means of speeding up detoxification reactions.

A promising approach to treating aqueous waste streams is being explored by Los Alamos National Laboratory. A high-pressure autoclave will be used to allow organic compounds to be oxidized in supercritical water. If successful, the technology will be widely adaptable and may yield reaction products that can be delisted and taken out of the hazardous waste inventories of the DOE installations.

Two studies are aimed at converting high-volume wastes into forms more suitable for disposal. Several DOE installations produce high volumes of nitrate salts as a by-product when using nitric acid to recover fission products from process streams. Nitrate is readily leached from these salts into groundwater

if not properly disposed of. Westinghouse Hanford Company, a prime contractor at the Hanford, Washington, facility, is testing a method for converting waste nitrate salts to a free-flowing carbonate powder suitable for immobilization in cement. Once immobilized, the material can be easily transported and may be disposed of with few restrictions.

All DOE facilities generate waste reactive metals which are difficult to manage safely. Argonne National Laboratory is developing a spray-burning process capable of handling large quantities of reactive metal wastes. The product of the spray burner will be converted to a glass, which can be disposed of by land burial and which will retain any remaining hazardous or radioactive material.

Finally, Pacific Northwest Laboratory is exploring the use of microorganisms for in situ decontamination of soil and water previously contaminated with hazardous substances. They will test both indigenous populations and commercially available cultures for their response to nutrient amendments and enrichments. Experiments will be carried out both in the laboratory and in the field.

IMPROVING DISPOSAL

Disposal of hazardous wastes is becoming increasingly difficult because of the increasingly stringent regulatory requirements. The 1984 amendments to the Resource Conservation and Recovery Act contain a strategy to eventually ban land disposal of all but the most innocuous of wastes. Yet, it is highly unlikely that our best efforts at waste generation reduction and waste treatment will totally eliminate the need for waste disposal. We must, therefore, be working toward a means of disposing of the wastes that remain. Lawrence Livermore National Laboratory is evaluating alternatives to land disposal as it is currently practiced. They are evaluating deep geologic disposal, such as mined repositories, deep burial, deep well injection, and hydrofracture. Hydrofracture combines some features of mined repositories and deep well injection. A waste grout is injected into a deep shale formation, the layers are fractured, and a cavity is created where the waste grout then solidifies. They are also investigating the advantages of burial in arid land, where leaching of hazardous constituents may not occur at all and where groundwater is sufficiently deep that contamination is unlikely.

SUMMARY, STATUS, AND PROSPECTS

The Department of Energy manages wastes that are common to industry everywhere, but also manages wastes that are unique. Most of the unique wastes are both chemically hazardous and radioactive, and some have national security implications. The Department has managed these wastes for the protection of human health and the environment for over 40 years, and management practices have evolved as our understanding of the hazards posed by these wastes has improved. The evolution of management practices has recently been accelerated by changes in regulatory requirements and public opinion. In response, the Department has initiated an R&D program to improve our waste management practices.

The Department's R&D program is based on exposure reduction, generation reduction, improved treatment technology, and alternatives to land disposal. The coordinated effort, which is less than a year old, addresses issues identified as needs by the DOE Defense Programs operating contractors. These needs are continually reassessed, and new R&D efforts will be initiated as further needs and priorities are identified.