MIXED WASTE INTEGRATED PROGRAM PROBLEM-ORIENTED TECHNOLOGY DEVELOPMENT

Paul W. Hart
Program Manager
U.S. Department of Energy
Washington, D.C. 20874

Jeanette B. Berry
Integrated Program Coordinator
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831

ABSTRACT

The U.S. Department of Energy (DOE) is responsible for the management and treatment of its mixed low-level wastes (MLLW). MLLW are regulated under both the Resource Conservation and Recovery Act and various DOE orders. Over the next 5 years, DOE will manage over 1.2 m^3 of MLLW and mixed transuranic (MTRU) wastes. In order to successfully manage and treat these mixed wastes, DOE must adapt and develop characterization, treatment, and disposal technologies which will meet performance criteria, regulatory approvals, and public acceptance. Although technology to treat MLLW is not currently available without modification, DOE is committed to developing such treatment technologies and demonstrating them at the field scale by FY 1997.

The Office of Research and Development's Mixed Waste Integrated Program (MWIP) within the DOE Office of Environmental Management, Office of Technology Development, is responsible for the development and demonstration of such technologies for MLLW and MTRU wastes. MWIP advocates and sponsors expedited technology development and demonstrations for the treatment of MLLW.

MWIP encourages appropriate public participation in the development and demonstration of its technologies. Therefore, the structure of MWIP reflects the two-pronged approach that is required for mixed waste technology development: 1) demonstration/commercialization – user, stakeholder, and regulator interfaces facilitate technology demonstration and support implementation in a systems context; and 2) technology development – unit operations are tested to collect data for technical evaluations. Mixed waste treatment process development is unique because regulatory, stakeholder, and user requirements and needs provide the driving forces for technology selection. Moving technologies from development to demonstration requires approvals and acceptance from these diverse oversight groups. Therefore, steps to support demonstration/commercialization must be clearly defined and implemented. Technology development is ongoing in technical areas required to process mixed waste: materials handling, chemical/physical treatment, waste destruction, off-gas treatment, final forms, and process monitoring/control.

MWIP is expediting the development of a suite of technologies to process heterogeneous waste. One robust process is the fixed-hearth plasma-arc process that is being developed to treat a wide variety of contaminated materials with minimal characterization. Additional processes include steam reforming and a catalytic extraction process that uses molten metal technology. Both processes are being demonstrated by the commercial developer of the technology. Advanced off-gas systems are also being developed.

Vitrification technologies are being demonstrated for the treatment of homogeneous wastes such as incinerator ash and sludge. An alternative to conventional evaporation for liquid removal—freeze crystallization—is being investigated. Since mercury is present in numerous waste streams, mercury-removal technologies are being developed.

INTRODUCTION

The mission of the Mixed Waste Integrated Program (MWIP) is to identify, evaluate, modify, develop, demonstrate, and transfer technologies and systems to characterize, treat, and dispose of U.S. Department of Energy (DOE) mixed low-level wastes (MLLW). Once commercialized, these technologies and systems will used by internal DOE organizations tasked with environmental restoration and waste management activities. These technologies and systems must permit DOE to achieve compliance with regulatory requirements for the characterization, treatment, and disposal of DOE MLLW and Mixed Transuranic (MTRU) waste. They must reduce risk, provide improved performance relative to current technologies, minimize life-cycle costs, meet regulatory requirements, and achieve public acceptance. In many cases, no treatment technology, treatment capacity, or waste disposal criteria currently exist.

MWIP advocates and sponsors expedited technology development and demonstrations for the treatment of MLLW through a variety of funding vehicles, which include cooperative research and development agreements, Program Research and Development Announcements, Research Opportunity Announcements, the Small Business Innovative Research program, and Technical Task Plans, through the DOE National Laboratory System). The MWIP is developing and demonstrating treatment technologies that are superior to existing ones in risk reduction, lower life-cycle costs, and improved process performance. As a matter of policy, MWIP is committed to fostering industry involvement and to privatizing technologies developed under its programs (technology transfer and commercialization).

The Federal Facility Compliance Act of 1992 (FFCAct) provides for the inclusion of stakeholders, [e.g., the Western Governor's Association (WGA), state and local governments, environmental groups, and key members of the general public] in DOE's technology development and demonstration process. Technology selection, development, and implementation must, therefore, be provided in a manner and a time frame which is acceptable to the stakeholders and which meets the requirements of the Act.

To accomplish its mission, MWIP seeks to draw on private-sector technical, engineering development, manufacturing, commercialization, and implementation (e.g., site/waste stream remediation) capabilities. This can be accomplished through a variety of contractual mechanisms and often involves a collaborative relationship between the private sector and DOE's national laboratories. The private sector, including academia, industry, and individuals, is encouraged to contact the MWIP to assist DOE in providing technologies to characterize, treat, and dispose of mixed wastes in a timely and effective manner.

BACKGROUND

Types and Sources of Mixed Waste

During the next 5 years, DOE will manage over 1,200,000 m^3 of MLLW and MTRU waste at 50 sites in 22 states (see Table I). The difference between MLLW and MTRU waste is in the concentration of elements that have a higher atomic weight than uranium. Nearly all of this waste will be located at 13 sites. More than 1400 individual mixed waste streams exist with different chemical and physical matrices containing a wide range of both hazardous and radioactive contaminants. Their containment and packaging vary widely (e.g., drums, bins, boxes, and buried waste). This heterogeneity in both packaging and waste stream constituents makes characterization difficult, which results in costly sampling and analytical procedures and increased risk to workers.

Based on radioactive characteristics, hazardous components, and physical/chemical matrices, DOE has grouped its wastes to reflect salient treatment considerations for each waste stream. These "treatability groups" relate waste streams to treatment facilities and to technology development needs (1). Aqueous liquids include all pumpable aqueous liquids which may have total or settled solid levels as high as 40%. Organic liquids, sludges, and solids are primarily treated by incineration; however, considering the inventoried and projected quantities of organic liquids, solids, and sludges to be generated, DOE estimates that there is insufficient capacity for treating these mixed wastes to Land Disposal Restriction (LDR) standards. Inorganic sludges and solids are generally stabilized prior to disposal. Again, DOE does not have the treatment capacity to handle this treatability group. Soil and debris present a distinct problem to DOE. Other wastes include several distinct categories (e.g., laboratory packs, reactive metals, elemental mercury, elemental lead, explosives, and compressed gasses).

TABLE I
DOE-Managed Mixed Low-Level Waste and Mixed Transuranic Waste Volumes

Source of Mixed Waste	Volume (m^3)
Current Site Inventories	247,000
Mixed Low-Level Waste	58,000
Mixed Transuranic Waste	
Operations Generated (Five-Year Projection)	
Mixed Low-Level Waste	280,000
Mixed Transuranic Waste	2,800
Environmental Restoration (Five-Year Projection)	
Mixed Low-Level Waste	620,000
Mixed Transuranic Waste	300
Total	1,208,100
NOTE: Information from the Interim Mixed Waste Inventory Report	

Regulatory Considerations

The FFCAct of 1992 waives sovereign immunity for federal facilities, thereby allowing DOE to be subject to fines and penalties for failure to manage mixed waste according to the Resource Conservation and Recovery Act (RCRA). This congressional mandate for the DOE to treat its mixed waste establishes a 3-year timetable for development of site treatment plans, during which time there is a delay of the waiver of sovereign immunity for mixed waste LDR violations (see Table II).

TABLE II
Federal Facility Compliance Act Milestones

Deliverable	Date
Conceptual Site Treatment Plans	October 1993
Draft Site Treatment Plans	August 1994
Site Treatment Plans	February 1995
Plans in place, orders issued (EPA/States)	October 1995

The Act gives states approval authority over the site treatment plans. After plans have been reviewed, it is anticipated that equity brokering between states will occur regarding treatment, storage, and disposal-facility locations.

Stored and future-generated MLLW must be treated according to RCRA guidelines covered in the FFCAct or in other existing compliance agreements. Stored and future-generated MTRU waste must be prepared to meet transportation and waste acceptance criteria (not RCRA disposal requirements). Additional schedule requirements have been established by other compliance agreements (e.g., Federal Facility Compliance Agreements), which, in some cases, have shorter deadlines than the FFCAct.

Negotiations will be necessary to reach agreements between the states/U.S. Environmental Protection Agency (EPA) and DOE on treatment methods that will be used to comply with regulatory requirements. The National Governors' Association (NGA) is providing a forum for states, the EPA, and DOE to discuss FFCAct implementation. The NGA has endorsed the WGA initiative to foster use of innovative technologies and early involvement of regulators and stakeholders in technology demonstrations. The MWIP has been involved and will continue to build on this initiative.

Key Stakeholder Considerations

Public: The public interest in safety and environmental issues related to nuclear waste demands that DOE use adequate methods of dealing with nuclear defense wastes. The most effective treatment methods must be used to treat mixed wastes in a safe and cost-effective manner, and implementation must have public acceptance. Existing DOE activities are designed to facilitate public outreach and interaction with a diverse set of environmental, citizen, and business groups; Indian tribes; and state/local governments and elected officials. Examples of these initiatives include the WGA–Develop On-Site Innovative Technologies (DOIT) Committee's Mixed Waste Working Group and site-specific advisory boards.

Regulatory Agencies: EPA and state agencies are required to enforce the FFCAct. The FFCAct gives states (and in some cases EPA) approval authority over the site treatment plans. The above-mentioned public participation groups also include regulators and can provide a forum for building consensus regarding treatment options. Regulatory involvement at the project level can identify areas of concern early in the development of a technology, so that technical issues that are important to the public and the regulators are addressed during process development. This involvement can potentially expedite implementation of innovative technologies.

An example of public enhancement of technology development and implementation is the WGA–DOIT Committee's Mixed Waste Working Group, which is bringing together stakeholders from around the nation to chart a course and develop consensus for accelerated testing of innovative mixed waste technologies and encouraging new private-sector partnerships through formal solicitation of proposals for creative new technological, regulatory, or institutional approaches to mixed waste. The Mixed Waste Working Group has identified nine DOE projects for candidate 1994 demonstrations that offer potential for breakthrough innovation, regulatory and host community acceptance, broad deployment, and ultimate commercialization.

State of Technology Development

Although hazardous waste treatment is a relatively mature technological area, processes for treatment of hazardous waste have not been fully demonstrated for use with mixed waste. Major technology gaps include adaptation of existing processes to handle radionuclides present in MLLW and MTRU waste, as well as the RCRA hazardous constituents, while processing a wider range in the amount and type of contaminants in the waste streams than are typically seen in hazardous waste streams.

MWIP DEMONSTRATION/COMMERCIALIZATION INITIATIVES

MWIP has fostered and participated in cooperative efforts that are now being implemented throughout the DOE Office of Environmental Management (EM). For example, MWIP is working with the Office of Waste Management (OWM) on strategic planning for mixed waste. Baseline flowsheets, developed by the Mixed Waste Treatment Project, have served as the basis for MWIP technology development needs identification and selection of projects for development. This has resulted in focusing technology development activities on overcoming major obstacles to progress in mixed waste treatment to ensure that treatment leads to disposal. Major needs include 1) robust treatment processes, 2) enhanced waste forms to facilitate disposal, and 3) a systems approach to the mixed waste problem to ensure development of technology with improved cost/benefit over existing technologies.

MWIP has addressed the need for public acceptance of emerging technologies through participation with the WGA–DOIT Committee's Mixed Waste Working Group and through project-specific interaction with local regulators. Incorporating the interests and needs of regulators and the public is accomplished by initiating the permitting process during early stages of technology development and by working with the WGA. This stakeholder involvement is expected to ease implementation of innovative and emerging technologies.

MWIP is joining with OWM in reviewing site-specific treatment plans in order to make recommendations regarding consistency in technical approach across the DOE complex (including use of emerging technologies) and to support sites with limited technical resources. This joint participation has allowed MWIP to take a national view of mixed waste issues while maintaining access to site-specific needs and issues.

Systems Analysis

The cost of treating and disposing of MLLW and MTRU waste is estimated in the multibillion dollar range. This cost provides incentives to develop versatile treatment capabilities that do not require excessive characterization costs for safe and effective operations and that can be standardized to assist with regulatory and public acceptance. MWIP's customers, OWM and the Office of Environmental Restoration, are responsible for treating mixed waste and for selecting treatment technologies. There is disagreement over the acceptability of existing, proven technologies and their effective implementation in systems to treat a wide diversity of DOE waste streams. Incentives for use of evolving and/or innovative technology are dependent upon the potential for reduction in life-cycle cost, reduction in risk, and improved performance. Results of systems analyses conducted under MWIP have been documented (2,3,4,5).

The challenge for MWIP is to clearly establish the cost/benefit of using emerging technologies and technology systems to support selection for implementation. Technology selection will, therefore, be based on the following:

- A systems analysis, founded on technical rationale, that identifies deficiencies and gaps in present technologies that prevent fast and effective implementation of waste treatment systems.
- A systems analysis that clearly demonstrates the cost/benefit of implementing emerging and/or modified technologies.
- Public and regulator participation in and acceptance of emerging and/or innovative technologies. These factors play a major role in specific technologies being selected for implementation. Consensus building between numerous stakeholders is the preferred method of determining those technologies that will be developed and deployed.

One component of the systems analysis is to ensure that data are comparable when they are collected from experiments conducted at various locations by researchers with diverse backgrounds. To this end, surrogate formulations have been devised that represent major categories of waste throughout the DOE complex (6,7,8). For more waste stream–specific applications, simulants have been developed (9). An additional factor that contributes to data comparability is the specification of the parameters of importance for which data must be collected (10,11).

MWIP TECHNOLOGY DEVELOPMENT INITIATIVES

MWIP has been organized into technology areas that reflect major components of a generalized train of mixed waste treatment operations. These technical areas include materials handling, chemical/physical treatment, waste destruction, off-gas treatment, final forms, and process monitoring/control (see Fig. 1).

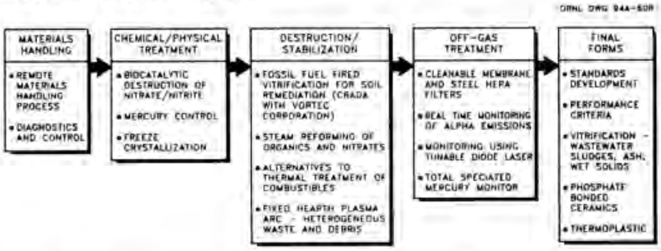

Fig. 1. Systems approach to technology development.

MWIP is conducting laboratory tests and field demonstrations using site-specific wastes to provide data for decision making regarding full-scale implementation. MWIP uses diverse contractor support from the national laboratories, academia, and private industry, allowing for a wide range of experience and expertise pertinent to mixed waste treatment to assist the Program and its principal investigators in meeting DOE needs. Table III summarizes MWIP technology development initiatives by technical area. Descriptions of each project have been complied elsewhere (12,13,14).

Technology Area Status Reports (TASRs) identifying and describing currently available technologies for the management, treatment, and disposal of MLLW were developed and issued in FY 1993 in the areas of chemical/physical treatment (15), waste destruction and stabilization (16), final waste forms (17), and off-gas treatment (18). TASRs will soon be published in the areas of materials handling, alternatives to thermal treatment, and process monitoring and control. These documents are available from the Program and through the National Technical Information Service. MWIP descriptive documentation includes a *Mixed Waste Integrated Program (MWIP) Technology Summary*, to be available through the Government Printing Office, and *FY 1993 Program Summary, Office of Research and Development, Office of Demonstration, Testing and Evaluation*, available as DOE publication DOE/EM-0109P.

The principal thrusts of MWIP are to develop the technological bases to reduce the characterization requirements for DOE's heterogeneous wastes, reduce waste volumes by significant amounts (sometimes orders of magnitude), and produce, by the most direct route, final waste forms which can be directly disposed of (i.e., disposed of without further processing). MWIP is also committed to developing and fielding technologies in a timely manner and, therefore, is sponsoring expedited demonstrations of technologies in application to actual mixed wastes. These demonstrations are usually sited at DOE facilities to help reduce regulatory and public acceptance impediments to demonstrations and to facilitate commercialization of the technology.

MWIP is supporting three expedited demonstrations at this time: fixed-hearth plasma arc, vitrification, and molten metal technology. The status of each expedited demonstration is discussed below.

Fixed-Hearth Plasma Arc

Incineration is applicable for treatment of many mixed waste streams, but it has limited public acceptance. Other waste destruction technologies have been evaluated (16). The fixed-hearth plasma-arc furnace is being demonstrated using a variety of mixed wastes (19,20). This process offers benefits of direct production of enhanced final waste forms, potentially reduced waste feed characterization, potentially reduced off-gas volumes, and the ability to treat a broader array of waste streams. The process, designed to accept unopened/unsorted drummed wastes, recently underwent a series of surrogate tests. The principal objectives were to establish the treatability of priority MWIP waste streams and to generate off-gas composition data to aid in off-gas component selection and design. Three simulated mixed waste types – an organic sludge, an inorganic sludge, and a heterogeneous combustible debris (wood, paper, rubber, steel, etc.) – were spiked with hazardous components (heavy metals and organics) and radionuclide surrogates. A total of six tests, two replicates for each waste type, were successfully completed.

Preliminary results indicate that all the tests were very successful. All test materials were converted to a dense, vitrified monolith that is expected to test favorably for leach resistance using the toxicity characteristic leaching procedure and the product consistency test. Off-gas samples are currently being analyzed for particulate loading, particle-size distribution, and total metals content at the secondary stage outlet (prior to off-gas equipment) and for particulate loading, total metals content, HCl, and organics destruction at the off-gas system outlet (stack). The testing was completed ahead of schedule and well within the allocated budget.

This experimental series completed proof-of-principle tests of the plasma-hearth process. The tests generated valuable data that will be used to assess potential mixed waste treatment applications for the technology. Test data will also support radioactive system permitting and safety assessment activities as well as provide baseline data to support hardware design and optimization. Currently, a pilot-scale system is being designed and will be constructed and tested to gain the process engineering information needed to design a field-scale unit. The field-scale system will be demonstrated and a final assessment of the technology will be made by FY 1996.

Off-gas systems are commercially available for particulate capture, destruction of products of incomplete combustion, and abatement of nitrogen oxides. However, improvements in off-gas treatment are needed and are being developed under MWIP. Off-gas technology development initiatives include cleanable high-efficiency particulate air filters and systems designed to capture mercury [ ]. Current capabilities for process control and monitoring, especially for off-gas subsystems, are not adequate for DOE needs.

Vitrification

Grouting is a commonly used process for stabilization of waste. However, the ultimate disposition of grouted waste is highly uncertain due to the lack of disposal requirements or disposal sites. The volume increase associated with grouting conflicts with waste minimization policies and makes the final product costly to store or dispose of.

TABLE III
Technology Development Needs by Functional Area and Waste Class[a]

Waste Class/ Functional Area	Homogenous Waste: Sludges, Aqueous, and Organic Liquids	Heterogeneous Waste: Debris and Others
Waste Destruction	• Concentration • Separations and removal of specific species for subsequent processing • NO_x-Ammonia destruction • Innovative thermal processes with closed-loop off-gas systems • Nonthermal processes with closed-loop off-gas systems – Freeze crystallization • Particulate removal • On-line monitoring/control • Mobile systems	• Decontamination • Mercury removal • Mercury vapor control • Innovative thermal processes with closed-loop off-gas systems • Nonthermal processes with closed-loop off-gas systems • Particulate removal • On-line monitoring/control • Mobile systems • Metal reuse
Waste Stabilization	• Concentration • Pretreatment processes such as – Nitrate/organic destruction – Mercury removal • Separations and removal of specific species for waste stabilization • Enhanced, stable waste forms • Waste form testing and performance assessment • Transportation	• Separations and removal of specific species for waste stabilization • Enhanced, stable waste forms • Transportation
Systems Analysis and Integration (Note: This analysis addresses alternative technology subsystems and treatment systems, not macrolevel systems analysis)	• Validated set of customer needs • Project priorities based on needs • Life-cycle costs • Risk assessment • Project integration • Data consistency	• Validated set of customer needs • Project priorities based on needs • Life-cycle costs • Risk assessment • Project integration • Data consistency

[a]Note: Waste minimization initiatives are applicable for all technical areas and waste classes in Table III.

A viable alternative to waste grouting is vitrification of MLLW with emphasis on sludges. Building on in-depth data generated for high-level waste vitrification has contributed to the success of MLLW glass formulations and bench-scale and pilot-scale experiments. Glass formulation tests for surrogate wastewaters and incinerator ashes using surrogate wastes have been successfully completed. Tests have been conducted using pilot-scale vitrifiers to obtain operational data. For example, a vitrification demonstration of surrogate incinerator ash was completed in December 1993 (21). Tests of actual waste streams using a pilot-scale joule-heated ceramic melter are scheduled for FY 1994. Demonstrations of a field-scale mobile (transportable) melter using actual wastewater sludge and/or incinerator ash are scheduled for completion during FY 1995. Data will be available to design and support the operation of full-scale units. These data will include the limits of vitrification equipment for destruction of some RCRA organic constituents (22-26).

Molten Metal Technology

A demonstration on radioactive MLLW using molten metal technology is planned by the commercial developer. The catalytic extraction process is a commercially available, flexible process designed to accept materials in most chemical and physical forms. The technology uses the catalytic effect of a molten metal bath to revert injected feed streams into their elemental components. The co-feeding of reactants and controlled operating conditions allow selective partitioning of elements to gas, ceramic, or metallic product streams. Recovered resources, which may include synthesis gas and ferroalloys, are complemented by the concurrent stabilization of many radioactive isotopes in a ceramic product suitable for final form disposal. Potential technical benefits of the technology include destruction of the hazardous and toxic organic contaminants in mixed waste; controlled partitioning of radionuclides; containment of radionuclides in a nonleachable ceramic matrix suitable for final disposal; decontamination of metals allowing reuse or recycle; minimal feed pretreatment, handling, and analytical requirements; minimal generation of secondary waste; and minimal operator interaction.

Demonstrations using surrogate material are being conducted under a Program Research and Development Announcement. A joint commercial venture to conduct tests using radioactive wastes has been implemented while a full scale demonstration on actual mixed waste is proposed for FY 1996 (27).

Chemical/Physical Treatment

Pretreatment may be required before mixed waste can be processed. Technologies are generally available for pretreatment and effluent polishing (e.g., ion exchange, filtration, evaporation) [ ]. Additional treatment is required to destroy organics and to stabilize or, where appropriate, to recycle radioactive or metallic or other constituents of the waste subject to RCRA LDRs. Decontamination technologies are being considered to prepare waste for reuse within the DOE complex (28).

Pretreatment may also be required in conjunction with waste stabilization. An alternative to evaporation to concentrate waste by liquid removal is freeze crystallization. Destruction of nitrates and organics and removal of mercury may be achieved most effectively at the beginning of a waste treatment process (29,30).

Alternatives to Thermal Treatment

Alternatives to thermal treatment processes require development. Examples of alternatives to thermal treatment that are being developed under MWIP include thermal desorption, steam reforming, and biocatalytic destruction of nitrate/nitrite. A literature survey found that acid digestion and catalyzed wet-air oxidation appear to be attractive alternatives to thermal treatment (31). Investigation of these technologies is planned.

Final Waste Forms

Development of waste form performance criteria and standardized test methodologies is critical to the resolution of mixed waste problems. Neither disposal criteria nor uniform test methods have been established. Consensus of the technical community, regulators, and stakeholders is necessary to establish these criteria. As the technical arm of EM addressing mixed waste, MWIP has documented test methods and is proposing revisions to the DOE performance assessment methodology [ ]. An objective of MWIP is that these data will be used in establishing waste acceptance criteria for disposal.

TECHNOLOGY DEVELOPMENT NEEDS

The MWIP has identified specific needs for its ongoing program in the following areas.

Closed-Loop Off-Gas Systems. Real-time instrumentation is needed to monitor the release of heavy metals, radionuclides, and various hydrocarbons from thermal processes used to treat mixed wastes (e.g., incinerators, vitrifiers, and plasma furnaces) in order to alleviate public concern and reduce the difficulty of siting and permitting a mixed waste thermal treatment facility.

Expedited Demonstration of a Mixed Waste Treatment Technology. MWIP needs to perform expedited treatment demonstrations on actual mixed wastes within 1 year. Technologies that can treat a wide variety of waste streams and high-volume streams in the inventory (e.g., sludges and solids) are a priority.

Process Monitoring and Control Technology. MWIP needs to develop hardware and software systems that support mixed waste treatment technologies. Real-time monitoring of off-gas species such as radionuclides, heavy metals, carbon monoxide, and hydrocarbons are a priority.

Low-Temperature Mixed Waste Treatment Processes. Low-temperature treatment technologies are needed to simplify waste processing in response to stakeholder concerns and the need for lower life-cycle costs. A low-temperature technology is defined by an approximate 300°C process limit.

Long-Term Performance Assessment of Final Waste Forms. There is a need to predict long-term physical and chemical integrity of solidified wastes. Leaching rates and mechanisms by which waste forms release their toxic constituents need to be understood and modeled.

Application of the Debris and Empty Container Rules. MWIP's goal is to apply the rules governing hazardous debris to mixed waste debris, evaluate the performance of debris treatment technologies in the treatment of mixed wastes, and potentially achieve best demonstrated available technology status of such technologies.

Efficient Separations of Mixed Wastes. There is a need for new and improved separations methods for treating mixed wastes. Species such as sulfates and volatile metals may inhibit the formation of a durable glass or generate a toxic species. Separation of the radioactive and hazardous elements could allow each to be handled under only one set of regulations. Minimization of secondary wastes and recycle of as many of the process reagents as possible is desirable.

CONCLUSION

DOE faces major technical challenges in the management of low-level radioactively contaminated mixed waste. Several conflicting regulations and lack of definitive mixed waste treatment standards hamper implementation of mixed waste treatment technologies. Disposal capacity for mixed waste is also expensive and severely limited. DOE now spends millions of dollars annually to store mixed waste because of the lack of accepted treatment technology and disposal capacity. Currently available waste management practices require extensive, and hence expensive, waste characterization before treatment. Therefore, DOE must pursue technology that leads to better and less expensive characterization, retrieval, handling, treatment, and disposal of mixed waste.

Selection of technologies that are acceptable and have improved cost/benefit over existing technologies will be accomplished under the following approach:

- teaming with the customers in EM to identify, develop, and implement needed technology;
- focusing technology development activities on major problems such as heterogeneous waste destruction and homogeneous waste stabilization;
- involving industry in developing and implementing solutions including both technology transfer to the

Department and technology transfer from DOE to the private sector;

- enhancing mechanisms for regulator and stakeholder involvement; and
- enhancing mechanisms for commercializing technologies and systems.

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